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Original Contributions

Predictors of medication refill–seeking behavior in the ED

Adam H. Miller MD, MSc*, Gregory L. Larkin MD, MSPH, Claudie H. Jimenez MD, MSc

Division of Emergency Medicine, University of Texas Southwestern Medical Center and the Parkland Health and Hospital System, Dallas, TX 75390-8579, USA

Received 2 January 2005; accepted 8 January 2005

Abstract

Objective: Determine predictors of medication refill–seeking behavior in ED patients with chronic illness.

Methods/Design: Prospective cross-sectional ED survey conducted for 6 weeks.

Setting: Public hospital ED (>140,000 visits per year).

Subjects: ED patients (>18 years) taking chronic medications for congestive heart failure, diabetes, and/or hypertension.

Results: Of 1168 patients surveyed, 344 (29%) presented to the ED secondary to running out of medications and requiring a medication refill. Univariate predictors included age younger than 50 years, non-Hispanic ethnicity, low income (<US$5000 per year), self-pay payor status, and being told to call a primary care physician before medication would be refilled. Lack of knowledge about refill or pharmacy numbers on the medication bottle resulted in patients being more than twice as likely to be in the ED for a medication refill (odds ratio 2.4 [1.6, 3.6] and 2.0 [1.3, 2.9], respectively).

Conclusion: Presenting for medication refills is common in ED patients with chronic illness.

1. Introduction

EDs have seen an ever-increasing volume of users, fueling an overcrowding crisis in EDs across the nation [1]. In the year 2000, ED visits were at an all-time high of 108 million [2]. Contributing to the overcrowding problem, a small group of patients (3-4%) present to the ED for medication refills, and some studies suggest that this group accounts for a disproportionate number (12%-20%) of total ED visits [3,4]. These frequent ED users reflect the urban social problems of poverty, chronic illness, health care access [3-6], and the inverse trend between prescription drug costs and insurance benefits [7].

Total prescription drug expenditures in the United States have more than doubled in the past decade to more than US$160 billion, and prescription drug spending per capita has nearly tripled over the same period to approximately US$500 per person per year [8,9]. Prescription drug costs currently represent the fastest growing component of all health care spending in the United States (15.3%) [8,10] and have led consumers to Mexico, Canada, the World Wide Web, and even the EDs in search of affordable medications.

Although numerous authors have investigated the overall reasons for presenting to the ED for medical care [3,4,11-16], few have measured the associated risks of relying on the ED as a pharmacy of last resort for routine medications. Therefore, we sought to evaluate the preva-
2. Methods

The local institutional review board approved this study and the attendant consent process. Adult patients (age >18 years) presenting to a large public ED (serving over 140,000 patients per year) who, by initial history taking, carried the diagnosis of congestive heart failure (CHF), diabetes mellitus (DM), and/or hypertension (HTN) were eligible for enrollment. Patients were excluded if they were pregnant, unable to speak in Spanish or English, had acute trauma, or were otherwise in extremis.

From June 1 to July 15, 2002, trained research assistants were instructed to come in to the ED during random time blocks to identify eligible patients for the study. After consent was obtained, researchers administered the 39-question survey in English or Spanish. The survey instrument was reviewed by an independent panel of health policy experts and psychologists and found to have good face validity using a modified Delphi technique for measuring the construct of “medication refill-seeking behavior.”

For analysis and weighting, the 3 chronic disease states were further defined as follows: patients who carried an antecedent diagnosis of CHF were categorized into the “CHF group” even if they also had DM or HTN. Patients with DM alone or DM in combination with HTN were categorized into the DM group. Patients with HTN alone were categorized into the HTN group. Confirmation of disease status and the chronic use of medication for these disease states were obtained when patients voluntarily demonstrated their medication bottles to the investigators.

Patients were also categorized by demographics and insurance status. Patients with public assistance from the county government were classified as having “Medicaid managed care.” Privately insured patients (with or without a managed care component) were categorized as “private” even if they had other types of insurance. Patients without private insurance or Medicaid managed care were categorized into 3 remaining groups: Medicaid, Medicare, or “uninsured.”

2.1. Data analysis

Descriptive statistics, frequency counts, and means were compared using 2-tailed t tests or nonparametric (Mann-Whitney U or Kruskal-Wallis) tests as appropriate. Differences of proportion for categorical variables were compared for the 3 chronic disease states using standard χ² statistics and Fisher exact test, P < .05 being significant and multiple comparisons being controlled for with Bonferroni correction, when appropriate (P < .01). Bivariate comparisons were made using simple odds ratios (ORs) with 95% confidence intervals (CIs), and multivariate analyses were conducted using logistic regression; candidate variables were chosen a priori and entered into the multivariate analysis if they were significant at the P = .15 level or better, and they were retained, provided P < .05.

3. Results

3.1. General demographics

Research assistants identified 1168 consecutive patients who were eligible for the study. No patient refused. Upon audit of the ED electronic record, there were no statistical differences in sex, ethnicity, age, or insurance status compared with the survey data obtained. Of the 1168

<table>
<thead>
<tr>
<th>Demographic</th>
<th>% Of all patients in study</th>
<th>% Of the “average ED patient” nationwide</th>
</tr>
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<tbody>
<tr>
<td>Sex (men)</td>
<td>41.7%</td>
<td>45.9%</td>
</tr>
<tr>
<td>Age &gt;50 y</td>
<td>59.3%</td>
<td>33.0%</td>
</tr>
<tr>
<td>Weight &gt;225 lb</td>
<td>20.9%</td>
<td></td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>African American</td>
<td>51%</td>
<td>22.6%</td>
</tr>
<tr>
<td>White</td>
<td>20%</td>
<td>74.2%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>27%</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>2%</td>
<td>3.3%</td>
</tr>
<tr>
<td>Insurance status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private insurance</td>
<td>6%</td>
<td>38.9%</td>
</tr>
<tr>
<td>Medicaid managed care</td>
<td>33%</td>
<td>19.7%</td>
</tr>
<tr>
<td>Medicare</td>
<td>19%</td>
<td>15.4%</td>
</tr>
<tr>
<td>Medicaid</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td>No insurance</td>
<td>33%</td>
<td>14.5%</td>
</tr>
<tr>
<td>Household income (US$/y)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;5000</td>
<td>51%</td>
<td></td>
</tr>
<tr>
<td>5000-10000</td>
<td>23%</td>
<td></td>
</tr>
<tr>
<td>10000-30000</td>
<td>23%</td>
<td></td>
</tr>
<tr>
<td>30000</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>Unemployed</td>
<td>8.7%</td>
<td></td>
</tr>
<tr>
<td>Social factors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lacking social support (lives alone)</td>
<td>28%</td>
<td></td>
</tr>
<tr>
<td>Noncitizen</td>
<td>6.6%</td>
<td></td>
</tr>
<tr>
<td>Non–English-speaking</td>
<td>25%</td>
<td></td>
</tr>
<tr>
<td>Own home</td>
<td>59%</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td></td>
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<tr>
<td>“High school education”</td>
<td>46.5%</td>
<td></td>
</tr>
<tr>
<td>High school education</td>
<td>53.5%</td>
<td></td>
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<tr>
<td>Some college</td>
<td>22.1%</td>
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<tr>
<td>Medical history</td>
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<td></td>
</tr>
<tr>
<td>DM</td>
<td>49.2%</td>
<td></td>
</tr>
<tr>
<td>HPN</td>
<td>79.3%</td>
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</tr>
<tr>
<td>CHF</td>
<td>19.7%</td>
<td></td>
</tr>
<tr>
<td>Two or more conditions</td>
<td>38.7%</td>
<td></td>
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</table>

Also included are the national percentages of the “average ED patient” for age, sex, ethnicity, and insurance status (column 2) [48].
patients surveyed, 20% were categorized into the CHF group, 39% DM, and 41% HTN alone. Of the 229 patients categorized as CHF, 13% reported a diagnosis of CHF alone, 5% also had DM, and 34% also had HTN, whereas 48% had all 3 chronic diseases. Of the 449 patients with DM, 55% also had HTN. The average age was 54 years (±SD 13). The most common type of insurance in the overall cohort was Medicaid managed care (32%), whereas 6% had private insurance, and 33% had no insurance. Most patients (51%) were African American, and the next largest ethnic group was Hispanic (27%), whereas 24% of the sample preferred to communicate in Spanish (Table 1).

### 3.2. Univariate and multivariate associations

Of the 344 (29%, 95% CI 26.3%-32%) patients presenting to the ED who ran out of medications, 51% had been out for 10 days or more. Only 22% were out for 1 day, and 27% were out from 2 to 9 days. Significant univariate predictors of “being in the ED for a medication refill” included age younger than 50 years, non-Hispanic, African-American ethnicity, low income (<US$5000 per year), and being uninsured. In addition, patients who had diminished awareness of documented refill information were also at risk. Specifically, patients who did not know where refill number is on their medication bottle were nearly 2.4 times (OR 2.4 [1.6, 3.6]) as likely to be in the ED for a medication refill. Similarly, patients unaware of a pharmacy phone number on the bottle were twice as likely (OR 2.0 [1.3, 2.9]) to need a medication refill. Conversely, patients who had called the pharmacy for a refill in the past were only approximately 25% as likely to be in the ED for a medication refill. As these 2 factors are not independent, they were combined into a third variable, “uninformed about refill or prescription numbers” which was subsequently entered into the multivariate logistic regression model. Nearly 9% of all patients (n = 100) were told that they must call a primary care physician (PCP) before obtaining a refill, and they were more than 9 times as likely (OR 9.2 [5.7, 14.8]) to come to the ED in need of medication refills (Table 2).

### Table 2 Univariate predictors of 1168 patients with chronic disease (eg, CHF, DM, and HTN) who were “out of medication” when presenting to the ED

<table>
<thead>
<tr>
<th>Covariate</th>
<th>Out of medication (%)</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographic</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Men</strong></td>
<td>28.4</td>
<td>0.97 (0.75, 1.3)</td>
</tr>
<tr>
<td><strong>Age &gt;50 y</strong></td>
<td>26.3</td>
<td>0.73 (0.56, 0.94)*</td>
</tr>
<tr>
<td><strong>Weight &gt;225 lb</strong></td>
<td>25.1</td>
<td>0.78 (0.57, 1.1)</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>White</strong></td>
<td>26.2</td>
<td>0.84 (0.61, 1.17)*</td>
</tr>
<tr>
<td><strong>African American</strong></td>
<td>31.8</td>
<td>1.3 (1.0, 1.7)*</td>
</tr>
<tr>
<td><strong>Hispanic</strong></td>
<td>24.9</td>
<td>0.76 (0.57, 1.0)</td>
</tr>
<tr>
<td>Household income (US$/y) &lt;5000</td>
<td>32.1</td>
<td>1.4 (1.1, 1.7)*</td>
</tr>
<tr>
<td>Having to pay &gt;US$10 to see PCP</td>
<td>29.9</td>
<td>1.2 (0.77, 1.8)</td>
</tr>
<tr>
<td>Social factors</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Low social support</strong></td>
<td>25.5</td>
<td>0.78 (0.58, 1.0)</td>
</tr>
<tr>
<td><strong>Noncitizen</strong></td>
<td>22.4</td>
<td>0.69 (0.4, 1.2)</td>
</tr>
<tr>
<td><strong>Unemployed</strong></td>
<td>29.8</td>
<td>1.2 (0.89, 1.7)</td>
</tr>
<tr>
<td><strong>Own home</strong></td>
<td>27.1</td>
<td>0.81 (0.62, 1.0)</td>
</tr>
<tr>
<td><strong>Have own physician</strong></td>
<td>92.4</td>
<td>0.54 (0.78, 1.1)</td>
</tr>
<tr>
<td><strong>ED reliant for most of care</strong></td>
<td>31.5</td>
<td>1.2 (0.96, 1.6)</td>
</tr>
<tr>
<td><strong>Uninsured</strong></td>
<td>32.5</td>
<td>1.49 (1.13, 1.9)**</td>
</tr>
<tr>
<td><strong>&lt;High school education</strong></td>
<td>27.9</td>
<td>0.93 (0.72, 1.2)</td>
</tr>
<tr>
<td><strong>Some college</strong></td>
<td>28.6</td>
<td>0.99 (0.73, 1.4)</td>
</tr>
<tr>
<td>Medical history</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Diabetes</strong></td>
<td>28.2</td>
<td>0.92 (0.71, 1.2)</td>
</tr>
<tr>
<td><strong>Hypertension</strong></td>
<td>29.2</td>
<td>1.1 (0.8, 1.5)</td>
</tr>
<tr>
<td><strong>Congestive heart failure</strong></td>
<td>31.4</td>
<td>1.2 (0.85, 1.6)</td>
</tr>
<tr>
<td><strong>Two or more conditions</strong></td>
<td>30.0</td>
<td>1.11 (0.86, 1.4)</td>
</tr>
<tr>
<td>MD exposure in previous 12 months</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>See physician every 12 months</strong></td>
<td>30.9</td>
<td>1.2 (0.9, 1.5)</td>
</tr>
<tr>
<td><strong>See physician every 4 weeks</strong></td>
<td>30.9</td>
<td>1.2 (0.9, 1.5)</td>
</tr>
<tr>
<td><strong>See physician every 6 months</strong></td>
<td>30.9</td>
<td>1.2 (0.9, 1.5)</td>
</tr>
<tr>
<td><strong>Admitted to hospital in prior 12 months</strong></td>
<td>30.7</td>
<td>1.2 (0.45, 1.6)</td>
</tr>
<tr>
<td><strong>Know where pharmacy number is</strong></td>
<td>55.4</td>
<td>0.51 (0.34, 0.75)***</td>
</tr>
<tr>
<td><strong>Called pharmacy for refill</strong></td>
<td>28.6</td>
<td>24 (0.16, 0.34)***</td>
</tr>
<tr>
<td>Prescription factors</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Told to see PCP for refill</strong></td>
<td>75.4</td>
<td>9.2 (5.7, 14.8)***</td>
</tr>
<tr>
<td><strong>Attempted to call PCP/clinic</strong></td>
<td>59.3</td>
<td>0.92 (0.62, 1.4)</td>
</tr>
<tr>
<td><strong>Rx filled at county hospital</strong></td>
<td>33.3</td>
<td>1.4 (1.0, 1.8)*</td>
</tr>
<tr>
<td><strong>Refills listed on bottle</strong></td>
<td>37.7</td>
<td>0.31 (0.2, 0.49)***</td>
</tr>
</tbody>
</table>

* Lives alone.
* Fisher exact test P = .05.
** Fisher exact test P = .01.
*** Fisher exact test P = .001.

### Table 3 Multivariate logistic regression model predicting those patients with chronic disease (eg, CHF, HTN, and DM), who present to the ED “out of medication”

<table>
<thead>
<tr>
<th>Covariate</th>
<th>Odds ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Uninsured</strong></td>
<td>2.1 (1.5, 2.95)*</td>
</tr>
<tr>
<td>Admitted in previous 12 months 500</td>
<td>1.5 (1.1, 2.0)**</td>
</tr>
<tr>
<td>Uninformed at refill or prescription number</td>
<td>5.05 (3.7, 6.9)*</td>
</tr>
<tr>
<td>Told to see PCP at refill</td>
<td>6.2 (3.7, 10.4)*</td>
</tr>
<tr>
<td>ED reliance/insurance status</td>
<td>1.8 (1.2, 2.6)**</td>
</tr>
</tbody>
</table>

The model is significant; Wald statistic = 183.4, Nagelkerke $R^2 = 0.255$. Fisher exact test P = .05.

* Fisher exact test P = .001.
** Fisher exact test P = .001.
In a multivariate logistic regression model controlling for age, ethnicity, employment status, income, PCP contact, and social support, 5 candidate variables remained significant predictors of being out of medication and presenting to the ED (Table 3). Lack of insurance, being admitted in the previous year, being uninformed about refill or prescription number, being told to see their PCP about a refill, and the interaction between ED reliance and insurance status were all significant in the multivariate model.

4. Discussion

This is 1 of the first studies to describe the prevalence of refill-seeking behavior in the ED. Others have examined medication nonadherence phenomena in other settings and discovered similar associations with being uninsured and younger age with medication compliance [17-35]. Previous work has shown that patients do not follow their prescribed regimen of medication because of a perceived lack of susceptibility to illness, severity of illness, benefits of treatment, and access to treatment [36-38]. However, we could find no other studies demonstrating the strong association between showing up in the ED for a medication refill and modifiable risk factors such as knowledge about common refill practices.

The relationship between medication adherence and medical outcomes in those with chronic disease (eg, DM [21,22], HTN [23-26,28-31,39], CHF [17], organ transplant [32-35]) is well documented. Indeed, when noncompliance occurs, hospital admissions increase, and less favorable outcomes ensue [32,33,40]. The potential economic value to be gained in more favorable health outcomes from uninterrupted insurance coverage and medication adherence is estimated to be between US$65 and US$130 billion each year [41].

Although not tested here, patient knowledge and perceptions can be altered by interventions, which link communication to improved compliance [23,31,42]. The so-called “ESFT model” for communication and compliance described by Betancourt et al [23] addresses 4 domains: (1) the explanatory model (domain E) whereby the physician must first understand the patient’s conceptualization of his or her illness; (2) providers must then address the patient's ability to afford or physically obtain a prescribed medication described as social risk for noncompliance (domain S); (3) fears and concerns about the medication (domain F) dangers including a variety of sociocultural conceptualizations and folk beliefs; and (4) therapeutic contracting and playback (domain T) for patients with linguistic or contextual barriers to communication ensuring that patients understand the prescribed regimen and can repeat or “play back” medication instructions.

Cramer [42] also suggests that if the provider delivers specific feedback about missed doses, timing, and other adherence behaviors, overall compliance might improve. In our study, the univariate and the multivariate model both revealed that if the patient knew where the refill number was on the bottle and called the pharmacy for a refill, they were unlikely to present to the ED for a medication refill. This finding is indirectly supported by Mandelberg and Kohn [3], who found that access to a telephone was itself associated with lower overall ED use.

PCP access was contributory as well, because patients who were told to see their PCP before getting a refill were significantly more likely to present for an ED refill. (Table 2). The most recent annual report from the Centers for Medicare and Medicaid Services suggests that health care costs in the United States reached US$1.6 trillion in 2002 which is a 9.3% increase from 2001. The prescription drug costs rose to 15.3% in 2002, higher than any other component of the health care dollar [8,10].

Indeed, refill compliance problems are, in part, caused by the inverse relationship between drug costs and declining Medicare, Medicaid, and managed care reimbursements. Increasing co-pay and out-of-pocket costs for prescriptions [20,34], coupled with poor economic conditions [5,11,36-38, 43,44] and the expediency of provider access are powerful incentives to refill seeking behavior in the ED.

Didlake et al [32] studied how poor compliance with immunosuppressant medications in renal transplant patients, in part caused by the high cost of the medication as well as discontinuation of immunosuppressant medication by Medicare after the first year from transplantation (1992), is a leading cause of transplant rejection [33,34]. In addition, hospital readmission rates per patient among noncompliant renal transplant patients (5.9) was higher than compliant renal transplant patients (2.5); the mean length of stay was 11.3 versus 8.6 days, and mean costs were US$28 542 versus US$12 885, respectively [34].

Soumerai et al [40] reported that the limitation of reimbursement to 3 medications, for example, insulin, thiazide, and furosemide, resulted in a decline in the use of the medication and an increase in nursing-home admissions in those patients older than 60 years. Monane et al [17] examined digoxin therapy for CHF in the face of decreased reimbursement and demonstrated that digoxin was not used regularly throughout a 1-year follow-up (111/365 days). Only 10% of patients obtained enough refill to have sufficient digoxin for the whole study period.

Our study confirms previous findings as both being uninsured and a frequent visitor were both statistically significantly associated with presenting to the ED for a medication refill. We found that social issues were associated with patients presenting to the ED for medication refill: lack of social support (living alone), low income, and being a noncitizen, unemployed, and uninsured. However, there was no significant association between having a PCP or not, when presenting to the ED for a medication refill. (Table 2) In a multivariate model, we found that uninsured patients who had been admitted to the hospital in the previous 12 months and who were
heavily reliant on the ED for most of their care were significantly more likely than other chronically ill patients to present to the ED for medication refills (Table 3).

Increased dependence on the ED “safety net” as the source of routine [7,30,45-47] care directly impacts hospital admission rates and the evolving scope and role of the ED for the treatment and maintenance of chronic health problems [36-38]. The old practice paradigm of “fewer prescriptions in the ED and follow-up with primary care” is not going to work in a population that is increasingly reliant on the ED to fill gaps in routine care. New strategies are needed. Pharmacist refill algorithms, for example, have demonstrated decreased cost, unscheduled physician visits, urgent care visits, emergency room visits, and hospital admissions days [45]. “Bridging prescriptions,” once taboo, may give way to novel “prescription desk” strategies and advanced educational and triage interventions to mitigate the ED refill phenomenon.

5. Limitations

Scientifically unvalidated instruments and self-report data are fraught with some limitations and reporting biases. Although most of the survey instrument questions have face validity when subsequently reviewed by independent health policy experts and psychologists, there may be other unmeasured risk and protective factors that could have accounted for prescription refill-seeking behavior in the ED. The candidate predictors offered here were obtained cross-sectionally and do not account for long-term trends in behavior, but provide an important first step into understanding this phenomenon. Although reliance on self-report data is an important second limitation, the direction of these biases would tend toward patients underreporting of using the ED for medication refills, and the actual prevalence of this behavior may be even greater than the 29% measured here.

The sample was predominately of low-income patients who were already in the ED, which may lend itself to adherence differences when compared with a wealthier population who primarily receive their care in private physician offices or private hospitals. However, our data were obtained in 1 of the largest EDs in the country with a highly diverse population that represents many EDs across the nation. The demographics from our study (Table 1, column 2) can be compared with those of the “average ED patient” (Table 1, column 3) [48].

The inclusion criteria consisted of the 3 chronic illnesses that represent a sample of problems commonly seen in the ED, however, other presenting diseases may have different refill-seeking characteristics than the reported study group. The selected chronic diseases may bias toward a more severely ill population, although we carefully excluded the sickest patients and those in need of critical care.

As a single site study, our results may not be generalizable to other rural or nonurban settings, although we had a 0% refusal rate and randomly sampled from an ethnically diverse, large county hospital ED population. Future work in other ED and clinic setting would be important to confirm the alarmingly high prevalence of refill-seeking behavior seen in this study.

6. Conclusion

In ED patients with chronic disease, coming to the ED for medication refills is common. Significant predictors of refill-seeking behavior include age younger than 50 years, African-American ethnicity, low income (<US$5000 per year), unfamiliarity with common medication refill practices, and being told to call their primary care provider for a refill. While the gaps in knowledge and awareness regarding medication refill practices may be remedial to intervention with high-risk patients, further study will be required to document the ultimate impact of ED prescription writing on patient-centered outcomes.

References


Pulse oximetry in the adult ED patient with sickle cell

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Abstract We performed a retrospective chart review of adult patients with sickle cell presenting with vasoocclusive crisis to determine the association between pulse oximetry and emergency department (ED) disposition. Subjects were divided into a NORMAL (pulse oximetry ≥95%) and a LOW (pulse oximetry <95%) group. Two hundred ten consecutive charts showed no significant difference between NORMAL (n = 163) and LOW (n = 47) groups regarding admission or discharge from the ED (P > .05). A higher percentage in the LOW group received chest radiographs (40.9% vs 29%, P < .05), suggesting that pulse oximetry may have influenced ordering of this test. No significant differences in historical and physical exam characteristics were found. The pulse oximetry level does not appear to be associated with a particular ED disposition in adult sickle cell anemia.

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1. Introduction

Sickle cell anemia (SCA) is the most common inherited blood disorder in the United States, affecting about 1 in 600 African Americans [1]. Uncomplicated vasoocclusive crisis (VOC) represents the most common emergency department (ED) presentation and is the result of microvascular sludging and thrombosis causing tissue hypoxia and ischemia. The emergency physician has 2 main duties regarding a patient with SCA: to provide analgesic therapy and to evaluate for the presence of coexisting and potentially life-threatening illness. The patient with SCA is at risk for a number of disease states. They are at high risk for infection with encapsulated organisms and are thus more susceptible to pneumonia [2]. More ominous is acute chest syndrome, a condition of new pulmonary infiltrates, fever, chest pain, and hypoxia. Acute chest syndrome is the leading cause of death and second leading cause of hospitalization in the patient with SCA [3]. For this reason, the ability to accurately evaluate the pulmonary status of patients with SCA is important.

Pulse oximetry is a noninvasive and commonly used test in the ED for detecting hypoxemia. Although it has been found useful in many conditions, its usefulness in SCA, especially in the ED, has not been fully determined. The few studies available, typically comparing pulse oximetry to arterial blood gas and/or measured oxygen saturation, show conflicting results regarding the accuracy of pulse oximetry in determining oxygenation in the sickle cell population [4-6]. Further, the vast majority of the studies have been done in children and in either an inpatient or an outpatient setting; the ED literature is deficient. In the only ED study done to date, we found that pulse oximetry underestimated arterial oxygenation in 13 adult ED subjects...
presenting with uncomplicated VOC [7]. No studies have examined its actual use in the ED setting. The purpose of this study was to examine the association between pulse oximetry and ED disposition in VOC through a retrospective chart review. We hypothesize that a categorical range of pulse oximetry reading is not associated with differences in the disposition of the adult patient with VOC presenting to the ED.

2. Methods

This study was approved by the Institutional Review Board. We conducted a retrospective chart review of all subjects who presented to an urban university ED from March through October 2003 with either an initial complaint of or a final ED diagnosis of VOC. Included were those 18 years or older with at least one chief complaint of VOC and who had a pulse oximetry reading obtained in the ED. Subjects with sickle cell heterozygous SS, homozygous SC, and β thalassemia disease as documented by prior hemoglobin electrophoresis in our SCA center were eligible. Excluded were those younger than 18 years.

To assure capture of consecutive patients with VOC, subjects were identified retrospectively on a daily basis. The research nurse or assistant reviewed both the daily ED computer log as well as the ED charts for the preceding 24 hours for sickle cell disease and VOC. In addition, the names of commonly treated patients with sickle cell (identified from a list of patients with SCA treated at our institution—we are a National Institutes of Health designated regional sickle cell center with a regular cohort of 150 patients) were searched. Charts were reviewed to determine if the subject presented with typical (defined by the subject as pain of typical severity and location based upon prior episodes) or atypical (different severity and/or location or presence of a coexistent infectious illness) VOC. Because of our designation as an NIH Regional Sickle Cell Center, we routinely document if a patient with sickle cell who presented to the ED met inclusion/exclusion criteria and were reviewed. All subjects enrolled were patients of our Sickle Cell Center. The mean age of the group was 34.9 ± 1.1 years; 114 were men and 96 were women.

In the NORMAL group (n = 163), the mean pulse oximetry was 97.87% ± 1.7%; the LOW group (n = 47) was 91.55% ± 2.44%. There was no significant difference between NORMAL and LOW groups with regards to patient disposition (Table 1, $P > .05$). There was no significant difference in historical and physical exam characteristics between groups.

A higher percentage of subjects in the LOW group had a chest radiograph done when compared to the NORMAL group (19 [47%] vs 47 [29%], $P < .05$) (Table 2). All 47 in the NORMAL group and all but one in the LOW group were read as “no new infiltrate.” The one subject with the new infiltrate presented with atypical VOC accompanied by chest pain and shortness of breath had a temperature of 100.5°F, a heart rate of 123, a pulse oximetry reading of 86% (the lowest reading of our cohort), and was admitted with a final ED diagnosis of sickle cell crisis with possible acute chest syndrome. The most common blood tests ordered in the evaluation of the patient with sickle cell in the ED are the complete blood count and reticulocyte count. In our study, 87 (53.3%) in the NORMAL and 26 (55.3%) in the LOW group had a complete blood count/reticulocyte count drawn ($P > .05$), illustrating that no significant association with pulse oximetry level and blood testing was noted. There was a nonsignificant trend toward lower hemoglobin levels in the LOW group (8.75 ± 2 g/dL NORMAL vs 7.92 ± 2.2 g/dL LOW, $P = .07$; $t$ test).

<table>
<thead>
<tr>
<th>Table 1 Disposition by pulse oximetry category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal (≥95%)</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Admitted (n = 88)</td>
</tr>
<tr>
<td>Discharged (n = 120)</td>
</tr>
<tr>
<td>Left during treatment (n = 2)</td>
</tr>
</tbody>
</table>

$P > .05$, $\chi^2$.}

For the purposes of comparison, subjects were divided into 2 groups—a NORMAL group (pulse oximetry ≥95%) and a LOW group (pulse oximetry <95%). Ninety-five percent was chosen as the cutoff based upon the fact that it represents a PaO$_2$ of 75 mm Hg, considered by many to be the lower end of normal. The groups were compared for differences in historical/physical examination data, laboratory testing, radiographs, and final ED disposition. Categorical data were analyzed using $\chi^2$ testing; continuous data were analyzed with the $t$ test. Continuous data were presented as mean ± SD.

3. Results

Two hundred ten consecutive charts representing all patients with sickle cell who presented to the ED met inclusion/exclusion criteria and were reviewed. All subjects enrolled were patients of our Sickle Cell Center. The mean age of the group was 34.9 ± 1.1 years; 114 were men and 96 were women.

In the NORMAL group (n = 163), the mean pulse oximetry was 97.87% ± 1.7%; the LOW group (n = 47) was 91.55% ± 2.44%. There was no significant difference between NORMAL and LOW groups with regards to patient disposition (Table 1, $P > .05$). There was no significant difference in historical and physical exam characteristics between groups.

A higher percentage of subjects in the LOW group had a chest radiograph done when compared to the NORMAL group (19 [47%] vs 47 [29%], $P < .05$) (Table 2). All 47 in the NORMAL group and all but one in the LOW group were read as “no new infiltrate.” The one subject with the new infiltrate presented with atypical VOC accompanied by chest pain and shortness of breath had a temperature of 100.5°F, a heart rate of 123, a pulse oximetry reading of 86% (the lowest reading of our cohort), and was admitted with a final ED diagnosis of sickle cell crisis with possible acute chest syndrome. The most common blood tests ordered in the evaluation of the patient with sickle cell in the ED are the complete blood count and reticulocyte count. In our study, 87 (53.3%) in the NORMAL and 26 (55.3%) in the LOW group had a complete blood count/reticulocyte count drawn ($P > .05$), illustrating that no significant association with pulse oximetry level and blood testing was noted. There was a nonsignificant trend toward lower hemoglobin levels in the LOW group (8.75 ± 2 g/dL NORMAL vs 7.92 ± 2.2 g/dL LOW, $P = .07$; $t$ test).
Most of the patients (196/210) presented to the ED with typical VOC. The other 14 presented with atypical VOC alone or with a coexistent illness. Interestingly, 11 of these were categorized in the NORMAL pulse oximetry group.

4. Discussion

Our study suggests that categorical ranges of pulse oximetry do not have a significant association with the disposition of adult patients with SCA in the ED. It would seem intuitive that a low pulse oximetry reading would be suggestive of and associated with either more severe disease or the presence of a coexistent illness (and hence, a higher amount of admissions to the hospital). Conversely, it would seem likewise intuitive that a high pulse oximetry reading might suggest either a less severe presentation or an absence of a coexistent illness (and thus, a higher likelihood of being discharged from the ED). We found neither to be the case. In our study, a low pulse oximetry reading was not associated with higher admission rate, nor was a high pulse associated with a higher likelihood of being discharged from the ED. In addition, an atypical presentation (with or without coexistent illness) was not associated with lower pulse oximetry as 11 of the 14 had normal readings. These findings help to confirm our observation over the years that the pulse oximetry reading in adult VOC may not be a reliable indicator of ED disposition.

Interestingly, there was a higher percentage of subjects in the LOW group that received chest radiographs. Given the potential for a pulmonary process as a cause for hypoxia, this is not surprising and might suggest that the pulse oximetry reading may have influenced diagnostic testing. However, when viewed in another manner, there was a significant number in the LOW group that did not have a chest radiograph done, suggesting that pulse oximetry was not always a determinant. Only one patient in our study had an abnormal chest radiograph—this patient had the lowest pulse oximetry reading of our cohort and had presenting complaints beyond her typical sickle cell VOC. Laboratory testing did not appear to be affected by pulse oximetry reading as there were equal percentages of patients in the NORMAL and LOW groups having a complete blood count/reticulocyte count drawn.

Pulse oximeters measure arterial hemoglobin saturation and pulse rate by positioning a pulsatile arterial vascular bed between red and infrared light sources and a detector, and detects the differential absorption of light by oxy- and deoxyhemoglobin. A microprocessor then converts this detected light into an arterial blood saturation reading [8,9]. Although it should also work well in SCA, certain characteristics of the disease (such as peripheral arteriolar damage from multiple acute episodes of vascular occlusion over the years, the increased presence of met- and carboxyhemoglobin) [10,11] may prevent it from being a reliable predictor of hypoxemia. In addition, the rightward shift of the oxyhemoglobin dissociation curve [12] commonly found in sickle cell disease may also alter the estimation of oxygenation.

The literature on the use of pulse oximetry in SCA is not definitive. Fitzgerald and Johnson [4] measured initial pulse oximetry readings in pediatric ED and intensive care unit patients in a children’s hospital and found correlation with cooximeter-measured saturation in patients with sickle cell. They found that pulse oximetry underestimated arterial O₂ saturation but stated that the bias found was clinically insignificant and concluded that pulse oximetry could be used as a reliable estimate. Blaidsell et al [6] simultaneously measured pulse oximetry and cooximetry in outpatient sickle cell children. They found that pulse oximetry in this setting had poor specificity in detecting hypoxemia and commented that “many more patients would have been considered hypoxic based on pulse oximetry measurements alone than were hypoxic enough to require intervention.” The usefulness of pulse oximetry in the adult ED patient with sickle cell is unclear. In our previous study, we found, similar to the Blaidsell study, that pulse oximetry underestimated oxygenation in acute VOC. In contrast to these other studies, this study aimed not to determine correlation of pulse oximetry to oxygenation, but rather, attempted to examine pulse oximetry readings as a predictor of disposition in the clinical setting.

Our study has a number of limitations due mostly to its retrospective nature. We are unable to determine the true effect of the pulse oximetry reading on test ordering, decision-making, and disposition. Rather, we could only make the associations or lack thereof between oxygen saturation and the various outcomes. Inadequate documentation may have affected the conclusions. This study may also reflect a selection bias of a subgroup of patients with sickle cell who frequent the ED, and thus our findings may not be generalizable to all adult ED patients. Despite these, and given the paucity of literature in this setting, our study appears to shed more light on the actual use of pulse oximetry in the adult patient with sickle cell.

In conclusion, we found that the determination of a normal or abnormal pulse oximetry reading in the adult ED patient with SCA was not associated with a particular patient disposition.

References

Ultrasound image transmission via camera phones for overreading

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Abstract

Emergency physicians using ultrasound frequently encounter unfamiliar findings during routine ultrasound examination. This is especially common for less experienced practitioners.

Objective: To compare high-resolution thermal printer ultrasound images and images recorded and transmitted via commercial camera cell phones.

Methods: This was a study comparing randomly selected images of actual ultrasound examinations performed in an academic level I ED with hospital-based emergency ultrasound credentialing. Two hospital credentialed emergency sonologists with extensive experience were asked to review 50 randomly selected images from actual patients as seen on a camera cell phone screen after being captured from a high-resolution thermal printout and sent to a similar phone. Reviewers recorded initial impression of the image and identified structures, measurements, and pathology. After hearing a brief clinical vignette, reviewer rated the images for image quality, detail, resolution, as previously defined, on a 10-point Likert scale. This process was then repeated with the original thermal printouts. Data were analyzed using descriptive statistics, agreement analysis, and the Student t test.

Results: Reviewers showed good interrater agreement for pathology and structure detection between phone and thermal printer images. There was no statistically significant difference in image quality, resolution, and detail between phone images and thermal printer images. However, there was statistically significantly increase in confidence in diagnosis for reviewers when using thermal printer images as compared with phone images, \( P = .003 \) and \( P = .02 \). Several phone images were felt to be suboptimal, and there was moderate agreement on these between reviewers.

Conclusions: Ultrasound pictures recorded by one phone and then sent to another yielded images that showed no statistically significant differences from traditional high-resolution thermal printouts in image quality, detail, and resolution. Measurements were too small to be read on the camera phones, and reviewers had statistically significantly lower confidence in their diagnosis when using the camera phones to review images.

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1. Introduction

Ultrasound use by emergency physicians can has many benefits for patient care, satisfaction, department length of
stay, and group finances [1-4]. However, the speed of its spread is limited to some degree by the lack of experienced emergency sonologists. Emergency sonologists may be trained in residency or fellowships, and this training often continues once in practice. Others work to obtain ultrasound skills when already in practice through continuing education and self-education efforts. Unfortunately, novice ultrasound users are unfamiliar with the pitfalls of emergency ultrasound and may feel uncomfortable performing ultrasound examinations without oversight from a more experienced emergency sonologist. Novice emergency sonologists are often able to obtain adequate images long before they are familiar with the range of pathology and normal anatomy, thus limiting their ability to accurately diagnose or rule out typical pathology.

Such limitations are usually not a factor when the ED has a more experienced emergency sonologist, such as a department designated ultrasound director, who is able to preside over the ultrasound examinations by the novice user. Such review can also take place after the ultrasound examination has been completed by reviewing thermal printer images on a report and thus providing feedback to the novice user [5]. This occurs commonly with attending radiologist overreading of resident scans 1 or 2 days after a night or weekend shift in many academic institutions [6]. However, although this delayed review may work for general radiology, the problems with having a delay in the expert reading are magnified in emergency ultrasound. In most cases, emergency ultrasound is used to evaluate time-sensitive emergency conditions, and a misinterpreted ultrasound can be disastrous. Ideally, oversight should be performed in real-time or at least before the completion of the ultrasound examination so that additional images could still be obtained and the diagnosis clarified or corrected.

Radiologists have explored the use of telemedicine systems allowing them to review images and render a diagnosis from remote locations such as the physicians home at night [7-9]. However, the cost of such transmission systems can be prohibitive to most EDs [10]. The solution may lie in the rapidly developing information technology that is available to the general population and is often marketed to young cell phone users in a recreational or entertainment fashion. Specifically, the cameras available on many new cellular phones may be of use for transmitting images for fashion. Specifically, the cameras available on many new cellular phones may be of use for transmitting images for

2. Methods

This was a study with comparison of ultrasound images printed on a standard high-resolution thermal printer compared with images photographed with and sent between 2 camera-equipped cellular phones. The study was approved by the institutional review board. This study took place at a level 1 trauma center ED with an accredited emergency medicine residency program and an active emergency ultrasound program. Emergency ultrasound credentialing is available through the hospital, allowing performance and interpretation of ultrasound examinations. Currently, the department is in transition to a fully credentialed faculty. Ultrasound services are available from the department of radiology during business hours and are not available during most evenings and nights as well as weekends.

Emergency ultrasound education is mandatory for all faculty and residents, and biannual courses, monthly lectures, and quality review sessions, as well as individual instruction, are available. Diagnostic ultrasound services provided by the ED include pelvic, focused cardiac, lower extremity venous, biliary, renal, abdominal aortic, trauma, procedural, and superficial structure ultrasound. Credentialed faculty issue a written ultrasound report based on several preprinted forms. The report contains examination findings and diagnosis, as well as high-resolution thermal print images on the side of the report. Typically, 3 images are added to the report unless more are called for to illustrate pathology. The report then becomes a part of the medical record and is scanned into an electronic medical record system accessible throughout the medical campus.

Fifty images were randomly selected from approximately 200 ultrasound examinations during a 1-month period. Only 1 image was randomly picked from each examination. Studies performed by either of the 2 reviewers were disallowed to avoid unfair bias. All of the studies selected had thermal printed images to document study results. Randomly selected images were then graded by a hospital credentialed sonologist with fellowship training and approximately 10 years’ experience.

The premise of this study was to duplicate a scenario where an emergency ultrasound provider has performed an ultrasound examination and has questions about the findings or is required to have study conclusions confirmed by the emergency ultrasound director or his/her designate. The provider then takes images of the same thermal ultrasound prints used for examination documentation in the medical record with a camera-equipped cellular phone and transmits the images to the designated reviewer. The designated image reviewer can be anywhere that a cellular connection is available. Depending on the particular cellular service, this can mean in much of North America and the rest of the industrialized world, thus not limiting the reviewer to an internet connection and computer for reviewing.

We used a commonly available camera phone produced by Motorola (Schaumburg, IL). The phone, a V-400, contains a digital camera capable of capturing a 640 × 480 pixel image in color, Fig. 1. The image can then be transmitted to another phone or e-mail account. Images were captured in the ED with overhead fluorescent lighting to simulate the less-than-ideal lighting conditions that are likely to be
Camera phone ultrasound

Fig. 1  A cell phone with an image of a heart in the subxiphoid view is being held after the ultrasound image was captured and sent between phones. Note in this figure that the image on the screen is too distant to be seen clearly. Some glare is seen on the right side of the cell phone screen.

One month after image selection, 2 credentialed emergency sonologists with extensive ultrasound experience including study performance, interpretation, ultrasound education, and research and publication were asked to evaluate the images. For each phone ultrasound image, the reviewers were initially asked if they could tell what the image was without any clinical data. A limited clinical vignette was then read to each of the 2 reviewers describing patient complaint and area of the body being scanned by the less experienced sonologist. For example, the reviewers may be told that a 45-year-old woman with 2 days of right upper quadrant pain that has now worsened was being scanned for gallbladder pathology. Reviewers performed the evaluation in isolation from each other and could not compare notes or discuss the patient or image. Each reviewer was allowed to manipulate the camera phone as they wished, tilting and angling the LCD screen to maximize image quality.

Based on previous studies that compared ultrasound images, each one was graded for the following [12,13]: (1) total image quality, defined as an overall assessment encompassing contrast of solid and fluid-filled structures, and absence of noise; (2) image resolution, defined as the sharpness and crispness of the image and a lack of haziness/blurriness; (3) image detail, which was defined as the clarity of organ outlines and ease with which boundaries of structures are seen and how well they are defined. Each reviewer ranked their impression on a 10-point Likert scale with 1 being the worst and 10 the best. Reviewers were also asked if any pathology was seen in the image, if any measurements were present and what they were, and if a diagnosis could be given and to list major visible structures. Finally, each reviewer was asked if the image being viewed was either suboptimal for review or contained image artifacts other than expected from ultrasound. Two weeks later, this review process was repeated for the thermal printer images, or originals, which were viewed in random order, Fig. 2. Emergency physicians (EPs) filled out the standardized data form, which was then entered into a computerized database.

Fig. 2  A thermal print image used for comparison during the second phase of the study of the cardiac view seen in Fig. 1 on the phone screen.
phone and hard copy images, respectively. Initial impression
j
all cases. Reviewers showed good agreement in listing
image measurements were too small for reviewers to read in
ments were missed on any image. However, cell phone
hard copy images were felt to be suboptimal. No measure-
images were produced by the camera phone. None of the
suboptimal images with a
was moderate agreement among the reviewers about
diagnosis by the reviewers are given in Table 2. There
was moderate agreement among the reviewers about suboptimal images with a \( \kappa = 0.47 \). All of the 6 suboptimal
images were produced by the camera phone. None of the
hard copy images were felt to be suboptimal. No measure-
ments were missed on any image. However, cell phone
image measurements were too small for reviewers to read in
all cases. Reviewers showed good agreement in listing
identifiable structures with \( \kappa = 0.67 \) and 0.6 between cell
phone and hard copy images, respectively. Initial impression
of the cell phone image had good agreement between the 2
reviewers with \( \kappa = 0.55 \). Agreement for initial impression of
the hard copy image between reviewers was very good with
\( \kappa = 0.83 \). Agreement for initial impression by each reviewer
between phone and printer images was good with \( \kappa = 0.76 \)
and 0.69. Agreement for presence of pathology on phone
images between the 2 reviewers was very good at \( \kappa = 0.79 \).
Agreement for presence of pathology between the 2
reviewers for printer images was also very good at \( \kappa = 0.8 \).
Agreement for each reviewer between phone and paper
images was good with \( \kappa = 0.59 \) and 0.67.

There was a statistical difference between Likert scale
ranking for confidence in cell phone image diagnosis
between the reviewers with \( P = .01 \). There is no statistical
difference between the Likert scale ranking for confidence
of diagnosis between the 2 reviewers for printer images,
\( P = .29 \). However, statistically significant differences
existed for each reviewer’s confidence between phone and
hard copy images, \( P = .003 \) and \( P = .02 \). The differences
between phone and printer image quality scores were not
statistically significant for the 2 reviewers, \( P = .56 \) and
\( P = .12 \). The differences between phone and printer image
quality were not significant for each reviewer, \( P = .47 \) and
\( P = .36 \). The differences between phone and printer image
resolution scores were not statistically significant for the
2 reviewers, \( P = .45 \) and \( P = .45 \). The differences between
phone and printer image resolution was not significant for
each reviewer, \( P = .35 \) and \( P = .41 \). The differences between
phone and printer image detail scores were not statistically
significant for the 2 reviewers, \( P = .18 \) and \( P = .43 \). The
differences between phone and printer image detail was not
significant for each reviewer, \( P = .31 \) and \( P = .5 \).

3. Results

A total of 50 images were randomly selected from 200
studies. Of the 50 randomly chosen, 26 contained pathology.
Distribution of ultrasound study types represented by the
50 images is shown in Table 1. Five attempts were made at
transmitting 1 image of 44 kilobytes in size from one phone
to another. The median time was 1 minute 38 seconds with a
range of 1 minute 35 seconds to 2 minutes 43 seconds.
Similarly, 5 attempts were made to transmit 3 images at a
time. This is a typical number of hard copy images attached
to a formal medical record report in our ED. The median
time was 3 minutes 12 seconds with a range of 3 minutes
4 seconds to 3 minutes 18 seconds. No transmission failures
were noted; however, failure can occur if the cellular signal
is lost during transmission.

Results for image quality scores and confidence in
diagnosis by the reviewers are given in Table 2. There
was moderate agreement among the reviewers about suboptimal images with a \( \kappa = 0.47 \). All of the 6 suboptimal
images were produced by the camera phone. None of the
hard copy images were felt to be suboptimal. No measure-
ments were missed on any image. However, cell phone
image measurements were too small for reviewers to read in
all cases. Reviewers showed good agreement in listing
identifiable structures with \( \kappa = 0.67 \) and 0.6 between cell
phone and hard copy images, respectively. Initial impression

\[ t \text{ test with 95% confidence intervals. Data were analyzed}
\text{using statistical calculators from a commercially available}
\text{software package, StatsDirect. (Cheshire, United Kingdom).} \]

\begin{table}[h]
\centering
\begin{tabular}{|l|c|}
\hline
\textbf{Study type} & \textbf{No. of images and percent of total} \\
\hline
Pelvic & 14 (28\%) \\
Biliary & 13 (26\%) \\
Renal & 4 (8\%) \\
Trauma & 4 (8\%) \\
Lower extremity r/o deep vein thrombosis & 5 (10\%) \\
Ocular & 2 (4\%) \\
Cardiac & 3 (6\%) \\
Abdominal aorta & 4 (8\%) \\
Peritonsillar abscess localization & 1 (2\%) \\
\hline
\end{tabular}
\caption{Distribution of emergency ultrasound study types captured}
\end{table}

4. Discussion

Information technology invaded the house of medicine
approximately a decade ago, but it was not until the last
few years that most physicians felt its impact in their daily
practice. Although initially relegated to limited computer
systems in hospital accounting and supply departments,
modern information technology is likely impacting many of
us at this time. Patient medical records are frequently
available for rapid review on computer screens as well as
laboratory results for previous visits to the ED. Patients are
being registered at bedside in their room with remotely
linked computers. Specially designed computer programs

\begin{table}[h]
\centering
\begin{tabular}{|l|c|c|c|c|c|c|}
\hline
\textbf{Reviewer} & \textbf{Phone confidence} & \textbf{Thermal print confidence} & \textbf{Phone image quality} & \textbf{Thermal print image quality} & \textbf{Phone image resolution} & \textbf{Thermal print image resolution} \\
\hline
1 & 6.5 & 7.8 & 7.8 & 7.5 & 7.9 & 7.8 \\
2 & 7.3 & 8.0 & 7.9 & 7.8 & 7.9 & 7.9 \\
\hline
\end{tabular}
\caption{10-Point Likert scale scores for the reviewers}
\end{table}
are helping triage patients into appropriate categories. Others write portions of patients’ charts automatically from triage data and even recognize the human voice for dictation. It appears that many of the information technology innovations implemented in EDs have been driven by the necessity to be more efficient and provide better care to our patients. Similarly, emergency ultrasound’s evolution has been driven by the desire to improve patient service and care.

Emergency ultrasound is a relatively new field in clinical medicine. Borne out of the need for immediate diagnosis for many emergency conditions, emergency ultrasound fills a void caused by dwindling resources including ultrasound technologists. However, despite the proven utility and accuracy of emergency ultrasound for many applications, emergency ultrasound is a technical skill that must be acquired over time. Traditionally, supervision in sonography involves direct review of the sonologist’s images with verification of the findings, clarification of uncertainties, and the provision of ongoing feedback for improvement [14]. In emergency ultrasound, this supervision includes hands-on instruction, review of previously performed ultrasound examinations, and didactic teaching. Typically, this service is provided by the expert in the department, usually the emergency ultrasound director.

Teleradiology is used in many locations around the world to review ultrasound examinations performed by providers unable to render adequate interpretation of the acquired images. Typically, static or dynamic images of examinations performed at remote locations are transmitted electronically via network connections to the radiologist for interpretation. However, the systems and system support for teleradiology can be cost-prohibitive for emergency ultrasound. Estimates for the cost of acquiring the equipment only for transmitting medical images of sufficient quality to perform medical diagnostics vary in the literature, depending on the bandwidth used, from US$25 000 to US$55 000 per site, in addition to transmission and maintenance costs [10,11]. However with the recent advances in mobile phone systems and cellular phone networks, it may be possible to transmit high-quality medical images over cellular phone connections. Currently, newest generation cellular camera phones have a resolution of 640 × 480 pixels. Prior studies have shown that the required resolution for a medical image to be diagnostic depends on the image being interpreted. Mammography, for instance, requires higher resolution for diagnostic purposes than computed tomography which typically uses a 512 × 512 matrix at an 8-bit gray level. However, compared with analog images, 80% of viewers found images with resolution as low as 530 × 400 to be indistinguishable [15]. In a study by Yamada et al [11], using images obtained by a cell phone camera, computed tomography scans and magnetic resonance imaging scans were of sufficiently high quality for interpretation.

In this study, the cell phone camera used had a display size of 31 × 30 mm and only 120 × 128 pixel resolution (110000-pixel). This resolution is considerably less than what was used in our study.

Our study results indicate that, although images are not the same on a camera cell phone as a high-resolution thermal prints, reviewers were still able to accurately interpret the images. In fact, there was no statistically significant difference between image quality, resolution, and detail scores between the 2 image types on a 10-point Likert scale. On the other hand, the reviewers were less confident in the interpretation of the image from cell phones as compared with thermal prints suggesting that the 2 are not identical in quality. There was good agreement by reviewers for identification of important structures between image types, as well as among themselves. Another important drawback to our cell phone images was the inability of reviewers to read measurements which appeared in too small a print on the image. However, this problem is easily solved in the real-world application by reading all measurements off when discussing the case with a cell phone reviewer.

This type of system can have a significant impact in the practice of emergency medicine. As emergency ultrasound becomes more widespread, real-time feedback on pathology and diagnosis can be provided easily by those more experienced in the field. This system can reduce medical errors by encouraging the use of emergency ultrasound which has been shown to prevent unnecessary treatment [16]. In addition, the novice user can be provided with real-time quality assurance from the director of ultrasound and provide ongoing education when there is diagnostic uncertainty. This is not only of utility in the review of images generated by attending physicians but may be a great way to overread ultrasound examinations performed by residents.

The camera cell phone offers other benefits to its users. The phone can send the pictures to several phone and e-mail addresses simultaneously. Therefore, the ED could have an “EDQA” address for the pictures sent. Hence, a database is built simultaneously with the quality assurance process. This database can also be used for comparison review on subsequent ultrasound examinations not only those done in the ED, but also on follow-up examinations done by radiology. This is advantageous as some emergency ultrasound examinations may require follow-up evaluations at some point in the future.

The initial investment for the equipment used was US$200 to US$300 per camera phone, and the communication charge for the image was approximately US$0.25 per image. Image transfer took approximately 1.5 minutes on average for a single image and 3.5 for 3 images. In addition, the confidentiality of the image data and patient information is protected by the server in the same manner as is e-mail between personal computers. However, if this method of security for data transfer is unacceptable, patient names and personal information are easily left off of the images. Hence, there is no personal information associated with the image.
This study has several limitations including the potential bias of ultrasound image reviewers against the images on the cellular phones that are smaller and more difficult to interpret. Although actual ultrasound images were used from diagnostic ultrasound examinations on ED patients, we did not actually evaluate rendering diagnosis from a cellular phone on real-time patients. This is a subject for further study now that such review appears possible. Fifty-four percent of images randomly chosen contained some kind of pathology. This may not represent a common distribution. The spectrum of studies included may not represent the spectrum found at other facilities using ultrasound in the ED.

Real-time image transfer of diagnostic emergency ultrasound examinations is possible using existing cell phone camera equipment and technology. This system is inexpensive compared with traditional teleradiology systems. Ultrasound pictures recorded by one phone and then sent to another yielded images that showed no statistically significant differences with traditional high-resolution thermal printouts in image quality, detail, and resolution. Measurements were too small to be read on the camera phones, and reviewers had statistically significantly lower confidence in their diagnosis when using the camera phones to review images.

References

The inadvertent administration of anticoagulants to ED patients ultimately diagnosed with thoracic aortic dissection

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Abstract

Objectives: Aortic dissection (AD) may present similarly to acute coronary syndrome or pulmonary embolus; however, anticoagulation may be detrimental to patients with AD.

Methods: Clinical data were abstracted from medical records of emergency department (ED) patients with nontraumatic AD. Patients administered with anticoagulants were compared with non–anti-coagulated patients with regard to presenting symptoms, chest radiograph and electrocardiogram (ECG) findings, and outcome.

Results: A total of 44 ED patients with nontraumatic AD was identified over a 4-year period; anticoagulants were administered to 9 (21%). Anticoagulated patients had a higher incidence of chest pain without back pain (78% vs 23%; \( P = .002 \)) and ST elevations or depressions on ECG (89% vs 6%; \( P < .001 \)) and were less likely to have a widened mediastinum on chest radiograph (0% vs 67%; \( P < .001 \)). Two ED anticoagulated patients died, one required a second surgery for bleeding complications, and another suffered a stroke after reversal of anticoagulation.

Conclusions: There is a clinically significant incidence of anticoagulation administration to ED patients ultimately diagnosed with AD, especially in the presence of ambiguous ECG and radiographic findings.

1. Introduction

Each year, nearly 4.6 million patients present with nontraumatic chest pain in the emergency department (ED), making chest pain the second most common ED complaint [1]. Although most protocols are oriented toward the rapid identification and treatment of acute coronary syndrome, other potentially life-threatening diagnoses including pulmonary embolus and aortic dissection (AD) must be considered. Although anticoagulation of patients with either acute coronary syndrome or pulmonary embolus can be life saving, the administration of anticoagulants to patients later diagnosed with AD may have catastrophic

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consequences such as aortic wall rupture and bleeding complications during surgery.

Current screening standards for AD are neither sensitive nor specific, with postmortem diagnoses made in up to 30% of cases. A widened mediastinum on plain chest radiograph is commonly used as a screening strategy; however, chest radiographs are prospectively interpreted as suggestive of the diagnosis in only 25% of AD cases [2,3]. Retrospective review by chest radiologists improved the sensitivity to 48% [4]. This leads to the potential for inadvertent administration of anticoagulation to patients with AD. We review our experience with ED patients ultimately diagnosed with nontraumatic AD, focusing on the reasons and consequences of anticoagulation in this patient group.

2. Methods

2.1. Design

We performed a retrospective cohort analysis using medical records from 1997 to 2000. Approval was obtained from our institutional investigational review board.

2.2. Setting

This study was conducted in a university-affiliated urban ED with an annual census of approximately 45,000 visits.

2.3. Subjects

Patients were identified using a hospital discharge diagnosis of nontraumatic AD. Patients were excluded for death immediately upon arrival in the ED or incomplete medical records.

2.4. Data collection

The following data were abstracted from the ED records: age, sex, past medical history, presenting chief complaint, triage vital signs, and ED course including medications administered. Diagnostic studies, formal chest radiograph and electrocardiogram (ECG) interpretations, hospital course, complications, and final outcome were obtained from the hospital medical records.

2.5. Data analysis

Data regarding demographics, past medical history, and chief complaint were analyzed descriptively. Aortic dissection patients with ED administration of anticoagulants were identified and compared with all other AD patients with regard to patient demographics, presenting complaint, vital signs, chest radiograph and ECG results, hospital course, and outcome. Anticoagulation was defined as one of the following: fibrinolytic therapy, heparin, or antiplatelet therapy. \( \chi^2 \) Analysis and \( t \) testing were used for all comparisons. Statistical calculations were performed using StatsDirect (StatsDirect Software Inc, Ashwell, UK). Statistical significance was assumed for \( P < .05 \).

3. Results

A total of 44 ED patients was identified with nontraumatic AD over the study period; 9 of them (20.5%) received anticoagulation (6 heparin/aspirin, 1 fibrinolytics, 2 aspirin). Table 1 defines the predominant presenting symptom as chest pain (63%), followed by back pain (43%) and shortness of breath (34%). About half of all patients (57%) presented with a systolic blood pressure of at least 140 mm Hg or greater. Demographic data, past medical history, and diagnostic studies are also included in Table 1.

The 9 anticoagulated patients were more likely than those not receiving anticoagulation to have chest pain without

<table>
<thead>
<tr>
<th>Table 1 Clinical presentation for all patients</th>
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<tr>
<td>Parameter</td>
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<tr>
<td>Demographics</td>
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<td>Male sex (%)</td>
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<td>Age (y)</td>
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<td>Past medical history</td>
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<td>Hypertension</td>
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<td>Marfan syndrome</td>
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<td>Prior aortic disease</td>
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<td>Presenting symptoms</td>
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<td>Syncope</td>
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<td>Shortness of breath</td>
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<td>( \geq 140 ) mm Hg</td>
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<td>100-139 mm Hg</td>
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<td>&lt;100 mm Hg</td>
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<tr>
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<tr>
<td>Chest radiograph</td>
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<td>Wide mediastinum</td>
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<td>Tortuous aorta</td>
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<td>Infiltrate/atelectasis</td>
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<td>Electrocardiogram</td>
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<td>Nonspecific T-wave abnormalities</td>
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<td>Diagnostic imaging modality</td>
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<td>Aortogram</td>
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back pain, more likely to have an ST-segment elevation or depression, and less likely to have a widened mediastinum (Table 2). Several complications that were directly attributable to the administration of anticoagulation including a stroke upon reversal of anticoagulation in one patient and multiple operations from bleeding complications in another were observed. Two other patients in the anticoagulation group died from uncontrolled hemorrhage. Complications for all patients are displayed in Table 3.

4. Discussion

We present our experience with the ED diagnosis of AD over a 4-year period. We observed a relatively high incidence of inadvertent anticoagulation administration in our patient group. The potential reasons for this include an ambiguous clinical presentation (including chest pain without back pain), the presence of ST-segment abnormalities, and the absence of a widened mediastinum on chest radiograph. This likely resulted in the initiation of appropriate therapy for acute coronary syndrome, including the use of anticoagulation therapy, which appeared to result in a measurable incidence of complications.

The timely diagnosis of AD appears to prevent complications and improve prognosis, with an estimated increase in the death rate of 1% each hour that the disease goes undiagnosed [5,6]. The American College of Emergency Physicians published a clinical policy for patients presenting to the ED with chest pain, recommending the presence of particular symptoms along with the results of diagnostic studies to determine a causative etiology [1]. In light of the lack of sensitivity for clinical evaluation, plain chest radiographs, or ECG in differentiating patients with AD from those with acute coronary syndrome, it is not surprising that a significant percentage of patients with AD are inappropriately treated with anticoagulation therapy. The extent of this clinical problem has not been studied previously.

The classic presentation of AD includes chest or back pain, often described as “tearing,” “ripping,” or “knife-like” [7]. In our study, patients with AD were more likely to complain of chest pain (63%) than back pain (43%), with previous investigations supporting these figures. The occurrence of chest pain on presentation has been described in 69% to 75%, with back pain in 33% to 64% [8-11]. The variability in the location of pain makes this difficult, although our physicians appeared to use the presence of chest pain without back pain as more consistent with acute coronary syndrome, especially with a provocative ECG and normal mediastinal width.

The use of plain chest radiography to screen for AD can be problematic. A widened mediastinum can be observed in up to 75% of patients with AD but can easily be confused with widening in the ascending aorta, aortic arch, or the descending portion of the thoracic aorta resulting from aortic tortuosity [7]. The sensitivity of plain chest radiography for detecting AD is even lower if the real-time ED reading is used, with Armstrong et al [8] reporting a sensitivity value of 64% for the treating physician’s interpretation as compared with 72% for that of radiologists trained in aortic pathology. We used the final attending radiologist’s interpretation in this study, with a wide mediastinum observed in 55% of all AD patients but none of those administered with anticoagulation. More subtle

<table>
<thead>
<tr>
<th>Parameter</th>
<th>ED anticoagulation</th>
<th>No ED anticoagulation</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chief complaint</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chest pain</td>
<td>8/9 (89)</td>
<td>23/35 (66)</td>
<td>.174</td>
</tr>
<tr>
<td>Back pain</td>
<td>1/9 (11)</td>
<td>15/35 (43)</td>
<td>.077</td>
</tr>
<tr>
<td>Chest pain without back</td>
<td>7/9 (78)</td>
<td>8/35 (23)</td>
<td>.002</td>
</tr>
<tr>
<td>Chest radiograph findings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Widened mediastinum</td>
<td>0 (0)</td>
<td>22/33 (67)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Electrocardiogram findings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST elevation or depression</td>
<td>8/9 (89)</td>
<td>2/31 (6)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

ASA indicates acetylsalicylic acid.
abnormalities may increase sensitivity but may not be detected reliably by the treating physician [12]. Despite its limited sensitivity and specificity, the use of chest radiography as a screening test for AD has continued because of its relatively low cost when compared with other modalities such as chest computed tomography, transesophageal echocardiography, and aortography [13].

Abnormalities in the ECG have long been described in association with AD but are neither sensitive nor specific. Nonspecific ECG abnormalities have been reported in up to 80% of patients with AD [3,8,10,11,13]. The presence of ST-segment abnormalities can be especially problematic in patients with AD given the potential for misinterpretation of the presentation as part of an acute coronary syndrome.

The relatively high percentage of AD patients (1 in 5) receiving anticoagulation is alarming, especially considering the potential to adversely affect outcome. On the other hand, these patients appear to have been treated appropriately, considering the presence of chest pain, ST-segment abnormalities, and normal mediastinal width on chest radiograph, which would lead clinicians to suspect the alternative and more common diagnoses of an acute coronary syndrome or pulmonary embolus. Excessive concern about administering anticoagulation to AD patients could result in delays for time-critical therapies in patients with acute coronary syndrome or pulmonary embolus. This is especially true given the lack of specificity for AD observed with plain chest radiography [12,14]. The optimal diagnostic and therapeutic approach in patients with a clinical presentation that is suspicious for AD and an abnormal mediastinum on plain chest radiograph is not as clear and warrants additional research.

Limitations to this analysis include the retrospective design and relatively small sample size, although we were able to demonstrate statistically significant differences between the groups that provide a plausible explanation for the high rate of inadvertent anticoagulation in patients with AD. In addition, we used the final cardiology and radiology interpretations of ECG and chest radiographs rather than the ED physician’s interpretation; if the “wet read” were used instead, the results would likely have been even more disparate because nonradiologists are less likely to detect subtle abnormalities in the mediastinal silhouette. Finally, a limited amount of clinical data was available from ED records, limiting the data available for this analysis.

5. Conclusions

The inadvertent administration of anticoagulation to ED patients with a clinical presentation suggesting acute coronary syndrome is a problem in the management of AD. Potential solutions to increase sensitivity to the diagnosis of AD likely come at the price of decreased specificity and delays to definitive therapy in patients with acute coronary syndrome or pulmonary embolus, both of which are far more common than AD.

References

Real-time paramedic compared with blinded physician identification of ST-segment elevation myocardial infarction: results of an observational study

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Abstract The aim of the study were to determine if paramedics can accurately identify ST-segment elevation myocardial infarction (STEMI) on prehospital 12-lead (PHTL) electrocardiogram and to compare paramedic with blinded physician identification of STEMI. Paramedics identified definite STEMI, or possible acute myocardial infarction but not definite, and nondiagnostic. Two blinded readers (cardiologist and emergency physician) independently categorized each PHTL. A third reviewer assigned final diagnoses and determined whether the PHTL met STEMI criteria. One hundred sixty-six PHTL were acquired over an 8-month period. Fifteen were excluded from analysis. Sixty-two percent of the patients (94/151) were male, mean age was 61.1 years (\pm 14.8 SD, range 20-92 years), and 81% had chest pain. Twenty-five patients (16.6%; 95% confidence interval [CI], 11%-23.5%) had confirmed STEMI and 16 (10.6%) had confirmed non-STEMI acute myocardial infarction. Paramedic sensitivity was 0.80 (95% CI, 0.64-0.96); specificity was 0.97 (95% CI, 0.94-1.00) with positive likelihood ratio of 25.2 and negative likelihood ratio of 0.21. Overall accuracy was similar for paramedic and physician reviewers (0.94, 0.93, 0.95). Highly trained paramedics in an urban emergency medical services system can identify patients with STEMI as accurately as blinded physician reviewers.

1. Introduction

The use of prehospital 12-lead (PHTL) electrocardiogram (ECG) provides more rapid diagnosis and improves treatment for patients with acute myocardial infarction (AMI). The American Heart Association’s ECC-CPR Guidelines recommended the use of diagnostic 12-lead ECGs in urban and suburban emergency medical services (EMS) systems as a class I (evidence supports) recom-
mendation in 2000 [1]. Research has shown that prehospital ECGs may identify patients who are candidates for reperfusion therapy and improve the accuracy of the evaluation of patients with prehospital chest pain [1-3], may be accurately acquired by paramedics [3,4], and will usually have minimal effect on scene times [5-7]. In addition, transmission of the ECG by cellular modem to the ED has been shown to reduce time delay for treatment of AMI [8,9] and provide accurate information for field thrombolysis decisions to ED physicians [8,10,11].

The American Heart Association guidelines and most PHTL ECG studies suggest that a prehospital ECG program include the acquisition of a diagnostic 12-lead ECG with transmission to a receiving hospital for physician review [1,3,12] noting that approximately 85% of obtained tracings can be successfully transmitted [1]. Few investigators have explored whether transmission of 12-lead ECGs, incurring additional costs as well as potential for transmission failure, is required when highly trained paramedics provide interpretations to receiving facilities [13].

During the formative years of prehospital emergency medical care, routine telemetry transmission to a base physician was considered essential until the information provided beyond paramedic interpretation was directly examined [14-18]. Some have suggested that computerized interpretation could improve the sensitivity and specificity of prehospital 12-lead ECG review [16,19,20]. However, computer interpretations have been demonstrated to be less sensitive for anterior and inferior AMI as compared to cardiologists’ review [21].

We hypothesized that highly trained paramedics in a large urban EMS system could identify patients with ST-segment elevation myocardial infarction (STEMI) with sufficient accuracy that transmission of 12-lead ECGs for physician review would be unnecessary. Furthermore, in EMS systems where patient information and an ECG are provided to the base physician [16,22], it is unclear how much additional information is contributed by physician review. Previous studies have suggested that clinical information can influence ECG interpretations for both experienced and novice ECG readers [23]. Thus, we wished to examine the performance of paramedic ECG interpretation in real time as compared with blinded physician ECG review.

2. Methods

This prospective observational study was carried out between May and December 1997 at Boston EMS, an urban third-party 2-tiered advanced life support (ALS)/basic life support (BLS) system providing emergency services to the city of Boston. Boston EMS responds to more than 100,000 calls to 911 with more than 9000 ALS transports per year. There were 41 field ALS providers at the time of the 12-lead project.

2.1. Phase 1: training and certification

All department field paramedics completed a 6-hour training course including practical and written examinations. The training course emphasized pathophysiology of the acute coronary syndrome, proper acquisition of a 12-lead ECG, and accurate ECG interpretation with emphasis on diagnostic changes associated with AMI and recognition of STEMI patterns. Paramedics were trained to identify common sources of misclassification such as bundle-branch block, ventricular aneurysms, pericarditis, and the early repolarization variant. The goal of the training program was to maximize specificity of interpretations (minimize false-positive STEMI identification). We instructed paramedics to identify patients with STEMI only when they were quite certain of the ECG diagnosis.

2.2. Phase 2: patient enrollment

Paramedics obtained 12-lead ECGs on patients with a clinical suspicion of AMI from May to December 1997. Electrocardiograms were acquired using the LIFEPAK 10 with serial 12-lead adapter and LIFEPAK 12 (both manufactured by Medtronic Physio-Control, Redmond, WA). Included were patients presenting with chest pain, syncope, weakness, dyspnea, or other symptoms considered by the field provider to be strongly suggestive of acute cardiac ischemia. Paramedics were instructed to exclude patients with left bundle-branch block and pacemaker artifact from further analysis. Prehospital 12-lead interpretation was conducted in real time and recorded on a data collection form. Electrocardiograms were assigned to 1 of 3 categories: definite STEMI (certainty of diagnosis), possible AMI or ischemia (to be used even if STEMI thought probable, but not certain), and nondiagnostic.

All ALS transfers with PHTL were identified by daily trip sheet review. A board-certified emergency physician and a board-certified cardiologist independently reviewed each PHTL without clinical data available. We included all ECCs with multiple leads submitted by paramedics with a data sheet completed (intent to perform 12-lead ECG). These included 4 tracings without complete 12 leads recorded where providers believed clear-cut ST segment changes were evident before completion of the serial 12-lead recording (LIFELPAK 10) used at the inception of the project.

Data were collected upon ED presentation, during hospitalization, and at discharge. These included sociodemographic information, initial and follow-up clinical features, ECGs, cardiac biomarker, and other diagnostic tests. Time to treatment by either thrombolysis or time to arrival at the cardiac catheterization laboratory was recorded. A third physician blinded to both paramedic and physician PHTL interpretations assigned final diagnoses using the World Health Organization (WHO) criteria for AMI diagnoses. The WHO criteria for assignment of diagnoses of AMI [24-26] required at least 2 of the following criteria: (1) a clinical history of ischemia-type
chest discomfort; (2) changes on serial ECGs; and (3) a rise and fall in serum cardiac markers. Cardiac troponins were not measured at the time of this study. Patients with aborted AMI were considered to have had a STEMI if they had ischemic symptoms, diagnostic ST elevation on the PHTL, and evidence of reperfusion with thrombolysis or angioplasty without characteristic biomarker changes.

The third reviewer then classified the PHTL as either STEMI or not based upon the PHTL demonstrating 0.1 mV or higher in 2 contiguous limb leads or 0.2 mV or higher in 2 contiguous precordial leads. All discordant final diagnoses and the final determination as to whether the PHTL met STEMI criteria were resolved by consensus.

Data were entered into a database (Microsoft Access 2000, Microsoft Corporation, Redmond, Wash) and analyzed using SAS 8.2 (SAS Institute Inc, Cary, NC). We calculated sensitivity, specificity, negative and positive predictive values, likelihood ratio (LR), and overall accuracy with 95% confidence intervals (CIs) where appropriate. We compared readers’ analyses with McNemar test and Cohen κ. The institutional review board at Boston Medical Center, the Medical Control Base Station for Boston EMS, approved this study. Patient consent was not required for 12-lead acquisition because this technology was implemented as a new standard of care and no intervention was planned based upon the paramedic interpretation of the PHTL.

3. Results

A total of 166 patients had PHTL ECGs acquired by prehospital providers over an 8-month period. Of these, 15 subjects were withdrawn for the following reasons: 14 could not be assigned confirmed diagnoses (7 with no follow-up data available, 3 left receiving sites AMA, 2 with missing PHTL, 2 with missing case report forms [1 with confirmed STEMI, 1 confirmed non-STEMI]) and 1 because the PHTL available was too poor in quality for reviewers to code. Sixty-two percent of the patients (94/151) were male with a mean age of 61.1 years (±14.8 SD, range 20-92 years), and most (123 [81%]) had a chief complaint of chest pain. The prehospital 12-lead population is summarized in Table 1.

Of the 151 patients, 25 had confirmed STEMI (prevalence, 16.6% [95% CI, 11%-23.5%]). Two patients with STEMI did not report chest pain as a complaint, but had PHTL obtained for suspected AMI.

The paramedics correctly identified 20 of the 25 patients with confirmed STEMI. The paramedics categorized 4 patients as having STEMI who did not meet diagnostic criteria for confirmed STEMI. Of these misclassifications, 1 was considered a misread, 2 patients had “AMI mimics” (1 patient with early repolarization and prior history of MI and 1 patient with left ventricular hypertrophy and anterior septal ST elevations). The fourth patient had confirmed acute coronary syndrome with unstable angina and had coronary artery bypass graft within 24 hours, but did not satisfy the WHO criteria for AMI. The overall performance of paramedic interpretation (Table 2) was a sensitivity of 80%, specificity of 97%, positive predictive value of 83%, negative predictive value of 96%, accuracy of 94%, and positive LR of 25.2 for recognition of STEMI (95% CI, 9.4-67.4) (Table 3).

The 2 physician reviewers were blinded to any patient characteristics, clinical information, or follow-up data. The physician and paramedic interpretations are compared in Table 3. The overall accuracy of paramedic classifications performed in real time with the incorporation of clinical data (94%; 95% CI, 90%-98%) was comparable to blinded emergency medicine (93%; 95% CI, 89%-97%) and cardiology review (95%; 95% CI, 92%-99%). There was good agreement among all 3 paired readings (paramedic–emergency physician, paramedic-cardiology, emergency physician–cardiology) with κ of 0.73, 0.67, and 0.79, respectively (Table 4).

4. Discussion

Our study demonstrated that paramedics can acquire prehospital 12-lead ECGs and independently identify those patients with STEMI without transmission or review by a Base Hospital physician. The overall accuracy of paramedic interpretation is comparable to the results of other studies that have examined clinician (paramedic, emergency physician, cardiologist) performance on static test cases or scenarios [10,27,28] and consistent with other prehospital systems [13]. The high specificity of paramedic interpretations and very high positive LR observed indicate that paramedic classification of STEMI has strong diagnostic value (LR >10) and that few false positives would be expected in our EMS system. Furthermore, paramedics interpreting ECGs in a clinical setting are as accurate as physicians who classified tracings without the benefit of clinical data. It is possible that prior studies that have required physician review may have been confounded by

**Table 1** Characteristics of the 12-lead study group (n = 151)

<table>
<thead>
<tr>
<th>Age (y)</th>
<th>61.1 (14.8, 20-92)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male sex</td>
<td>94 (62)</td>
</tr>
<tr>
<td>Chief complaint—chest pain</td>
<td>123 (81)</td>
</tr>
</tbody>
</table>

Values are expressed as mean (SD, range) or n (%).
additional clinical data provided along with the transmitted 12-lead ECG.

Like any diagnostic test, prehospital ECG interpretation can involve a trade-off between sensitivity and specificity. The purpose of prehospital STEMI identification affects the desired or optimal performance goals. In the case of initiating thrombolysis in the prehospital setting where there may be important risks to treatment of false positive patients, extremely high specificity is most appropriate. In such systems, paramedic interpretation, computer and base station review may be indicated to maximize specificity [10,29]. It may also be appropriate to modify ECG criteria to maximize sensitivity by increasing the cut-point for ST elevation [30,31], especially in the septal leads by requiring a threshold of more than 0.2 mV or more than 0.3 mV for identification of STEMI [32]. Increasing the ST-elevation requirement has a reported sensitivity and specificity with computer analysis of 52% and 98% and cardiologist online review of 62% and 98% [33].

Another well-described role for PHTL is to aide in the triage and transportation decisions for these patients. In such a setting, it is appropriate to apply PHTL screening to a much broader population of patients with a lower prevalence of disease and to accept a lower specificity and a higher sensitivity for STEMI classification. In this configuration, the decision to initiate reperfusion therapy is made by physicians in the hospital. The risks of thrombolytic therapy or the costs associated with activating a percutaneous reperfusion teams [38]. In these systems there may be some cost to false positives; however, there should not be additional risks. There can be costs to facilities that are bypassed (lost patient volume and revenue) and to receiving PCI centers (unnecessary activation of PCI teams, especially if not on site 24/7). In such a system, high specificity is still desirable from the system’s perspective, although not as high as would be required for field thrombolysis.

We conducted this observational study with the goal of achieving a very high specificity and positive predictive value for prehospital identification of STEMI. We trained providers to identify STEMI only with high ECG certainty and to obtain PHTL only in patients with high clinical suspicion of AMI (high prevalence of disease). Thus, we did not mandate that all prehospital patients with symptoms suggestive of possible acute coronary syndrome or all chest pain patients have a PHTL. Paramedic judgment rather than strict protocol guidelines directed the decision to obtain 12-lead ECGs. During this initial phase, concerns were raised that obtaining 12-lead ECGs on all patients with symptoms suggestive of acute cardiac ischemia, including those thought to be at very low risk of STEMI, might adversely affect the operation of the EMS system. Therefore, paramedics were instructed to obtain PHTLs only on patients felt to have a reasonable suspicion of AMI, rather than observe a strict complaint-driven protocol such as requiring that a PHTL be obtained on all patients over a certain age with a complaint of chest pain regardless of the clinical characteristics of the complaint.

The prevalence of STEMI in our sample (16.6%; 95% CI, 11%-23.5%) was higher than was observed in earlier prehospital thrombolysis studies. The STEMI prevalence rates reported in the earlier MITI project (4.2%) and Milwaukee feasibility study reported (8.6%) differ because disease prevalence will vary with the population included for PHTL [10,22,39]. Patients were not excluded from 12-lead ECG based upon factors that might affect reperfusion decisions such as duration of symptoms, contraindications to thrombolytic therapy, or clinically compromised condition. In fact, patients with evident contraindications to thrombolysis or shock, exclusions for PHTL in other studies, were eligible for PHTL based upon the assumption that prehospital identification of STEMI may play an even more important role in determining appropriate triage and transportation decisions for these patients.

### Table 3: Estimates (95% CI)

<table>
<thead>
<tr>
<th></th>
<th>Paramedic</th>
<th>EM MD</th>
<th>Cardiology MD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>0.80 (0.64-0.96)</td>
<td>0.80 (0.64-0.96)</td>
<td>0.92 (0.81-1.00)</td>
</tr>
<tr>
<td>Specificity</td>
<td>0.97 (0.94-1.00)</td>
<td>0.96 (0.93-0.99)</td>
<td>0.96 (0.93-0.99)</td>
</tr>
<tr>
<td>Positive predictive value</td>
<td>0.83 (0.68-0.98)</td>
<td>0.80 (0.64-0.96)</td>
<td>0.82 (0.68-0.96)</td>
</tr>
<tr>
<td>Negative predictive value</td>
<td>0.96 (0.93-0.99)</td>
<td>0.96 (0.93-0.99)</td>
<td>0.98 (0.96-1.00)</td>
</tr>
<tr>
<td>Overall accuracy</td>
<td>0.94 (0.90-0.98)</td>
<td>0.93 (0.89-0.97)</td>
<td>0.95 (0.92-0.99)</td>
</tr>
<tr>
<td>Likelihood ratio</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>25.2 (9.4-67.4)</td>
<td>20.16</td>
<td>23.18</td>
</tr>
<tr>
<td>Negative</td>
<td>0.21</td>
<td>0.21</td>
<td>0.08</td>
</tr>
</tbody>
</table>

EM indicates emergency medicine.
The results of our study confirm the hypothesis that the additional costs required to transmit PHTL ECGs, especially in large urban systems, may not be necessary. Furthermore, a system reliant on accurate paramedic interpretation is not subject to equipment or transmission problems. Subsequent studies must examine the impact of paramedic-identified STEMI on hospital treatment practices, including the accuracy of prehospital diversion of selected patients with AMI such as those with high-risk features, STEMI, or contraindications to thrombolytic therapy. Such a triage scheme is based upon the reliability of the prehospital clinical evaluation and accurate interpretation of the PHTL. Such a system requires highly trained ALS providers and rigorous medical control and review.

There were a number of limitations to our study. Because of the small sample size, small changes in ECG classifications could have a large effect on reader performance (paramedic and physician). A larger study could provide more robust estimates of accuracy and could possibly detect clinically important differences between ECG readers. This study was conducted with experienced urban system paramedics. The results may not generalize to all EMS providers or EMS systems. Indeed, one of the most important elements of this project is a stable force of highly trained, motivated, and experienced ALS providers. Other authors have noted the need for rigorous training and performance review of a 12-lead ECG program [12].

Furthermore, our system was predicated on the assumption that there would be real direct costs to false-positive paramedic STEMI diagnoses and that this required minimizing such misclassifications. Other systems could be envisioned where patients with suspected but less clear-cut STEMI could be reevaluated without direct costs in terms of activation of specialized personnel. These systems could include sites where PCI facilities are staffed for uniform 24-hour operation analogous to level I trauma centers. In such a setting, the sensitivity-specificity trade-off for STEMI might be different. In our system, we believed that mobilization of cardiac catheterization teams for patients with STEMI or pre-arrival preparation of an expensive thrombolytic agent, although facilitated by very early prehospital identification, would be problematic should teams be activated for an important number of “false alarms.” Finally, the focus of this project was prehospital identification of patients with STEMI. Further changes in the treatment of patients with non-STEMI may modify the role of prehospital ECG interpretation and prehospital triage of patients with non-STEMI AMI.

5. Conclusions

Experienced, highly trained urban paramedics can accurately and specifically identify STEMI. Paramedics without online physician review may be sufficiently accurate to allow triage of selected patients with AMI to catheterization centers, provision of prehospital thrombolysis, or mobilization of interventional teams. Independent paramedic ECG interpretation should aide in the timely delivery of reperfusion therapy for patients with STEMI.

Acknowledgments

The authors wish to recognize the efforts of (1) all of the paramedics who provide care for the citizens of Boston whose interest and enthusiasm made this project possible; (2) Ms Clara Safi, ANP, for her tireless efforts on behalf of the 12-lead Project; (3) the Data Coordinating Center at the Boston University School of Public Health and Ms Jeena Easow, MPH, for their assistance with the statistical analysis; and (4) Supriya Mehta PhD, MHS, for her thoughtful comments on the manuscript.

References


Predictive value of C-reactive protein at different cutoff levels in acute appendicitis

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Abstract Determining the different cutoff values of C-reactive protein (CRP) on the basis of how long the patient’s symptoms were present can be used to early predict acute appendicitis. We analyzed retrospectively from 2001 to 2004 the hospital records of 568 patients who underwent appendectomies for suspected appendicitis. Receiver operating characteristic analysis has shown that CRP measurement can increase the diagnostic accuracy in acute appendicitis. The cutoff values of CRP concentration taken as the first, second, and third days after onset of symptoms that distinguish acute appendicitis from other acute abdominal diseases were 1.5, 4.0, and 10.5 mg/dL, respectively; the values that distinguish perforated appendicitis from other acute abdominal diseases were 3.3 mg/dL (first day), 8.5 mg/dL (second day), and 12.0 mg/dL (third day). The different cutoff values of CRP concentration may serve as a useful predictive parameter in the early diagnosis of acute appendicitis on the first 3 days after the onset of symptoms. © 2005 Elsevier Inc. All rights reserved.

1. Introduction

Acute appendicitis is the most common abdominal surgical emergency [1-6]. In the emergency department, a great number of patients with right lower quadrant pain are evaluated by clinicians to rule out appendicitis everyday. Classically, the diagnosis of acute appendicitis is based on a brief history of abdominal pain, nausea, migration of pain to the right iliac fossa, and signs of local peritonitis; diagnostic accuracy based on these symptoms ranges from 70% to 80% [2,3,5-7]. However, in some cases, the clinical presentations are atypical and diagnostic errors are made. The diagnostic difficulties lead surgeons to perform unnecessary laparotomies whereas misdiagnosis can lead to perforation and abscess formation [3,7,8]. Perforation of an inflamed appendix occurs in 15% to 25% of patients treated surgically for suspected acute appendicitis, with the highest rates encountered in young children and elderly patients [2-7,10]. In general, 2 important facts remain: a normal appendix found during appendectomy represents a misdi-
agnosis, and a delayed diagnosis of acute appendicitis may lead to perforation and peritonitis. Thus, improving accuracy is desirable both for earlier diagnosis and for avoiding unnecessary appendectomies. Comparatively new techniques, including nuclear medicine scans, ultrasonography, and computed tomographic scanning, have been used increasingly to evaluate patients with suspected appendicitis [1,4–6,8,9]. However, some authors have suggested that these tests are not easy to apply in primary healthcare settings and simply increase costs without significantly increasing diagnostic accuracy [1,3,4,10].

In contrast, preoperative laboratory tests can be performed easily in primary healthcare settings and often aid primary clinicians with decision making about patients with clinically suspected acute appendicitis. Among these tests, C-reactive protein (CRP) concentration is the most widely estimated acute phase protein and is considered to be a good predictor of acute appendicitis [6,7,9–16]. To our knowledge, however, the cutoff values of CRP concentration in distinguishing acute appendicitis from other acute abdominal disorders have not been determined. In this study, we aimed to determine the different cutoff values of CRP based on how long the patient’s symptoms were present to improve diagnostic accuracy of acute appendicitis.

2. Methods

2.1. Patients population

From 2001 to 2004, we analyzed retrospectively the hospital records of 568 consecutive patients who underwent appendectomies for clinically suspected acute appendicitis at the Changhua Christian Hospital, Taiwan. The term clinically suspected acute appendicitis was reserved for cases with clinical symptoms and signs that included abdominal pain, anorexia, nausea, vomiting, diarrhea, pyrexia, migration of pain, and tenderness over the right lower quadrant of the abdomen. The patients whose symptoms and signs lasted more than 3 days were excluded from our analysis. Also, patients with clinically suspected acute appendicitis who were treated by nonsurgical methods were excluded. Therefore, 542 patients of suspected appendicitis were studied in this series. The ultimate diagnosis of acute appendicitis was based on histological examination of the excised appendix.

2.2. Method

In the hospital charts, the following data were recorded on admission: age, sex, body temperature, time of onset of symptoms, and time of admission. On admission, the blood samples were obtained from all patients and the CRP concentration was recorded. The concentration of CRP in serum was measured by immunoturbidimetry (Beckman Coulter, Fullerton, Calif). In all patients with suspected appendicitis, the correlation between the CRP levels and the period from the onset of symptoms to admission was analyzed statistically based on the different cutoff levels of CRP obtained from data gathered at the time of admission.

2.3. Statistical analysis

The methods of statistical analysis were the t test, the Mann-Whitney U test, and the receiver operating characteristic (ROC) curve. Possibility levels of less than .05 were taken as significant. The informative value of each biological marker was determined, and the cutoff points were defined by ROC analysis. The area under the curve (AUC), calculated using the trapezoidal rule, was considered a global measure of the diagnostic value of the parameter. An optimal test result gives a value of 1.0, and a useless test result gives a value of 0.5. Positive and negative likelihood ratios (LRs) (positive LR = ratio of the fraction of true positives and false positives, and negative LR = ratio of

| Day | Normal | Appendicitis | P
<table>
<thead>
<tr>
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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD (No.)</td>
<td>95% CI</td>
<td>Mean ± SD (No.)</td>
</tr>
<tr>
<td>1</td>
<td>1.41 ± 2.29 (37)</td>
<td>0.67-2.15</td>
<td>2.31 ± 3.45 (180)</td>
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<tr>
<td>2</td>
<td>2.99 ± 2.92 (40)</td>
<td>1.75-3.56</td>
<td>7.09 ± 6.06 (145)</td>
</tr>
<tr>
<td>3</td>
<td>4.95 ± 4.95 (23)</td>
<td>2.93-6.97</td>
<td>15.47 ± 8.58 (117)</td>
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</table>

<table>
<thead>
<tr>
<th>Day</th>
<th>Simple</th>
<th>Appendicitis</th>
<th>Perforated</th>
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</thead>
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<tr>
<td></td>
<td>Mean ± SD (No.)</td>
<td>95% CI</td>
<td>Mean ± SD (No.)</td>
</tr>
<tr>
<td>1</td>
<td>2.05 ± 3.35 (167)</td>
<td>1.54-2.56</td>
<td>5.59 ± 3.10 (13)</td>
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<tr>
<td>2</td>
<td>6.14 ± 5.75 (116)</td>
<td>5.09-7.19</td>
<td>10.85 ± 5.87 (29)</td>
</tr>
<tr>
<td>3</td>
<td>11.81 ± 6.45 (67)</td>
<td>10.26-13.35</td>
<td>20.38 ± 8.67 (50)</td>
</tr>
</tbody>
</table>

a The period from the onset of symptoms to admission.

b Normal appendixes.

Table 1 The mean CRP levels of patients with simple appendicitis, perforated appendicitis, and normal appendices on the first 3 days after onset of symptoms.
the fraction of false negatives and true negatives, respectively) were calculated for the best cutoff values.

3. Results

The patient comprised 331 males (61.1%) and 211 females (38.9%) with a mean age of 22.3 ± 19.4 years (range, 0-89 years). Of those, 350 had histologically proven simple acute appendicitis (nonperforated), 92 had perforated, and 100 had normal appendices. Among those with normal appendices, only 6 patients who underwent laparotomies actually showed evidence indicating the need for surgical treatment, including perforation of diverticulum, intestinal perforation, and ruptured tubo-ovarian abscess. Thus, our diagnostic rate of acute appendicitis was 81.5% and normal appendicectomy rate was 18.5%.

The mean CRP levels of patients with simple appendicitis, perforated appendicitis, and normal appendices were analyzed on the first 3 days after onset of symptoms (Table 1). The mean CRP levels were statistically significantly higher in patients with appendicitis than those with normal appendices \( (P < .001) \) and also significantly higher in patients with perforated appendicitis than simple appendicitis \( (P < .001) \) during the first 3 days. The ability of CRP concentration on admission to predict appendicitis was analyzed by ROC curves (Fig. 1A-F). All CRP cutoff values had an AUC significantly greater than 0.5. On the basis of sensitivity, specificity, positive likelihood ratio (LR+), and negative likelihood ratio (LR-), and

<table>
<thead>
<tr>
<th>Group</th>
<th>CRP (mg/dL)</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>LR+</th>
<th>LR-</th>
<th>AUC (95% CI)</th>
</tr>
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<tbody>
<tr>
<td>Group I</td>
<td>Day 1</td>
<td>1.5</td>
<td>0.38</td>
<td>0.81</td>
<td>2.00</td>
<td>0.77</td>
</tr>
<tr>
<td>Day 2</td>
<td>4.0</td>
<td>0.63</td>
<td>0.78</td>
<td>2.88</td>
<td>0.45</td>
<td>0.77 (0.68-0.84)</td>
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<tr>
<td>Day 3</td>
<td>10.5</td>
<td>0.72</td>
<td>0.83</td>
<td>4.13</td>
<td>0.34</td>
<td>0.88 (0.80-0.95)</td>
</tr>
<tr>
<td>Group II</td>
<td>Day 1</td>
<td>3.3</td>
<td>0.77</td>
<td>0.89</td>
<td>7.12</td>
<td>0.26</td>
</tr>
<tr>
<td>Day 2</td>
<td>8.5</td>
<td>0.70</td>
<td>0.95</td>
<td>13.79</td>
<td>0.33</td>
<td>0.92 (0.85-0.98)</td>
</tr>
<tr>
<td>Day 3</td>
<td>12.0</td>
<td>0.90</td>
<td>0.96</td>
<td>20.70</td>
<td>0.10</td>
<td>0.96 (0.92-1.00)</td>
</tr>
</tbody>
</table>

\( ^a \) Comparison of the patients with appendicitis (both nonperforated and perforated) and the patients with normal appendices (group I); comparison of the patients with perforated appendicitis and the patients with normal appendices (group II).
negative likelihood ratio (LR−), the predictive values at different cutoff levels of CRP in diagnosing appendicitis on the first 3 days after onset of symptoms were determined, respectively (Table 2). The cutoff levels of CRP in distinguishing appendicitis from other acute abdominal diseases (group 1) were 1.5 mg/dL on the first, 4.0 mg/dL on the second, and 10.5 mg/dL on the third day after onset of symptoms. However, on the first day after onset of symptoms, the AUC (0.60) was smaller than that on the other 2 days (0.77 and 0.88). Thus, the diagnostic value of CRP on the first day decreased. The cutoff levels of CRP in distinguishing perforated appendicitis from other acute abdominal diseases (group 2) were 3.3 mg/dL on the first, 8.0 mg/dL on the second, and 12.0 mg/dL on the third day after onset of symptoms. The AUCs of the ROC curves were all favorable on the first 3 days after onset of symptoms (0.90, 0.92, and 0.96).

4. Discussion

Acute appendicitis is the most common problem requiring emergency abdominal surgery [1-6]. Early diagnosis of appendicitis can prevent perforation, abscess formation, and postoperative complications, and can decrease cost by shortening hospitalizations. However, despite intensive research and discussion, accurate diagnosis of acute appendicitis is still difficult. Although peritoneal aspiration cytology, ultrasonography, and computed tomographic scanning have all been applied to increase diagnostic accuracy in patients with clinically suspected acute appendicitis [1,3,4,7,9], these procedures are not available in all healthcare settings and the cost of performing them remains high. In contrast, some serum inflammatory markers today are fast, economical, and universally available, and have been used for many years to improve the preoperative diagnosis of acute appendicitis. C-reactive protein, an acute phase protein, can be used as a screening device for occult inflammation, as a marker of disease activity, and as a diagnostic tool [11]. Numerous studies have concluded that elevated CRP levels aid in the diagnosis of acute appendicitis [6,7,9-16]. Specifically, some authors claim that CRP can predict perforated appendicitis more effectively than simple appendicitis [11]. The diagnostic value of CRP concentration in predicting appendicitis appears to be reliable and widely applied to patients with suspected appendicitis [1,7,8,13]. Nevertheless, the application of the cutoff values of CRP concentration in distinguishing acute appendicitis from other acute abdominal diseases based on how long that patient’s symptoms were present has never been reported. In this study, 542 patients with clinically suspected acute appendicitis were analyzed and the results indicated that the cutoff values of CRP could predict significantly the presence or absence of acute appendicitis.

According to the results of ROC analysis, we determined the cutoff values of CRP concentration for early diagnosis of acute appendicitis on the first 3 days after onset of symptoms. Clinically, the probability of acute appendicitis increased when the CRP level was greater than 1.5 mg/dL on the first day, greater than 4.0 mg/dL on the second day, and greater than 10.5 mg/dL on the third day after onset of symptoms. However, we found that the AUC value on the first day was not as statistically significant as that on the other 2 days. Thus, the predictive value of CRP in diagnosing appendicitis on the first day after onset of symptoms decreased. Kinetic studies have reported that serial levels of CRP show an increase after 12 to 24 hours of symptoms [11-15]. When symptoms of acute appendicitis proceed rapidly, a patient’s levels of CRP may not increase on admission. Therefore, this explains why we found negative CRP values in some patients with appendicitis on admission, especially on the first day after onset of symptoms. Importantly, in further study, we need additional investigation to estimate whether other inflammatory markers can detect early acute appendicitis on the first day after onset of symptoms.

In our study, we noticed that the mean CRP level in patients with perforated appendicitis was much greater than in patients with simple appendicitis. Furthermore, we also found that the ROC curve analysis of the different cutoff values of CRP could be used to distinguish between perforated appendicitis and other acute abdominal diseases. Therefore, we calculated the cutoff values of CRP concentration on the first 3 days after onset of symptoms to see whether they indicated perforated appendicitis. We found that once the CRP level was greater than 3.3 mg/dL on the first day, greater than 8.5 mg/dL on the second day, and greater than 12.0 mg/dL on the third day after onset of symptoms, the probability of perforated appendicitis significantly increased. The role of CRP did serve as a strong predictive parameter in the differential diagnosis of perforated appendicitis.

In the emergency department, once the diagnosis of appendicitis is made, consequent surgical intervention will be indicated. However, the type of operation (open or laparoscopic appendectomy) is often based on the surgeon’s experience and whether the appendix is perforated or not [17,18]. Some studies have reported higher complication rates using laparoscopy for perforated cases [18-21]. Preoperative diagnosis of perforation, therefore, becomes important and essential. Indeed, we believe that the high predictive values of these different cutoff levels of CRP in diagnosing appendicitis can aid primary clinicians in detecting acute appendicitis before the appendix perforates. Clinically, the much higher CRP values found in the perforated appendicitis cases may be of use to surgeons in planning their operative approach. In our study, we have determined CRP levels using different cutoff values based on how long the patient’s symptoms were present to improve diagnostic accuracy of simple and perforated appendicitis. C-reactive protein will be helpful in predicting appendicitis earlier and reducing the rate of complications caused by delay in diagnosis.
Nevertheless, there was a limitation in this retrospective study. We did not report CRP serum values for patients with other clinical diagnoses who did not undergo laparotomy for suspected appendicitis during the study period. In our ongoing prospective study, these patients will be included. The results will be more useful if they show a significant difference in cutoff CRP levels between patients who did not undergo laparotomies and those who had either appendicitis or perforated appendicitis.

In conclusion, the different cutoff values of CRP concentration may serve as a predictive parameter in early diagnosis of acute appendicitis on the first 3 days after onset of symptoms. The predictive value of CRP is especially effective in the patients with perforated appendicitis. We therefore propose the addition of CRP measurement as a routine laboratory test in patients suspected of having acute appendicitis.

References

Pediatric prescription pick-up rates after ED visits

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Abstract
Objective: To determine the compliance rate in filling outpatient medication prescriptions written upon discharge from the emergency department (ED).

Methods: Emergency department records of children during a 3-month period were examined along with pharmacy claim data obtained in cooperation with the largest insurance carrier in the community (private and Medicaid). Pharmacy claim data were used to validate the prescription pick-up date.

Results: Overall, 65% of high-urgency prescriptions were filled. The prescription pick-up rate in the 0-to 3-year age group (75%) was significantly higher than in the rest of the cohort (55%) (P < .001). Children with private insurance were more likely to fill their prescriptions (68%) compared to children with Medicaid insurance (57%) (P = .03).

Conclusion: This study demonstrates that filling a prescription after discharge from an ED represents a substantial barrier to medication compliance.

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1. Introduction

Patients discharged from the emergency department (ED) are commonly prescribed drugs for the management and treatment of disease. Disease prognosis and drug efficacy are dependent upon patient compliance with prescribed medications. Compliance with drug therapy is essential as many ED patients do not obtain follow-up evaluations [1-4]. Repeat ED visits and subsequent hospital admissions have also been associated with prescription drug noncompliance [5,6].

The first requirement for outpatient medication compliance is to actually obtain the medication. Prescription
2. Methods

This is a retrospective study examining ED medical records at a children’s hospital. Pharmacy claim information was provided by the largest insurance provider in the state, which provides Medicaid and private insurance to approximately half of the state’s population. Daily ED records were reviewed to identify pediatric patients (age under 18 years) covered by this insurer who were discharged from the ED with a high-urgency drug prescription during a 3-month period (April 1, 2001-June 30, 2001).

High- and low-urgency drug prescriptions were determined to study only those prescription which needed to be filled soon (preferably, immediately after discharge from the ED). A low-urgency prescription does not mean that the drug is of low importance, but it does mean that filling this prescription is either optional or it can be delayed without significant medical consequence. High- and low-urgency medications were determined according to the following criteria: (1) children prescribed over-the-counter medications were placed in the low-urgency medication group. Private insurance does not cover over-the-counter medications, so the study methodology would not be able to determine when these medications were filled. (2) Children prescribed a medication they were currently taking in the same form (ie, a refill of medication) were placed in the low-urgency medication group. (3) Children given a new medication in the same drug class as a previous new prescription were placed in the low-urgency medication group (eg, on amoxicillin is changed to cephalexin). This was considered low urgency because in many instances the reason for a change is an allergic reaction, adverse effects, or findings suggesting the need for broader antibiotic coverage. These reasons were felt to be less urgent, as the patient was already partially treated. (4) Children administered a dose of medication in the ED before release, with the exception of albuterol (eg, IM/IV ceftriaxone given in the ED and then prescribed oral antibiotics), were placed in the low-urgency medication group. This was considered low urgency because the parenteral dose in the ED is sufficient for 12 to 24 hours, thus obtaining the outpatient prescription is less urgent. Primary care physicians might choose to administer a second parenteral antibiotic dose during office follow-up or provide the patient with antibiotic samples, which would delay or eliminate the need to fill the prescription.

Albuterol exceptions were as follows: (a) children on oral albuterol at home and prescribed aerosolized albuterol from ED were placed in the high-urgency group because this change is most often due to wheezing which is refractory to oral albuterol, resulting in respiratory difficulty. (b) Children on aerosolized albuterol at home and prescribed oral albuterol from ED were placed in the low-urgency medication group.

All children receiving prescriptions that did not fall under the above criteria were placed in the high-urgency medication group.

For the patients meeting the inclusion criteria, pharmacy claim information was linked, using the insurer’s member identification numbers, to determine whether and when the prescriptions given in the ED were filled. Prescription pick-up information (date of filled prescription) was obtained by examining medical insurance pharmacy claim data submitted to the health insurer. Presumably, an insurance reimbursement claim would be submitted by the pharmacy if it filled the prescription because without this claim the pharmacy would not be paid. A filled prescription was defined as having the prescription filled at a pharmacy and recorded as filled in the health insurance provider database (ie, compliant). Absence of the prescription claim in the health insurance provider database was determined to be an unfilled prescription (ie, noncompliant). The date of discharge from the ED was compared to the date the prescription was filled. It is possible that the patient paid for their prescription without using their medical insurance coverage, but this is unlikely as this insurance provider participates with nearly all the pharmacies in the state. Other demographic information was obtained from the ED records of the patient.

The primary outcome of the study was the proportion of high-urgency prescriptions written in the pediatric ED that were filled as determined by insurance claim data.

The \( \chi^2 \), Fisher exact test, and odds ratios with 95% confidence intervals (CIs) were used to compare categorical variables. Statistical analysis was performed using SPSS software, version 12.0 (SPSS Inc, Chicago, Ill).

This study was approved by the institutional review board of this medical center.

3. Results

There were 6354 total records reviewed during the 3-month study period, with 1829 excluded as adult patients (age \( \geq 18 \)). Of the remaining 4525 pediatric patient records, 2123 were covered by the participating health plan (47%). Of those remaining records, 1334 were eliminated because of hospital admission or no medication prescribed upon discharge. Of the remaining 789 patient records, 403 were prescribed high-urgency medications and are further described below.
The mean age of these 403 children was 5.9 years, with 88% younger than 13 years old. The mean age in the compliant group was 5.4 ± 4.9 years, compared to the mean age in the noncompliant group which was 6.8 ± 5.0 years.

Prescription pick-up rates in the different subgroups are summarized in Table 1. Overall compliance with prescription filling of high-urgency medications was 65% (260/403). Of those who picked up their medications, 83% (216/260) were filled on the same day of discharge from the ED, and 93% (243/260) were filled within 1 day after discharge. Ten patients filled their prescriptions 2 days after discharge, and 7 patients filled their prescriptions more than 2 days (3-20 days) after discharge.

Fifty-one children received multiple medications, of which 71% (36/51) filled their prescriptions. There were no children with multiple medications who filled partial prescriptions. Two hundred one children were discharged between 9 PM and 9 AM, of which 62% (125/201) filled their prescription. The most common prescriptions were anti-infectives (61%) and respiratory drugs (β-agonists/anticholinergics) (28%).

Prescription pick-up rates in the different age groups were as follows: 0 to 3 years, 75% (141/188); 4 to 12 years, 56% (93/165); 13 to 17 years, 52% (26/50). The prescription pick-up rate in the 0- to 3-year age group was significantly higher than in the rest of the cohort (4-17 years, 55% pick-up rate) (P < .001, odds ratio 2.42, 95% CI 1.58-3.70). Males were more likely to fill their prescriptions (69%) compared to females (57%) (P = .01, odds ratio 1.70, 95% CI 1.12-2.58). Children with private insurance were more likely to fill their prescriptions (68%) compared to children with Medicaid insurance (57%) (P = .03, odds ratio 1.63, 95% CI 1.07-2.49). No association was found between prescription filling and ethnicity, prescription of multiple medications, time of discharge from the ED, type of medication prescribed, or diagnosis.

### Table 1: Prescription pick-up rates among subgroups

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Number in group</th>
<th>Prescription pick-up rate (%)</th>
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<tbody>
<tr>
<td>Overall total</td>
<td>403</td>
<td>65</td>
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<tr>
<td>Age group*</td>
<td></td>
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</tr>
<tr>
<td>0-3 y</td>
<td>188</td>
<td>75</td>
</tr>
<tr>
<td>4-17 y</td>
<td>215</td>
<td>55</td>
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<td>68</td>
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<tr>
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<td>55</td>
<td>71</td>
</tr>
<tr>
<td>Others/unknown</td>
<td>32</td>
<td>50</td>
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</table>

* Statistically significant difference (see text for P values, odds ratios, and 95% CIs).

### 4. Discussion

Children represent a unique population for prescription filling as compliance is dependent on the reliability of their parents or guardians [14-17]. In addition, other factors such as insurance type, income level, age of the child, and ethnicity have been shown to be important factors affecting compliance [13,14,18-20]. Although most published studies on prescription filling for patients discharged from the ED have focused on adults [7-11], our study is one of the few to assess children.

This medical insurance carrier has many different private insurance plans, all of which have an outpatient copayment (variable amount) for medications. Some patients who are covered by 2 or more insurance plans will have no copayment, but this is dependent on the specifics of the 2 insurance plans. All Medicaid plans have no medication copayments. The pick-up rates were lower in the Medicaid group, despite the absence of copayments.

The prescription filling rate of 65% in the present study is low compared to the 77% to 88% shown in 4 previous studies on prescription filling after discharge from EDs in the United States [7-9,14]. These studies assessed compliance based on telephone interviews of patients, and prescription fill rates were not verified by pharmacy claim data. In addition, a percentage of the patients initially surveyed in each study could not be contacted for study completion. For these reasons, these findings cannot be completely accurate for prescription fill rates. One study which used pharmacy claim data to assess prescription fill rates found a 74% compliance rate for filling a prescription of azithromycin [10]. Another study using pharmacy claim data to assess oral corticosteroid prescription filling found a 44% prescription fill rate [13]. However, both studies examined specific types of prescriptions and, thus, cannot be applied to other prescription types or prescription fill rates as a whole. Studies in other countries examining patients discharged from the ED found prescription fill rates of 75% of 92% [11,12]. Our present study using insurance claim data accurately assesses high-urgency prescription fill rates for children discharged from this ED during this study period.

The finding in our present study that children with private insurance were more likely to fill prescriptions than children with Medicaid insurance also confirms the findings of previous studies and further emphasizes improving compliance strategies for children with Medicaid insurance. When examining children discharged from the ED in the United States, Wang et al [14] found children with Medicaid or no insurance to have significantly higher noncompliance rates of 41% and 60%, respectively, compared to those with
private insurance. Cooper and Hickson [13] examined children with Medicaid insurance and found that less than half (44%) were compliant with oral corticosteroid prescription filling. Poor compliance by children with Medicaid also suggests that socioeconomic reasons such as insufficient funds, lack of transportation, and attitudes toward health care can play a major role in prescription filling after discharge from the ED [3,7,8,10,12,4,21]. The higher rates of noncompliant prescription filling could also contribute to the higher rates of ED visits and hospitalizations seen in pediatric Medicaid patients [22,23].

In a study by Ginde et al [10], patients given a prescription to be filled free of charge at a 24-hour pharmacy located in close proximity to the ED filled their prescription 74% of the time, compared to 100% who were given their medication in the ED. This serves to reinforce the point that a major factor in completion of a medication course is actually obtaining the medication. Going to a pharmacy to fill the prescription reduces potential compliance by 26% despite the absence of financial barriers.

Our finding that the younger children (0-3 years) were more likely to have their prescriptions filled than older children (11-17 years) is consistent with the literature which shows that adolescent patients are at higher risk for noncompliance with drug therapy [13,18,19].

Limitations of this study include limiting the patient base from one insurance carrier. However, we were fortunate to obtain cooperation with this major insurance carrier to provide this information for us. Certain factors involved in selection of insurance carriers could possibly select for certain patient types and influence the outcome of the data. However, this particular insurance carrier covers more patients than any other carrier in the state, and it covers private insurance and Medicaid insurance plans. The selection criterion of high-urgency medications is also another limitation. Although we elected to study only urgent medications, the inclusion of low-urgency medications could have altered the study outcome. It is likely that including low-urgency medications would have a lower rate of prescription medication pick-ups as these would be less urgent. Thus, the inclusion of low-urgency medications would most likely have lowered the overall prescription pick-up rates. Another limitation is that we do not know whether the patients actually took their medications as directed, so our estimate of “compliance” is only a measure of acquiring the medication and not actually taking it.

An obvious intervention to improve compliance would be to dispense the medication from the hospital pharmacy so that the medication is given to the patient upon discharge from the ED. This is often done for patients with limited resources (lack of a means to obtain the medication), such as lack of funds or lack of transportation. Yet, this is not done routinely for patients with insurance. Regulatory and statutory limitations might restrict the dispensing of medications from the hospital’s inpatient pharmacy. For example, if a prescription is dispensed for outpatient use, from the inpatient pharmacy of a not-for-profit hospital, many insurance plans will not reimburse the hospital for this medication. The rationale for this possibly originates from case law which restricts the use of Pharmaceuticals purchased by not-for-profit hospitals at reduced institutional rates [24] which creates an unfair competitive advantage over smaller community pharmacies. However, in most instances, patients fill their prescriptions at large chain pharmacies which might have similar purchasing power arrangements. Regulatory/statutory restrictions only serve to inhibit our ability to improve medication compliance.

This study clearly shows that there is a substantial percentage of patients who do not obtain high-urgency medications. Even for those who did obtain their medications, going to a community pharmacy is simply inconvenient and burdensome. After a comprehensive evaluation in an ED, the family of an ill child must now go to a pharmacy where they must wait for their prescription to be filled. Presumably, the patient is waiting in the car or a potentially contagious patient is in the pharmacy with its other customers. Calling or faxing a prescription to a pharmacy or using automated prescription forwarding systems could potentially reduce patient waiting time, but it still requires the patient’s family to drive to a pharmacy.

Anecdotally, patients inform us that even if the prescription is called in, it is not ready when they get to the pharmacy. The pharmacy potentially benefits financially if patients wait for their prescription, as family members browse the store while waiting and purchase other items (eg, snacks, drinks, household items) which adds to the revenue of the pharmacy. In addition, expensive antibiotic suspensions must be committed to use once water is added to the powder-containing bottle. If the patient decides to fill the prescription elsewhere or the prescription is not picked up at all, the expensive antibiotic must be discarded and the pharmacy must absorb the cost of this. It is understandable that a pharmacy would be reluctant to commit and prepare the expensive antibiotic suspension until the patient actually arrives in the pharmacy.

In summary, the prescription pick-up rate for children discharged from the ED is approximately 65%. Age and insurance type play a significant role, with younger children and children with private insurance more likely to fill prescriptions than older children and children with Medicaid, respectively. This study demonstrates that filling a prescription after discharge from an ED represents a substantial barrier to medication compliance.

References


Does the presence or absence of sonographically identified cardiac activity predict resuscitation outcomes of cardiac arrest patients?

Philip Salen MD³,*, Larry Melniker MD, MS⁴, Carolyn Chooljian MD⁵, John S. Rose MD⁶, Janet Alteveer MD⁷, James Reed PhD⁸, Michael Heller MD⁹

Abstract This study evaluated the ability of cardiac sonography performed by emergency physicians to predict resuscitation outcomes of cardiac arrest patients. A convenience sample of cardiac arrest patients prospectively underwent bedside cardiac sonography at 4 emergency medicine residency-affiliated EDs as part of the Sonography Outcomes Assessment Program. Cardiac arrest patients in pulseless electrical activity (PEA) and asystole underwent transthoracic cardiac ultrasound B-mode examinations during their resuscitations to assess for the presence or absence of cardiac kinetic activity. Several end points were analyzed as potential predictors of resuscitations: presenting cardiac rhythms, the presence of sonographically detected cardiac activity, prehospital resuscitation time intervals, and ED resuscitation time intervals. Of 70 enrolled subjects, 36 were in asystole and 34 in PEA. Patients presenting without evidence of cardiac kinetic activity did not have return of spontaneous circulation (ROSC) regardless of their cardiac rhythm, asystole, or PEA. Of the 34 subjects presenting with PEA, 11 had sonographic evidence of cardiac kinetic activity, 8 had ROSC with subsequent admission to the hospital, and 1 had survived to hospital discharge with scores of 1 on the Glasgow-Pittsburgh Cerebral Performance scale and 1 in the Overall Performance category. The presence of sonographically identified cardiac kinetic motion was associated with ROSC. Time interval durations of cardiac resuscitative efforts in the prehospital environment and in the ED were not accurate predictors of ROSC for this cohort. Cardiac kinetic activity, or lack thereof, identified by transthoracic B-mode ultrasound may aid physicians’ decision making regarding the care of cardiac arrest patients with PEA or asystole.

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1. Introduction

Cardiac arrest results in the absence of signs of circulation, including the absence of a pulse. The pulse check has been the “gold standard” usually relied on by clinicians to determine if the heart is or is not beating [1]. Absence of a pulse has been used to indicate the need to place automated external defibrillator leads and initiate chest compressions. Unfortunately, the pulse check is neither a rapid nor a reliable means for detecting the presence or absence of circulation for both laypersons and healthcare providers [1]. Multiple studies have concluded that as a diagnostic test to assess for perfusion during suspected cardiac arrest, the pulse check has serious limitations in specificity, sensitivity, and accuracy [2-4]. The absence of a palpable pulse does not always reflect cardiac standstill during cardiac resuscitation as inefficient cardiac contractions occur because of many factors, including cardiac tamponade, pulmonary embolism, and pneumothorax [5]. Because some causes of inefficient cardiac contractions are more reversible than others, (ie, hypo/hyperkalemia, hypovolemia, hypothermia, acidosis, cardiac tamponade), a tool that would allow for early identification of groups of pulseless patients with more or less likelihood of resuscitation would be welcome [1,6]. Ultrasound (US) is well suited to bedside ED use in the care of critically ill patients and provides rapid, noninvasive, potentially useful information regarding the patient’s clinical condition. The importance of transesophageal cardiac US has been recognized in the American Heart Association guidelines for differentiating patients with true electromechanical dissociation (EMD; pulseless patients with cardiac electrical activity but no cardiac contractility) from patients with pseudo-EMD (pulseless patients with cardiac electrical activity and cardiac contractility), a group that should be aggressively treated [1,6]. Recent reports have suggested that transthoracic cardiac sonography might assist in identifying patients with potentially treatable conditions when pulses are not palpable, but its role in the setting of cardiac arrest is unclear [7,8]. This multicenter trial examined the use of cardiac sonography as an adjunctive diagnostic aid and as a predictor of resuscitation outcomes in cardiac arrest patients with pulseless electrical activity (PEA) and asystole.

2. Methods

This institutional review board–approved multicenter trial, carried out at 4 academic EDs with volumes of at least 40 000 visits per year and served by extensive emergency medical services systems, all with both basic life support and advanced life support units but with advanced life support units transporting cardiac arrest patients. These study sites prospectively enrolled a convenience sample of nontrauma pulseless adult subjects in cardiac arrest as part of the Sonography Outcomes Assessment Program. In all 4 centers, the policy and practice was to continue resuscitation once initiated and transport cardiac arrest victims to the nearest ED; no change in transport policy was instituted for this study. The institutional review board granted an exemption of informed consent with the caveat that there were explicit instructions in the study protocol that cardiac US results do not influence the standard American Heart Association decision-making guidelines in the care of the cardiac arrest subjects. Pulseless subjects underwent an initial cardiac US examination on presentation and sequential examinations every 3 to 5 minutes during the resuscitation at the time during which carotid pulse checks were carried out to determine if there was cardiac kinetic activity. Sonographic evidence of cardiac kinetic activity was defined as any detected motion within the heart: atrial, valvular, or ventricular. Emergency physician sonographers used the transthoracic, subxiphoid, or the parasternal long-axis B-mode–view approaches to visualize the heart with 3.5-MHz curvilinear or sector probes. The end points of the resuscitations were death, return of spontaneous circulation (ROSC), admission to the hospital, survival to discharge from the hospital, and functional status after discharge. Return of spontaneous circulation was defined as resumption of a palpable pulse and blood pressure, even if transient. Recorded outcome variables were demographic data, the presence of PEA (evidence of electrical rhythm) or asystole, results of cardiac US examinations (evidence or absence of US-detected cardiac kinetic activity), whether the cardiac arrest occurred in the prehospital environment or the ED, estimated duration of prehospital cardiac arrest resuscitation, duration of ED cardiac arrest resuscitations, cardiac US evidence of pericardial effusion, and resuscitation outcomes. Whenever applicable for our inhospital study design, data were collected according to the recommended guidelines for uniform reporting of data from out-of-hospital cardiac arrest, the Utstein Style [9]. All data were contemporaneously noted on a standardized data collection forms along with a still image of the cardiac US. Statistical analysis included descriptive statistics, 95% confidence intervals based on proportions, univariate logistic regression, and receiver operating characteristic curve analysis; z was set at .05, 2-tailed.

3. Results

During a 12-month period, 70 subjects were enrolled, each center with at least 10 subjects. Demographically, the cohort consisted of 61% males and 39% females with an age range of 16 to 94 years. Resuscitations were begun in the prehospital environment for 67 of 70 cardiac arrest subjects; the prehospital resuscitation intervals ranged from 5 to 77 minutes. Resuscitation duration intervals for 60 of the 70 subjects lasted less than 12 minutes in the ED. Within the asystole cohort, 31 of 36 resuscitation intervals lasted 12 minutes or less in the ED; for the PEA cohort, 29 of 34 lasted 12 minutes or less. As a point of comparison to the
predictive abilities of cardiac sonography, a logistic regression model was conducted to control for cardiac arrest resuscitation intervals both in the prehospital and ED environments to correlate resuscitation times with ROSC. The univariate logistic regression model for prehospital and ED resuscitation intervals showed correlation for 4 (52%) of the 7 patients that had ROSC and subsequent admission to the hospital with an area under the curve of 0.26 (95% CI, 0.0-0.52; P = NS). Therefore, duration of resuscitation time intervals of our cardiac arrest cohort was not significantly associated with ROSC.

The presenting rhythms before US were asystole in 36 and PEA in 34 (Table 1). Serial cardiac USs, more than a single US examination, were carried out in 53 of the subjects. Single cardiac US examinations were carried out in 17 of the subject: 9 for asystole subjects and 8 for PEA subjects. Eight subjects presenting with PEA had ROSC and survived long enough for admission to the intensive care unit; all subjects with asystole died. Fifty-nine subjects had no evidence of sonographically identifiable cardiac kinetic activity and their resuscitations were uniformly unsuccessful. Subjects with asystole on presenting rhythm strip uniformly lacked sonographic evidence myocardial contractions and did not have ROSC. Twenty-three subjects (68%) presenting with PEA had no sonographic evidence of cardiac activity (true EMD) and did not have ROSC. The presence of sonographically identified cardiac kinetic activity (pseudo-EMD) during the resuscitation was identified in 11 PEA subjects (32%). Eight of this pseudo-EMD subgroup had sonographic evidence of cardiac activity and also had ROSC with 6 surviving for less than 12 hours after intensive care admission. Two subjects, who were noted to have cardiac activity both in their presenting sonographic examination and all subsequent examinations, survived a more than 24-hour stay in the intensive care unit. One of these subjects survived to hospital discharge after hemodialysis for renal failure–induced hyperkalemia with scores of 1 on the Glasgow-Pittsburgh Cerebral Performance scale (good cerebral performance) and 1 in the Overall Performance category (capable of normal life) [9].

Table 1

<table>
<thead>
<tr>
<th>Rhythm</th>
<th>+ Sonographic cardiac activity</th>
<th>+ Sonographic cardiac activity</th>
<th>− Sonographic cardiac activity</th>
<th>− Sonographic cardiac activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROSC +</td>
<td>PEA</td>
<td>Asystole</td>
<td>PEA</td>
<td>Asystole</td>
</tr>
<tr>
<td>ROSC –</td>
<td>3</td>
<td>0</td>
<td>23</td>
<td>36</td>
</tr>
</tbody>
</table>

* Only 1 of 8 survived to hospital discharge with scores of 1 on the Glasgow-Pittsburgh Cerebral Performance scale (good cerebral performance) and 1 in the Overall Performance category (capable of normal life) [9].

4. Discussion

The resuscitation of ED patients with PEA or asystole may entail considerable time and effort with only a very small chance of success. Unfortunately, there is no consensus as to when the resuscitation should be terminated or continued. Time to cardiopulmonary resuscitation, time to defibrillation, comorbid diseases, precardiac arrest condition, initial arrest rhythm, and duration of resuscitative effort have been reported to have prognostic importance for cardiac arrest patients [10]. A time-efficient, reliable means of determining those patients who are potentially salvageable from cardiopulmonary resuscitation from those who are not would be of great clinical use.

Although there are few studies on the use of transthoracic B-mode cardiac US to predict the outcome of cardiac arrest, this study is consistent with prior data that showed that patients with sonographically identified cardiac standstill do not have ROSC regardless of the initial cardiac electrical rhythm [7,8]. Cardiac sonography confirmed lack of cardiac kinetic motion in our entire asystole cohort. It also distinguished between pseudo-EMD and true EMD in our PEA cohort. Our entire true-EMD cohort like our asystole cohort did not have ROSC, which is consistent with previously published data regarding true EMD [5,7]. Our data further support previously published data that sonographically identifiable cardiac kinetic activity is associated with ROSC [8,10,11]. Specifically, our study suggests that sonographic evidence of cardiac kinetic motion during cardiopulmonary resuscitation is a potential predictor of ROSC (accuracy = 0.95, 95% CI, 0.92-1.0). This is evidenced by the fact that 8 of 11 subjects in our PEA cohort with cardiac kinetic motion on US examination had ROSC. The sonographic determination of cardiac kinetic motion was also an accurate predictor of survival to hospital discharge vs death (accuracy = 0.87, 95% CI, 0.79-0.95); 1 subject survived to hospital discharge with scores of 1 on the Glasgow-Pittsburgh...
Cerebral Performance and Overall Performance scales [9]. Other physician investigators studying pseudo-EMD both invasively and with US have noted pseudo-EMD as proportion of the total PEA population to range from 42% to 86% [5, 11-13]. It is notable that our pseudo-EMD population, which was primarily a population that had their resuscitations started in the prehospital environment, only constituted 23% of our PEA cohort.

Previously suggested parameters for the prediction of ROSC, including prehospital resuscitation time intervals and ED resuscitation time intervals, were not reliable predictors for this cohort [14]. For this data set, there was no correlation between ROSC and time duration of resuscitation for patients with PEA. These data suggest that duration of resuscitation may be a more useful predictor in the setting of cardiac arrests secondary to ventricular tachyarrhythmias than for subjects with PEA and asystole.

Important limitations of our study are notable. The total sample size of 70 was relatively modest and limits the confidence of our speculations that the presence or absence of sonographically detected cardiac activity can predict positive or negative outcomes. The predictive accuracy of cardiac standstill on US appears to be reliable; however, a large sample size of subjects with pseudo-EMD would be required to confidently associate ROSC with the sonographic detection of cardiac kinetic motion. Although the multicenter nature of our trial may enhance the universality of our results, the fact that our subjects were a convenience rather than a consecutive sample of cardiac arrest patients should be noted. This may be partly explained by (1) the availability of the US machine and (2) the availability of the study participant physician sonographers within their respective departments. Further 17 of 70 subjects did not receive sequential sonographic examinations after initial cardiac US examination, or the sequential examinations were not recorded on the data sheets. This is partially mitigated by the fact that of the 70 subjects, 60 had resuscitations lasting less than 12 minutes. The sonographic cardiac examinations were not videotaped and were not reviewed for accuracy. Finally, although there were instructions in the study protocol that cardiac US results do not influence the standard American Heart Association decision-making guidelines, the study was not blinded in that the sonographers were aware of the progress and results of the resuscitative efforts.

5. Conclusion

These data support the idea that transthoracic B-mode cardiac sonography can provide physicians involved in the resuscitation of pulseless patients with asystole and PEA with information that may help in making pertinent management decisions regarding cardiopulmonary resuscitation.

References

The effect of pesticide spraying on the rate and severity of ED asthma

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Abstract We report on the incidence of emergency department (ED) asthma presentations and admissions to the Lincoln Hospital, located in the South Bronx of New York City, during the 1999 eradication program of the mosquito vector for West Nile virus. Spraying of Malathion and Resmethrin occurred in the hospital’s geographic area over 4 days in September 1999. During that time, 1318 pediatric and adult patients were seen in the ED for asthma-related symptoms. Of these, 222 (16.8\%) were hospitalized. Emergency department visits, during days when spraying occurred, were compared with visits during days when no spraying occurred. Comparisons were made with previous years as a reference point. Findings showed that the spraying of insecticides did not increase the rate or severity of asthma presentations as measured by the Lincoln Hospital’s ED asthma census or hospital admissions for asthma.

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1. Background

The first known outbreak of the West Nile virus in the western hemisphere occurred in the summer of 1999 in an area in northern Queens, a borough of New York City. The New York City Department of Health (DOH) received a report of an unusual cluster of cases of meningocerebro- alisis associated with muscle weakness suggestive of an arboviral cause. An environmental investigation was undertaken and, simultaneously, an independent investiga-

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2. Insecticide toxicity

Eradication of mosquito vectors may be accomplished by spraying of insecticides, although these have known toxicity to human beings depending on the dosage and extent of exposure [4,5]. Malathion is an organophosphate insecticide that can be absorbed through virtually any route [6]. Organophosphates exert their toxicity primarily by the inhibition of acetylcholinesterase, resulting in excess accumulation of acetylcholine at the synapse. Organophosphate toxicity compromises the airway via a muscarinic effect, causing bronchorrhea and bronchospasm. Onset of symptoms is most rapid after inhalation and least rapid after percutaneous absorption. Most patients become symptomatic within 12 hours of exposure. Routine occupational exposure to Malathion regularly causes wheezing even in patients without asthma [7,8].

Resmethrin is a man-made pyrethroid insecticide found to be effective against adult mosquitoes including Culex, the species most commonly associated with the West Nile virus. Pyrethrins, synthetic analogs of natural pyrethrins, are active extracts from Chrysanthemum cinerariaefolium [9]. The major site of action of all pyrethroids has been shown to be a voltage-dependent sodium channel. Poisoning syndromes manifest as reflex hyperexcitability, fine tremor, salivation, choreoathetosis, and seizures [10]. In general, pyrethrins are much less acutely toxic to rats and presumably to human beings than are the natural pyrethrins. Although the mechanism of toxicity of pyrethrins is not known to induce bronchospasm, wheezing in response to tetramethrin (a pyrethroid) has been reported [11]. In addition, there is a well-documented bronchospastic reaction that occurs with acute exposures to pyrethrins in sensitized patients, as well as several case reports of fatality from bronchospasm associated with a pyrethrin shampoo [12,13].

The effect of spraying of insecticides on the health of the exposed population was of concern to the DOH. In particular, the risks of exacerbating airway disease among vulnerable populations, notably among asthmatics, needed to be taken into account. Only one study in the literature examined the risk posed to asthmatics by insecticide spraying over urban areas and findings showed neither an increase in shortness of breath after spraying of Malathion in Santa Clara County, California, nor increased emergency department (ED) use for asthma-like symptoms [14].

3. Rationale for study

This study seeks to ascertain adverse risks of insecticide spraying in an area that has one of the highest rates of asthma in New York City. This study seeks to answer the question “To what extent did the spraying of insecticides over the South Bronx in 1999 contribute to an increase in asthmatic symptoms as measured by ED presentations?” It was hypothesized that the spraying of insecticides was not likely to have adverse health consequences to those exposed. Indeed it was thought that there would be less significant risks from spraying than there would be risks by transmission of the West Nile virus from mosquito bites [15]. It was assumed that any adverse effect of pesticide spraying would be evident by an increase in visits for asthma to the Lincoln Hospital’s adult and pediatric EDs.

4. Study area

The densely populated South Bronx area of New York City has one of the highest rates of hospitalization and death from asthma [16-18]. Hospitalization for asthma among those younger than 14 years in this area was approximately 23 per 1000 in 1997. The New York State, by contrast, had about one tenth the hospital admissions for asthma in this age group (2.4 per 1000) [19]. The ED at the Lincoln Hospital sees approximately 14500 asthma visits per year, resulting in 1500 annual hospital admissions for this disease and representing about 5% of all asthma hospitalizations in New York City [20]. The ED sees a full spectrum of asthmatic symptoms, not just the most acute presentations, because most asthmatic patients tend to use the ED for both primary and emergency care.

During the mosquito eradication program in 1999 in this area, 5349 gallons of Adulticide were used in the West Nile eradication effort, and Malathion made up 4561 gallons, or about 80%, of that [21]. Malathion was sprayed from helicopters and Resmethrin from trucks. The South Bronx, which contains a large majority of the Lincoln Hospital’s patient population, was sprayed on 4 days in September 1999: on the 11th, 12th, 13th, and again on the 20th. Spraying occurred during evening hours and continued past midnight into the early hours of the following morning.

5. Methods

A retrospective review of all pediatric and adult asthma visits and asthma hospital admissions for August and September of 1999 was undertaken. Included were all patients with a primary diagnosis of asthma from the ED. To assess the usual patterns of asthma presentations to the ED, data were also collected on all adult and pediatric asthma ED visits for August and September of 1997 and 1998. Asthma presentations to and admission rates from the adult and pediatric EDs were noted for the 11th, 12th, 13th, and 20th of September, the days the city conducted spraying in the South Bronx. These data were compared with the other days of the month when no spraying occurred. To account for the fact that spraying was conducted before and after midnight on the spraying days, we conducted the same analysis for the 12th, 13th, 14th, and 21st of September as well. A third analysis compared the 5 days after each spraying episode with the days of nonspraying to capture any delayed
presentation to the ED. Two-tailed Student $t$ tests with $z$ set at .05 were used to calculate statistical significance.

6. Results

Fig. 1 shows asthma presentations to the adult and pediatric EDs for August and September of 1997, 1998, and 1999. The expected seasonal increase in asthma was consistent for each year. During September 1999, a total of 1318 patients presented to the Lincoln Hospital ED with a primary diagnosis of asthma exacerbation (753 or 57.1% adult patients and 565 or 42.9% pediatric patients). Of those patients, 222 (16.8%) were admitted (102 or 45.9% adult patients and 120 or 54.1% pediatric patients). When rates of admission for asthma in September 1999 were compared with those in September 1997 and September 1998, no significant differences were seen. Twenty-four percent of pediatric patients seen in the ED for asthma were admitted in 1997 vs 22% in 1998 and 27% in 1999. Among adult
patients seen in the ED for asthma, approximately 16% were admitted to the hospital during all 3 periods.

The data show that in 1999, the adult ED evaluated approximately 25.1 patients with asthma per day on the nonspraying days and 25 patients per day on the spraying days. In the pediatric ED, 19.3 asthma patients were evaluated per day on the nonspraying days and 15.8 patients on the spraying days. These differences are not statistically significant.

Data collected on the 12th, 13th, 14th, and 21st of September show that an average of 22 asthma patients per day was evaluated in the adult ED whereas 13 patients per day were evaluated in the pediatric ED. Fig. 2 illustrates the average number of ED asthma visits and hospital admissions per day for the adult and pediatric EDs in September 1999. The admission rate was used as an indicator for the severity of illness. The percentage of total adults with asthma who were admitted to the hospital during September 1999 was 13.6% on the nonspraying days and 13.0% on the spraying days. The percentage of pediatric admissions on nonspraying and spraying days was 20.7% and 25.4%, respectively.

A 5-day running average of patient ED asthma visits was calculated to account for possible delayed effects of spraying; no significant difference between spraying and nonspraying days was seen. Figs. 3 and 4 show adult and pediatric ED visits during September 1999. There were no statistically significant differences between spraying and nonspraying days in September 1999.

7. Discussion

Since the first outbreak of the West Nile virus in New York City in 1999, the virus has spread across most of the United States and has become enzootic and endemic in the central and eastern parts of the country and
feeding; intrauterine transmission also has been reported through organ donation, blood transfusions, and breast feeding; transmission of the West Nile virus has been found to occur recently reported.

Certainly, the rapid spread of this dangerous disease is a cause for concern, and public health measures, including eradication of its mosquito vector, seem warranted. Yet, in light of the very high burden of asthma morbidity and mortality in the South Bronx, the spraying of insecticides in this inner city, an urban population with a high prevalence of asthma, was a cause for concern given the potential for exacerbation of the disease. Findings from this study showed no acute effect on asthma patients after insecticide spraying. The New York City DOH reported on citywide statistics for hospital-based treatment of asthma during the mosquito eradication of September 1999 and found no significant increases in hospital admissions or acute outpatient asthma care during the period of interest.

Although this study showed no increase in asthma-like symptoms as a result of spraying, we acknowledge limitations that may have influenced the results. Our methodology does not allow us to assess individual exposures to insecticides. Also, because of the small number of spraying days and a changing baseline caused by seasonal variability, subtle acute effects of spraying on asthmatic airways could have been missed. Possible confounders include other factors relating to air quality such as ozone and particulate matter and epidemics of viral upper airway infections. Finally, the epidemiology of asthma is complicated, multifactorial, and incompletely understood. The long-term effects on individuals with asthma or on those at risk for developing asthma of exposure to chemicals such as Malathion and Resmethrin are difficult if not impossible to predict.

Given the high concentration of asthma patients in the Lincoln Hospital population and the high volume of asthma patients treated at the ED, it is unlikely that a significant number of patients in the South Bronx would develop clinically significant symptoms of bronchospasm without there being a corresponding increase in emergency asthma presentations to the Lincoln Hospital. We feel confident that the sample of patients presenting to the Lincoln Hospital with asthma during the study period is representative of the experience of individuals with asthma in the South Bronx during September 1999. Therefore, we are confident that the data presented accurately portray the negligible effect of insecticide spraying on this study population as reflected by those seeking care for asthma during the spraying.

References

Changes in cardiac troponin T measurements are associated with adverse cardiac events in patients with chronic kidney disease

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Abstract The purpose of this study was to determine whether long-term and short-term changes in cardiac troponin T (cTnT) were associated with adverse cardiac events (ACEs) in patients with chronic kidney disease. Long-term changes were defined as changes in cTnT between ED visits, and short-term changes were defined as changes between 2 consecutive serial cTnT measurements within an ED visit. A retrospective chart review of patients with chronic kidney disease with suspected acute coronary syndromes presenting to the ED between December 1999 and November 2003 was conducted. The primary outcome variable was an ACE which was a composite endpoint consisting of a discharge diagnosis of acute myocardial infarction, unstable angina, revascularization, cardiac dysrhythmias, all-cause mortality, or congestive heart failure exacerbation. The primary predictor of ACE abstracted from the charts was the initial cTnT measured during each ED presentation. There were 90 patients with 397 visits enrolled in the study. Using a mixed-models analysis of variance, cTnT was higher in the ACE group than in the non-ACE group (difference in log cTnT = 0.054, 95% CI 0.006-0.101) after adjusting for age, race, sex, dialysis status, and smoking history. No other variables were found to be associated with cTnT. To evaluate the clinical significance of acute changes in cTnT, a secondary analysis was performed on 64 patients with an initial cTnT measurement above 0.10 ng/mL. For in-hospital and 30-day ACE, a short-term increase in cTnT of 0.11 ng/mL had a positive likelihood ratio of 13.3 and 11.9, respectively. Long-term and short-term increases in cTnT are associated with an ACE.

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1. Introduction

Patients with chronic kidney disease who present to the ED with symptoms suggestive of acute coronary syndromes (ACS) are a diagnostic challenge. In this population, an elevated cardiac troponin T (cTnT) is often thought to be nonspecific; elevated cTnT has been observed in both dialyzed and nondialyzed patients with chronic kidney
Changes in cTnT measurements are associated with ACEs in patients with chronic kidney disease

2. Methods

This was a retrospective cohort study with data obtained using chart review methodology. This study was approved by the institutional review board and was conducted at an urban, academic ED which has approximately 88,000 patient visits per year. Patients were initially identified by ICD-9 code indicative of chronic kidney disease (585, 586, 403.01, 403.11, 403.91, 404.02, 404.03, 404.12, 404.13, 404.92, 404.93). Medical record numbers were obtained from electronic hospital databases. These patients were then screened to determine whether they had a cTnT measured during an ED visit.

Patients were selected based on the primary hypothesis. They were included if they had presented to the ED with symptoms suggestive of ACS, had at least 2 ED presentations with suspected ACS presentations within a 12-month period, had cTnT drawn during their ED visits, and had chronic kidney disease defined as a serum creatinine greater than 2.0 mg/dL (estimated creatinine clearance <30 mL/min) for at least 6 months before enrollment. Patients were excluded if they had received a kidney transplant, died secondary to trauma, or had terminal cancer. Terminal cancer was defined as metastatic disease requiring ongoing chemotherapy, radiation therapy, or palliative care. An interim analysis was conducted with 90 patients; because our primary hypothesis was adequately answered, no additional patients were enrolled. The final sample included patients with consecutive medical record numbers for ED visits between December 1999 and November 2003.

To test the secondary hypothesis, we included patients from this cohort with an initial cTnT level greater than 0.10 ng/mL and 2 consecutive cTnT markers within a 12-hour period. This represents the patient population in which there is greatest uncertainty as to how to interpret the cTnT; 0.10 ng/mL is the upper limit of normal at our institution, and values below this would be considered negative whether the patient had known chronic kidney disease or not. If the patient had multiple visits meeting inclusion and exclusion criteria, the first ED visit was used.

All cTnT measurements were performed using the Elecsys 2010 (Roche Diagnostics Inc, Indianapolis, Ind), which uses a third-generation cTnT immunoassay. In our laboratory, the maximum coefficient of variation measured during this period was 9.5% for a cTnT value of 0.09 ng/mL and 5.0% for a cTnT value of 0.42 ng/mL. Patients were followed using medical record review and the Social Security Death Index for adverse events during hospitalization. Chart review used predefined data definitions and a standardized case report form. Data were entered into a customized Microsoft Access database (Microsoft Corp, Redmond, Wash), which included secondary data checks to ensure all data values were within range and consistent with clinical course. The primary outcome variable was an ACE, which was a composite endpoint consisting of a discharge diagnosis of acute myocardial infarction, unstable angina, revascularization, cardiac dysrhythmias, all-cause mortality, or congestive heart failure (CHF) exacerbation. Diagnoses were made by the primary admitting team if the patient was admitted, or the emergency physician if the patient was discharged home from the ED. The diagnosis of acute myocardial infarction and unstable angina was usually based on evidence obtained from electrocardiograms, cardiac catheterization, or noninvasive cardiac imaging.

Baseline data were summarized using means and standard deviations for continuous variables, and frequencies with proportions for categorical variables. Data were compared between adverse event and nonevent groups using a $\chi^2$ test or a Student $t$ test where appropriate.

To determine the clinical significance of long-term changes in cTnT, a mixed-models analysis of variance was performed to evaluate the relationship between changing levels of cTnT within an individual and an ACE. A common statistical approach to binary outcome data is to use logistic regression modeling the change in cTnT, the rate of change counted
in cTnT, the percentage change in cTnT, or some other derived variable as a predictor variable. This would involve assumptions as to the nature of the relationship between changing cTnT and outcome, and would not allow us to consider all of the information contained in the dataset; patients made a variable number of visits to the ED at variable intervals. A mixed-models analysis of variance is an alternative statistical model, which takes full advantage of all data, as well as minimizing assumptions about how the manner of changing cTnT is related to outcomes. Using this statistical method, cTnT was considered the dependent variable and the occurrence of an adverse event was an independent variable. This allowed us to consider the fixed effects, such as sex and race, while at the same time considering the random effect of within-individual variation not related to a measured or controllable difference. Thus, we could include multiple visits for patients with different outcomes at each visit and with visits variably spaced over time. The interpretation of this model is such that the parameter estimate for the adverse event predictor variable is an estimate of the difference in cTnT between a visit with an ACE and a visit without an ACE for the same individual. An unadjusted model and a model adjusted for demographics and medical history were computed. Because of positive skew and kurtosis, a log transformation was used.

To evaluate the diagnostic accuracy of short-term changes in cTnT, the change in cTnT between the first and second measurement during a single ED visit was computed. Receiver-operating-characteristic curves were constructed, and the area under the curve was calculated using the nonparametric approach, and interval likelihood ratios were calculated. Sensitivity and specificity were assessed for the breakpoints in interval likelihood ratios. The prognostic value of acute changes in cTnT to predict in-hospital, 30-day, and 6-month ACEs was tested in a similar manner. Thirty-day and 6-month ACEs were based on medical record and Social Security Death Index review. Data analyses were performed using SPSS version 12.0 (SPSS Inc, Chicago, Ill) and SAS version 8.2 (SAS Institute, Cary, NC).

### Table 1
Characteristics of the patient cohort, data are given as frequency and percentage except for age, which is given as mean and SD

<table>
<thead>
<tr>
<th>Demographics</th>
<th>All visits</th>
<th>Visits without ACE</th>
<th>Visits with ACE</th>
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<tr>
<td>Age (y)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>African American</td>
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</tr>
<tr>
<td>White</td>
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</tr>
<tr>
<td>Unknown</td>
<td>1 (1.1)</td>
<td></td>
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</tr>
<tr>
<td>Male</td>
<td>47 (52.2)</td>
<td></td>
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</tr>
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<td>Female</td>
<td>43 (47.8)</td>
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<td></td>
</tr>
<tr>
<td>History</td>
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<tr>
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<td>HTN</td>
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<td>Hypercholesterolemia</td>
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</tr>
<tr>
<td>CHF</td>
<td>30 (33.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PVD</td>
<td>14 (15.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family history of CAD</td>
<td>28 (31.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoker</td>
<td>47 (52.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dialysis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>54 (60.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hemodialysis</td>
<td>33 (36.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peritoneal dialysis</td>
<td>3 (3.3)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

HTN indicates hypertension; PVD, peripheral vascular disease.

### Table 2
Twelve-lead ECG, serum creatinine, and cTnT for each patient group

<table>
<thead>
<tr>
<th>ECG Findings</th>
<th>All visits</th>
<th>Visits without ACE</th>
<th>Visits with ACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>13 (3.6)</td>
<td>12 (4.2)</td>
<td>1 (1.2)</td>
</tr>
<tr>
<td>ST Elevation</td>
<td>3 (0.8)</td>
<td>2 (0.7)</td>
<td>1 (1.2)</td>
</tr>
<tr>
<td>ST Depression</td>
<td>8 (2.2)</td>
<td>1 (0.4)</td>
<td>7 (8.5)</td>
</tr>
<tr>
<td>T-wave inversion</td>
<td>40 (10.9)</td>
<td>33 (11.6)</td>
<td>7 (8.5)</td>
</tr>
<tr>
<td>Hyperacute T wave</td>
<td>1 (0.3)</td>
<td>0 (0.0)</td>
<td>1 (1.2)</td>
</tr>
<tr>
<td>LBBB</td>
<td>2 (0.5)</td>
<td>1 (0.4)</td>
<td>1 (1.2)</td>
</tr>
<tr>
<td>RBBB</td>
<td>5 (1.4)</td>
<td>2 (0.7)</td>
<td>3 (3.7)</td>
</tr>
<tr>
<td>Hemiblock</td>
<td>5 (1.4)</td>
<td>1 (0.4)</td>
<td>4 (4.9)</td>
</tr>
<tr>
<td>A-fib/flutter</td>
<td>5 (1.4)</td>
<td>1 (0.4)</td>
<td>4 (4.9)</td>
</tr>
<tr>
<td>SVT</td>
<td>5 (1.4)</td>
<td>5 (1.8)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Sinus bradycardia</td>
<td>4 (1.1)</td>
<td>4 (1.4)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Nonspecific ST changes</td>
<td>112 (30.6)</td>
<td>92 (32.4)</td>
<td>20 (24.4)</td>
</tr>
<tr>
<td>Unchanged</td>
<td>163 (44.5)</td>
<td>130 (45.8)</td>
<td>33 (40.2)</td>
</tr>
<tr>
<td>cTnT</td>
<td>0.14 (0.21)</td>
<td>0.12 (0.13)</td>
<td>0.23 (0.41)</td>
</tr>
<tr>
<td>Creatinine</td>
<td>6.82 (4.15)</td>
<td>7.32 (4.20)</td>
<td>4.58 (3.18)</td>
</tr>
</tbody>
</table>

Laboratory values are given as mean and SD and ECG findings as frequency and percentage.

LBBB indicates left bundle branch block; RBBB, right bundle branch block; SVT, supraventricular tachycardia.

### 3. Results

#### 3.1. Long-term changes in cTnT

An interim analysis of 90 patients with 397 ED visits was performed; because our primary hypothesis was answered, additional patients were not enrolled. The minimum number of ED visits per patient was 2 and the maximum was 11. Patient demographics, past history, and dialysis status are listed in Table 1. The mean (SD) age was 56 (13.4) years, 83% were black and 48% were females. Thirty-seven percent of the patients were on hemodialysis and 3% of the patients were on peritoneal dialysis at the start of the study. The mean (SD) serum creatinine for the index visit was 6.82 (4.15) mg/dL. Of the patients who were not on dialysis, 34 were placed on long-term dialysis during the study period.
Table 2 describes laboratory values and ECG findings for all ED visits stratified by whether an adverse event was evident or not. Eighty-three ACEs were recorded. Mean (SD) cTnT for visits without an ACE was 0.12 (0.13) ng/mL, whereas for visits with an ACE was 0.23 (0.41) ng/mL. Unadjusted cTnT was higher for visits associated with an ACE than for visits that were not associated with an ACE (mean difference in log cTnT = 0.057, 95% CI 0.010-0.104). Adjusted for demographics, medical history, and dialysis as given in Table 1, the mean difference in log cTnT was 0.054 (95% CI 0.006-0.101).

3.2. Short-term changes in cTnT

Sixty-four patients had 2 cTnTs drawn within a 12-hour period with an initial cTnT measurement greater than 0.10 ng/mL. This cohort is described in Table 3. Thirty-nine percent of the patients were on hemodialysis and 4% were on peritoneal dialysis. Patients with a 6-month ACE tended to be older, African American, diabetic, and have previous history of coronary artery disease (CAD) and CHF.

Table 3 Characteristics and outcomes of the patient cohort for subanlysis looking at acute changes in cTnT. Data are given as frequency and percentage except for age, which is given as mean and SD

<table>
<thead>
<tr>
<th>Demographics</th>
<th>All patients</th>
<th>Patients with no 6-mo event</th>
<th>Patients with a 6-mo event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>54.9 (13.7)</td>
<td>48.1 (11.1)</td>
<td>61.0 (13.2)</td>
</tr>
<tr>
<td>African American</td>
<td>51 (79.7)</td>
<td>21 (77.8)</td>
<td>27 (79.4)</td>
</tr>
<tr>
<td>White</td>
<td>12 (18.8)</td>
<td>5 (18.5)</td>
<td>7 (20.6)</td>
</tr>
<tr>
<td>Unknown</td>
<td>1 (1.6)</td>
<td>1 (3.7)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Male</td>
<td>37 (57.8)</td>
<td>17 (63.0)</td>
<td>17 (50.0)</td>
</tr>
<tr>
<td>Female</td>
<td>27 (42.2)</td>
<td>10 (37.0)</td>
<td>17 (50.0)</td>
</tr>
<tr>
<td>History</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>39 (61.9)</td>
<td>14 (53.8)</td>
<td>25 (73.5)</td>
</tr>
<tr>
<td>HTN</td>
<td>55 (85.9)</td>
<td>23 (85.2)</td>
<td>29 (85.3)</td>
</tr>
<tr>
<td>Hypercholesterolemia</td>
<td>9 (14.1)</td>
<td>1 (3.7)</td>
<td>7 (20.6)</td>
</tr>
<tr>
<td>Prior CAD</td>
<td>26 (40.6)</td>
<td>7 (25.9)</td>
<td>19 (55.9)</td>
</tr>
<tr>
<td>Prior ACS</td>
<td>27 (42.2)</td>
<td>8 (29.6)</td>
<td>19 (55.9)</td>
</tr>
<tr>
<td>CHF</td>
<td>24 (37.5)</td>
<td>6 (22.2)</td>
<td>17 (50.0)</td>
</tr>
<tr>
<td>PVD</td>
<td>14 (21.9)</td>
<td>6 (22.2)</td>
<td>8 (23.5)</td>
</tr>
<tr>
<td>Family history of CAD</td>
<td>17 (26.6)</td>
<td>7 (25.9)</td>
<td>9 (26.5)</td>
</tr>
<tr>
<td>Smoker</td>
<td>30 (46.9)</td>
<td>13 (48.1)</td>
<td>16 (47.1)</td>
</tr>
<tr>
<td>Dialysis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>36 (56.3)</td>
<td>13 (48.1)</td>
<td>22 (64.7)</td>
</tr>
<tr>
<td>Hemodialysis</td>
<td>25 (39.1)</td>
<td>11 (40.7)</td>
<td>12 (35.3)</td>
</tr>
<tr>
<td>Peritoneal dialysis</td>
<td>3 (4.7)</td>
<td>3 (11.1)</td>
<td>0 (0.0)</td>
</tr>
</tbody>
</table>

Table 4 Changes in cTnT given in means and SDs seen in patients with and without an event during hospitalization, 30 days, and 6 months

<table>
<thead>
<tr>
<th></th>
<th>Patients with no event</th>
<th>Patients with an event</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-hospital</td>
<td>0.04 (0.21)</td>
<td>0.47 (1.05)</td>
</tr>
<tr>
<td>30 d</td>
<td>0.04 (0.21)</td>
<td>0.45 (1.03)</td>
</tr>
<tr>
<td>6 mo</td>
<td>0.05 (0.24)</td>
<td>0.35 (0.92)</td>
</tr>
</tbody>
</table>

The mean (SD) time between cTnT levels was 6.9 (2.3) hours. Table 4 shows the mean changes in cTnT in patients with and without ACEs during hospitalization, at 30-days, and at 6 months. The mean difference between patients with and without an in-hospital ACE in the change in cTnT was 0.43 (95% CI −0.01 to 0.87). For patients with and without 30-day ACEs, the difference was 0.40 (95% CI −0.02 to 0.83). For 6-month ACEs, the difference between groups was 0.30 (95% CI −0.04 to 0.63). In all cases, there was a tendency toward a greater increase in cTnT in the ACE group than in the non-ACE group.

The areas under the receiver-operating-characteristic curves for changes in cardiac troponin T were 0.63 (95% CI 0.48-0.78), 0.58 (95% CI 0.43-0.73), and 0.60 (95% CI 0.45-0.74) for in-hospital, 30-day, and 6-month events, respectively. An increase in cTnT of 0.11 ng/mL was 36% sensitive and 97% specific to in-hospital ACEs, with a positive likelihood ratio of 13.3. For 30-day ACEs, an increase of 0.11 ng/mL had a sensitivity of 35%, a specificity of 97%, and a positive likelihood ratio of 11.9. For 6-month ACEs, an increase of 0.11 ng/mL had a sensitivity of 27%, a specificity of 96%, and a positive likelihood ratio of 7.2.

4. Discussion

Interpretation of absolute cTnT measurements in patients with chronic kidney disease is problematic. These elevations have been thought to be nonspecific [8] and have been attributed to a reexpression of fetal cTnT in skeletal muscle [9]. Although the development of second- and third-generation cTnT immunoassays are believed to have eliminated this problem, cTnT elevations have still been reported in up to 20% of asymptomatic patients on hemodialysis [2,10]. Similar elevations have been observed in patients with chronic kidney disease who are not on dialysis [1]. Our study suggests that measuring changes in cTnT between ED visits and serial cTnT measurements within an ED visit may improve our ability to diagnose ACEs in patients with chronic kidney disease.

The majority of studies investigating the relationship between elevated cTnT and chronic kidney disease have observed long-term outcomes in asymptomatic patients over a period of several years. However, little is known about how to interpret a single elevated cTnT in patients with chronic kidney disease and suspected ACS.
et al [11] analyzed data from GUSTO-IV, a double-blind placebo-controlled trial evaluating the use of abciximab. Although these investigators found that subjects with a creatinine clearance less 58.4 mL/min and a cTnT greater than 0.10 ng/dL had an adjusted odds ratio of 2.5 for death and myocardial infarction within 30 days, only 11 of the 7000 patients had end-stage renal disease, and the study sample was a high-risk patient group [11]. Van Lente et al [6] evaluated absolute measurements of cTnT in a case-matched prospective study of 51 patients with chronic kidney disease and suspected ACS. The diagnostic accuracy for in-hospital and 6-month adverse cardiac outcomes (myocardial infarction, revascularization, positive angiography, CHF, and death) was significantly lower for patients with chronic kidney disease than for patients with normal renal function. For in-hospital outcomes, the optimal cTnT cutoff for patients with chronic kidney disease was 0.50 ng/mL, with a sensitivity of 29% and a specificity of 87% [6].

There are limited data available concerning the significance of long-term changes in cTnT for detecting ACEs. In asymptomatic patients on hemodialysis, Ooi et al [12] reported that patients with cTnT levels increasing by more than 60% over a period of several weeks had a relative risk of 2.0 for death. Wayand et al [13] measured cTnT levels at 0, 4 weeks, 3 months, 6 months, and 1 year in asymptomatic patients on dialysis. Patients with an ACE tended to have increasing cTnT levels [13].

Our data extend these findings by showing that for a patient with chronic kidney disease presenting to the ED with suspected ACS, an increased cTnT compared to a prior non-ACS-related measure should not be ignored. Routinely measuring a non–event-related cTnT may enhance the emergency physician’s ability to interpret elevated cTnT in this difficult patient population.

Similarly, measuring acute changes in cTnT also improves diagnostic accuracy. A typical rise and fall in cardiac biomarkers indicates myocardial necrosis in patients with normal renal function [7]. Our study found that an increase in cTnT of 0.11 ng/dL over several hours had 36% sensitivity and 97% specificity for predicting in-hospital ACEs, indicating that the typical rise and fall of cardiac biomarkers seen in myocardial necrosis may indeed be generalizable to the chronic kidney disease population. This analysis purposefully included patients with initial cTnT values above the diagnostic cutoff because it is in this patient population that cTnT interpretation is problematic. Only 25% of this cohort experienced an ACE, reflecting the poor specificity when using a single absolute value.

5. Limitations

This study has several limitations; we used retrospective chart review methodology with a relatively small sample size. The study was stopped when a statistically significant association was found between increasing cTnT levels and ED visits and in-hospital events. Analysis pertaining to our secondary hypothesis was not sufficiently powered to detect a significant association between acute changes in cTnT and adverse events. However, the strong trend toward a positive association suggests a strong likelihood for a relationship that could be evaluated by a more thorough study of acute changes in cTnT in patients with chronic kidney disease being evaluated for ACS.

The limitations of a retrospective chart review are well documented. Chart review methodology is prone to bias. To limit bias in this study, patients were selected based upon strict adherence to inclusion and exclusion criteria. The primary outcome variable was based upon the judgment of the treating physicians and objective evidence of a cardiac event, and not chart reviewer opinion. Because not all patients underwent cardiac catheterization or noninvasive stress testing, there is a possibility of workup bias and missed patients.

Cardiac troponin T measurements were not blinded to the treating physician, which may have also biased the results. However, at our institution elevated cardiac troponin levels are routinely considered “nonspecific” in patients with chronic kidney disease, and ancillary studies such as cardiac catheterization or stress cardiac imaging are usually performed to confirm ACS diagnosis.

6. Conclusion

Changes in cTnT, both in the long-term and acutely, may be more useful than considering a single absolute value; a single elevated cTnT might be misconstrued as nonspecific if interpreted individually. Our results suggest that increases in cTnT measured between ED visits and through serial cardiac biomarker measurements indicate higher risk in patients with chronic kidney disease and suspected ACS. A prospective study should be performed to validate these findings and better define the diagnostic cutoffs for both long-term and short-term changes in cTnT.

References

Changes in cTnT measurements are associated with ACES in patients with chronic kidney disease


Moderate-to-severe blood pressure elevation at ED entry
Hypertension or normotension?

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Abstract

Purpose: It is controversial whether arterial hypertension (AHT) can be diagnosed in the emergency department (ED). We sought to prospectively investigate the natural time course of blood pressure (BP) to define an optimal period for AHT screening in ED patients with an elevated initial BP.

Procedures: Patients with a BP greater than 160/100 mm Hg upon ED admission underwent repeated BP measurements every 5 minutes for 2 hours using an automated device. Arterial hypertension was confirmed using 12-hour ambulatory BP measurement or repeated office BP measurement according to the Joint National Committee VII guidelines by the primary care physician after discharge from the hospital.

Main Findings: Systolic BP decreased significantly during the first 10 to 20 minutes of ED stay in hypertensive and normotensive patients without further significant changes thereafter. Diastolic BP remained stable in both hypertensive and normotensive patients. Discrimination between hypertensive and normotensive patients was best between minutes 60 and 80 after ED admission. An average BP of 165/105 mm Hg or higher during this period strongly suggests AHT whereas a BP of less than 130/80 mm Hg excludes AHT with high sensitivity.

Conclusions: Screening for AHT in the ED is possible with high specificity and sensitivity. Blood pressure measurements between minutes 60 and 80 after entry into the ED yield the highest diagnostic value.

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1. Introduction

Elevated arterial blood pressure (BP) in an emergency department (ED) setting is a frequent observation.

Zampaglione et al [1] reported symptomatic high BP (ie, hypertensive urgencies and emergencies) in 27.5% of patients in an ED. A retrospective study found an incidence of asymptomatic hypertension in the ED of 2.3% of the patients after excluding those with cardiovascular, renal, or central nervous dysfunction [2]. High BP in this setting might be transient and be caused by a physiological reaction to acute disease, pain, and stress [3] or simply be caused by a white coat effect [4]. It is therefore
controversial whether elevated BP in the ED reflects hypertension and whether the ED is an appropriate site for screening for high BP.

However, several studies have shown that elevated BP in the ED might be a useful indicator for arterial hypertension (AHT) [5]. Even a single elevated BP value in the ED indicates AHT in about 25% of patients [6]. Both studies support the notion that elevated BP in the ED may be a useful indicator for AHT.

It is known that BP assessment by a physician or a nurse elicits an alerting reaction in patients [7]. Office BP values taken by physicians or nurses were markedly higher than the previst BP values but dropped considerably during the first 10 minutes of the office visit [7]. It might be speculated that the stress caused by an ED visit might lead to an even higher BP increase compared with BP values outside the hospital and that repetitive BP measurements during the ED stay might better reflect a patient’s true BP. Surprisingly, neither prospective data on the spontaneous time course of initially elevated BP in an ED setting nor data on the diagnostic value of repeated BP measurements in the ED for the screening for AHT are available in the literature.

Therefore, the aims of this study were to evaluate prospectively the time course of initially elevated BP by serial BP measurements in patients without current antihypertensive treatment admitted to a medical ED and to prospectively define the diagnostic value of repetitive BP measurements in the ED for the screening for AHT.

2. Methods

2.1. Study design

The natural time course of BP in medical ED patients presenting with moderate-to-severe BP elevations but without signs of target organ damage during the first hours of an ED stay is unknown. It is also unknown whether it is possible to diagnose AHT in the ED by repeated measurements of BP. We assessed these questions in a prospective study in a convenience sample of patients presenting to the medical ED at any time of the day during a 3-month period.

The study was approved by the local ethical committee.

2.2. Setting

The study was performed at the medical ED of the University Hospital Basel. This ED is the only institution in town providing 24-hour emergency care for a population of 300,000 people. Twelve thousand medical patients are treated per year. Fifty-five percent of all patients are treated as outpatients and 45% require inpatient treatment.

Medical care is primarily provided by ED physicians (ie, house staff with 2-3 years of experience in internal medicine on their regular ED rotation). Supervision is provided 24 hours a day by attending physicians, board certified in internal medicine.

2.3. Selection of patients

Patients with unknown or presently untreated AHT admitted to the medical ED for any reason were eligible for enrollment into the study. Systolic BP at the time of admission to the ED had to be 160 mm Hg or higher and diastolic BP had to be 100 mm Hg or higher.

Predefined criteria for noninclusion were life-threatening conditions or conditions needing emergent BP control such as hypertensive encephalopathy, suspected intracerebral hemorrhage or ischemic stroke, acute myocardial infarction, acute pulmonary edema, or aortic dissection. Further criteria for noninclusion were the inability of a patient to give informed consent and the need for immediate transfer to other departments that made consecutive BP measurements in the ED impossible.

2.4. Methods of measurement

2.4.1. Blood pressure measurement in the ED

The first BP measurement was conducted in supine position directly after entry into the ED using a standard mercury sphygmomanometer. If eligible for the study, patients were informed by the study physician about the study’s rationale and procedures. After having obtained written informed consent, the following BP measurements were conducted in supine position with a validated automat-ed ambulatory BP measurement (ABPM) device (Profilomat II, Disetronic, Switzerland) programmed to 5-minute intervals over a period of 2 hours. Maximal delay between initial BP measurement and ABPM was 15 minutes. Diagnostic procedures such as drawing of blood samples, electrocardiogram, and chest x-ray were usually done within the first hour after admission as ordered by the treating ED physician.

2.4.2. Confirmation of AHT

Definite diagnosis or exclusion of AHT was made after discharge from the hospital by a 12-hour daytime ABPM with 20-minute intervals between measurements. Cutoff values for 12-hour daytime mean BP were defined as 135 mm Hg for systolic BP and 85 mm Hg for diastolic BP. Ambulatory BP measurement was performed within 1 week after discharge from the hospital. If ABPM could not be performed (n = 15), repeated BP values obtained by the family physician according to the Joint National Committee (JNC) VI [3] and JNC VII [8] guidelines were used to determine the presence of AHT.

2.4.3. Selection of best time interval for diagnosis or exclusion of AHT

Obtaining BP values at distinct time points is often not feasible in an ED. Moreover, JNC [3,8] and World Health Organization guidelines [9] recommend to average 2 or more BP readings for each BP measurement. Therefore, time intervals instead of time points for the screening for AHT in the ED should be defined. To get an estimate of the average BP in a given time interval, BP values obtained with the ABPM device were averaged around distinct time points.
For example, the mean BP at 15 minutes was calculated as the average of the BP readings at 10 to 20 minutes after entry into the ED. Similar calculations were done for each 15-minute interval up to 120 minutes after entry into the ED. Averaged BP readings from hypertensive patients were compared with those from patients diagnosed as normotensive after discharge from the hospital to define the best time interval for the screening for AHT in the ED setting.

Sensitivities and specificities of different cutoff values for the screening for AHT at different time intervals were computed. From these data, receiver operator characteristic curves for systolic and diastolic BP measurements were constructed and the area under the curve was calculated.

2.5. Statistics

All statistical analyses were performed using an SPSS (SPSS, Chicago, IL) for Windows version 11.0 statistical package. For comparison of dichotomous variables and comparison of continuous variables, $\chi^2$ analysis and the Student’s $t$ test, respectively, were used. Repeated-measures analysis of variance was used for within- and between-group comparisons of consecutive BP measurements. Post hoc comparisons were done using the Fisher protected $t$ test. A $P$ value less than .05 was considered to be statistically significant.

3. Results

3.1. Patient characteristics

Forty-five ED patients with BP values greater than 160/100 mm Hg were included into the study. Four patients were not willing to perform the confirmatory follow-up ABPM and data on office BP measurements were not available in these patients. Data of 41 patients (91%) were included into the analysis. Patient characteristics and classification of diagnoses upon entry into the ED are given in Tables 1 and 2. At entry into the ED, 22 patients (54%) had BP values of 160/100 mm Hg or higher and 19 patients (46%) had BP values of 180/110 mm Hg or higher. Arterial hypertension was confirmed by ABPM or repeated office BP measurement according to JNC guidelines in 26 patients (61%). Thirty-nine percent had normotension. Normotensive and hypertensive patients did not differ concerning sex distribution, risk factor, or pain status. No differences were observed for medical history and physical examination (data not shown).

3.2. Blood pressure at entry into the ED

Mean systolic BP at the time of entry into the ED was $176 \pm 14$ mm Hg and diastolic BP was $99 \pm 11$ mm Hg ($n = 41$ patients). Systolic BP upon entry into the ED in patients with proven hypertension ($n = 26$) during follow-up was $180 \pm 14$ mm Hg ($n = 26$) and did not differ from that in normotensive patients ($171 \pm 14$ mm Hg; $n = 15$). Also, no significant differences between hypertensive and normotensive patients were found for diastolic BP ($102 \pm 11$ vs $94 \pm 9$ mm Hg). All patients had systolic BP values greater than 140 mm Hg at the time of entry into the ED. Five patients had diastolic BP values lower than 90 mm Hg at this time point, 2 of them were subsequently proven to be hypertensive during follow-up examinations.

3.3. Time course of BP in the ED

The time course of BP in hypertensive compared with normotensive patients is given in Fig. 1. Systolic BP decreased significantly during the first 10 to 20 minutes of ED stay in hypertensive and normotensive patients. In both groups, no further statistically significant changes were observed between consecutive time intervals. Com-

<table>
<thead>
<tr>
<th>Table 1 Patient characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>All patients</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>No. of patients</td>
</tr>
<tr>
<td>Age (y)</td>
</tr>
<tr>
<td>Sex (male/female)</td>
</tr>
<tr>
<td>Body mass index (kg/m$^2$)</td>
</tr>
<tr>
<td>Blood pressure at entry into the ED (mm Hg)</td>
</tr>
<tr>
<td>Smoker</td>
</tr>
<tr>
<td>Diabetes</td>
</tr>
<tr>
<td>Pain</td>
</tr>
</tbody>
</table>

Data are given as mean $\pm$ SD where applicable.
comparisons between hypertensive and normotensive patients revealed significant BP differences between minutes 25 and 95, with highly significant differences between minutes 55 and 80.

Diastolic BP remained stable between consecutive time intervals in both hypertensive and normotensive patients. However, intergroup comparisons showed significant differences in diastolic BP between minutes 40 and 80 after entry into the ED.

Of 15 normotensive and 26 hypertensive patients, 7 and 5, respectively, reached normal BP values lower than 140/90 mm Hg at this time point \( (P < .1) \). No adverse events occurred during the ED stay.

### 3.4. Screening for hypertension in the ED

Receiver operator characteristic curves were constructed for each time interval, revealing best diagnostic accuracy between minutes 70 and 80 after entry into the ED. The areas under the curve are given in Fig. 2 for each time interval. Including the time points 60 and 65 minutes and thus averaging BP measurements for the time points 60 to 80 minutes increased the area under the curve further from 0.73 to 0.8 for systolic BP and from 0.71 to 0.76 for diastolic BP (Fig. 2).

Arterial hypertension can be predicted with a specificity greater than 90% if the mean BP taken between minutes 60 and 80 after entry into the ED is 165/105 mm Hg or higher. On the other hand, AHT can be excluded with a sensitivity greater than 90% if the BP is lower than 130/80 mm Hg.

### 4. Discussion

An elevated arterial BP in an ED is frequent [1,2], but it remains unclear whether patients with an elevated arterial BPs actually suffer from AHT with persistent high BP or whether the hypertensive values are merely related to the ED admission and will normalize soon thereafter. Although several studies show that elevated BP in the ED predicts AHT in a high percentage of patients [5,6], elevated BP values generally are considered to be associated with pain and apprehension with ED visits and to be of low value for the diagnosis of AHT. Furthermore, there is controversy as to whether or not initially elevated BP should be lowered immediately.

Surprisingly, neither the natural time course of initially elevated BP nor the diagnostic value of repeated BP measurements in an ED has been systematically assessed and therefore the optimal time point for BP measurement in this setting allowing to differentiate between hypertension and normotension is unknown.

In this study, we addressed these points by determining prospectively the time course of BP in patients with an elevated BP at entry into a medical ED. Patients presenting with an initial BP of 160/100 mm Hg or higher without signs of acute target organ damage were included into the study. We chose this limit because JNC VI guidelines recommended a referral of these patients for further evaluation within 1 week [3] and the new JNC VII guidelines recommend an initial 2-drug combination treatment [8].

At admission, BP did not differ between hypertensive and normotensive patients and no clinical features that could identify hypertensive patients at this time point were found. Highly significant systolic and diastolic BP differences between normotensive and hypertensive patients were found between minutes 55 and 80 after entry into the ED. In addition, there was a trend indicating that more normotensive than hypertensive patients reached normotensive BP values during this time interval. The time interval between minutes 60 and 80 after entry into the ED yielded the best diagnostic accuracy for the detection or exclusion of hypertension. In patients presenting an average BP of 165/105 mm Hg or higher during this time interval, AHT can be assumed with a specificity greater than 90%. Arterial
Hypertension may be excluded with a sensitivity greater than 90% when BP values lower than 130/80 mm Hg are documented in this time interval.

Our data show and confirm the view of others that the ED may be a useful site for the screening for AHT [5,6]. Moreover, the data extend previous findings showing that even diagnosis or exclusion of AHT in the ED is possible with high accuracy if repeated BP measurements are taken 60 to 80 minutes after admission to the ED.

Several aspects may have influenced the results of this study. Because of the inclusion of a convenience sample, we could not provide data on the prevalence of AHT in medical ED patients. Although normotensive and hypertensive patients did not differ significantly at admission, small differences that might help to identify hypertensive patients cannot be completely excluded because of the relatively small number of patients.

We could not address the influence of medication, especially pain medication, or interventions in the ED on the time course of BP in all patients. It is likely, however, that such interventions can influence the diagnostic value of BP measurements in the ED. A further limitation is the noninclusion of patients with a mild initial BP elevation. Nothing can be said about this population but it is likely that these patients will more often be diagnosed as normotensive. Finally, time of admission to the ED might play an important role because daytime BP usually is higher than nighttime BP. Therefore, the time course of BP in the ED might be different during the day compared with that during nighttime.

In summary, we conclude from our findings that a substantial percentage of patients presenting to the ED with high BP reaches normalized BP values without therapy within 2 hours after admission. Despite the limited sample size and despite the likely effect of medications and

**Fig. 2** Diagnostic accuracy of averaged BP measurements for different periods. A and B, Comparison of diagnostic accuracy at different periods for systolic (A) and diastolic (B) BP measurements. The areas under the receiver operator characteristic curve are given together with the 95% CIs. C and D, Receiver operator characteristic curve showing the sensitivity and specificity of different BP cutoff values for the screening for AHT by averaged BP values taken between minutes 60 and 80 after entry into the ED for systolic (C) and diastolic (D) BP measurements.
interventions on BP, it was possible to define a period during which screening for hypertension is possible with relatively high accuracy. Elevated BP values in untreated ED patients with a persistent elevated BP 1 hour after admission are likely to be caused by definite AHT. Further evaluation of these patients has to be ensured. A considerable part of ED patients with an initial BP elevation is finally normotensive. Repeated measurements of BP between minutes 60 and 80 after ED entry allow best discrimination between normotensive and hypertensive patients.

Acknowledgments

We thank Mrs. Verena Brenneisen and the ED team for logistic support in conducting this study. We appreciate the help of M. Trindler, MD, P. Schlegel, MD, and C. Kaufmann, MD in the enrollment of patients.

References


Comparing 2 methods of emergent zipper release

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Abstract

Background: There are several types of emergent zipper release methods described. The standard method can be difficult. The purpose of this study is to determine if an alternate method of zipper release can be easier to accomplish.

Methods: Subjects were provided with zippers and were taught 2 methods of emergent zipper release using a standard method (cutting the median bar of the actuator) and an alternate method (cutting the closed teeth of the zipper). The elapsed times to successful zipper release for both methods were measured.

Results: Mean zipper release times were faster for the alternate method (10.5 seconds) compared with the standard method (75.8 seconds) (P < .001).

Conclusion: The alternate method of zipper release is faster and easier than the standard method of zipper release; however, the optimal procedure is also dependent on the location of the entrapped tissue relative to the zipper actuator and the type of zipper.

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1. Introduction

Penile zipper injury is usually caused by entrapment of the penile tissue (foreskin, shaft, or glans) in the actuator or the teeth of the zipper. The most commonly described method of zipper release is to sever the median bar of the actuator (the mobile portion of the zipper) [1-5]. This bar holds the upper and lower halves of the actuator together. This standard method can be difficult to accomplish because the metal bar is strong and penile tissue entrapment within the zipper actuator can limit access to the metal bar. An alternate method of releasing the zipper is to cut the closed teeth of the zipper, permitting the unzipping of the zipper from the rear [5]. The purpose of this study is to compare the 2 methods of emergent zipper release.

2. Methods

Commercially available zippers and diagonal cutting pliers were prepared for this study. Forty practitioners (pediatricians, residents, and medical students) volunteered to participate in this study. After obtaining signed informed consent, the participants were instructed on how to release the zipper using the 2 different methods: (1) standard (cutting the median bar of the zipper); (2) alternate method (simply cutting the closed zipper teeth at any position to unzip the remaining zipper). Elapsed time to complete the zipper release was recorded for each method. The sequence of the methods was not randomized. The standard method was always done first. If one took more than 5 minutes to
release the zipper, then the time was recorded as 5 minutes (300 seconds) because prompt zipper release is less likely at this point. Study subjects were also asked after completing both methods which method was easier to release the zipper.

3. Results

Of 40 participants, there were 20 males and 20 females. The mean times to complete the procedure are summarized in Table 1. Release times were faster for the alternate method compared with the standard method for the group as a whole and for each sex. The magnitude of the difference was greater for females. The standard method of zipper release showed a large statistically significant time difference between males and females (males accomplished the release faster). The alternate method did not show a significant time difference between males and females.

There were 4 subjects who could not complete the standard method within 5 minutes and all 4 subjects were female. There were 38 subjects who preferred the alternative method as faster and easier method and only 2 subjects who preferred the standard method rather than the alternate method.

4. Discussion

Penile injuries (trauma) are relatively uncommon, but when it occurs, zipper entrapment is involved in 3% to 14% cases [6-8]. This injury usually occurs between 3 and 6 years of age and many of the victims were not wearing underpants [4,5].

There are variety types of methods for releasing the zipper. These include forcibly unzipping the zipper [1,3,9], cutting off the actuator of the zipper with the standard method [1-5], or cutting the zipper itself (the alternative method) [5]. Circumcising the penile foreskin entrapped in the zipper actuator has been described [1-3,5]. Soaking the penile tissue in mineral oil for 10 minutes followed by gentle traction has also been described [5,10]. Cutting the actuator bar with a mini hacksaw has also been described [11]. Although the standard zipper release method was more commonly discussed in textbook references, this study shows that the alternative method is faster and preferred.

The standard method of zipper release requires substantial strength. The median bar of the zipper actuator, which must be severed, is fairly strong. It can be severed more easily if the diagonal cutting pliers are very large. Severing this bar is substantially more difficult if a small diagonal cutter is used. Our study only used large diagonal cutters. This explains why females took longer time in the standard method compared to males. There was no significant time difference between males and females for the alternate method, probably because less strength is required for the alternate method.

This study used zippers that are very inexpensive. This type of zipper has a small metal actuator and plastic zipper teeth, which is most commonly found on small coin purses and dress pants. Larger all-metal zippers with metal teeth (usually brass) are more commonly found on jeans and casual shorts. The actuator on these heavy-duty zippers is larger and heavier. In preliminary trials, we broke several large diagonal cutters trying to cut the median bar of the actuator. Thus, our study results are limited to the standard light-duty zipper more commonly found on dress pants. If a patient entrap penile tissue within a heavy-duty all-metal zipper, it will be very difficult to release the zipper using the standard method. The alternate method is easier in this case. If the standard method is used, an extra large heavy-duty diagonal cutter will be required.

Other types of zippers exist, such as those with very large plastic or metal teeth, most commonly on large sports bags and luggage. It is unlikely that penile tissue will become entrapped in these, but hair or other tissue of medical concern could become caught in these zippers, requiring release.

Penile tissue entrapments could occur at several locations within a zipper: (1) within the actuator adjacent the open side of the zipper against the median bar; (2) within the actuator on the closed side of the zipper; (3) within the enclosed zipper without involvement of the actuator.

For location 1 above, the standard method of zipper removal would be impeded by the entrapped penile tissue because the tissue would be blocking access to the median bar. If the alternate method is attempted, it would release the zipper from the wrong side of the actuator and this method will not necessarily succeed in releasing the tissue from the zipper. Both methods are problematic here. Local anesthesia (infiltrated or topical) would likely be beneficial to facilitate moving the actuator to a more favorable position permitting one of the methods to be used.

For location 2 above, it is likely that the standard method would succeed, but as the median bar of the actuator is

<table>
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<tr>
<th>Location</th>
<th>Description</th>
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<tbody>
<tr>
<td>1</td>
<td>Within the actuator adjacent the open side of the zipper against the median bar.</td>
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<tr>
<td>2</td>
<td>Within the actuator on the closed side of the zipper.</td>
</tr>
<tr>
<td>3</td>
<td>Within the enclosed zipper without involvement of the actuator.</td>
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<tr>
<th>Table 1 Mean zipper release times ± SD (range)</th>
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<td>Males</td>
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<td>Females</td>
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<td>P** (males vs females)</td>
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* Paired t test (standard vs alternate method).
** Conventional t test (males vs females).
severed, it is likely to briefly put additional pressure on the entrapped tissue. The alternate method would also succeed if the actuator could be moved away from the entrapped tissue. Local anesthesia might be beneficial for this location as well.

For location 3 above, the alternate method of zipper removal would clearly succeed and because this method is easier, it should be the preferred method of zipper release.

In conclusion, the alternate method of zipper release is faster and easier than the standard method of zipper release; however, the optimal procedure is also dependent on the location of the entrapped tissue relative to the zipper actuator and the type of zipper.

References

The interrater variation of ED abdominal examination findings in patients with acute abdominal pain

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Abstract

Objective: The physical examination of the abdomen is crucial to emergency department (ED) management of patients with abdominal pain. We sought to determine the interrater variation between attending and resident physicians in detecting abdominal exam findings.

Methods: Research enrollers surveyed attending and resident physicians on abdominal exam findings in the ED in patients with abdominal pain. Strength of agreement was calculated using the \( \kappa \) statistic.

Results: A convenience sample of 122 surveys was completed. Calculated \( \kappa \) results are in parentheses. There was almost perfect agreement on the presence of masses and substantial agreement on the need for laboratory tests and surgical consultation. For 88 (72\%) patients with tenderness, substantial agreement was calculated for epigastric tenderness, moderate agreement on right upper quadrant, supraumbilical, suprapubic, left lower quadrant, right lower quadrant tenderness, and fair agreement on left upper quadrant tenderness. Twenty-four (20\%) patients received pain medicine in the ED. Among those, there was fair agreement on a presence of a surgical abdomen. Upper level resident physicians noted a higher level of agreement with the attending physician for tenderness than junior resident physicians.

\( \kappa \) This work was presented at the Plenary Session of the SAEM mid-Atlantic meeting in Washington, DC, in March 2003 and also as an oral presentation for the SAEM national assembly in Boston in May 2003.

Dr Pines developed and conceived the idea for this study, prepared and submitted the IRL proposal, and prepared the first draft and implanted the revisions into the manuscript. Ms Uscher was involved in the extensive manuscript editing, and was involved in helping Dr Pines develop the study idea. Mr Hall and Mr Hunter attended development meetings for this project and were in charge of data entry and initial data analysis. Dr Srinivasan attended development meetings and performed the statistical analysis for this project. Dr Ghaemmaghami was involved with the conception and development, and helped edit the manuscript. He oversaw the project.

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1. Introduction

Abdominal pain is a common chief complaint in patients presenting to the emergency department (ED). According to 1999 statistics, about 3.4 million patients with acute abdominal pain sought care in EDs in the United States [1]. Acute abdominal pain can be caused by a large variety of pathology, ranging from the benign to the acutely life threatening [2,3]. Overall, about 20% to 25% of patients presenting with acute abdominal pain are found to have a serious condition requiring hospital admission [4].

The approach to diagnosing and treating acute abdominal pain in ED routinely includes a complete history and physical examination and may include laboratory tests, x-rays, computed tomography scans, and/or other ancillary diagnostic testing. Sometimes, a surgeon, a gynecologist, a gastroenterologist, or another specialist is asked to render an opinion about the diagnosis and treatment of patient in the ED [5]. On initial assessment, the emergency physician attempts to sort out patients who have immediately life-threatening diseases from those who may have more benign causes for their abdominal pain [6]. However, even with the best clinical judgment, laboratory testing, and imaging, the actual diagnosis of a patients’ abdominal pain remains ambiguous in more than 40% of cases [7]. This is discouraging given the fact that the physical examination often plays a pivotal role in determining the urgency of the problem [7].

In both academic and community practice, multiple health care providers of various skill and experience levels examine patients. Physical exam findings of resident physicians are often used to determine the diagnostic modalities and patient treatment of patients with abdominal pain. This requires confidence that the physician in training’s assessment of the abdominal examination is accurate.

Because of the highly subjective nature of the physical examination presents the opportunity for discrepancy between attending and resident assessments, we sought to determine the interrater variation between attending and resident physicians on detecting abdominal exam findings in patients with the chief complaint of abdominal pain.

2. Methods

2.1. Study design

A prospective observational study using a convenience sample of nonconsecutive patients was performed surveying resident and attending physicians at the University of Virginia Health Sciences Center, Charlottesville, Va, from September 2002 to December 2002, 7 days a week, during the hours of 8 AM to 12 PM. The institutional review board reviewed the study and declared it exempt from informed consent because no unique patient or physician identifiers appeared on the questionnaire forms.

2.2. Study setting and population

University of Virginia Health Sciences Center is a suburban hospital located in Charlottesville, Va, with approximately 60000 patient visits per year. Undergraduate enrollers asked both resident and attending physicians to fill out a questionnaire regarding the results of their abdominal examination.

A convenience sample of patients presenting with the chief complaint of abdominal pain were enrolled in this study. Minors (younger than 18 years), prisoners, and pregnant patients were excluded from this study. In addition, the treated physicians filled out the questionnaires at their convenience. Occasionally, physicians found themselves too busy to fill out the questionnaires.

2.3. Study protocol

Resident and attending physicians filled out questionnaires detailing the results of their abdominal examination in the ED. Each study patient was examined by both an attending and resident physician. Questionnaires were paired to include the resident and attending interpretation of the physical examination. Specifically, the surveys included yes/no questions on the presence of the following: tenderness, distension, masses, rebound, guarding, and the presence of a “surgical abdomen.” If tenderness was marked yes, surveys detailed the location of the tenderness: left upper quadrant (LUQ), epigastric, right upper quadrant (RUQ), left lower quadrant (LLQ), right lower quadrant (RLQ), suprapubic, and supra- pubic. Surveys also included an assessment of whether the patient needed laboratory tests, imaging studies, or surgical consultation. There was also a question about whether or not the patient received pain medicine in the ED. If yes was checked in either the resident or attending survey, the assumption was that the patient received pain medicine in the ED.

2.4. Data analysis

Interrater variability for 122 pairs was calculated using the κ statistic. Significance of the association was determined as a confidence interval (CI) that did not cross 0 or 1.
(κ was significantly different from 0). Subgroup analysis was done for patients who were found to have any tenderness, among those who received pain medicine, and among different resident training levels. Specific κ’s were interpreted using the following parameters. A κ less than 0 was interpreted as no agreement between raters, 0.00 to 0.19 as poor agreement, 0.20 to 0.39 as fair agreement, 0.40 to 0.59 as moderate agreement, 0.60 to 0.79 as substantial agreement, and 0.80 to 1.00 as almost perfect agreement [8]. (see Table 1)

3. Results

A total of 122 patients were enrolled in this study over a 3-month period, and data were collected from resident and attending physicians’ questionnaires. The interrater variation and 95% CIs for 122 patients is detailed in Table 2. There was almost perfect agreement on the presence of masses (κ = 0.82; 95% CI, 0.56-1.00). There was moderate agreement on the presence of guarding (κ = 0.49; 95% CI, 0.31-0.68), distension (κ = 0.42; 95% CI, 0.23-0.61), and tenderness (κ = 0.42; 95% CI, 0.16-0.68). Also, there was moderate agreement on the need for laboratory tests (κ = 0.46; 95% CI, 0.28-0.64) and surgical consultation (κ = 0.55; 95% CI, 0.36-0.74) and substantial agreement on the need for imaging studies (κ = 0.60; 95% CI, 0.46-0.75).

Tenderness was noted by at least 1 examiner in 88 (72%) of patients. There was substantial agreement on the location of epigastric tenderness (κ = 0.69; 95% CI, 0.54-0.84) and moderate agreement on RUQ (κ = 0.57; 95% CI, 0.40-0.75), suprapubic (κ = 0.56; 95% CI, 0.34-0.78), suprapubic (κ = 0.44; 95% CI, 0.23-0.64), LLQ (κ = 0.43; 95% CI, 0.24-0.64), and RLQ tenderness (κ = 0.40; 95% CI, 0.20-0.59). There was fair agreement on the presence of LUQ tenderness (κ = 0.39; 95% CI, 0.16-0.62).

Sixty-one (50%) out of the 122 patients received pain medicine. For those patients who received pain medicine, there was fair agreement on the presence of a surgical abdomen (κ = 0.32). κ was not significant for tenderness or rebound. Post-graduate year (PGY) and PGY-3 resident physicians noted a higher level of agreement with the attending physician for tenderness (PGY-2: κ = 0.49; 95% CI, 0.18-0.81; PGY-3: κ = 0.49; 95% CI, 0.11-0.86) than PGY-1 resident physicians (κ = 0.33; 95% CI, 0.01-0.63). Similarly, on the need for laboratory tests, PGY-2 and PGY-3 resident physicians noted a higher level of agreement with the attending physician (PGY-3: κ = 0.51; 95% CI, 0.09-0.92; PGY-2: κ = 0.49; 95% CI, 0.23-0.75) than PGY-1 resident physicians (κ = 0.45; 95% CI, 0.13-0.77). In distinguishing the need for imaging studies, there did not seem to be a learning curve among PGY-years (PGY-1: κ = 0.59, 95% CI, 0.36-0.83; PGY-2: κ = 0.68; 95% CI, 0.47-0.90; PGY-3: κ = 0.52; 95% CI, 0.19-0.85). Other subgroup comparisons for individual PGY-years were not significantly different from 0 (P > .05).

4. Discussion

The practice of medicine in the 21st century involves a team approach. In most hospitals, multiple health care providers examine patients and render opinions on the diagnosis, treatment, and need for laboratory testing and imaging studies. Therefore, practitioners often trust that another’s examination or evaluation of a patient is accurate. In some instances, the patient may be examined by the following persons: the triage nurse, ED nurse, ED resident, medical student, attending physician, consulting resident physician, and consulting attending physician. Across this group of providers, there is a wide range of experience and expertise in the evaluation of the abdomen. Although this is true in academic practice, the same may not be true in community practice.

The physical examination of the abdomen, the vital signs, and the degree of subjective discomfort the patient is feeling often guides the diagnosis and treatment of patients presenting with abdominal pain. Often a judgment is rendered and a degree of concern is determined at the time of the physical examination. Location of tenderness, distension, and the presence or absence of bowel sounds also guides diagnostic test ordering, consultation, and ultimate treatment.

This study found highly variable interrater agreement—from fair to almost perfect in the presence and/or absence of specific features of the abdominal examination between resident and attending physicians in a real-time ED setting.

<table>
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<tr>
<th>Table 1</th>
<th>Interpretation of κ values [8]</th>
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<tr>
<td>κ</td>
<td>Interpretation</td>
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<tr>
<td>&lt;0</td>
<td>No agreement</td>
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<tr>
<td>0.0-0.19</td>
<td>Poor agreement</td>
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<tr>
<td>0.20-0.39</td>
<td>Fair agreement</td>
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<tr>
<td>0.40-0.59</td>
<td>Moderate agreement</td>
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<tr>
<td>0.60-0.79</td>
<td>Substantial agreement</td>
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<tr>
<td>0.80-1.00</td>
<td>Almost perfect agreement</td>
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<tr>
<th>Table 2</th>
<th>κ Values for individual physical examination findings (n = 122)</th>
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<tr>
<td>Masses palpated</td>
<td>0.82 0.59</td>
</tr>
<tr>
<td>Guarding</td>
<td>0.49 0.31-0.68</td>
</tr>
<tr>
<td>Tenderness</td>
<td>0.42 0.23-0.61</td>
</tr>
<tr>
<td>Distension</td>
<td>0.42 0.16-0.68</td>
</tr>
<tr>
<td>Normal bowel sounds</td>
<td>0.36 0.1-0.61</td>
</tr>
<tr>
<td>Surgical abdomen</td>
<td>0.27 -0.05-0.61</td>
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<tr>
<th>Table 2</th>
<th>κ Values for perceived need for ED management (n = 122)</th>
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<tr>
<td>Labs</td>
<td>0.46 0.28-0.64</td>
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<tr>
<td>Imaging studies</td>
<td>0.6 0.46-0.75</td>
</tr>
<tr>
<td>Surgical consultation</td>
<td>0.55 0.36-0.74</td>
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</table>
This corroborates what other studies have indicated about the physical examination; what we do/how we treat patients with abdominal pain is also highly variable depending upon the physician [9]. For example, in some instances, neither specialization nor experience has been shown to affect the accuracy in diagnosing a common clinical condition such as anemia on physical examination [10,11]. Although studies show that there is poor intraexaminer reliability for bimanual pelvic examinations in ED patients [12], the level of interobserver variability for abdominal examination in a university ED setting had never been studied. A recent study found a poor interrater agreement among family practitioners in predicting whether a child had a streptococcal throat infection based upon examining the throat [13]. A similarly designed study on ED patients found a poor interobserver reliability between senior ED resident physicians and attending physicians on the results of a pelvic examination, which was between only 17% and 33% for positive findings [11]. Even among the same rater, Levy’s for many subjective and sometimes objective findings often showed only fair to moderate agreement among examiners.

Our study found only moderate agreement on the presence of both rebound and guarding. Worrisome signs such as the presence of rebound and guarding suggest that the patient has developed peritoneal irritation and may have an acutely life-threatening condition [15]. Presence of these signs is often associated with a high level of concern and certainly warrants further evaluation of the patient’s condition, whether it be laboratory tests, imaging studies, or specialty consultation.

There was only fair agreement on the presence of a surgical abdomen. This may suggest that the classic exam for a surgical abdomen may not be as stereotypical as was thought. The fair level of interrater agreement between resident and attending physicians may suggest that the determination of whether a patient needs surgery is indeed highly subjective. And paradoxically, the level of interrater agreement was slightly higher for patients who received pain medicine in the ED. Multiple studies have supported the contention that the use of analgesia in patients with acute abdominal pain does not affect ultimate diagnosis and management [16-19]. This is consistent with the new guideline teachings in Cope’s acute abdomen to not withhold analgesia until patients are examined by the surgeon [15]. However, a recent survey by Graber et al [20] in 1999 found that 67% of general surgeons believed that pain medicines interfere with diagnostic accuracy, so attitudes regarding this practice are still controversial.

Exactly half of the patients enrolled in this study received pain medicine in the ED, which highlights the undertreatment of pain in the ED. A recent publication found that 43% of patients with acute abdominal pain wait too long to receive analgesia in an ED population [21]. Our results showed that the administration of pain medicine in the ED actually increased the interrater agreement slightly; however, there were large CIs for both values.

The interrater agreement on the need for laboratory tests, imaging studies, and surgical consultation was moderate to substantial. Laboratory tests and imaging studies are ordered for a myriad of reasons; however, the need for laboratory tests and imaging studies often points to diagnostic uncertainty and/or concern that a patient may have a serious condition.

For more than two thirds of the patients who had tenderness associated with their abdominal pain, there was substantial agreement on the presence of epigastric tenderness. There was moderate agreement on tenderness in other areas, such as the RUQ, LQ, LLC, and suprapubic and suprapubic regions. Regional tenderness suggests a specific diagnosis, and moderate interrater agreement in, for example, RLQ tenderness may indicate a variable rate of suspicion for appendicitis or gallbladder disease (in the case of RUQ tenderness.)

Looking at subgroups of resident physicians reveals a trend toward a learning curve for a few measures such as the presence of tenderness and the need for laboratory studies. Where was greater than 0 (P ≤ 0.05), upper level resident physicians tended to agree more frequently with attending physicians than junior (PGY-1) resident physicians. These results, however, were not significantly different as the CIs overlapped significantly.

Although there were very few masses palpated in this study (n = 5), there was substantial agreement in this area. In fact, there was almost perfect agreement on the presence of masses. This may be due to an a priori awareness of the presence of a mass. Intraabdominal masses are often difficult to palpate, particularly in obese patients. However, a recent study did find that there is a high rate or interrater agreement (77%) in the evaluation of patient with an abdominal aortic aneurysm [22].

5. Limitations and future questions

This study has several limitations. First, the abdominal examination can change over time as the underlying pathology may progress or regress making serial examinations vary. Also, examination results can vary depending upon the use of pharmaceuticals and fluids. The data points recorded in this study were usually separated in time, sometimes by hours; thus, disagreement between raters may be partially due to a very different objective experience. The medical therapy in the interim between physician examinations was not taken into account.

This study is also a convenience sample and was only collected during times when enrollers were available and...
physicians could fill out the study forms. Another problem with the methodology was that the enrollers did not record adequately when there was a refusal to fill out a study form. Therefore, it was impossible to calculate a response rate for this study. There also may be a significant recall and reporting bias in the way the data were collected because attending physicians may have already heard the resident physicians’ presentation before they examined the patient. In addition, many physicians were too busy to fill out the survey. Enrollers did not record when they were too busy so it is impossible from our data set to determine a response rate.

An inherent flaw in this study is the use and interpretation of the \( \kappa \) statistic. There is a lot of disagreement among statisticians on how to interpret \( \kappa \). When quantifying actual levels of agreement, \( \kappa \)’s calculation uses the proportion of chance/expected agreement. However, because this concept is only relevant if raters are truly independent (which by definition is impossible to achieve), \( \kappa \) is not truly a chance-corrected measure of agreement. In addition, many statisticians have written about \( \kappa \)’s paradoxes. There are occasions when \( \kappa \) may be low although there are high levels of agreement [23].

The results of this project suggest the inherent subjectivity of the physical examination and corroborate the results of previous researchers. Future investigators may consider measuring the interrater variation of other common ED decision points in patient management to characterize which management decisions may require either objective confirmation, more careful examination, or focus in a resident teaching curriculum.

6. Conclusions

This study demonstrates that for the emergency physician in a real-time ED setting, the abdominal examination is a highly subjective diagnostic experience. Some findings show higher interrater variation than others. This finding raises concern because the interpretation of the physical examination is often used to determine the diagnosis, treatment, and ultimate disposition of ED patients. Academic emergency physicians must carefully evaluate resident assessments of the physical examination, particularly in high-risk areas, such as the assessment of acute abdominal pain.

Acknowledgments

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References


Biphasic extrathoracic cuirass ventilation for resuscitation

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Abstract

Purposes: The MRTX portable lightweight respirator (MRTX) provides noninvasive respiratory support using biphasic extrathoracic ventilation via a cuirass fitted around the patient’s chest.

Methods: MRTX was applied with or without full protective gear, on adult volunteers simulating nerve agent (NA) victims by nonmedical caregivers. Assessment was made based on scores for correct positioning of the cuirass, quality of seal, and rapidness.

Results: For the unprotected and protected personnel, the respective median (±95% confidence interval) scores for correct positioning of the cuirass were 2 (1.4–1.9) and 1 (1.2–1.8) (n = 15 per group, P = NS); quality of seal scores were 2 (1.5–2.0) and 2 (1.3–1.8) (P = NS); and mean (±SD) time required for instituting mechanical ventilation was 90.5 ± 10.9 and 100.3 ± 7.9 seconds (P < .05). The respirator was activated at first attempt 11 times in the group of 15 without protective gear and 8 times in the group of 15 with protective gear (P = NS).

Discussion: Biphasic cuirass ventilation is an easily learned and rapidly applied method suitable for use by nonmedical personnel, even when wearing cumbersome protective gear.

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1. Introduction

Chemical warfare using nerve agents (NA) can cause high mortality rates, as demonstrated in the terrorist attacks against urban populations in Japan in 1994 and 1995 and in the military use of NA by Iraq against Iran and the Iraqi Kurdish population during the 1980s. The high toxicity of NA derives from their powerful ability to irreversibly inhibit acetylcholinesterase, which regulates the activity of both the nicotinic and muscarinic synapses. The resultant accumulation of acetylcholine at the neuro-effector junctions leads to disruption of normal synaptic transmission in both the peripheral and central cholinergic systems, leading to the clinical manifestations of severe cholinergic crisis [1]. The immediate cause of death is usually rapid progressive respiratory failure brought about by NA’s poisonous and depressive action on the central respiratory center and on the neuromuscular junction and airways.
Irritation of both the upper and lower airways, their blockade by secretion, toxic pulmonary edema, and severe bronchoconstriction are all parts of the effects of the NA-induced severe parasympathetic overstimulation that increases airway resistance and poses mechanical obstruction to ventilation.

Initial resuscitative efforts for NA-poisoned victims focus upon immediate respiratory support to prevent instant death from hypoxia. Current therapeutic protocols stress the need for urgent laryngoscopy and intubation, with concomitant provision of positive pressure ventilation until signs of muscle paralysis disappear [1]. In the event of a sudden and unexpected need to resuscitate multiple victims who are highly diverse in age and size and in an atmosphere of chaos, there will inevitably be a shortage in personnel who are well trained in airway management. Moreover, the cumbersome protective gear, including thick rubber gloves, worn by the rescue teams will inevitably present difficulties in performing a laryngoscopy.

The MRTX respirator (MRTX; Medivent, London UK) is a lightweight, easy to operate, portable respirator which can provide proper artificial ventilation by means of external high-frequency oscillation (EHFO) via a cuirass that is tightly fitted around the patient's chest. The cuirass consists of a clear, flexible plastic enclosure surrounding the chest and abdomen. Its borders are covered by a soft foam rubber, which creates an airtight seal around the patient. By choosing the appropriate cuirass size, the apparatus is capable of ventilating a wide range of different-sized subjects, from infants to the obese adult. The cuirass is connected to a computerized power unit by a wide-bore tube and the respiratory parameters are controlled by a feedback mechanism between the two. The power unit works by creating cyclic pressure changes inside the cuirass. The negative pressure (vacuum) creates chest expansion-inhalation. The positive pressure creates chest compression-exhalation. Thus, both inspiratory and expiratory phases are actively controlled, and the chest is oscillated around a variable negative baseline pressure. The system was found to be effective in a variety of clinical settings, with pressures of −25 to +15 cm H₂O, inspiratory/expiratory (I/E) ratios of 1/1 to 1/3, and frequencies of 60 to 150 cpm [2-4]. In an experimental study in cats intoxicated with organophosphate [5], EHFO was reported to be capable in keeping animals alive until spontaneous recovery from the poisoning occurred. In addition, excessive bronchial secretions, typical of organophosphate intoxication, drained spontaneously through the mouth making airway protection and suction unnecessary.

We hypothesized in the present preliminary study that proper respiratory assistance using the portable MRTX respirator can be provided to adult volunteers simulating NA victims by a nonmedical rescue team, even when wearing protective gear.

2. Methods
2.1. Participants

An institutional review board approval for the study was obtained as well as verbal consent from each of the participants. Two groups of 15 nonmedically trained personnel participated in this prospective comparative study. All were members of nonmedical extrication teams with similar professional skills. Members were randomly assigned to either one of the 2 groups. They were asked to connect the MRTX respirator to adult volunteers (age range, 25-40 years; weight, 70-100 kg) who simulated a NA-poisoned patient and who was lying fully dressed on a stretcher. One group wore ordinary clothing while treating the “patient” and the other group wore complete antichemical warfare gear, which included a full-body plastic suit, rubber gloves, and a gas mask with an attached filter. Both groups were given 15 minutes to read the instruction manual for operating the MRTX respirator as well as a short demonstration on its use.

2.2. Study protocol

The ease and efficacy of operation of the MRTX by both groups was prospectively and comparatively assessed by the following score parameters which were validated in preliminary experiments:

1. Scoring for correct positioning of the cuirass around the simulated NA-poisoned victim's chest using a scale of 0 to 2 (0 = cuirass positioned on the abdomen, 1 = cuirass partially positioned on the chest, 2 = cuirass correctly positioned around the chest).
2. Scoring for air leakage using a scale of 0 to 2 (0 = audible and tactile leak of air around the rim of the cuirass, 1 = tactile leak only, 2 = no air leak [ie, an adequately tight fit of the cuirass to the body]).
3. Recording the number of times the respirator was actually activated on the first attempt.
4. Measurement of the time needed for instituting respiratory assistance. This included removing the cuirass from its box, fixing it onto the patient's chest, connecting it to the power unit, switching on the respirator, and inspecting that chest inflation is symmetrical.

2.3. The MRTX portable respirator

The MRTX consists of a flexible, lightweight plastic cuirass that covers the anterior part of the chest and upper abdomen. It has a wide foam rim, which creates an airtight seal, and a back plate, which is secured by straps. The cuirass is connected by wide-bore flexible tubing to a mobile and microprocessor-controlled power unit. The power unit contains a turbine that generates an oscillatory pressure that operates over a wide range of frequencies (ie, 6-1200 cpm) and pressures (−50 to +50 cm H₂O). The
frequency, I/E cuirass chamber pressures, and the I/E ratio are automatically set and controlled by negative feedback loop [6] which makes it possible to achieve high frequencies. This is in contrast to regular negative pressure ventilation, which depends on passive recoil of the chest during the expiratory phase, thus, limiting the attainable frequencies.

2.4. Statistical analysis

Timing events are presented as means ± SD with differences among groups analyzed using the 2-tailed unpaired Student t test. All scores are presented as medians and 95% confidence intervals with differences analyzed using the nonparametric independent 2-group comparisons Mann-Whitney U test. χ² Tests were used to compare categorical values. P < .05 was considered significant.

3. Results

Slightly better scores were achieved by the 15 operators not wearing protective gear as compared with the group of 15 operators with protective gear, but differences did not reach significance. For the unprotected and protected personnel, the respective median (±95% confidence interval) scores for correct positioning of the cuirass were 2 (1.4-1.9) and 1 (1.2-1.8) (n = 15 per group, P = NS). For quality of seal, the scores were 2 (1.5-2.0) and 2 (1.3-1.8) (P = NS).

Mean (±SD) time required for instituting mechanical ventilation was 90.5 ± 10.9 and 100.3 ± 7.9 seconds (P < .05). The respirator was activated at first attempt 11 times in the group of 15 without protective gear and 8 times in the group of 15 with protective gear (P = NS). Initial inadequate placement of the cuirass and failure to switch on the respirator were rapidly corrected and respiratory support could be speedily provided in all cases.

4. Discussion

The results of the present study, although descriptive in nature, indicate that the cuirass can be rapidly and easily applied to apneic victims by gear-protected caregivers and, if necessary, biphasic external cuirass-based ventilation can be instituted by the portable MRTX respirator. Thus, this method of ventilation might serve as an effective tool in case of need for urgent resuscitative respiratory support to adult victims of NA poisoning. Nonmedical personnel, with no previous experience with patient ventilation, could efficiently operate the device and respiratory support could be rapidly instituted, even when wearing bulky protective gear. Its simplicity of use and the need for fewer medical staff members compared with a hand-operated respirator (ie, self-inflating bag) are additional benefits. There are earlier reports on resuscitative respiratory support having been given by intubation followed by positive pressure ventilation for mass casualties from NA poisoning [7], but there are none on the use of any type of negative pressure ventilation in such a scenario.

The MRTX respirator is a portable, relatively small (14 × 14 × 18 cm), lightweight (3 kg including battery), battery-operated rugged respirator. It is a modern version of the Hayek Oscillator that has long been used for administering respiratory support for both children and adults [2-4]. Its small dimensions and lightweight permit it to be easily carried by rescue personnel even under difficult conditions (ie, the wearing of cumbersome protective gear, the need to carry other equipment, etc), making it easily deployed and capable of operation both indoors and outdoors. The power supply can suffice for a period up to 3 hours.

Mass casualties can be anticipated from the exposure of a population to nonconventional warfare agents. The safest mode of airway protection in NA poisoning is probably endotracheal intubation [1], but this may not be the case for intubation performed by physicians who are unskilled in the procedure and who must perform it in the prehospital setting under chaotic conditions. The application of biphasic cuirass-based negative pressure ventilation using the MRTX respirator may spare the need for laryngoscopy and intubation, both exacting procedures that may well be hampered by the impaired vision and manual dexterity of protected medical personnel. In addition, cross-contamination of the acute rescue team can cause ocular signs and symptoms, such as severe miosis, dim vision, and persistent rhinorrhea which, although not lethal, can compromise even the most proficient physician’s ability to function [1]. Another potential benefit for obviating laryngoscopy is sparing the use of muscle relaxants, which might act unpredictably in cases of underlying systemic inhibition of acetylcholinesterase [8].

Because systemic toxicity of NA is invariably associated with severe bronchorrhea [8], repeated active drainage of bronchial secretions is a major component of the respiratory care of the intoxicated patient. Clearance of secretions was shown to be enhanced by using biphasic cuirass-based negative pressure EHFO because of reduction in sputum viscosity and enhancement of ciliary’s clearance [5,9]. In the prehospital setting where massive numbers of casualties need to be treated and when medical personnel is expected to be too limited to be available for performing airway suctioning for every patient that needs it, periodic emergency ventilation using the MRTX respirator might serve as a useful solution.

The EHFO is a relatively new modality of noninvasive ventilation which controls the inspiratory and expiratory phases of respiration, both of which are active [10]. The peak-inspiratory chamber pressure and the end-expiratory chamber pressure are controllable as well. The inspiratory pressure will always be negative to expand the chest and inflate the lungs, but the expiratory pressure may be negative, atmospheric, or positive to produce an end-expiratory lung volume above functional residual capacity. Tidal volume is determined by the pressure difference between the expiratory
and peak inspiratory chamber pressure and frequency: increasing this pressure difference increases tidal volume, whereas increasing the frequency reduces it. Because minute ventilation is the product of frequency and tidal volume, minute ventilation increases as long as the increment in frequency is higher than the decrease in tidal volume [5]. With both the inspiratory and expiratory phases being controlled, high respiratory rates (up to 1200 oscillations per minute) may be achieved, in contrast to normal negative pressure ventilation (which does not have an active component of expiration). Optimal carbon dioxide removal is achieved with a rate of 90 per minute in adults with normal lungs. An I/E of 1/1 is optimal, although changing the I/E ratio may be needed for optimal ventilation in patients with inspiratory or expiratory obstruction [5].

Trials have proved the efficacy of EHFO in ventilating normal and sick lungs [3,4]. Potential preservation of cardiac output by EHFO compared with conventional positive pressure ventilation [3] might be preferred in light of the negative inotropic effects induced by NA [8]. Although EHFO can actively aid in secretion clearance in a forceful manner, a fact that probably reduces the chances for aspiration [5], adequate separation of the digestive and respiratory tracts is not maintained with this method. Hence, it would be prudent to exchange the extrathoracic ventilation that had been provided by the cuirass by the placement of an endotracheal tube as soon as possible. This is especially true when respiratory failure is prolonged and support is needed for an extended period.

Our study is based on a descriptive model. For obvious reasons, experimental studies using models of NA intoxication are difficult to conduct even in animals because of the extreme lethal potency of these agents and the need for special well-equipped laboratory and personnel familiar with the use of NA.

In conclusion, the methodology of instituting biphasic extrathoracic cuirass-based ventilation via an MRTX portable respirator is easily learned and rapidly applied by nonmedical personnel, even those wearing cumbersome, full-body antichemical protective gear. This method, when used for urgent respiratory support, saves the need for laryngoscopy and aids in secretion removal. Our encouraging preliminary findings warrant further assessment as for its beneficial role in resuscitation of mass casualties from NA poisoning.

References

Effect of a social services intervention among 911 repeat users

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Abstract

Objective: To determine whether emergency medical services (EMS) 911 frequent users would benefit from social services intervention.

Methods: The design was a descriptive prospective subject evaluation. All nonhomeless frequent EMS users (>3× in 1 month) were identified monthly from December 2 to May 3 and contacted by 2 social workers. Information extracted from their contact with the subjects included demographics, ability to enter a social services intervention, and reason for transport.

Results: Eighty-four patients were eligible for inclusion in the study. Seventy-four patients were unable to enter a social services intervention for the following reasons: not home (2× (26%), not at address (19%), refused (13%), unable to complete Mini-Mental Status Exam (10%), deceased (6%), hospitalized (5%), safety issues (4%), and others (10%). The reasons for frequent EMS use were cardiac (24%), asthma/chronic obstructive pulmonary disease (25%), seizures (14%), dialysis problems, alcohol problems, and diabetes-related problems (<10% each).

Conclusion: Among all patients, the primary reasons for transport were cardiac, asthma/chronic obstructive pulmonary disease, and seizures. Only 12% of patients contacted could enter a social services intervention. On the basis of the small cohort of patients that were able to enter a social services interventions, more targeted interventions are warranted. © 2005 Elsevier Inc. All rights reserved.

1. Introduction

Frequent users of the medical system represent a burden to the system, to society, and to their own care [1,2]. We recently showed that a small group of patients were...
accounting for a large number of ambulance transports [2]. No previous studies have evaluated the emergency medical services (EMS) 911 calls and the problems among frequent users. People who call 911 repeatedly within a short period not only overburden the existing systems, but also may be in need of extra help or ancillary services. The rationale of this study was to determine if these repeat callers could be contacted for a social services intervention and whether such an intervention could improve the quality of the subject’s life. The EMS system is not presently able to assist with alternative referrals to resources that could help these individuals. Social services interventions have been proven to be cost effective and helpful in other emergency settings [3-9]. We devised this study to determine if a social service intervention was feasible.

The hypothesis of this study was that a social services intervention is feasible for frequent EMS users and is an efficient use of the social worker’s time.

2. Methods

The study population included all nonhomeless men and women 18 years and older who had at least 3 calls to 911 in the previous month and can be found by our representatives within 2 attempts. These data were obtained from 911 dispatch records available through the County/City EMS. The City Department of Social Services was consulted and 2 social workers contacted each frequent user. Descriptive information was extracted from charts and social services paperwork regarding problems and age.

3. Targeted intervention pilot study

If patients were willing to undergo a social services intervention, the social workers continued their care for a period of 1 month. Reasons that patients were not able to have an interaction with social services included if they were unwilling or unable to consent, if they could not be found or were unavailable, if their Mini-Mental Status Exam (MMSE) [1,9-11] score was less than 22, if they were incarcerated at the time they were entered in the study, if they did not speak English, if there was a safety issue to the social workers, or if the patients could not complete the forms.

We then randomized the available patients to either a social services intervention or observation. We tracked their progress using 2 outcome variables pre- and poststudy: (1) the frequency of EMS calls and (2) the subject’s quality of life (QOL) as measured by the SF-36. The SF-36 is a nationally recognized validated scale for QOL determination that is split into physical component scale and a mental component scale [1,10,12-29] in injured patients [30,31] and in geriatric populations [32]. Both the physical and mental scales of the SF-36 scale have national averages of 44 ± 10.

After signing a consent form, all subjects completed the SF-36. The intervention consisted of traditional social services management including an intake questionnaire, assessment of the patient’s specific problems, and referral to specific community services. All resources of the Department of Health and Human Services (DHHS) were made available. After 30 days, the subjects completed another QOL questionnaire. Outcome variables included number and types of interventions, past vs future ambulance transports, and changes in the QOL as measured by the SF-36. The investigator extracted numbers and types of interventions from the social services records for the subjects. At the end of the 30-day period, all subjects in both arms of the study were offered social services follow-up.

Changes in QOL results were compared using an independent samples t test. Results for ambulance use were compared using χ² and relative risks. The University and City Department of Health Services Institutional Review Board both approved all phases of this study.

4. Results

Eighty-four patients were included in the study. The average age was 49 ± 2 years with 4 patients younger than 18 years and 17 patients older than 65 years. The reasons for frequent EMS use were cardiac (24%), asthma/chronic obstructive pulmonary disease (COPD) (25%), seizures (14%), dialysis problems, alcohol problems, and diabetes-related problems (<10% each). In 25 cases, all transports were for different complaints. The number of calls per month ranged from 2 to 8 with an average of 2.9. These results are summarized in Table 1.

Seventy-four of the 84 patients identified were unable to participate in the intervention. A total of 10 patients (12%) were enrolled in the intervention over the 6-month course of the study. Reasons patients were excluded from the intervention were the following: not home (2) (26%), not at address (19%), refused (13%), unable to complete MMSE (10%), deceased (6%), hospitalized (5%), safety issues (4%), and others (10%). Reasons patients were unable to take part in a social services intervention are summarized

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>N</th>
<th>%</th>
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<tbody>
<tr>
<td>Cardiac</td>
<td>20</td>
<td>24</td>
</tr>
<tr>
<td>Asthma/COPD</td>
<td>21</td>
<td>25</td>
</tr>
<tr>
<td>Seizures</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Dialysis problems</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Alcohol problems</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Diabetes-related problems</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>No contributing factors</td>
<td>17</td>
<td>13</td>
</tr>
</tbody>
</table>

Some patients had enough transports to fit into more than one category.
in Table 2. There were no deviations from the study as planned.

5. Targeted intervention pilot study results (10 patients)

Change in the SF-36 results for the physical score was $-3.3 \pm 4.6$ in the control group and $+4.0 \pm 4.1$ in the intervention group. Changes in the physical component score were significantly different ($\text{diff} = 7.1 \pm 2.7, P = .02; 95\% \text{ CI}, 0.8-13.4$) between the 2 groups. Change in the mental component scale of the SF-36 was $+13.1 \pm 20.6$ in the control group and $+1.0 \pm 18.7$ in the intervention group. Changes in the mental component scale were not significantly different ($\text{diff} = 12.0, P = .4; 95\% \text{ CI}, -16.6$ to $40.7$). There were physical score improvements in 4/5 patients in the intervention group and none of the patients in the control group. There were mental score improvements in 4/5 of both groups. The number of EMS transports was equivalent between the 2 groups before the study at a rate of 3.2 transports per person per month for both the control and intervention groups. The 6-month transport rate after the intervention phase was 0.8 transports per person for the control group and 5.0 transports per person for the intervention group. This represented a significant increase in the intervention group’s use of EMS in the months after the study period ($RR = 1.76, 1.17$-$2.65, P < .01$).

6. Discussion

We found that an attempt to help all nonhomeless 911 repeat users with a social services intervention was not an efficient use of social services time. This is the most crucial finding in the study. The social services team made serious attempts to enlist all patients but were unable to include 88% of all the patients they contacted. For an interesting set of reasons, most frequent users of EMS were either unavailable or unconcerned in the intervention. This suggests that the broad use of social services would lead to a lot of time spent trying to find patients and get them interested in help, with little ability to intervene in their lives. After many discussions with our social workers, we have concluded from the fact that only 12% of the frequent EMS users are interested in being helped, and that social services support needs to be directed more critically to the needed problems or the specific EMS patients. This study was concluded with the belief that the social workers need to focus on a need-related group rather than on general frequent users. Future studies will look at the focused ability of social services to aid with patients with specific problems such as falls, drug/alcohol problems, seizures, chest pain, diabetes, asthma, dialysis, and cardiac disease.

The use of social services in conjunction with EMS is novel. This is the first in a series of studies evaluating the most practical way to include social services in the prehospital environment. Working with all nonhomeless repeaters was too broad and may have led to futile efforts by our social workers. By picking referrals carefully, we may see much more prominent changes in the patient outcomes. Table 3 shows suggested social services interventions that could be accomplished in a diagnosis-focused system.

Even for many of the patients amenable to social services, our social workers were unable to make significant inroads into the system problems that they were facing. Often, the subjects had exhausted social services systems and were still not improving. Again, this suggests that social services support needs to be focused on patients with solvable problems.

ED social services have been depicted as one of the significant types of interventions, according to the Society for Academic Emergency Medicine (SAEM) preventative task force. The theoretical basis for this is found in the social services literature. A social worker within the medical system can use Crisis Intervention and Task Centered theories to provide optimum care in brief patient care settings. Payne [33] describes the Crisis Intervention model as an action to interrupt a series of events, which lead to a disruption in people’s normal functions, whereas Task Centered models focus in the defined categories of a problem. According to a study by Keehn et al [9], the greatest decline of emergency department recidivism occurred when social workers used a proactive approach after the Task Centered model. Both models, although somewhat different, are attempting to improve a patient’s capacity to deal with the problems vital for overall life satisfaction [33]. Harrington [34] supports the use of the Crisis Intervention model by stating that “the emergency room social worker exemplifies in a crisis-oriented context, to make a difference in real terms in situations of patient and family need—physical, environmental, and emotional needs”.

On the basis of limited pilot study data, if patients were amenable to social services intervention, there was a significant improvement in the physical portion but not the mental portion of the QOL. This was unexpected by us because emotional support is more of a social workers’ focus. We believe that it may be a reflection of usage and knowledge of resources. Many of the clients were house-
bound and cared for by family members who may or may not have proper medical training. Therefore, the intervention may have improved the ability of the patient to physically manage his or her own care or the ability of the caregiver to physically manage the patient’s care.

We were surprised to find that patients receiving the intervention uniformly used EMS more in the follow-up months of the study. We would explain this as being related to increased attention from the medical establishment leading to an increased awareness of available resources. However, this effect was on the basis of a small number of patients and needs to be reproduced in larger studies.

Preventive services are an important part of the future of EMS. Consensus articles have been written but only a few studies have been completed. This direction for expansion of scope of practice for EMS personnel is practical, realistic, and cost effective.

7. Limitations

The length of the study was a limitation. We originally estimated that 20% to 25% of patients contacted could be enrolled. We found that the final results were closer to 10%.

Another limitation was bias among patients. Many of the patients were weary of being labeled as frequent users of the system and were resistant to taking part in a study that tagged them as such. The low recruitment for a social services intervention was not a deficit in patient entry but a statement about the problems encountered by frequent users of the EMS system. The systems in place are not adequate for this marginal group of people.

8. Conclusion

Most frequent users were nonelderly adults. Three categories of problems comprised the great majority of the cases (cardiac, asthma/COPD, and seizures). Use of a social services intervention on all frequent users of EMS is not an efficient use of their time as only 12% of patients contacted can enter a meaningful interaction. In cases with meaningful interactions, these interactions do seem to improve physical QOL and increase EMS use. A more focused use of social services may be more efficient.
References


The sensitivity of room-air pulse oximetry in the detection of hypercapnia

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Abstract
Objective: To estimate the sensitivity of room-air pulse oximetry in the detection of moderate hypercapnia.
Methods: In this retrospective case-control study, charts were reviewed from patients with and without moderate hypercapnia (PaCO₂ > 50 mm Hg), as determined by analysis of arterial blood gas samples obtained in the ED. Test characteristics (sensitivity, specificity, and likelihood ratios [LR]) for room-air pulse oximetry <96% to detect hypercapnia were calculated, as were confidence intervals.
Results: A total of 349 charts were eligible for abstraction—92 cases and 257 controls. A room-air pulse oximetry reading <96% detected 88 of 92 cases of hypercapnia. Test characteristics were as follows (with 95% confidence interval): sensitivity, 0.96 (0.89-0.99); specificity, 0.39 (0.33-0.45), LR of a room-air pulse oximetry value <96%, 0.1 (0.04-0.3); and LR of a room-air pulse oximetry value <96%, 1.6 (1.4-1.7).
Conclusion: Room-air pulse oximetry detects moderate hypercapnia with high sensitivity.
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1. Introduction

Respiratory status, one of the cardinal determinations in every ED evaluation, has 2 components: oxygenation, assessed by the arterial blood oxygen (PaO₂) level, and ventilation, assessed by the arterial carbon dioxide (PaCO₂) level. Either level can be measured accurately using an arterial blood gas (ABG) sample, but this process is expensive, painful, labor-intensive, and time consuming. The advent of pulse oximetry, allowing real-time assessment of oxygenation, has revolutionized clinical practice. One would expect a real-time test for hypercapnia to also have a great impact on clinical practice. However, although noninvasive methods of measuring CO₂ levels have been invented [1,2], they require technology that is unavailable in most EDs and other outpatient settings.

Many reports, including one from the American Society of Anesthesiologists, have indicated that pulse oximetry cannot be used to assess ventilation, these claims being based entirely on failure to detect hypoventilation in patients receiving supplemental oxygen [1,3-8]. However, in patients breathing room air, the alveolar gas equation imposes an
upper limit on the pulse oximetry value for any given PaCO2 value [9]. In fact, a room-air pulse oximetry cutpoint of 96% detected 12 of 12 cases of hypercapnia in a small validation set [10]. In this study, we estimate the sensitivity of room-air pulse oximetry \( \leq 96\% \) to detect moderate hypercapnia (PaCO2 > 50 mm Hg) in a larger number of patients.

2. Materials and methods

This was a retrospective case-control study of patients presenting to the ED of a university-affiliated community hospital. Pulse oximeters used in this ED were all from Nellcor (Pleasanton, Calif) or Datascope (Montvale, NJ); all had a pulsed plethysmographic display, and all had specified accuracy within 2%. The study design was approved by the institutional review board.

2.1. Chart selection

A study manual was maintained throughout the data collection period. Two groups were defined: a hypercapnia group (PaCO2 > 50 mm Hg) and a control group (PaCO2 \( \leq 50 \) mm Hg). Lists of patients with PaCO2 > 50 mm Hg and with PaCO2 \( \leq 50 \) mm Hg based on ABG sampling done in the ED were obtained from the hospital laboratory. Two unmatched control patients were selected for each case. A trained assistant reviewed these lists and determined which patients met preliminary inclusion criteria: arrival by means other than ambulance and ABG obtained within 8 hours of ED arrival. The assistant prepared charts that met preliminary inclusion for chart review by eliminating all identifying information, masking all pulse oximetry and ABG values, assigning each chart a study identification number, and assorting cases and controls in random order.

In the chart review, 2 board-certified emergency physicians independently reviewed the ED charts for eligibility according to the following exclusion criteria: arrival by ambulance; coma; absence of a documented room-air pulse oximetry value; potential decline in ventilation between pulse oximetry measurement and ABG sampling, such as when noted by decreased alertness, increased fatigue, narcotic administration, or ED intubation; a diagnosis of carboxyhemoglobinemia or methemoglobinemia. During periodic training sessions, these attending physicians compared charts, keeping only those with independent agreement for later abstraction. Percent agreement regarding eligibility was calculated.

2.2. Data abstraction

During the independent review, each attending physician circled the position of the best masked room-air pulse oximetry value. The following hierarchy was used in determining the best value: (1) physician note indicating “room air” oxygen saturation, (2) triage value if the patient was not on home oxygen, (3) nurse’s note in response to order for “room air” oxygen saturation measurement, (4) nurse’s note indicating “room air” or the absence of oxygen therapy. If 2 values at the same hierarchical level were present, the one obtained closer to the time of ABG sampling was selected. Differences in selection of oximetry value positions were reconciled during regular training sessions.

The assistant abstracted data from eligible charts using a standardized abstraction form. The following variables were collected: age, the times of room-air pulse oximetry measurement and ABG sampling, whether the ABG sample was taken on supplemental oxygen, and whether improvement was noted during the ED visit.

2.3. Analysis

A 2 \( \times \) 2 contingency table was constructed for hypercapnia status (\( \leq 50 \) mm Hg, > 50 mm Hg) versus room-air pulse oximetry test result. A positive room-air pulse oximetry test was defined prospectively as a value \( \leq 96\% \), and a negative test was defined as a value > 96%. This table was used to calculate sensitivity, specificity, and likelihood ratio (LR) values. Confidence intervals (CIs) for proportions were calculated using formulas described by Fleiss [11]. LRs and CIs were calculated as described by Simel et al [12].

The sample size was chosen to allow, with a power of 0.8, adequate precision to exclude 0.9 from the 95% CI about a sensitivity of 0.98. This required a minimum of 77 cases.

3. Results

Of 520 charts selected for secondary review, 171 were excluded by one or both reviewers for the following reasons: no available pulse oximetry value, 30; all oximetry values on supplemental oxygen, 71; arrival by ambulance (not detected by preliminary screen), 11; narcotic adminis-

![Fig. 1 Scattered plot of room-air pulse oximetry values versus PaCO2 values. Graph includes 342 of 349 patients; 7 patients with room-air pulse oximetry values from 52% to 74% and PaCO2 values from 57 to 85 mm Hg are not shown.](image)
Room-air pulse oximetry to detect hypercapnia

The association between the prospectively defined room-air pulse oximetry test (≤96%) and moderate hypercapnia (PaCO2 >50 mm Hg from ABG testing) is shown in Table 1. The following test characteristics are noted (with 95% CI): sensitivity, 0.96 (0.89-0.99); specificity, 0.39 (0.33-0.45); LR [−], 0.1 (0.04-0.3); and LR [+], 1.6 (1.4-1.7).

Of the 4 false-negative cases, 3 were on supplemental oxygen at the time of ABG sampling, and oxygen status was undocumented in the other. Two of the 3 patients (97%, 70 mm Hg; 99%, 80 mm Hg) were significant outliers. All 21 patients with ABG noted to be measured on room air had a room-air pulse oximetry value >96%.

Table 1: 2 × 2 Contingency table for room-air pulse oximetry result versus moderate hypercapnia, from ABG result

<table>
<thead>
<tr>
<th>PaCO2 &gt;50 mm Hg</th>
<th>PaCO2 &gt;50 mm Hg</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sat ≤96%</td>
<td>88</td>
<td>158</td>
</tr>
<tr>
<td>Sat &gt;96%</td>
<td>4</td>
<td>99</td>
</tr>
<tr>
<td></td>
<td>92</td>
<td>257</td>
</tr>
</tbody>
</table>

4. Discussion

Chapters on virtually every emergency medicine topic emphasize the primary importance of the “ABCs.” Avoidance of hypercapnia requires that the first 2, “airway” and “breathing,” are intact. Many authors have emphasized the limitations of pulse oximetry in detecting hypercapnia, based solely on its poor record in patients breathing supplemental oxygen [1,3-8]. However, the common-sense notion that patients breathing room air will develop hypoxemia when they hypoventilate is based on a physical law—the alveolar gas equation [10]. This report provides evidence that room-air pulse oximetry, as measured by emergency personnel, can detect moderate hypercapnia (PaCO2 >50 mm Hg) with high sensitivity.

An earlier report found that room-air pulse oximetry ≤96% identified 12 of 12 patients with hypercapnia [10]. In that study, unlike the current one, pulse oximetry measurement and ABG sampling occurred nearly simultaneously, and most oximetry measurements were taken by the study’s principal investigator. The data from this study also suggest that sensitivity to detect hypercapnia is quite high (96%) and that a room-air pulse oximetry value >96% provides strong evidence against hypercapnia, with a LR [−] value of 0.1.

One feature of this study is that pulse oximetry was measured outside a study protocol. Those who were measuring oxygen were not specially trained for the study. This is representative of most clinical settings. Pulse oximetry measurement is not taught routinely in medical school, and we have noted that resident physicians and nurses occasionally record an erroneous oximetry measurement based on a low-amplitude tracing. It is possible that an erroneous oximetry reading was recorded initially for some of the 4 false-negative patients, because oxygen was eventually given to 3 of them, 2 of whom were significant outliers in the scatterplot. Improving measurement accuracy may lead to even higher sensitivity than we observed.

In addition to limiting the use of ABG sampling, room-air pulse oximetry hypercapnia screening has a potential use in conscious sedation. The goal of conscious sedation is achieving a depth of anesthesia at which patients can still respond to stimulation while maintaining airway protection and ventilatory reflexes [8,13]. In an emergency setting, where patients frequently have full stomachs, conscious sedation is the preferred depth of anesthesia. In these patients, failure to detect hypoventilation may cause excessive sedation and undue risk. If an end-tidal CO2 monitor is not available, a room-air pulse oximetry drop to 95% or below can alert the treating physician to the onset of hypoventilation, cautioning against inducing deeper sedation.

4.1. Limitations and future questions

This study was limited by a time lag between pulse oximetry measurement and ABG sampling, during which a patient’s hypercapnia status may have changed. Interval worsening or improvement could have affected our results. It is not clear whether the clinicians recognized or recorded these changes; hypercapnia is virtually never documented in an ED setting for patients breathing room air. In ED practice, clinicians tend to respond to low oximetry values by giving supplemental oxygen and implementing measures to improve ventilation, not by obtaining a room-air ABG measurement. Inducing hypercapnia for study purposes

tration, 33; venous ABG sample, 7; intubated, 9; other decline in status, 6; pediatric age, 2; and carbon monoxide exposure, 2. The remaining 349 charts met eligibility criteria according to both reviewers. Agreement with regard to eligibility of individual charts was 95%.

Of the 349 eligible charts, 92 were cases and 257 were controls. Cases had median age of 61 (interquartile range, 46-73) years versus 51 (interquartile range, 41-65) years for controls. The triage saturation measurement was selected in 93% of charts. The lag between saturation and ABG sampling was <2 hours in 151 (43%), 2 to 5 hours in 156 (45%), and 5 to 8 hours in 42 (12%), with a similar distribution between cases and controls. Interval improvement was noted in 40 (43%) cases versus 57 (22%) controls. ABG values were determined on supplemental oxygen in 30 (57%) of 53 cases versus 27 (17%) of 156 controls where this information was available.

Fig. 1 shows a scatterplot of abstracted room-air pulse oximetry values versus PaCO2 values. As shown, the frequency of hypercapnia was inversely related to the room-air pulse oximetry value. For each high oximetry value (>96%), aside from a few outlying values, the distribution of PaCO2 values is skewed toward lower values. This is consistent with the concept that at high room-air pulse oximetry values, the alveolar gas equation imposes an upper bound on PaCO2 values.

The association between the prospectively defined room-air pulse oximetry test (≤96%) and moderate hypercapnia (PaCO2 >50 mm Hg from ABG testing) is shown in Table 1. The following test characteristics are noted (with 95% CI): sensitivity, 0.96 (0.89-0.99); specificity, 0.39 (0.33-0.45); LR [−], 0.1 (0.04-0.3); and LR [+], 1.6 (1.4-1.7).

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would be unethical, so we felt that this study design was the safest, most efficient way to evaluate the potential of room-air oximetry to screen for hypercapnia in an ED setting.

An additional limitation of this study is that it was a retrospective chart review. Retrospective chart reviews often suffer from missing data, and such reviews are prone to bias unless specific methodologic steps are taken [14]. The methods we used to limit bias were formal inclusion criteria, blinding reviewers to pulse oximetry values and case/control status, a standardized abstraction form, prospectively determined selection of room-air pulse oximetry values, maintenance of a study manual, and periodic training [14].

Despite the limitations of this study’s design, it allowed inclusion of many more patients with hypercapnia than the earlier study and produced a more precise sensitivity estimate. The use of room-air oximetry as a screening test for hypercapnia requires further study. One way to do this noninvasively would be to substitute end-tidal CO2 measurement for formal ABG measurement. End-tidal CO2 can be measured simultaneously with room-air pulse oximetry, either during conscious sedation or in a population with a high prevalence of hypercapnia, such as a clinic for patients with chronic obstructive pulmonary disease.

Acknowledgments

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References

Correlation between chest x-ray and B-type natriuretic peptide in congestive heart failure

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Abstract

Introduction: B-Type natriuretic peptide (BNP) values greater than 400 pg/mL have high positive likelihood ratio (>10) for the diagnosis of clinical congestive heart failure (CHF). However, in patients with CHF, it is not known what correlation, if any, exists for the BNP levels above 400 pg/mL and the findings on the initial chest x-ray (CXR).

Methods: Retrospective review of emergency department patients with CHF and initial BNP greater than 400 pg/mL. Descriptive statistics were analyzed and logistic regression was performed.

Results: Fifty-four patients mean age of 81.7 (SD, 8.2), 64.8% women. The mean BNP was 1493 pg/mL (SD, 1106). Only 68.5% had a finding of CHF on CXR. Logistic regression showed no correlation (Wald P = .568; $R^2 = 0.8\%$).

Conclusion: In patients with clinical CHF, there is no correlation between very high BNP levels (>400 pg/mL) and CXR readings. Clinicians should not be surprised to find patients with very high BNP levels but negative CXR.

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1. Introduction

The diagnosis and treatment of heart failure continues to be an extraordinary cost burden to the health care system [1]. Rapid bedside B-type natriuretic peptide (BNP) testing has made the diagnosis of congestive heart failure (CHF) more rapid and more accurate for the clinician [2,3]. Figuring out how to integrate new BNP testing into the diagnosis and treatment in a cost-saving manner is the next step in heart failure management [4,5].

Recent studies have proved the accuracy of BNP levels in the diagnosis of CHF in the emergency department (ED) [6]. Elevated BNP levels were also shown to be more accurate than chest x-ray (CXR) findings in the diagnosis of CHF [7]. An algorithmic approach to the diagnosis of patients presenting with dyspnea has been proposed. In this algorithm, BNP levels greater than 400 pg/mL should be treated as if CHF is “very likely” [8]. The proposal is based on the fact that BNP levels greater than 400 pg/mL display a positive likelihood ratio greater than 10 [9].

This retrospective chart review had the objective of determining the correlation between very elevated BNP
levels and CXR findings confirming the diagnosis of CHF. We hypothesize that very high BNP levels would, in fact, predict a positive confirmatory CXR.

2. Methods

We designed a retrospective 6-month chart review of patients with a final diagnosis of CHF or pulmonary edema and a very high BNP levels (>400 pg/mL). Only patients with ED chief complaints of dyspnea or leg edema were included. Exclusion criteria included renal failure (serum creatinine >2.5 mg/dL), final diagnosis other than CHF, and those in which a final diagnosis was not available.

The setting of our study is a suburban/urban community hospital with a very large elderly population. Our ED is staffed by residents and attending physicians. Inpatient services are staffed by residents in some cases and attending physicians with final diagnosis left to the attending physicians. The attending radiologists performed all CXR readings. Both ED and inpatient records were reviewed so that only cases of actual clinical CHF were included in the study. Internal review board approval was obtained before the study. The data collected included age, sex, history of CHF, BNP levels, CXR readings, ED diagnosis, and final discharge diagnosis.

Descriptive statistics were analyzed and logistic regression was performed to correlate BNP levels with CXR findings. All statistical calculations were performed on SPSS Ver 11.5 (SPSS, Inc, Chicago, Ill, 2002).

3. Results

A total of 82 cases were reviewed (Fig. 1). Seventeen cases were excluded before chart review based on the fact that the patients had renal failure on laboratory analysis. Of the 65 cases reviewed, 6 were excluded because the final diagnosis was not available, and 5 were excluded because of a final diagnosis other than CHF leaving a total of 54 patients.

The mean age was 81.7 years (SD, 8.2). Women comprise 64.8% of the cases. Dyspnea was the chief complaint in 94.4%, with the remaining cases presenting with a chief complaint of pedal edema. There was a history of CHF in 59.3% of the patients. The mean BNP level was 1493 pg/mL (range, 411-4910). Eighteen patients (33.3%) had CXR readings of pulmonary edema. Eleven patients (20.4%) had CXR readings of CHF. Eight patients (14.8%) had CXR readings of both CHF and pulmonary edema. Combining those 3 groups revealed a cumulative total of 37 patients (68.5%) with CXR readings consistent with active heart failure. Other x-ray readings are shown in Table 1.

On logistic regression, BNP levels and CXR readings were not correlated. The coefficient for BNP was 1.000 (95% CI, 1.000-1.001). The Wald P value was .568 and the $R^2$ was only 0.8%.

4. Discussion

Because of its high prevalence in the US population, heart failure is a significant financial burden on the health care system as a whole [1]. Recent advances in diagnosis

<table>
<thead>
<tr>
<th>Table 1</th>
<th>CXR not read as CHF or pulmonary edema</th>
</tr>
</thead>
<tbody>
<tr>
<td>CXR reading</td>
<td>No. (%)</td>
</tr>
<tr>
<td>Cardiomegaly</td>
<td>6 (11.1%)</td>
</tr>
<tr>
<td>Cardiomegaly with effusion</td>
<td>4 (7.4%)</td>
</tr>
<tr>
<td>Cardiomegaly with infiltrates</td>
<td>3 (5.6%)</td>
</tr>
<tr>
<td>Effusion only</td>
<td>2 (3.7%)</td>
</tr>
<tr>
<td>Infiltrates only</td>
<td>2 (3.7%)</td>
</tr>
</tbody>
</table>
and treatment of heart failure have offered hope of trimming some of those costs [5]. Physical and radiographic signs of heart failure are unreliable [10,11]. Recently, elevated BNP levels have proven to be a more reliable indicator of heart failure than CXR findings [7]. Our study evaluates whether there is a correlation between elevated BNP values greater than 400 pg/mL and CXR findings.

The results of our study show that there is virtually no correlation between very high BNP levels and CXR findings. One secondary result of note was that of the 5 patients excluded for final diagnosis other than heart failure; none would have likely had their diagnosis and management altered by CXR findings. The one patient with bronchiectasis had known prior bronchiectasis. Our study numbers, however, are far too small to comment on the ability of BNP levels to exclude alternative diagnoses.

4.1. Study limitations and future questions

Primary limitations of our study include the age of our patient population, the high prevalence of cardiovascular disease in our institution, and the relatively small study size. The age of our patient population may not accurately reflect the average age in most emergency rooms. The high prevalence of cardiovascular disease may be the primary reason that there were no more patients excluded because of alternate diagnoses.

Our study indicates that there is no correlation between very high BNP levels and CXR findings. As previously stated, BNP has proven more reliable than CXR findings in the diagnosis of heart failure. Further studies may be needed to determine whether CXR results do in fact alter the diagnosis and the management of heart failure patients with very high BNP levels. Clinicians should not be surprised when patients have very high BNP levels, yet display insignificant findings on CXR. In this situation, it may be prudent to treat according to BNP results.

4.2. Summary

In patients with clinical CHF, there is no correlation between very high BNP levels (>400 pg/mL) and a finding of CHF or pulmonary edema on CXR. Clinicians should not be surprised to find patients with very high BNP levels but negative CXR.

References

Sudden cardiac death in athletes: a guide for emergency physicians

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Abstract A conditioned athlete is usually regarded as a member of the healthiest segment of society, and exercise itself is looked upon as a means to improve health. Although extremely uncommon, sudden cardiac death (SCD) in young athletes is a devastating medical event to all involved (patient, family, community, team, and caregivers). Most etiologies of SCD in athletes result in the same final common denominator (cardiac arrest) on presentation to an emergency physician. There are, however, certain historic, physical examination, and electrocardiographic features of many of these disease processes that emergency physicians should have a working knowledge of to try to identify them before they result in SCD. This review examines the clinical presentation, diagnostic techniques, and management options applicable to emergency practitioners.

1. Introduction

The first proposed case of sudden cardiac death (SCD) in an athlete involved Pheidippides in 490 BC. This trained runner was reported to have collapsed and died after running to Athens from Marathon with the news of the military defeat of Persia [1]. More recent accounts of athletes dying suddenly include Loyola Marymount basketball player Hank Gathers (1990), marathon runner Jim Fixx (1984), US Olympic volleyball player Flo Hyman (1986), former professional basketball players Pete Maravich (1980) and Reggie Lewis (1993), and Olympic figure skater Sergei Grinkov (1995). All these professional athletes suffered from presumed SCD.

Conditioned athletes are regarded to constitute the healthiest segment of the society while exercise itself is considered a means of improving personal health and decreasing the chance of cardiovascular disease. Although relatively uncommon, the sudden death of an athlete can have a tragic and devastating impact on the family, community, and medical staff involved. For many years, the lack of understanding regarding the causes of such catastrophes was reflected by vague descriptions of these events such as sudden death syndrome [2]. Over the past decade, however, a greater comprehension of the underlying cardiovascular processes of SCD in athletes has been achieved.

The role of emergency physicians (EPs) in this setting is primarily to attempt resuscitation and stabilization of the patients. However, it is helpful for EPs to be aware of the demographics, risk factors, etiologies, and current preventive strategies regarding SCD.
2. Definition

There is no universally accepted definition for SCD. One popular definition is that of a nontraumatic and unexpected sudden cardiac arrest that occurs within 6 hours of a previously normal state of health [3]. Other definitions limit the time frame in relation to sport participation and symptoms anywhere from within 1 to 24 hours [4-6].

The term athlete implies involvement in a regimented exercise program with participation in a team or individual sport. To better differentiate the etiology of SCD, athletes are often classified as “young” or “old.” Although open for debate, for the purpose of this review, the term young athlete will refer to those aged younger than 35 years because most studies in this arena have defined it as such.

3. Epidemiology

Sudden cardiac death in young athletes is rare. The exact prevalence is not known because there is no national database to track the death of athletes. The largest available studies estimate the incidence among high school and collegiate athletes to be between 1 per 100,000 and 1 per 300,000, respectively, each year [7-10]. An estimated number of 50 to 100 cases occurs annually in the United States [7,9,11].

The overall estimate of incidence may be low given that fatal arrhythmias associated with subtle structural abnormalities or a normal heart would be difficult or impossible to identify on postmortem examination. Also, often it is a coroner’s priority to exclude foul play rather than establish a precise cardiovascular diagnosis [12]. Likewise, lack of a national registry for SCD in athletes might lead to an underestimation. There is often reliance on media coverage rather than on voluntary or mandatory reporting for identifying cases of SCD.

Despite the overall low incidence of SCD, it represents 30% of all nontraumatic deaths, with one third of victims younger than 65 years [13]. For young athletes, SCD remains a significant cause of nontraumatic exercise-related death. The incidence of cardiovascular collapse as the cause of athletic fatalities in high school and college athletes outnumbers death caused by trauma by nearly 2 to 1 [11,14].

Most (>80%) cases of SCD in young athletes occur either during or immediately after strenuous exercise [15]. This suggests that physical activity may be a trigger for cardiac arrhythmias in those with certain cardiac disease. Athletes suffering from SCD participate in a large variety of sports, most frequently basketball and football (about 68%) [15]. Most cases of SCD occur in men with a ratio ranging from 5:1 to 9:1 [8,15]. This may be because of the lower participation rate of women in competitive sports in addition to the higher incidence of hypertrophic cardiomyopathy (HCM) among men [15]. A considerable proportion of SCD occurs in African American athletes [16]. Although African Americans constitute only about 12% of the US population, this subset represents a large portion (>40%) of individuals experiencing SCD. This fact is probably a result of a disproportional level of participation in certain competitive sports.

4. Causes of SCD in athletes

Sudden death in young athletes is predominantly caused by structural non-atherosclerotic heart disease [17]. Sudden cardiac death is caused by the combination of exercise and underlying heart disease rather than by exercise alone, which usually leads to the final common pathway of lethal arrhythmia [11,18-20]. By far, the most common reason for SCD is HCM, accounting for at least 36% of deaths [15]. The second most frequent cause of death, encountered in 17% to 19% of deaths, is congenital coronary anomalies [11,15]. The next most common cause of SCD in young athletes is idiopathic left ventricular hypertrophy (ILVH), accounting for 9% to 10% of cases [11,15]. Infrequent causes include aortic rupture, arrhythmogenic right ventricular dysplasia, aortic valve stenosis, prolonged QT syndrome, mitral valve prolapse (MVP), commotio cordis, Wolff-Parkinson-White (WPW) syndrome, and atherosclerotic coronary artery disease.

On the other hand, in mature athletes (those older than 35 years), coronary artery disease is found in most cases of SCD [3,5,21,22]. In fact, atherosclerotic heart disease is found to be the cause of SCD in anywhere from 73% to 95% of this patient population [5,6,10,23,24].

4.1. Hypertrophic cardiomyopathy

By and large, HCM is the predominant cause of sudden death in young athletes, occurring in more than one third of all cases [15]. The estimated prevalence of HCM in the general population is about 1 in 500 [11], although many cases may go undetected during a patient’s lifetime.

The diagnostic criteria for HCM include a left ventricle that is hypertrophied but not dilated in the absence of other cardiac or systemic diseases that would produce left ventricular hypertrophy [23]. This pathological hypertrophy contributes to decreased ventricular compliance and diastolic dysfunction with impaired filling. The left ventricular outflow obstruction and possibly small lumen intramural vessels may potentiate myocardial ischemia. Arrhythmias arise in the context of an electrically unstable myocardial substrate caused by cardiac muscle cell disorganization, replacement fibrosis, or myocardial ischemia [24].

Hypertrophic cardiomyopathy is genetically transmitted as an autosomal dominant condition with variable expression because it may not manifest itself until adolescence or young adulthood [23,25]. If a family history of HCM is confirmed, it is recommended that all first-degree relatives be examined with echocardiography [23,26]. It may be difficult, however, to distinguish mild HCM from...
the normal cardiac hypertrophy that occurs in highly trained athletes [27].

Unfortunately, often the first clinical manifestation of HCM is sudden death. In a series of SCD occurring during exercise in patients with HCM, only 35.7% had a previous cardiac evaluation for risk factors that included syncope, family history, murmurs, fatigue, or ventricular tachycardia on exercise testing [17]. In another study, 21% of athletes who died from HCM had symptoms of cardiovascular disease before their death [15]. Symptoms may include chest pain, exertional dyspnea, lightheadedness, or syncope.

Hypertrophic cardiomyopathy should be suspected in any patient in whom a harsh systolic ejection murmur is heard on examination. The characteristic murmur increases in intensity with maneuvers that decrease venous return such as Valsalva’s maneuver. Examination may also reveal the presence of a fourth heart sound or a rapid initial upstroke of the carotid pulse. These patients will also demonstrate signs of left ventricular enlargement electrocardiographically and radiographically. If HCM is suspected clinically, the diagnosis should be confirmed by echocardiography. If seen in the ED, patients should be proscribed from exertion or exercise until they can have an echocardiogram and cardiology consultation.

4.2. Coronary artery abnormalities

Second in frequency to HCM as a cause of SCD in this population is congenital coronary abnormalities. These congenital abnormalities are also infrequently diagnosed during life. The most common coronary anomaly associated with SCD in athletes is a left main artery arising from the right sinus of Valsalva [28,29]. Coronary anomalies presumably lead to myocardial hypoperfusion during exercise; however, the precise mechanism is often unknown. Possible reasons for ischemia in anomalous coronary artery include a slit-like ostium that narrows with aortic dilatation during exercises, an acute-angled takeoff, and compression of the artery as it passes between the aorta and pulmonary trunk [3,9,15,23]. Other coronary anomalies include origin of the right coronary artery from the left sinus of Valsalva or from the pulmonary artery, presence of a single coronary artery, and coronary aneurysm [3,8,9,15].

Some individuals with coronary artery anomalies may demonstrate symptoms such as syncope or angina before an event. Among athletes who died of this disorder, 31% were found to have symptoms before death [15]. A high index of suspicion in conjunction with an echocardiogram may help suggest the presence of an anomaly in order for angiography to be obtained and to confirm this often surgically correctable abnormality [6]. It should be noted that recent research have shown that both magnetic resonance imaging and computed tomographic coronary angiography have demonstrated promise in detecting coronary artery anomalies [30,31].

4.3. Idiopathic left ventricular hypertrophy

This condition accounts for approximately 10% of all SCD in young athletes [11,15]. Idiopathic left ventricular hypertrophy is a symmetric, concentric hypertrophy where the left ventricular mass exceeds that of physiological hypertrophy. Unlike HCM, ILVH is not associated with genetic transmission and there is no cellular disarray microscopically. However, it is uncertain whether some cases of ILVH represent mild morphological expressions of HCM, unusual instances of exercise-induced cardiac hypertrophy (“athlete’s heart syndrome”) with nonbenign consequences, or possibly examples of undetected right ventricular dysplasia with mild left ventricular hypertrophy [27,30-32]. The precise mechanism of death is poorly established but thought to be similar to that of HCM.

5. Less common causes of SCD

5.1. Myocarditis

This inflammatory condition of the myocardium is frequently the result of a viral infection most commonly caused by either coxsackievirus or echovirus. Characteristic symptoms of myocarditis include a prodromal viral illness followed by progressive exercise intolerance and congestive symptoms of dyspnea, cough, and orthopnea. On physical examination, an audible $S_3$ gallop or soft apical murmur as well as signs of congestive heart failure may be present. The electrocardiogram (ECG) may show low-voltage complexes, diffuse ST-segment and T-wave changes, and sinus tachycardia. Sudden cardiac death may occur in the presence of either active or healed myocarditis [9]. Thus, a convalescent period of at least 6 months is recommended before a return to sports [9,33].

5.2. Mitral valve prolapse

Idiopathic MVP is the most common valvular disorder, occurring in approximately 5% of the population [28,34]. Although sudden death from MVP has been reported, it is extremely rare and most athletes with MVP are totally asymptomatic. Physical examination of patients with MVP may reveal a midsystolic click and a late systolic murmur. If an athlete with known MVP develops syncope, exertional chest pain, or moderate-to-severe mitral regurgitation, it is recommended that athletic participation be restricted [33].

5.3. Aortic rupture

Aortic rupture makes up 5% to 7% of sudden death in young athletes according to investigations by Maron et al [3,15]. Half of these cases occur in athletes with the Marfan syndrome, which is an autosomal dominant disorder with a prevalence in the general US population of 1 per 10000 [9,35]. In the Marfan syndrome, the aortic media are deficient in the number of elastic fibers, which leads to
Sudden cardiac death in athletes: a guide for emergency physicians

5.4. Arrhythmogenic right ventricular dysplasia

Arrhythmogenic right ventricular dysplasia was found to be the most common cause of sudden death in young athletes in the Veneto region of Northern Italy [36]. However, this disease appears to be much less prevalent in the United States, occurring in approximately 3% of SCD cases [15]. Right ventricular dysplasia is an autosomal dominant condition leading to fibrosis and fatty infiltration of the right ventricle.

This process results in the thinning and dilatation of the right ventricular wall and leads to recurrent and intractable ventricular tachyarrhythmias. Diagnosis of this disease often proves difficult. If echocardiography does not demonstrate right ventricular dilation and dysfunction, a magnetic resonance imaging can be diagnostic in demonstrating fatty infiltrates of the myocardium [11,37].

5.5. Wolff-Parkinson-White syndrome

The WPW syndrome is an abnormality of the cardiac conduction system whereby an additional electrical pathway can lead to tachycardia and, rarely, SCD [11,37,38]. This conduction abnormality is relatively rare, affecting only 0.15% to 0.2% of the general population, and has a very small risk of sudden death (<0.1%) [11]. These individuals may have various symptoms including palpitations, syncope, and lightheadedness. The mechanism of SCD is the development of atrial fibrillation with rapid atroventricular conduction via the bypass tract, resulting in rapid ventricular response and subsequent ventricular fibrillation [38]. The resting ECG may demonstrate an initial slurred upstroke of the QRS complex (delta wave), short PR interval, and wide QRS complex.

5.6. Long QT syndrome

The long QT syndrome is an abnormality of the electrical conduction system characterized by prolonged repolarization of the ventricle with an associated high risk of SCD [11]. This syndrome can be congenital, pharmacogenic, or metabolic. It is often defined as a corrected QT interval of more than 440 milliseconds. The mechanism of SCD is the development of wide, polymorphic tachycardia (ie, torsades de pointes) [11,39]. These potential fatal rhythms can be provoked by exercise-related tachycardia; thus, anyone with this condition should be restricted from competitive sports.

5.7. Commotio cordis

Commotio cordis is an electrophysiological event caused by precordial chest impact that occurs in individuals free from structural cardiac disease. The mechanism of SCD appears to be ventricular fibrillation that is produced when the chest impact is delivered within a narrow, electrically vulnerable period of the cardiac cycle [40]. Specifically, the susceptible time is during repolarization, just before the peak of the T wave. Resuscitation of these victims is possible with prompt cardiopulmonary resuscitation and defibrillation. A US commotio cordis registry has reported a 10% survival rate, with 2.8% experiencing full recovery [41].

5.8. Brugada syndrome

The Brugada syndrome, described as a syndrome of SCD caused by unpredictable episodes of recurrent ventricular tachycardia, is also postulated to be a possible etiology of death in this patient population. It is characterized as a syndrome of SCD in individuals with a structurally normal heart and no evidence of atherosclerotic coronary artery disease. Patients are noted (if identified before their event) to have a distinct set of ECG abnormalities that include a complete or incomplete right bundle branch block with ST-segment elevation in the right precordial leads. Originally thought to be a disease primarily of men from Southeast Asia, it is now identified in women, children, and non–Asian ethnic groups. Patients may present with self-terminating episodes of ventricular tachycardia during exertion. If the diagnosis is supported by ECG findings, referral should be made for EP testing and consideration of automated implantable cardiac defibrillator placement.

5.9. Atherosclerotic coronary artery disease

Acquired coronary artery disease is occasionally responsible for sudden death in young athletes. Atherosclerotic coronary artery disease is thought to be responsible for approximately 2% of SCD cases in young athletes [15]. However, atherosclerotic disease is responsible for the vast majority of SCD cases in mature athletes (>35) [6,23].

6. Medications

Sudden cardiac death has been attributed to proarrhythmic drugs such as epinephrine, ephedrine, cocaine, and related sympathetic medications. Deaths have also been linked to performance-enhancing agents such as erythro-
poietin and anabolic steroids [5,23]. Anabolic steroids may cause cardiac hypertrophy, myocardial fibrosis, and accelerated atherosclerosis that could promote cardiac necrosis and ischemia.

7. Emergency department management

The role of EPs is primarily to attempt resuscitation of patients experiencing SCD events. Although few athletes are electrocardiographically monitored at the time of death, most sudden deaths are thought to be caused by ventricular arrhythmias in the setting of an underlying heart disease. In one population of 16 athletes who survived cardiac arrest, 2 were found to have long QT syndrome, 5 had WPW syndrome, 8 had ventricular tachycardia or ventricular fibrillation, and 1 athlete had atrial fibrillation with heart block [42,43]. Treatment of these rhythms is established by advanced cardiac life support based on American College of Cardiology/American Heart Association recommendations and continued data from ongoing studies. Individuals experiencing successful resuscitation require a complete cardiac workup including echocardiogram, cardiac catheterization, and electrophysiological testing.

Emergency physicians should maintain a high index of suspicion when syncope or near-syncope occurs in the presence of exercise. Exertional syncope is a distinct red flag and all patients with this symptom should be excluded from participation until they have a complete cardiac evaluation. Likewise, the evaluation of athletes is similar to that of other patients with possible symptoms and signs of arrhythmic disorders. Symptoms of arrhythmias in athletes are similar to those in nonathletes and range from brief palpitations to syncope and resuscitated sudden death [42]. The key elements of the evaluation include the severity of the symptoms, the presence of structural heart disease, and the family medical history. In one study, 18% of athletes with SCD were known to have had symptoms judged to be cardiovascular in origin during the 36 months preceding death [15]. These symptoms included chest pain, syncope, exertional dyspnea, and dizziness. A family history of congenital heart disease, syncope, or unexpected death at an early age may indicate an underlying cardiac abnormality. The physical examination may elicit evidence of Marfan syndrome, aortic stenosis, MVP, HCM, or ILVH. When findings of the physical or historic evaluation suggest a syndrome associated with high risk for SCD, further diagnostic testing is necessary. This will include an ECG and usually an echocardiogram. Likewise, long-term ECG monitoring with a Holter monitor can be useful in patients who present with frequent or reproducible symptoms. Investigative work and further risk stratification will usually be performed or followed up by a primary care physician. Participation in high-risk sports activity should remain forbidden until this workup is complete.

8. Conclusion

Sudden cardiac death rarely occurs in athletes with a structurally normal heart. Therefore, an assessment for structural heart disease is essential in evaluating athletes with possible cardiac signs or symptoms. Because certain SCD patients will lack a history of symptoms and physical findings, not all patients at risk will be identified. However, by knowing how to guide history and physical examination, potential diagnostic clues may help identify most patients at risk for SCD. Once cardiac arrest has occurred in patients, most of them may initially appear the same and death may not be preventable. In many cases, however, warning symptoms, a suggestive family history, clinical findings, or underlying conduction abnormalities will be present.

References

Diagnostics

Electrocardiographic ST-segment elevation in the trauma patient: acute myocardial infarction vs myocardial contusion

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Abstract The diagnosis of myocardial contusion in the setting of blunt trauma engenders much discussion and controversy—partly because of the lack of a gold standard for its identification other than histologic findings at autopsy. Furthermore, blunt cardiac trauma represents a spectrum of disorders ranging from transient electrocardiographic change to sudden death from myocardial rupture; hence, no single terminology exists to define such a wide range of scenarios. Here, we present 2 cases of electrocardiographic ST-segment elevation after high-speed motor vehicle crashes resulting in numerous injuries, including blunt chest trauma. Both patients demonstrated electrocardiographic ST-segment elevation, resulting from myocardial contusion and acute myocardial infarction.

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1. Introduction

Blunt chest trauma may affect all of the thoracic organs, including the heart, with sequelae ranging from subclinical myocardial contusion to potentially life-threatening hemorrhage. These diverse injuries are classified into direct and indirect causes, as it relates to the mechanism of trauma and the physiologic response of the cardiovascular system. The electrocardiographic manifestations related to the insult can be equally diverse, ranging from a normal electrocardiogram (ECG) or subtle, inconsequential changes, to sudden cardiac death with ventricular fibrillation. The ECG, obtained by the clinician suspecting the potential for significant myocardial injury, should be interpreted within the context of the clinical situation. It must be stressed that the ECG is not the ultimate diagnostic tool in the evaluation of the patient with possible traumatic myocardial injury. In fact, the 12-lead ECG is rarely used in the vast majority of trauma patients.

The diagnosis of myocardial contusion engenders much discussion—this is partly because of the lack of a gold standard for its identification other than histologic findings at autopsy. Furthermore, blunt cardiac trauma represents a spectrum of disorders ranging from minor, transient electrocardiographic change to sudden death from myocardial rupture; hence, no single terminology exists to define such a wide range of scenarios (Table 1). Not surprisingly, incidence rates among trauma victims range from “negligible” to 76% [1,2]. Although moderate speeds have

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been implicated in the mechanism, these injuries often result from high-speed deceleration incidents. Other causes include sports injuries, falls, blast injuries, crush trauma, and direct blows to the chest. Mechanisms proposed to explain its evolution include sudden impaction and direct compression of the heart against the sternum and vertebrae, as well as intrathoracic transmission of increased intrathoracic pressure.

Blunt cardiac trauma encompasses a wide range of clinical entities. The most acute form, termed myocardial concussion, occurs when blunt injury to the anterior chest stuns the myocardium and produces a transient dysrhythmia, hypotension, or loss of consciousness. Within this class of disorders, commotio cordis refers to sudden cardiac death after low-impact chest trauma, usually secondary to ventricular fibrillation. The blow is thought to arrive at the vulnerable period of cardiac repolarization, causing the well-studied R-on-T phenomenon [3], and producing ventricular fibrillation.

Myocardial contusion has been used to define injuries including transient and persistent dysrhythmias, traumatic myocardial infarctions, cardiac rupture resulting in pericardial tamponade, mechanical complications including valve rupture or septal perforation, pericardial injuries, and damage to coronary arteries [4-10]. Histologic findings in the myocardium are often seen at autopsy, typically involving subendocardial hemorrhage associated with focal areas of edema, interstitial hemorrhage, and cytolysis.

Table 1  Clinical and electrocardiographic findings in blunt cardiac injury

(A) Prospective investigations

<table>
<thead>
<tr>
<th>Condition</th>
<th>Prospective studies (n=58)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventricular ectopy</td>
<td>40%</td>
</tr>
<tr>
<td>Supraventricular arrhythmia</td>
<td>36%</td>
</tr>
<tr>
<td>Symptomatic bradycardia</td>
<td>4%</td>
</tr>
<tr>
<td>Hypotension</td>
<td>4%</td>
</tr>
<tr>
<td>RV Thrombus</td>
<td>2%</td>
</tr>
<tr>
<td>Tamponade</td>
<td>7%</td>
</tr>
<tr>
<td>Conduction block</td>
<td>4%</td>
</tr>
</tbody>
</table>

(B) Retrospective investigations

<table>
<thead>
<tr>
<th>Condition</th>
<th>Retrospective studies (n=112)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventricular arrhythmia</td>
<td>67%</td>
</tr>
<tr>
<td>Supraventricular arrhythmia</td>
<td>11%</td>
</tr>
<tr>
<td>CHF</td>
<td>5%</td>
</tr>
<tr>
<td>Myocardial Infarction</td>
<td>5%</td>
</tr>
<tr>
<td>Hypotension</td>
<td>4%</td>
</tr>
<tr>
<td>Effusion/ Block/ Thrombus</td>
<td>8%</td>
</tr>
</tbody>
</table>

Fig. 1  Wide complex tachycardia consistent with monomorphic ventricular tachycardia.
Finally, traumatic myocardial infarctions are known. Reports of direct injury to coronary vasculature causing intimal tears, vessel rupture, and traumatic occlusion have attempted to explain the pathophysiology. More importantly, many of the cases of acute myocardial infarction (AMI) after blunt chest trauma have shown no injury to the coronary vessels at all, but occur as a result of severe, direct injury to myocardium itself. Clinical outcomes have varied from excellent to fatal, often determined by the presence of other injuries.

Short of autopsy, there is no gold standard for the diagnosis of myocardial contusion. The ECG, serum cardiac marker, and echocardiogram have been used in conjunction to identify these cases [11]. Other tests, including radionuclide scanning and computed tomography, have been used, but their utility has not been established [1,11].

Although various algorithms for the diagnosis and management of myocardial contusions exist, no single method has been chosen as a “best practice.” There remains no gold standard for the diagnosis of blunt myocardial injury. In the ED, diagnostic modalities are most important in attempting to differentiate low-risk patients who can be discharged safely home from those who may develop cardiac complications—the former being exceedingly more common than the latter. Among those diagnostic modalities studied are use of the history and physical examination, the ECG, serial cardiac markers, and the echocardiogram.

This report will review the electrocardiographic findings of traumatic myocardial injury. We present 2 cases of blunt trauma patients presenting with chest pain and electrocardiographic ST-segment elevation. The differential diagnosis of this electrocardiographic finding is similar to the nontrauma chest pain presentation, particularly concerning AMI and myocardial contusion.

2. Case presentations

2.1. Case 1

A 62-year-old man with a history of hypertension presented to the ED after a motor vehicle crash. The patient was the restrained driver of a small truck that suffered a head-on collision with a large tree at approximately 45 mph. Although there was significant damage to the front of the vehicle, the patient was able to self-extricate. The patient was transported by emergency medical services (EMS) to the ED. On arrival, the patient noted chest pain. Examination revealed an alert man with moderate distress; a strong odor of alcohol was present. The chest revealed bilateral breath sounds with tenderness in the mid-sternal area; the abdomen was tender in the right upper quadrant. While assessing the patient, a 20-beat run of ventricular tachycardia was noted (Fig. 1). A lidocaine bolus with infusion was started. A 12-lead ECG revealed prominent ST-segment elevation in the right to mid-precordial leads (Fig. 2). Rapid consultation was made to both trauma surgery and cardiology while appropriate radiographs and computed tomographic scans were performed. A bedside echocardiogram revealed hypokinesis of the right ventricle and the anterior wall of the left ventricle. The radiographic trauma evaluation was unremarkable. The patient was then taken...
emergently to the cardiac catheterization laboratory where normal coronary arteries with normal flow were noted. The patient was transferred to the intensive care unit and monitored. No further dysrhythmias were noted. The patient’s ECG demonstrated normalization of the ST-segment changes over the next 72 hours. Creatinine phosphokinase values were elevated with positive MM and MB fractions. The patient was discharged with a diagnosis of myocardial contusion.

### 2.2. Case 2

A 54-year-old man with a past history of angina presented to the ED via EMS with substernal chest pain after a single motor vehicle crash. The automobile struck a telephone pole at approximately 55 mph. The EMS evaluation revealed evidence of alcohol intoxication, a tender chest, and an electrocardiographic rhythm strip (V lead) demonstrating sinus tachycardia with prominent T-wave and ST-segment elevation (Fig. 3). Examination in the...
ED revealed an intoxicated man complaining of chest pain with chest tenderness. A 12-lead ECG demonstrated prominent T waves and early ST-segment elevation in leads V1 to V4 along with ST-segment depression in the inferior leads (Fig. 4). An expedited radiographic trauma evaluation was undertaken while both surgery and cardiology consultations were requested. The patient was taken to the catheterization laboratory. Left-ventricle catheterization revealed 90% proximal left anterior descending artery occlusion with thrombus. The ventriculogram showed hypokinesis of the anterior wall of the left ventricle; cardiac serum markers were elevated, confirming the diagnosis of acute myocardial infarction. The ultimate cause of the infarction was never determined—whether it resulted from the blunt injury to the coronary anatomy or a spontaneous acute coronary event—although the patient had noted new-onset intermittent chest discomfort (consistent with angina) over the preceding 2 weeks.

3. Discussion

The ECG has long been used as an initial diagnostic study in blunt trauma patients with chest pain. Maenza et al [1] conducted a large review of prospective and retrospective studies, concluding that abnormal electrocardiographic findings correlated directly with complications requiring treatment; these investigators noted that a normal ECG was associated with clinically insignificant injuries. Dysrhythmias were the most common manifestation, with sinus tachycardia (Fig. 3) present in up to 70% of patients with confirmed myocardial contusion [12]. Other electrocardiographic findings included nonspecific ST-segment–T-wave changes, ST-segment elevation and depression (Fig. 5), T-wave abnormalities (Fig. 6), atrioventricular and bundle branch blocks (Figs. 7 and 8), bradycardia, premature ventricular contractions, supraventricular tachycardias including nodal tachycardias (Fig. 9), atrial fibrillation and flutter, ventricular tachycardia (Fig. 2), and ventricular fibrillation (Fig. 10).

The electrocardiographic manifestations of cardiac trauma are diverse and very nonspecific. Blunt myocardial injury is seen not infrequently in the patient with blunt thoracic injury; one large study reported a 54% incidence of electrocardiographic abnormality in patients with blunt chest injury. Such injury may present electrocardiographically in many ways. The vast majority of electrocardiographic abnormalities were nonspecific with nonspecific ST-segment–T-wave changes predominating; the remainder of findings included conduction abnormalities, axis deviation, and dysrhythmias [13]. The most frequently encountered electrocardiographic pattern included sinus tachycardia with nonspecific ST-segment–T-wave changes—extremely nonspecific findings which are seen in many trauma victims, both with and without cardiac injury. Although less frequent yet more suggestive of myocardial injury, conduction system abnormality is another electrocardiographic sign of cardiac contusion, manifested most often by right bundle branch block followed by nonspecific intraventricular conduction delay. Significant ST-segment changes, including both elevation and depression, as well as T-wave

![Fig. 7](image7.png) Complete right bundle branch block.

![Fig. 8](image8.png) Second-degree, high-grade atrioventricular block in a hypotensive blunt trauma patient with myocardial injury.
abnormalities are also seen in blunt trauma patients with cardiac injury. The entire range of dysrhythmia is encountered; in the majority of such presentations, sinus tachycardia is the only dysrhythmia encountered followed by frequent premature ventricular contractions—these 2 dysrhythmias are very nonspecific and are more often encountered in trauma patients without significant blunt cardiac trauma. Blunt thoracic trauma may cause direct injury to the coronary arteries with spasm, dissection, or thrombosis; these events would all present with ST-segment–T-wave changes typical of an acute coronary event.

In the majority of penetrating thoracic trauma presentations, the ECG as a test has low priority in the initial stabilization and evaluation phase. If performed in this situation, the ECG may reveal ST-segment changes suggestive of acute coronary syndrome. A retrospective review of penetrating cardiac trauma revealed multiple patterns in the presenting ECGs, including repolarization changes in 35%, pericarditis in 27% of patients, and changes consistent with AMI in 10% [14]. Penetrating pericardial injury may also manifest changes consistent with pericardial effusion and cardiac tamponade (tachycardia, low voltage, or electrical alternans).

Other diagnostic studies, such as serum markers and echocardiography, are of value in the trauma patient. Cardiac serum marker measurements have a significant role in the diagnosis of cardiac contusion. Although earlier studies have previously discounted its benefit, emergence of the highly sensitive and specific troponin within the last decade has suggested that this test is more useful than creatinine kinase measurements. Although an elevated troponin does not definitively diagnose cardiac contusion, a normal troponin in a hemodynamically stable patient 6 hours after injury reliably excludes significant blunt cardiac injury [15]. Furthermore, when used in conjunction with a normal admission ECG, the combined negative predictive value approaches 100% [16]. As with the ECG, the decision to measure cardiac serum markers must be based upon the individual clinical presentation; it is anticipated that such testing will be rarely required.

Transthoracic echocardiograms have also been used to evaluate the presence and extent of cardiac injury. However, its use as a screening tool is greatly limited by its lack of immediate availability in the ED, high cost, and operator expertise. Although use of transthoracic echocardiograms in patients with known myocardial contusions is widely known, its utility in risk stratifying blunt chest trauma patients with possible cardiac injury has been consistently inconclusive [1]. Combined with the aforementioned diagnostic screening tests, however, the TEE becomes very useful as a secondary study for evaluating the extent of myocardial damage.

Dysrhythmias remain the most common complication of myocardial contusion. These range from the frequently benign sinus tachycardia, atrial fibrillation, and premature ventricular contractions to the more ominous ativoventricular and intraventricular blocks and ventricular dysrhythmias. These dysrhythmias may be transient or long-term. It is thought that injuries to the anterior left side of the chest predominantly induce ventricular rhythm disturbances, whereas injuries to the right side of the chest produce sinoatrial or ativoventricular conduction disorders [17]. Given its anatomical position, the right ventricle appears more susceptible to blunt injury, in some reports twice as frequently injured, than the left ventricle [2].

Although relatively uncommon, myocardial infarction can result from blunt chest trauma. Retrospective reviews show an incidence of approximately 5% among patients with significant blunt chest injury [1]. Multiple mechanisms
have been reported, including complete occlusion [10,12,17,18] or direct injury to coronary vasculature [5]. Meluzin reports the occurrence of myocardial infarction diagnosed 3 weeks after a multitrauma patient’s discharge from the hospital, with cardiac catheterization later showing a ruptured coronary artery as culprit [5]. More common, however, is the finding of normal coronaries in patients with ST-segment elevation after blunt chest trauma, supporting the diagnosis of myocardial contusion [8,9,17].

Treatment of a patient with suspected myocardial contusion remains supportive [19,20]. In cases when myocardial infarction is suspected (ie, ST-segment elevation is observed), coronary angiography with potential angioplasty is the preferred method of evaluation and management. Thrombolytic agents are contraindicated in the setting of acute trauma [12]. Dysrhythmias are treated with appropriate medications. As yet, there is no role for prophylactic medications to suppress dysrhythmias; however, measures should be taken to treat and prevent conditions that increase myocardial irritability (ie, metabolic acidosis or electrolyte imbalance) [12]. When cardiogenic shock is present, judicious intravenous fluids should be administered, followed by appropriate vasopressors and inotropes as indicated.

4. Conclusion

With the absence of a gold standard for diagnosis, myocardial contusion remains an elusive entity. Admission electrocardiogram and cardiac enzyme measurements have been shown to correlate with the presence of cardiac injury, and those with normal results on admission may be discharged safely to home in the absence of comorbid injury or hemodynamic instability. Myocardial infarctions can occur after blunt chest trauma, and immediate treatment in the catheterization laboratory is advocated rather than anticoagulating the patient who is at high risk for exsanguination. Finally, ST-segment elevation has many etiologies, and the emergency physician must be astute in recognizing acute injury in the appropriate clinical setting [21].

References


Diagnosis of periorbital gas on ocular ultrasound after facial trauma

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Abstract Ocular trauma can occur from isolated facial trauma or in major blunt trauma such as motor vehicle accidents or falls. Despite the etiology of the injury, a thorough evaluation is important but may often be difficult if severe swelling is present. Recently, emergency ultrasound has seen the use of ocular ultrasound to evaluate visual changes and trauma. Literature suggests that unsuspected and difficult to diagnose pathology may be easily detected on ultrasound of the orbit. We present 3 cases of isolated facial trauma in which routine evaluation with ocular ultrasound led to the discovery of periorbital air with one patient having air insufflating the upper lid of the affected side.

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1. Introduction

Facial trauma is seen as a result of multiple etiologies in the emergency department. Drivers involved in motor vehicle crashes who chose not to restrain themselves are more likely to suffer head and subsequent facial injury. However, a new safety restraint introduced into most cars over the last decade, the airbag, itself is responsible for facial injury in persons sitting too close to the dash. Although brain injury is frequently of greatest concern for the evaluating emergency physician, injury to the facial bones, orbits, or eyes requires immediate attention as well.

Typically, head and facial injury is now evaluated using computed tomography (CT). This has largely replaced both the wait-and-see approach to head injury of the past as well as plain films to evaluate for occult skull and facial bone fractures. However, when significant head injury is not suspected, CT may not be ordered and unsuspected facial injuries could be missed. The eye can be particularly difficult to examine as the patient may experience significant pain and swelling. Previous work has shown that emergency physicians are able to accurately diagnose ocular pathology with ultrasound with little or no physical evaluation of the eye being required initially [1].

We present 3 cases of periorbital air diagnosed on bedside ultrasound. In all cases, manipulation of the lids was difficult and the extent of injury found on ultrasound was not suspected clinically. Computed tomography, not initially planned for in these cases, was ordered and confirmed orbital fractures.

2. Case 1

MH is a 24-year-old woman who was dancing in a club and was punched in the left eye by an unseen attacker 8 hours before presentation. The patient suffered no loss of consciousness and continued to dance. When she returned
home and fell asleep, she noticed increasing swelling and ecchymosis of the left eye but had no complaints of visual deficits. Upon awakening 5 hours later, she noticed severe orbital swelling and thought she noticed increased swelling of the upper eyelid after sneezing. On presentation, the patient had normal and stable vital signs. The left lid was swollen and ecchymotic. Retraction of the upper lid was difficult without significant manipulation because of the swelling (Fig. 1). A bedside ultrasound examination was performed to evaluate for globe injury and traumatic retinal detachment. The globe could only be visualized through the inferior aspect of the lower lid because of soft tissue gas in the upper lid of the patient’s eye (Fig. 2). The globe itself appeared intact and no evidence of retinal detachment was noted. A facial CT was ordered, which revealed fractures of the medial wall of the left orbit through the lamina papyracea. After ophthalmology consultation, the patient was started on prophylactic antibiotics and managed conservatively with clinic follow-up.

3. Case 2

WT is a 21-year-old man who was kicked in the left eye 2 hours before presentation. He denied loss of consciousness but did complain of generalized headache as well as left eye pain and blurry vision. He recalled having a bloody nose. Presenting vital signs were normal. Initial physical exam was remarkable for moderate orbital swelling and conjunctival injection in the affected eye. Visual acuity was 20/40 in the left vs 20/20 in the right. A moderate hyphema was present in the left eye. Pupils were equal and reactive and extraocular muscles were grossly intact. Fundoscopic exam was normal.

Bedside ultrasound examination demonstrated no evidence of retinal detachment; however, retroorbital gas was seen (Fig. 3). Head and orbital CT confirmed left lamina papyracea fracture with ethmoid air cell opacification and extensive left orbital emphysema and proptosis. The patient was seen by ophthalmology in the emergency department. He was instructed to avoid heavy lifting or nose blowing and to sleep with the head of the bed elevated. Eye drops were prescribed as well as prophylactic oral antibiotics. He was seen in follow-up in ophthalmology clinic for several weeks and was eventually discharged.

4. Case 3

CN is a 24-year-old man who was a restrained driver involved in a head on motor vehicle crash at moderate...
5. Discussion

Ocular trauma is frequently evaluated in the emergency setting and is often the result of isolated facial trauma or blunt trauma such as from motor vehicle accidents or falls. Although early recognition and treatment of orbital injuries is important, they are often difficult to evaluate and occult fractures may still be missed despite a thorough physical examination. Clinical findings of orbital fractures such as decreased eye motility, diplopia, and palpable crepitus due to subcutaneous emphysema may not always be present or detectable. Furthermore, severe swelling of the eye or facial tissues may further complicate initial examination [2].

The role of CT scanning in the diagnosis and management of orbital injuries is well documented. Thin-section coronal CT is typically regarded as the “gold standard” imaging method of midface fractures and orbital trauma. But even CT is not perfect and has resulted in false negatives and false positives in studies investigating orbital trauma using periooperative findings as a reference method [3]. Coronal CT evaluation also requires adequate patient positioning that may not be possible given coexisting injuries such as an unstable cervical fracture [4]. Furthermore, in the less traumatic scenario, orbital injury may not be suspected and therefore CT scan may not be ordered at all. The reasonable clinician may opt to forgo the extra expense and radiation dose that a CT may present to the patient if the physical examination or mechanism of injury fails to raise adequate suspicion for orbital injury.

Ultrasoundography has been used by ophthalmologists for decades in the diagnosis, evaluation, and treatment of various ocular diseases and injuries. However, in recent years, emergency physicians have used ultrasound as an effective tool in the evaluation of the smaller structures of the eye in the emergency setting, screening for such conditions as vitreous hemorrhage, retinal detachment, central retinal artery/vein occlusion, and globe rupture [1]. Ultrasound is also a useful modality in the evaluation of orbital trauma. The bony orbit is especially well suited to ultrasound imaging. The markedly different acoustic impedances of bone and soft tissue in the orbit make the orbital margins highly visible [4]. Described first in 1981, Ord et al [5] applied B-mode scanning ultrasound in the evaluation of orbital wall defects. Since then, the use of ultrasound as a reliable method in the diagnosis of orbital fractures is well described [3,6-9]. The findings of Forrest et al [6] suggest that high resolution ultrasound can diagnose orbital wall fractures and orbital emphysema with 94% correlation with axial and coronal CT images. In comparisons of ultrasound in the detection of orbital fractures vs CT as the standard, recent studies report sensitivity from 85% to 92% and specificity and positive predictive value of 100% [4,6]. Newer studies describe the use of curvilinear transducers, formally used for intraoral applications, for improved fitting and scanning of the anatomic structures of the orbital rims [10,11].

In the cases above, routine bedside ultrasound proved a useful adjunct in diagnosing facial fractures when clinical suspicion was low. In case 1, the presence of severe eyelid swelling made it difficult to satisfactorily examine the patient. The detection of orbital emphysema on bedside ultrasound led to further CT evaluation. The air was not immediately under the skin but rather toward the inner portion of the swollen lid. This caused us to miss the presence of air on mild palpation of the eyelid. The patient in case 2 had been kicked in the eye and had a relatively benign eye examination. Until the presence of retroorbital air was detected on ultrasound examination, CT examination had not been planned for. Likewise, the patient in case 3 had a fairly normal eye exam and the decision to obtain a CT was made only after the finding of retroorbital air on ultrasound. In the above cases, CT was not initially planned because of low clinical suspicion based upon physical examination and mechanisms of injury. Routine bedside ultrasound evaluation of the eye, however, demonstrated the presence of periobital air that prompted further evaluation by CT imaging that revealed orbital wall fractures.

In the future, ultrasound may become more widely used in the screening, diagnosis, and treatment of various ocular diseases and injuries in the emergency department. It already holds some advantages to CT in that it is less expensive and may be conducted at the patient’s bedside. Ultrasound is a widely available diagnostic modality without the associated radiation load of CT. Its use may be justified as an adjunct to physical examination when clinical suspicion of orbital wall fracture is low and CT may not otherwise be practical or clinically warranted.
References


Purple urine bag syndrome

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Abstract The purple urine bag syndrome (PUBS) is a rare condition associated with chronic urinary catheterization. It is characterized by the purple discoloration of the urine, collecting bag, and tubing. A number of factors are involved, but not always present, in its development including female sex, urinary tract infection, constipation, indicanuria, and alkaline urine. Despite multiple theories that involve the complex tryptophan metabolism to the tubing dye, the cause remains elusive. The syndrome resolves usually after treatment of urinary tract infection or changing of the collecting bag. We present a case of a patient with purple urine bag syndrome and a pertinent literature review.

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1. Introduction

The purple urine bag syndrome (PUBS) is a term that has been used to describe the purple discoloration of the collecting bag and tubing. The PUBS occurs predominantly in elderly women who are bedridden, chronically catheterized, and constipated and has also been described in patients with ileal diversions [1-3]. This condition appears hours or days after catheterization and has been related to indicanuria and urinary tract infection caused by indican (indoxyl sulfate) degrading bacteria [1-8].

Many hypotheses as to the etiology of this phenomenon have been formulated; most of them have not been proven to apply to all the patients reported in the literature [9-12]. We report a case of PUBS with absence of some of the typical features previously described.

2. Case report

We report on a 72-year-old gentleman who is bedridden, chronically debilitated, and a nursing home resident with a past medical history of chronic renal failure, cerebral vascular accident, hypertension, advanced Parkinson’s disease, and the requirement for a chronic indwelling urinary catheter. The patient was brought from a nursing home to the emergency department because he was found to be lethargic and had recent purple discoloration of his urine. A review of his medications failed to disclose any pharmacological agent that could cause urine discoloration but included an alkalinizing agent, sodium citrate and citric acid (Bicitra), to manage his chronic renal tubular acidosis. Upon arrival to the emergency department, purple discoloration of the urine bag and tubing was found (Fig. 1).

On physical examination, the patient was found to be hypotensive with a blood pressure of 70/50 mm Hg, afibrile, and lethargic and the urinary bladder was found...
to be distended above the umbilicus despite the presence of a urinary catheter.

His urinary analysis revealed a pH of 9.0, too-numerous-to-count white blood cells per high power field, positive leukocyte esterase, negative nitrites, red blood cells 20 to 25 per high power field, and marked bacteria. His urine culture grew more of 100,000 colonies of *Escherichia coli*. Urine indican and serum tryptophan were tested and there was no indicanuria (not detected in qualitative method), and the serum tryptophan level was 23 μmol/L (20-95 μmol/L). Ultrasound of the urinary bladder and kidneys revealed findings suggesting chronic bladder outlet obstruction, with presence of echogenic sediment in a distended urinary bladder and hydronephrosis. After changing the bladder catheter, frank pus drained from the bladder. The second collecting bag also turned purple.

A diagnosis of severe sepsis secondary to pneumonia and urinary tract infection was made; the patient was treated with piperacillin/tazobactam for the first 3 days and with levofloxacin for 14 days. After receiving antibiotic treatment, his urine bag did not become purple again. The patient improved clinically, returning to his baseline mental status, and was transferred back to the nursing home after 8 days of hospitalization (Fig. 2).

3. Discussion

The purplish or bluish discoloration of urine collecting bags was first described by Barlow and Dickson [1] in 1978 when they reported the classic discoloration of the disposable bags of children with spina bifida and urinary diversions. These authors assumed that the discoloration was secondary to the presence of indigo blue as identified by spectrophotometric analysis [1]. Their article described the presence of indigo to the metabolism of tryptophan in the setting of intestinal obstruction and constipation that undergoes bacterial decomposition to indoxyl sulfate (indican) and is then excreted to the urine, which, if exposed to the air, becomes oxidized into indigo blue.

Months later, Sammons et al [2] and Payne and Grant [3] recognized the basis for the long-standing theory that has prevailed. They described that this phenomenon is infrequent but not entirely unobserved and found this phenomenon in 5 elderly female patients with indwelling catheters of whom one was incontinent and the rest were constipated and all had indigo blue in the urine. Indicanuria was again suggested and the presence of blue discoloration happened with the addition of an oxidizing agent such as sodium hypochlorite. These authors also considered that alkaline urine favors the deposition of indigo; chronic urinary tract infection with *Pseudomonas aeruginosa* and/or *Proteus* spp was present in all the patients [2,3].

The PUBS was associated with the blue diaper syndrome described by Drummond et al [13] in 1964 and has been frequently cited as an explanation of the metabolism and intestinal transport of tryptophan as the cause of indicanuria that was correlated with blue discoloration of the diaper [2,5-9].

Hildreth and Cass [5] described 5 cases of asymptomatic discoloration of blue collecting bags in children with ileal diversion, all related with urinary tract infections (only mentioned *E coli* in one patient), of whom only 2 were tested and had indicanuria. Hinberg et al [6] described the process by which the purple discoloration of the urine was secondary to highly alkaline urine in contact with the plastic in the bags, after which the dye used to eliminate the yellow tint of the bag discolors the urine. In a similar observation, Pankau [7] placed indoxyl sulfate (indican) in a plastic tubing for 72 hours, after which it became oxidized and discolored the tubing to purple and the solution became colorless. Years later, Wagner and Joyner [8] described the process by which tryptophan is converted to indole by mixing enteric indole-producing bacteria with an enriched tryptophan media in the presence of liver enzyme extracts obtaining indigo blue pigment.

Fig. 1 Purple discoloration of the urinary catheter plastic tubing and bag.

Fig. 2 Foley catheter and tubing after removal.
More recently, Stott et al [9] described 3 elderly female patients with PUBS, all of whom had alkaline urine, concluding that the bacterial pathogens had no relation with the PUBS, that indicanuria is not a prerequisite, and that the blue diaper syndrome has possibly a different etiology than PUBS. Moreover, these investigators proposed that the structure of the dye suggests a steroidal or bile acid conjugate.

The PUBS has been associated with *Providencia stuartii*, *Klebsiella pneumoniae*, and *Enterobacter agglomerans*, bacteria with the ability to produce indigo [10,11].

Nobukuni et al [12] described that indicanuria is not a requirement for PUBS. Other investigators have shown that the activity of bacterial indoxyl sulfatase, which catalyzes the conversion of indican into indigo blue, was present only in strong alkaline urine [13-15].

Nakayama and Kanmatsuse [16] reported lower serum levels of tryptophan and valine in patients with PUBS, suggesting abnormal absorption of amino acids secondary to colonic dismotility and intestinal bacterial overgrowth.

As noted before, multiple bacteria have been isolated in the urine in several case reports of PUBS, some with known sulfatase and phosphatase activities but the rest without it.

The presence of alkaline urine is a common characteristic in most cases [3,5,8,9,17-24] (Table 1).

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Bacteria isolated in urine of some patients with PUBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcaligenes spp</td>
<td>Klebsiella ozaenae</td>
</tr>
<tr>
<td>Bacteroides spp</td>
<td>Klebsiella pneumoniae</td>
</tr>
<tr>
<td>Citrobacter diversus</td>
<td>Morganella morganii</td>
</tr>
<tr>
<td>Citrobacter freundii</td>
<td>Proteus mirabilis</td>
</tr>
<tr>
<td>Citrobacter koseri</td>
<td>Proteus vulgaris</td>
</tr>
<tr>
<td>Enterobacter aerogenes</td>
<td>Providencia rettgeri</td>
</tr>
<tr>
<td>Enterobacter agglomerans</td>
<td>Providencia stuartii</td>
</tr>
<tr>
<td>Enterobacter cloacae</td>
<td>Pseudomonas aeruginosa</td>
</tr>
<tr>
<td>Enterococcus avium</td>
<td>Pseudomonas spp</td>
</tr>
<tr>
<td>Enterococcus faecalis</td>
<td>Serratia marcescens</td>
</tr>
<tr>
<td>Escherichia coli</td>
<td>Staphylococcus epidermidis</td>
</tr>
<tr>
<td>Klebsiella oxytoca</td>
<td>Streptococcus agalactiae</td>
</tr>
</tbody>
</table>

It is interesting to note that PUBS usually occurs in patients in geriatric wards and that in most of these patients, common occurrences include alkaline urine and female predominance. No specific cause has been found. The PUBS has not been observed in short-term care facilities and has been associated with “hospital infection” transmitted by staff. There is no causative relationship between PUBS and bacteria strains, but bacterial counts are significantly higher in PUBS patients. Indican is present in the urine of healthy people, and the measurement can be hindered by sampling errors [24,25].

Of interest is the presence of this syndrome in patients with ileal diversion and urostomies having, in different degrees, the presence of hyperchloremic metabolic acidosis secondary to loss of bicarbonate through the ileal or sigmoid pouch. This evidently increases the urinary pH, which will increase even more if an infectious process is added [26,27]. In our patient, the renal loss of bicarbonate in addition to the infectious process created highly alkaline urine.

Since its description, the cause of PUBS has not been consistently proven, it remains to be elusive. Ultimately, the PUBS appears to be a benign condition. It has not been demonstrated to have any implication other than the possibility of a urinary tract infection and has not been proven to change the prognosis of patients. Clinicians dealing with patients who have indwelling bladder catheters need to be aware of this condition.

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**References**


Chest radiograph screening for severe acute respiratory syndrome in the ED

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Abstract The purpose of the study was to evaluate the use of chest radiography for the screening of severe acute respiratory syndrome (SARS). We retrospectively analyzed all patients who attended an Emergency Department SARS screening clinic during the outbreak in Hong Kong, from March 10 to June 5, 2003. Patients with clinical and epidemiologic suspicion of SARS were evaluated by serial chest radiography. All radiographs were reported by consensus from 2 radiologists, blinded to the clinical records. The prevalence of SARS was 13.3\% among 1328 patients included. The initial radiograph had sensitivity 50.3\%, specificity 95.0\%, positive likelihood ratio 10.06, negative likelihood ratio 0.52, positive predictive value 61.5\%, and negative predictive value 92.3\% for diagnosing SARS. Serial chest radiography had sensitivity 94.4\%, specificity 93.9\%, positive likelihood ratio 15.48, negative likelihood ratio 0.06, positive predictive value 71.4\%, and negative predictive value 99.0\%. The initial chest radiograph has poor sensitivity, and serial radiographs are required to rule out SARS.

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1. Introduction

The resurgence of severe acute respiratory syndrome (SARS) has been a topic of much interest. During April 22 to 29, 2004, the Chinese Ministry of Health reported a total of 9 new cases of SARS in China; 7 of the patients were from Beijing and 2 were from Anhui Province, located in east-central China. In January 2004, 4 confirmed cases were reported in Guangdong Province, southern China. The likely reemergence of this disease in Hong Kong has pressurized frontline health care workers, especially those working in EDs. The ED has to assume the challenging role of administering a rapid and accurate screen for SARS, at the same time of carrying out appropriate containment and infection control measures. Because of the high infectivity and high mortality nature of SARS, prompt diagnosis is...
essential. However, early clinical features of SARS are often nonspecific, and investigations have shown that screening at the ED is aided by laboratory and radiographic investigations [1-6]. Various symptom scores and associated prediction rules, applicable to the ED setting, have recently been derived and validated, and reported in emergency medicine literature [2,4,5]. This study mainly focuses on the use of chest radiography as a screening tool.

It is recognized that chest radiography plays an important role in the diagnosis of SARS [1,3,4,7-22]. At fever onset, almost 80% of patients with SARS had abnormal chest radiographs [9]. However, the sensitivity and specificity of chest radiography before fever onset and at early stages of the disease is not known. Chest radiographic abnormality may precede lower respiratory tract symptoms in some patients with SARS [3,22]. For suspicious cases of SARS with initially normal chest films, repeating chest radiography every 1 to 3 days is likely to increase the yield [20]. However, as yet, this subject has also not seen investigated in detail.

During the outbreak of SARS in Hong Kong that started in March 2003, the ED of Prince of Wales Hospital operated a screening center to evaluate patients with epidemiologic and clinical suspicion of SARS. The authors retrospectively analyzed all cases that were screened at the ED and followed up at the SARS review clinic. These cases included patients who were severely ill at presentation, as well as those who presented to the ED at an early stage of the illness. The prevalence of SARS in this setting was 13.3%.

The objectives of this study were:

1. To calculate the sensitivity, specificity, predictive values, and likelihood ratios of chest radiography in predicting SARS, as used in an ED-based screening clinic during a community outbreak;
2. To study the duration in days (i) since onset of symptoms and (ii) since initial presentation for plain chest radiography to develop abnormal changes consistent with SARS;
3. To report the yield and performance of chest radiography from screening patients who presented (i) without fever (temperature not exceeding 37.5°C) and (ii) with temperature not exceeding 38°C.

### 2. Methods

#### 2.1. Study design

This was a retrospective cohort study of the use of ED plain chest radiography in the diagnosis of SARS. All patient information remained confidential. The chief executives and associated institutional review boards of the Hospital Authority of Hong Kong and of the Prince of Wales Hospital approved the collection of clinical data for surveillance, analysis, research, and reporting.

#### 2.2. Study setting and population

The study was performed on all patients who attended the SARS screening clinic based in the ED of a 1400-bed university teaching hospital, during the outbreak in Hong Kong from March 10 to June 5, 2003. Patients during the early part of this period were triaged for assessment at the screening clinic (a designated section of the ED) if they had respiratory tract symptoms, influenza-like illness, or fever, together with a contact history. During the later stages, when the outbreak had become more widespread in Hong Kong, patients with the above-mentioned symptoms, even without a definite contact history, were triaged for assessment at the clinic. Patients were followed up at the clinic every 1 to 3 days until either hospitalization was required or until follow-up was no longer necessary because of satisfactory resolution of symptoms. Serial frontal chest radiography was performed at follow-up visits.

#### 2.3. Data collection

Patients’ medical records from the ED were retrieved and reviewed by a research nurse who extrapolated clinical and demographic details into a database. The record of patients’ body temperature during attendance was included in the collation.

#### 2.4. Interpretation of radiographs

Every ED chest film was retrospectively read by 2 of 3 radiologists (W-HN, P-NC, and K-KS) who were blinded to all clinical records. The radiologists had knowledge of the dates when the radiographs were taken and were allowed to evaluate serial chest films of each patient chronologically.

### Table 1 The performance of the initial chest radiograph in diagnosing SARS

<table>
<thead>
<tr>
<th></th>
<th>SARS</th>
<th>Non-SARS</th>
<th>Total number of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test (chest radiography) positive</td>
<td>True positive (A) = 88</td>
<td>False positive (B) = 55</td>
<td>With positive radiograph (A + B) = 143</td>
</tr>
<tr>
<td>Test (chest radiography) negative</td>
<td>False negative (C) = 87</td>
<td>True negative (D) = 1043</td>
<td>With negative radiograph (C + D) = 1130</td>
</tr>
<tr>
<td>Total number of patients</td>
<td>With SARS (A + C) = 175</td>
<td>Non-SARS (B + D) = 1098</td>
<td>(A + B + C + D) = 1273</td>
</tr>
</tbody>
</table>

Sensitivity = A/A + C = 50.3%,
Specificity = D/B + D = 95.0%,
The presence of airspace opacification was regarded as test positive for SARS. Using a structured pro forma, the 2 radiologists reported in consensus whether each radiograph was normal, suspicious, or positive. After the review of serial chest radiographs of each patient, the overall impression was also reported.

### 2.5. Outcome measure

The final diagnosis of SARS was based on the official list of patients recorded in the Hong Kong Department of Health’s SARS registry. This list had been prepared by public health experts in Hong Kong, according to the recommendations of the World Health Organization on interpretation of laboratory results for the diagnosis of SARS. The SARS-associated coronavirus (SARS-CoV) antibody status of these patients (immunoglobulin G levels measured by immunofluorescence assay) was also documented for reference.

### 2.6. Data interpretation and analysis

Descriptive statistics were generated. The performance of chest radiography was assessed by analyzing (i) the chest radiograph at the initial presentation and (ii) the overall conclusion after review of serial chest radiographs, in correlation with the final diagnosis. Reports that were suspicious were regarded as indeterminate and excluded from the analyses. Data were analyzed using Statview for Windows version 5.0 Statistical Analysis Software (Abacus Concepts, SAS Institute, Cary, NC) and MedCalc version 7.0 (MedCalc, Belgium).

### 3. Results

There were a total of 1378 consecutive patients during the study period. Fifty patients (3.6%) were excluded because their chest radiographs were unavailable for radiologists’ review. Of 1328 cases included for analysis, 38.7% were males and 61.3% females. The mean (SD) age was 38.4 (17.0) years. There were 177 cases with final diagnosis of SARS, and the prevalence in this setting was thus calculated to be 13.3%. The SARS-CoV antibody status was positive in 171 patients (96.6%) of those diagnosed with SARS in our study.

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**Table 2** The performance of serial chest radiography in diagnosing SARS

<table>
<thead>
<tr>
<th>SARS</th>
<th>Non-SARS</th>
<th>Total number of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test (chest radiography) positive</td>
<td>True positive (A) = 167</td>
<td>False positive (B) = 67</td>
</tr>
<tr>
<td>Test (chest radiography) negative</td>
<td>False negative (C) = 10</td>
<td>True negative (D) = 1034</td>
</tr>
<tr>
<td>Total number of patients</td>
<td>With SARS (A + C) = 177</td>
<td>Non-SARS (B + D) = 1101</td>
</tr>
</tbody>
</table>

Sensitivity = A/A + C = 94.4%.
Specificity = D/B + D = 93.9%.

The reports on the initial chest radiograph were indeterminate in 55 patients (4.1%). After excluding these from the analysis, the initial chest radiograph had a sensitivity of 50.3% (95% confidence interval [CI], 42.6-57.9), specificity of 95.0% (95% CI, 93.5-96.2), positive likelihood ratio of 10.06, negative likelihood ratio of 0.52, positive predictive value of 61.5%, negative predictive value of 92.3%, and an accuracy of 88.8% for predicting SARS (Table 1).

The reports on serial chest radiography were indeterminate in 50 patients (3.7%). After excluding these from the analysis, serial chest radiography had a sensitivity of 94.4% (95% CI, 89.9-97.3), specificity of 93.9% (95% CI, 92.3-95.3), positive likelihood ratio of 15.48, negative likelihood ratio of 0.060, positive predictive value of 71.4%, negative predictive value of 99.0%, and an accuracy of 93.9% for predicting SARS (Table 2).

**Table 3** The performance of serial chest radiography in identifying SARS in patients who presented with a temperature (i) ≤37.5°C and (ii) ≤38°C

<table>
<thead>
<tr>
<th>Disease prevalence</th>
<th>Presenting temperature ≤37.5°C</th>
<th>Presenting temperature ≤38°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease prevalence</td>
<td>9.1%</td>
<td>10.8%</td>
</tr>
<tr>
<td>Sensitivity (%)</td>
<td>90.7% (95% CI, 81.7%-96.1%)</td>
<td>92.8% (95% CI, 86.3%-96.8%)</td>
</tr>
<tr>
<td>Specificity (%)</td>
<td>96.0% (95% CI, 94.4%-97.3%)</td>
<td>95.6% (95% CI, 94.1%-96.9%)</td>
</tr>
<tr>
<td>Positive likelihood ratio</td>
<td>22.79</td>
<td>21.27</td>
</tr>
<tr>
<td>Negative likelihood ratio</td>
<td>0.010</td>
<td>0.08</td>
</tr>
<tr>
<td>Positive predictive value (%)</td>
<td>69.4</td>
<td>72.0</td>
</tr>
<tr>
<td>Negative predictive value (%)</td>
<td>99.0</td>
<td>99.1</td>
</tr>
</tbody>
</table>
For patients who have SARS with positive radiograph (n = 167), the mean (SD) duration from onset of symptoms to positive radiograph was 5.8 (5.4) days. Seventy-nine (47.3%) of these patients had negative or indeterminate chest radiographs at initial presentation, and the mean (SD) duration from initial presentation to positive chest radiograph was 5.4 (6.3) days.

Of 829 patients who initially presented with a temperature of 37.5°C or lower, serial chest radiographs identified 98 (11.8%) positive cases. Of these, 68 (69.4%) were finally diagnosed with SARS. Of 1028 patients who initially presented with a temperature of 38°C or lower, serial radiographs identified 143 (13.9%) positive cases. Of these, 103 (72.0%) were finally diagnosed with SARS. The performance of serial chest radiography in identifying SARS in these 2 categories of cases is shown in Table 3.

4. Discussion

The resurgence of SARS and its propensity to spread rapidly across international borders continue to cause concern for public health authorities worldwide. Recent cases linked to exposures at research laboratories have prompted concerns particularly to countries with laboratories working with live SARS-CoV. The US Centers for Disease Control and Prevention continues to update its guidelines and recommendations for the clinical evaluation of possible SARS-CoV disease [23]. Much has already been published about the etiology, diagnosis, clinical features, and treatment of this illness. Several authors investigated the early predictors of SARS in the ED setting [1,3,22], whereas others have reported the derivation and validation of symptom scores or prediction rules [2,4,5]. The chest radiographic features of SARS have also been extensively studied, and the most consistent initial sign is reported to be airspace opacities or shadowing [7-22]. Radiographic evidence is also an essential element of the case definition [24]. Most authorities would regard the chest radiograph as a very sensitive screening test for diagnosing SARS. However, unfortunately, most studies were based on patients who were already hospitalized, with a high probability of the diagnosis [7,9,12-16,18-20]. Very few looked at the use of chest radiography as an independent screening test in the ED setting, and few were able to report its performance objectively. Only by studies directed at the screening level can full details about “true negatives” and “false negatives” of the test be captured. For those investigators who did study at the screening setting, their studies were limited by the fact that chest radiographs were read by ED physicians who were not blinded to clinical details [1-4]. Therefore, despite the use of multivariate analyses to identify independent associations, their results need to be interpreted with the understanding that any merit identified for the accuracy of chest radiography might have been exaggerated because radiographs were interpreted with a beneficial knowledge of the patients’ clinical status. As far as we are aware, our study was the first to investigate the performance of chest radiography as an independent diagnostic test.

Our study found that the sensitivity (50.3%) of the initial chest radiograph was much lower than most authorities would expect. This result has important practical implications. Clinicians ought to be careful not to be falsely reassured by an initially negative chest film. The false-negative rate is high in this setting. Previous anecdotal reports suggested that the chest radiograph could be normal at first presentation [25]. Our results confirmed this possibility, and we report the incidence of its occurrence at our ED screening clinic (Table 1). In contrast, the sensitivity of serial chest radiography in our study was 94.4%, which is a marked improvement from the former. Only by close follow-ups with serial chest radiography and clinical reassessment can the condition be more confidently excluded. Hence, our study lends evidence to the statement that chest radiography is highly sensitive for SARS, but only in the context of interpretation of serial radiographs, instead of the initial screening chest film. The negative predictive value (the probability that the patient is disease-free if the test is negative) of serial chest radiography was 99.0%. The negative likelihood ratio of 0.06 also shows that it is a strong negative predictor. Serial chest radiography is thus extremely useful in ruling out SARS in the setting of a community outbreak.

It is also important to be aware of the specificity of chest radiography for predicting SARS in this setting. The initial radiographic appearance of SARS is not readily distinguishable from pneumonia caused by other etiologic agents [8]. Earlier reports suggest that the changes associated with SARS more commonly involve the lower zone and peripheral lung fields, and that features of cavitation, lymphadenopathy, and pleural effusion are rare [8,12,16-19]. However, the initial appearance and distribution of the airspace disease is also reported to be highly variable, and may be normal, unifocal, multifocal, bilateral, or even extensive [8,12-14,18,19]. Moreover, the cause of airspace opacification is not limited to infection. It may also be caused by the presence of fluid, such as in pulmonary edema. Because patients with clinical and radiographic evidence of SARS require hospitalization with full isolation measures, a low specificity (high false-positive rate) at the screening level would likely result in rapid overwhelming of the hospital system. Few of the earlier studies were able to report on the specificity of chest radiography because few were conducted at the screening level, with a database inclusive of the “true-negative” cases. The specificity is dependent upon the prevalence of other causes of pneumonia during the study period. Nevertheless, our study demonstrated that, despite the concerns mentioned above, the specificity of chest radiography under our setting was excellent, being above 90% for both the initial radiograph and serial chest radiography. The positive likelihood ratio for serial chest radiography was 15.48, showing that it is a
strong positive predictor, capable of generating conclusive changes in post-test probability.

Furthermore, our study revealed that there was considerable yield in screening afebrile patients, or patients with low-grade fever, with serial chest radiography. The 2 temperature cutoffs of 37.5°C and 38°C were chosen for analyses because these values were most often taken as inclusion criteria for triage to “fever clinics” or “SARS screening clinics” in many institutions around the world during the outbreak. Certain recently published prediction rules or novel scoring systems for SARS screening are only applicable to febrile patients with temperatures above 38°C [2,4,5,26]. Our findings show that relying only on these prediction rules would result in a substantial proportion of missed cases (those with temperature not exceeding 38°C) that are identifiable by chest radiography. Our findings provide further evidence to support the current Centers for Disease Control and Prevention recommendation that, when person-to-person transmission is occurring in the world, a patient with contact history who develops respiratory symptoms, even if afebrile, should promptly undergo screening inclusive of chest radiography [23].

5. Limitations

Our study was limited in that it was retrospective in design, and 3.6% of patients were excluded from the study because of the unavailability of radiographs. Nevertheless, the recall bias generally associated with retrospective studies did not affect data collection for the core parameters (the radiologists’ report and the final diagnosis) of our study. The patients’ body temperatures at presentation were also objectively charted. Our results may not be reproducible at other settings for a number of reasons. First, the prevalence of SARS at other settings may be different. The prevalence of other causes of pneumonia may also have geographic or seasonal variation. A notable example is the increased prevalence of influenza pneumonia during the winter period. This would theoretically affect the specificity of chest radiography, a concern already discussed above. Second, the radiologists who interpreted our radiographs were all specialists, Fellows of the Royal College of Radiologists. By contrast, in practice, chest radiographs in most ED settings are usually read by ED physicians. We do not believe, however, that this would cause significant difficulty in generalizing our results. Finally, our result applies to an ED screening setting during a community outbreak of SARS, with a disease prevalence of 13.3%. It may not be extrapolated to other settings.

6. Conclusions

In conclusion, our study shows that, in the setting of a community outbreak, serial chest radiography is extremely useful as a screening tool in ruling out SARS. However, the chest radiograph at initial presentation performs poorly as a screen, and practitioners are cautioned against overreliance on it to rule out SARS. Conversely, both the initial radiograph and serial radiography are highly specific for SARS in our setting and are therefore excellent in ruling in the disease. Radiographic changes of SARS may precede fever, and the use of chest radiography for screening should not be limited to febrile patients.

References

112 patients with SARS in acute stage. J Peking Univ (Health
[19] Zhao DW, Ma DQ, Wang W, et al. Early X-ray and CT appearances of
severe acute respiratory syndrome: an analysis of 28 cases. Chin Med
case of severe acute respiratory syndrome (SARS) in Singapore.
for identifying patients with severe acute respiratory syndrome out of
[23] Centers for Disease Control and Prevention. Clinical guidance on the
identification and evaluation of possible SARS-CoV disease among
persons presenting with community-acquired illness. Available:
May 31].
severe acute respiratory syndrome (SARS). Geneva: The Organi-
[accessed 2004 Jan 24].
chest radiograph in a doctor with SARS. Lancet 2003;361:
1520-1.
[26] Chan SS. Screening for severe acute respiratory syndrome in the
Clinical predictors of bleeding esophageal varices in the ED

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Abstract

Objectives: Some authors have found that thrombocytopenia (<118,000/mm³), splenomegaly, and ascites are useful predictors of large esophageal varices in cirrhotic patients. We decide to see whether these factors could also be used to predict bleeding esophageal varices in patients known to have chronic liver disease in the ED.

Methods: A case record review was done of all patients admitted to the ED of Changi General Hospital with upper gastrointestinal bleeding from esophageal varices from October 1999 to April 2004. The criteria of thrombocytopenia, splenomegaly, and ascites were applied retrospectively to these patients to see how accurately they performed in predicting bleeding esophageal varices.

Results: Only 55% of patients had thrombocytopenia, whereas 45% had splenomegaly, and 27.5% had ascites. Combining thrombocytopenia with the presence of either ascites or splenomegaly did not improve the yield (only 40%), and only 6 patients had all 3 criteria. Twelve patients with bleeding varices did not have any of the criteria.

Conclusions: Thrombocytopenia, splenomegaly, or ascites is an unreliable predictor of bleeding esophageal varices. Urgent or emergent endoscopy is still advocated to accurately diagnose bleeding esophageal varices.

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1. Introduction

It is not uncommon to have patients with chronic liver disease presenting to the emergency department (ED) with acute upper gastrointestinal (GI) bleeding. Often, the approach taken by the emergency physician is to assume that the bleeding originated from esophageal varices and to manage the patient as such until proven otherwise. This is because bleeding esophageal varices have a higher morbidity and mortality rate than any other source of upper GI bleeding [1]. In view of the high hospital mortality rate of 15% to 40% [1], it had been advocated that emergency physicians quickly place such patients on some kind of vasoactive treatment (somatostatin, octreotide, or terlipressin [2-5]) while in the ED, in tandem with rapid resuscitation with fluids and blood products. This is to be followed by urgent endoscopy, in which a number of therapeutic options (sclerotherapy [1], variceal multiband ligation [6-8], use of tissue-glue adhesives [6,8]) can be used to stop further esophageal variceal bleeding.

However, 20% to 50% of patients with symptoms and signs of chronic liver disease who develop upper GI bleeding—despite findings such as spider angiomas, asterixis, and ascites—do so from sources other than
esophageal varices [1]. For instance, in the study of Josen et al [9], only 27% of the patients in the liver disease group with varices (cirrhotics) had frank variceal hemorrhage, whereas 57% bled from hemorrhagic gastritis. Conversely, in approximately 50% of patients with known varices who present with upper GI bleeding, the bleeding is from a source other than the varices [10]. Our own experience in Changi General Hospital showed that for the years 2001 to 2003, only 27% of chronic liver disease patients who presented to the ED with upper GI bleeding did so from esophageal varices. Therefore, starting vasoactive treatment for all patients with chronic liver disease presenting with hematemesis and/or melena (on the assumption that bleeding is from esophageal varices) may not be cost-effective.

Recently, several authors have found that thrombocytopenia, splenomegaly, and ascites are useful predictors for large esophageal varices in cirrhotic patients [11-18]. We therefore decided to see whether these factors could also be used to predict bleeding esophageal varices in patients known to have chronic liver disease and presenting with hematemesis and/or melena to the ED.

2. Materials and methods

An electronic search was made of all patients admitted to the ED of Changi General Hospital with an admission diagnosis of GI bleeding (ICD-9 code 578). This search was made from our hospital’s medical record database and began from July 1999 to May 2004. These patients were then further selected for the presence of bleeding esophageal varices (ICD-9CM code of 4650). Patients thus chosen for study must have the diagnosis of bleeding esophageal varices confirmed on endoscopy.

Patients thus identified had their case records reviewed for their initial platelet levels taken at the time of presentation to the ED with upper GI bleeding. If the patient had previous attendances at the specialist clinic or ED within the 3 months preceding the bleeding episode, the baseline platelet levels (if any) was also traced. We identified all those in the 2 groups with a platelet level below 118 000/mm$^3$.

We also checked for the presence of ascites and splenomegaly for each patient. This can be from either clinical examination of the abdomen (as detected by the attending physicians) or with the aid of imaging studies (ultrasonography or computed tomography [CT] scan) performed during the same period of hospitalization. The causes of their cirrhosis were also determined. The use of diuretics in patients was also noted, as this could affect the volume of ascites and its clinical detection.

Patients who had splenectomy, splenorenal shunts, or transjugular intrahepatic portosystemic shunts done before were excluded from the study, as were patients with coexisting hepatocellular carcinoma and renal failure.

3. Results

Based on the search criteria outlined above, a total of 44 patients had been admitted to the ED of Changi General Hospital with upper GI bleeding from esophageal varices between July 1999 and May 2004. The presence of bleeding varices was confirmed in all cases by endoscopy. Four patients were excluded from the study, as 1 had a splenectomy before for hypersplenism, 2 had transjugular intrahepatic portosystemic shunts done before, and another had coexisting hepatocellular carcinoma. Of the remaining 40 patients studied, 19 had presented to our hospital for the first time. Thirteen (32.5%) were female. The ages of the 40 patients ranged from 29 to 86 years, with a mean age of 55.8 years. Fifteen patients (37.5%) had alcoholism as the etiology of the cirrhosis, 11 (27.5%) patients had hepatitis B, 4 (10%) had hepatitis C, 1 had Wilson’s disease, 3 patients had dual pathology (alcoholism and hepatitis B or C), with 6 cases being cryptogenic.

Of these 40 patients, the range of platelet counts at the time of presentation to the ED ranged from 38 000 to 300 000/mm$^3$, with a mean of 129 525/mm$^3$, and a median of 117 500/mm$^3$. Eighteen patients had platelet levels equal to or higher than 118 000/mm$^3$, both at the time of bleeding in the ED, or in the preceding 3 months at the specialist clinic (although 9 patients had no previous clinic visits).

<table>
<thead>
<tr>
<th>S/N</th>
<th>ED platelet levels (per mm$^3$) at the time of bleeding episode</th>
<th>Platelet levels (per mm$^3$) obtained from previous specialist clinic or ED visits in the preceding 3 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>38 000</td>
<td>No preceding visit</td>
</tr>
<tr>
<td>2</td>
<td>42 000</td>
<td>44 000</td>
</tr>
<tr>
<td>3</td>
<td>46 000</td>
<td>No preceding visit</td>
</tr>
<tr>
<td>4</td>
<td>61 000</td>
<td>No preceding visit</td>
</tr>
<tr>
<td>5</td>
<td>67 000</td>
<td>No preceding visit</td>
</tr>
<tr>
<td>6</td>
<td>67 000</td>
<td>65 000</td>
</tr>
<tr>
<td>7</td>
<td>74 000</td>
<td>No preceding visit</td>
</tr>
<tr>
<td>8</td>
<td>82 000</td>
<td>90 000</td>
</tr>
<tr>
<td>9</td>
<td>90 000</td>
<td>74 000</td>
</tr>
<tr>
<td>10</td>
<td>90 000</td>
<td>62 000</td>
</tr>
<tr>
<td>11</td>
<td>91 000</td>
<td>No preceding visit</td>
</tr>
<tr>
<td>12</td>
<td>91 000</td>
<td>82 000</td>
</tr>
<tr>
<td>13</td>
<td>93 000</td>
<td>94 000</td>
</tr>
<tr>
<td>14</td>
<td>93 000</td>
<td>No preceding visit</td>
</tr>
<tr>
<td>15</td>
<td>95 000</td>
<td>89 000</td>
</tr>
<tr>
<td>16</td>
<td>108 000</td>
<td>No preceding visit</td>
</tr>
<tr>
<td>17</td>
<td>109 000</td>
<td>72 000</td>
</tr>
<tr>
<td>18</td>
<td>110 000</td>
<td>No preceding visit</td>
</tr>
<tr>
<td>19</td>
<td>113 000</td>
<td>75 000</td>
</tr>
<tr>
<td>20</td>
<td>116 000</td>
<td>80 000</td>
</tr>
<tr>
<td>21</td>
<td>117 000</td>
<td>130 000</td>
</tr>
<tr>
<td>22</td>
<td>121 000</td>
<td>56 000</td>
</tr>
</tbody>
</table>
Twenty-two patients had platelet counts below 118,000/mm³, either at the time of bleeding in the ED or in the preceding 3 months at the specialist clinic (although 10 of these patients had no previous clinic visits; see Table 1). As such, the criterion was positive in only slightly more than half of the patients (55%; see Table 2).

Splenomegaly was detected on physical examination in 7 patients, and imaging studies (either ultrasonography or CT scan) showed the presence of splenomegaly in an additional 11 patients. In total then, 45% (18) of patients had splenomegaly (Table 2).

Ascites was detected on physical examination in 6 patients, and imaging studies (either ultrasonography or CT scan) showed the presence of ascites in an additional 5 patients. In total then, 27.5% (11) of patients had ascites. We would like to point out that 5 of 15 specialist clinic follow-up patients who had no ascites were on spironolactone treatment at the time of the bleeding episode (Table 2).

Finally, only 6 patients with bleeding had all 3 criteria of thrombocytopenia, splenomegaly, and ascites, whereas 12 patients had none of the 3 criteria (Table 2).

4. Discussion

Several authors [11-18] have put forward papers suggesting that thrombocytopenia, splenomegaly, and ascites are useful predictors for large esophageal varices in cirrhotic patients. This is intuitive as the triad is the result of portal hypertension in cirrhotic patients. These criteria were developed for the purpose of improving yield and cost-effectiveness when selecting patients for screening endoscopy and prophylactic therapy to decrease the incidence of bleeding. A brief summary of the salient points of these studies is listed in Table 3, along with the references. Interestingly, the authors found that the Child-Pugh score was not a reliable predictive criterion for esophageal varices.

We used 40 patients who had confirmed bleeding esophageal varices by endoscopy (taking endoscopy as the gold standard) and applied the criteria of thrombocytopenia, splenomegaly, and ascites to this group to see how accurately they could predict bleeding varices.

Levels of platelet counts recommended for the screening of esophageal varices by various authors [11-15] varied from 150,000/mm³ (proposed by Freeman et al [15]) to 68,000/mm³ (proposed by Madhotra et al [12]). However, Freeman et al [15] limited their study population to only alcoholic cirrhotic patients. For the purpose of our study, therefore, we applied the next highest platelet cutoff level of 118,000/mm³ (Table 3), which was proposed by Thomopoulos et al [11], whose study population included all forms of liver cirrhosis. We included platelet levels done both at the time of bleeding in the ED and any platelet levels done within the preceding 3 months (usually by the relevant discipline in the specialist outpatient clinics). Using this criterion, only 55% of patients with bleeding esophageal varices fulfilled it.
The criterion of splenomegaly was advocated in papers by Thomopoulos et al.[11], Madhotra et al.[12], Chalasani et al.[13], Zaman et al.[14], and Alacorn et al.[17]. The last 4 authors used both clinical examination and imaging studies to detect the presence of splenomegaly, whereas Thomopoulos et al.[11] used imaging studies. This is understandable as clinical examination alone to detect a mild-to-moderately enlarged spleen is often unreliable and subject to many variables such as the experience of the clinician, position of the patient (lying on the right as compared to lying supine), the presence of ascites, and the abdominal girth of a patient. In our series, only 7 patients had a palpably enlarged spleen on clinical examination at the time of the variceal bleeding, whereas imaging done within the same period of hospitalization revealed an additional 11 patients with splenomegaly. All in all, only 18 patients (40.0%) fulfilled the criteria of splenomegaly.

In the same vein, the criterion of ascites was advocated in papers by Thomopoulos et al.[11], Madhotra et al.[12], Barcia et al.[16], Alacorn et al.[17], and Lavergne et al.[18]. Madhotra et al.[12] and Alacorn et al.[17] used both clinical examination and imaging studies to confirm the presence of splenomegaly, whereas Thomopoulos et al.[11], Barcia et al.[16], and Lavergne et al.[18] used both imaging studies. The detection of free fluid in the abdomen by clinical examination depends on relatively crude techniques (percussion for shifting dullness, and fluid thrill)[19]. At least 500 to 1000 mL is required to produce abnormal physical signs, whereas ultrasound can detect as little as 50 mL.[19]. In our series, only 6 patients had ascites on clinical examination at the time of the variceal bleeding, whereas imaging done within the same period of hospitalization revealed an additional 5 patients with ascites. All in all, only 11 patients (27.5%) fulfilled the criteria of ascites. The use of spironolactone would have reduced the number of patients with ascites. (Some might argue against using imaging to detect splenomegaly and ascites in patients with bleeding varices. However, an increasing number of emergency physicians are using emergency ultrasonography for trauma to detect fluid in the traumatized abdomen. In the future, the experience thus gained can facilitate the bedside detection of splenomegaly and ascites in patients in the ED.)

Combining thrombocytopenia with either the presence of ascites and splenomegaly did not improve the yield (only 40%), and only 6 patients had all 3 criteria. We would also have missed 12 patients with bleeding varices, none of whom had any of the criteria. As the percentages were low, statistical analysis for tests of significance was not attempted.

One limitation was the small number of patients (40) in this study, which might lead to a type II error, but this represented all the patients seen in our hospital in the last 4 years with confirmed bleeding esophageal varices by endoscopy. Perhaps another study with a larger number of patients could be done, although we doubt whether any differences will arise.

5. Conclusion

Some authors have suggested that thrombocytopenia, splenomegaly, and ascites are useful predictors for large esophageal varices in cirrhotic patients and can be used for the purpose of improving yield and cost-effectiveness when electively selecting patients for screening endoscopy and prophylactic therapy to decrease the incidence of first-time variceal bleeding.

However, these 3 factors fail to translate into reliable predictors of bleeding esophageal varices in chronic liver disease patients presenting with hematemesis and/or melena to the ED. Urgent or emergent endoscopy is still advocated for such patients to accurately diagnose bleeding esophageal varices and institute appropriate treatment.

References


The epidemiology and early clinical features of West Nile virus infection

Jacek M. Mazurek MD, PhD, Kim Winpisinger MS, Barbara J. Mattson MAEd, MSE, Rosemary Duffy DDS, MPH, Ronald L. Moolenaar MD, MPH

Abstract
We studied early clinical features of the West Nile virus (WNV) infection. Case patients were Ohio residents who reported to the Ohio Department of Health from August 14 to December 31, 2002, with a positive serum or cerebrospinal fluid for anti–WNV IgM. Of 441 WNV cases, medical records of 224 (85.5%) hospitalized patients were available for review. Most frequent symptoms were fever at a temperature of 38.0°C or higher (n = 155; 69.2%), headache (n = 114; 50.9%), and mental status changes (n = 113; 50.4%). At least one neurological symptom, one gastrointestinal symptom, and one respiratory symptom was present in 186 (83.0%), 119 (53.1%), and 46 (20.5%) patients, respectively. Using multivariate logistic regression and controlling for age, we found that the initial diagnosis of encephalitis (P = .001) or reporting abdominal pain (P < .001) was associated with death. Because initial symptoms of WNV infection are not specific, physicians should maintain a high index of suspicion during the epidemic season, particularly in elderly patients with compatible symptoms. This is a US government work. There are no restrictions on its use. Published by Elsevier Inc.

1. Introduction

The West Nile virus (WNV) was first identified in 1937 in the West Nile district of Uganda [1]. Initially, WNV infections were characterized by mild disease with low-grade fever, malaise, anorexia, nausea and vomiting, eye pain, headache, myalgia, rash, and lymphadenopathy [2-4]. In recent years, an increase in the frequency and clinical severity of WNV infection has been observed [5-9].
2. Methods

2.1. Case definition

We defined a probable human WNV case patient as an Ohio resident with a positive serum or CSF anti–WNV IgM test result who was reported to the ODH between January 1 and December 31, 2002. A confirmed case patient was a probable case patient who tested positive for WNV infection at the CDC by PRNT (with or without serum- or CSF-positive anti–WNV IgM test results) or who had CSF test results that were positive for anti–WNV IgM and negative for anti–SLE IgM by ELISA. Probable and confirmed case patients who presented to Ohio EDs and were subsequently admitted to a hospital were included in the analysis.

2.2. Case ascertainment

We reviewed the serological WNV test results and information from WNV surveillance of human beings as reported to the ODH for 2002 and created a list of patients who tested positive for WNV at the ODH, a private, or the CDC laboratory. Sublists of WNV patients were provided to the local health departments in whose jurisdiction the patients resided and to the infection control practitioners at the hospital where the patients were evaluated. Local health departments and hospital staff ensured that case patient medical charts were available for review.

Twenty-eight abstractors from the ODH, local health departments, and hospital infection control departments reviewed ED medical charts by using a standard data collection form and collected demographic data, clinical data, CSF laboratory results, information on initial diagnoses, potential risk factors, disposition, and final diagnosis. Abstractors received detailed instruction on how to collect the data. If the desired information was not available, we reviewed the physicians’ and nurses’ notes. Test results other than WNV serology performed on CSF were obtained from the charts or directly from the hospitals’ laboratories.

2.3. Statistical analysis

We used Epi Info (CDC, Atlanta, GA) and SAS statistical software (SAS, Cary, NC) to analyze collected data [16,17]. Simple proportions and medians were generated to describe the demographic characteristics and the frequencies of initial diagnoses, signs or symptoms reported on admission, or underlying conditions. We used the Wilcoxon test to compare means of continuous data and the Fisher exact test to determine if any initial diagnosis, sign or symptom reported on admission, or underlying condition was associated with death; a 2-tailed $P$ value less than .05 was accepted as significant. We calculated 95% confidence intervals (CIs) of odds ratios (ORs) using exact method.

A multiple logistic regression analysis was used to evaluate the association of initial diagnosis, signs and symptoms, and underlying conditions reported on admission with death while controlling for age. Variables were
considered for inclusion in the multivariate model if they were associated with death at a statistical significance level of $P < 0.25$ in the univariate analysis and were reported by more than 5% of the study population. Using all-subsets regression, we then identified several models all of whose variables remained significantly associated with death at a significance level of $P = 0.05$.

3. Results

During the period of January 1 to December 31, 2002, a total of 441 probable cases with positive test results for WNV in CSF or serum (IgM ELISA) was reported to the ODH. Of these, 140 (31.7%) cases were tested and confirmed at the CDC by PRNT or at the ODH laboratory by ELISA CSF testing that was positive for anti–WNV IgM and negative for anti–SLE IgM. Thirty-one (7.0%) cases were fatal. The 441 patients had a median age of 61 years (range, 2-98 years); 227 (51.5%) were women. The median age of the 31 decedents was 75 years (range, 32-98 years); 9 (29.0%) were women. Onset of symptoms of WNV infection among reported patients occurred during the period of July 27 to October 19, 2002 (Fig. 1). Cases occurred among residents of 56 (63.6%) of Ohio’s 88 counties, with 219 (49.4%) cases reported from the most populated county in Ohio, Cuyahoga County (2000 population, 1.3 million). The attack rate during the period of January 1 to December 31, 2002, was 3.9 per 100 000 population for the state, compared with 15.6 per 100 000 for Cuyahoga County.

Of the 441 WNV patients reported in Ohio, 262 (59.4%) had medical charts available for immediate review. Of these, 224 (85.5%) were hospitalized, 28 (10.7%) were ED-only patients, and 10 (3.8%) were outpatients.

Of the 224 hospitalized case patients, 113 (50.4%) were women and 179 (79.9%) were white (Table 1). Their ages ranged from 11 to 98 years (median, 67 years). Over half of the patients were aged 65 years or older (n = 129; 57.6%). Fourteen (6.3%) case patients died. The median age of these 14 decedents was 75 years (range, 62-98 years); 7 (50.0%) were women. The highest proportion of deaths (1/3 [33.3%]) among hospitalized patients occurred among persons aged 90 to 99 years (Fig. 2). The median time from onset to death was 13 days (range, 2-44 days). Case patients were hospitalized in 47 hospitals in 27 counties.

The admission diagnoses of aseptic meningitis, encephalitis, and meningoencephalitis were made in 68 (30.4%), 21 (9.4%), and 9 (4.0%) of the hospitalized patients, respectively (Table 2). Frequent initial diagnoses included “fever of unknown origin” (n = 39; 17.4%), viral infections (n = 39; 17.4%), urinary tract infection (n = 33; 14.7%), and

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Number and percentage of hospitalized WNV-infected patients by selected demographic characteristics—Ohio, 2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristics</td>
<td>Nonfatalities [n (%)]</td>
</tr>
<tr>
<td>Age group (y)</td>
<td>n = 210 (93.7%)</td>
</tr>
<tr>
<td>10-19</td>
<td>5 (2.4)</td>
</tr>
<tr>
<td>20-29</td>
<td>7 (3.3)</td>
</tr>
<tr>
<td>30-39</td>
<td>14 (6.7)</td>
</tr>
<tr>
<td>40-49</td>
<td>31 (14.8)</td>
</tr>
<tr>
<td>50-59</td>
<td>25 (11.9)</td>
</tr>
<tr>
<td>60-69</td>
<td>41 (19.5)</td>
</tr>
<tr>
<td>70-79</td>
<td>58 (27.6)</td>
</tr>
<tr>
<td>80-89</td>
<td>27 (12.9)</td>
</tr>
<tr>
<td>90-99</td>
<td>2 (1.0)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>106 (50.5)</td>
</tr>
<tr>
<td>Men</td>
<td>104 (49.5)</td>
</tr>
<tr>
<td>Race</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>166 (79.0)</td>
</tr>
<tr>
<td>Black</td>
<td>30 (14.3)</td>
</tr>
<tr>
<td>Other/Unknown</td>
<td>14 (6.7)</td>
</tr>
</tbody>
</table>
dehydration (n = 32; 14.3%). In 12 (5.4%) cases, the admission diagnosis was WNV infection.

The signs and symptoms most frequently recorded at admission are reported in Table 3. At least one neurological symptom (headache, stiff neck, photophobia, muscle weakness, paresthesias, seizures, or mental status changes), one gastrointestinal symptom (nausea, vomiting, or diarrhea), and one respiratory symptom (cough or shortness of breath) was present in 186 (83.0%), 119 (53.1%), and 46 (20.5%) patients, respectively. Rarely reported symptoms included slurred speech, sore throat, blurred vision, lymphadenopathy, and paresthesias.

Some of the underlying medical conditions present in case patients at the time of admission are reported in Table 3. Diabetes and hypertension were the most prominent conditions reported, and asthma and history of cancer were the least reported. None of the patients were reported to be HIV positive or to take immunosuppressive medications.

In 65 (29.0%) case patients, CSF was collected on or before admission. The findings reflected changes characteristic of viral infection: mild leukocytosis (median, 128 cells/mm³; range, 0-725 cells/mm³; normal values [18], 0-5 cells/mm³), high protein (median, 72 mg/dL; range, 23-700 mg/dL; normal values, 15-45 mg/dL), and normal glucose (median, 61 mg/dL; range, 22-224 mg/dL; normal values, 50-80 mg/dL). Twenty-four (36.9%) patients had a predominance of neutrophils (>50%; normal values, 0%-8%) in the CSF.

The disease onset ranged between July 27 and October 2, 2002. Patients were admitted during the period of August 8 to October 17, 2002. The mean and median times from symptom onset to admission were 4.3 and 3 days, respectively (range, 0-32 days). The mean and median durations of hospitalization were 9.5 and 7 days, respectively (range, 1-65 days). There was no difference in time from symptom onset to admission (P = .242) and duration of hospitalization (P = .153) between those who subsequently died and those who survived. Hospitalization longer than 7 days was associated only with hypertension (OR = 2.4; 95% CI, 1.1-4.8; P = .021).

The final diagnoses of the 224 hospitalized patients, as noted in the medical charts at the time of data collection, included viral encephalitis (n = 77; 34.4%), aseptic meningitis (n = 64; 28.6%), WNV infection (n = 55; 24.6%), viral meningoencephalitis (n = 21; 9.4%), others (n = 6; 2.7%), and Guillain-Barré syndrome (n = 1; 0.4%).

Hospitalized patients were discharged home (n = 126; 56.3%), to a skilled nursing facility (n = 66; 29.5%), or to the patient caretaker’s home (n = 5; 2.2%). Nine patients (4.0%) were transferred to another acute care hospital.

Table 2  Admission diagnoses of hospitalized WNV-infected patients

<table>
<thead>
<tr>
<th>Admission diagnosis</th>
<th>Nonfatalities [n (%)]</th>
<th>Fatalities [n (%)]</th>
<th>Total [n (%)]</th>
<th>Crude OR</th>
<th>95% Confidence limits</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aseptic meningitis</td>
<td>66 (31.4)</td>
<td>2 (14.3)</td>
<td>68 (30.4)</td>
<td>0.36</td>
<td>1.71</td>
<td>.237</td>
</tr>
<tr>
<td>Fever</td>
<td>33 (15.7)</td>
<td>6 (42.9)</td>
<td>39 (17.4)</td>
<td>1.76</td>
<td>0.24</td>
<td>77.60</td>
</tr>
<tr>
<td>Viral infection</td>
<td>38 (18.1)</td>
<td>1 (7.1)</td>
<td>39 (17.4)</td>
<td>0.35</td>
<td>0.01</td>
<td>2.46</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>31 (14.8)</td>
<td>2 (14.3)</td>
<td>33 (14.7)</td>
<td>0.96</td>
<td>0.10</td>
<td>4.65</td>
</tr>
<tr>
<td>Dehydration</td>
<td>28 (13.3)</td>
<td>4 (28.6)</td>
<td>32 (14.3)</td>
<td>2.60</td>
<td>0.55</td>
<td>9.77</td>
</tr>
<tr>
<td>Mental status changes</td>
<td>23 (11.0)</td>
<td>2 (14.3)</td>
<td>25 (11.2)</td>
<td>1.36</td>
<td>0.14</td>
<td>6.69</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>21 (10.0)</td>
<td>1 (7.1)</td>
<td>22 (9.8)</td>
<td>0.69</td>
<td>0.02</td>
<td>5.08</td>
</tr>
<tr>
<td>Encephalitis</td>
<td>16 (7.6)</td>
<td>5 (35.7)</td>
<td>21 (9.4)</td>
<td>6.74</td>
<td>1.56</td>
<td>25.42</td>
</tr>
<tr>
<td>Sepsis</td>
<td>20 (9.5)</td>
<td>0 (0.0)</td>
<td>20 (8.9)</td>
<td>0.00</td>
<td>0.00</td>
<td>2.45</td>
</tr>
<tr>
<td>WNV infection</td>
<td>12 (5.7)</td>
<td>0 (0.0)</td>
<td>12 (5.4)</td>
<td>0.00</td>
<td>0.00</td>
<td>4.44</td>
</tr>
<tr>
<td>Cerebrovascular accident/stroke</td>
<td>9 (4.3)</td>
<td>1 (7.1)</td>
<td>10 (4.5)</td>
<td>1.72</td>
<td>0.04</td>
<td>14.18</td>
</tr>
<tr>
<td>Meningoencephalitis</td>
<td>8 (3.8)</td>
<td>1 (7.1)</td>
<td>9 (4.0)</td>
<td>1.94</td>
<td>0.04</td>
<td>16.47</td>
</tr>
<tr>
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<td>9 (4.0)</td>
<td>0.00</td>
<td>0.00</td>
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</tr>
<tr>
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<td>0 (0.0)</td>
<td>3 (1.4)</td>
<td>0.00</td>
<td>0.00</td>
<td>26.78</td>
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<tr>
<td>Rhabdomyolysis</td>
<td>3 (1.4)</td>
<td>0 (0.0)</td>
<td>3 (1.4)</td>
<td>0.00</td>
<td>0.00</td>
<td>26.78</td>
</tr>
</tbody>
</table>
In the univariate analysis, case patients who subsequently died were more likely than survivors to be aged 68 years or older (OR = 6.9; 95% CI, 1.5-31.4; \( P = .005 \)), to be initially diagnosed with encephalitis (Table 2), and to report the presence of the following symptoms: mental status changes (referred here to a constellation of symptoms including...
altered mental status, confusion, lethargy, increased sleepiness, slurred speech, or memory loss), lethargy, slurred speech, and abdominal pain (Table 3). Survivors were more likely than those who died to report headache (OR = 15.1; 95% CI, 1.9-117.9). The presence of at least one neurological symptom, one gastrointestinal symptom, and one respiratory symptom at admission was not associated with death, nor was any underlying condition.

We performed multivariable logistic regression analysis and evaluated 3 models within each group—initial diagnosis, sign and symptoms, and underlying condition—with the following predictor variables included in the models, respectively: (1) age, diagnosis of meningitis, dehydration, and encephalitis; (2) age, presence of headache, mental status changes, lethargy, decreased appetite, abdominal pain, neck stiffness, increased sleepiness, and back pain; and (3) age and hypertension. The final models included (1) age and diagnosis of encephalitis and (2) age and presence of abdominal pain. After controlling for age, hospitalized patients who subsequently died were more likely to be initially diagnosed with encephalitis (OR = 9.4; 95% CI, 2.4-36.7; \( P = .001 \)) and reported abdominal pain (OR = 10.5; 95% CI, 2.8-39.0; \( P < .001 \)) compared with case patients who survived.

4. Discussion

In this paper, we described the early clinical features of 224 WNV hospitalized patients during an outbreak of WNV infection in Ohio in 2002. We found that at least one neurological symptom was present in most patients (83%), but an initial diagnosis of encephalitis, meningitis, or meningoencephalitis was made in only 90 (34.4%) case patients. Despite an ongoing outbreak, the WNV infection was initially suspected in only 12 (5.4%) case patients. The small number of cases initially diagnosed with WNV infection might reflect the nonspecific presentation of the early phase of infection and the fact that this was the first year that human WNV infection was present in Ohio.

The clinical presentation of disease in Ohio was similar to that reported from the 1996 outbreak in Romania and the 2000 outbreaks in New York and New Jersey and in Israel [6,15,19,20], with frequent reports of fever, headache, and mental status changes. The clinical findings from the New York outbreak showed that neurological and gastrointestinal symptoms were present in about 89% and 58% of hospitalized patients, respectively. We observed similar frequencies of neurological and gastrointestinal symptoms in 83% and 53% of the hospitalized case patients, respectively (Table 2). Similarities in the frequencies of symptoms might be caused by the fact that the WNV strain circulating in the United States was genetically similar to the WNV strain that was responsible for the 2000 outbreak in Israel [21]. Although frequent, the presence of at least one neurological or one gastrointestinal symptom at admission was not associated with death.

We found that an initial diagnosis of encephalitis or reporting abdominal pain at admission placed patients at greater risk for death. West Nile virus encephalitis has been previously documented as a cause of death [22-26], but there are no previous reports discussing the significance of abdominal pain. Three categories of abdominal pain are recognized: visceral, somatoparietal, and referred pain [27]. Pain sensations are conveyed from neurereceptors through 2 types of afferent nerve fibers in which cell bodies are located in the dorsal root ganglia of spinal afferent nerves [27]. A lesion in the dorsal root ganglion can result in acute autonomic and sensory neuropathy [28,29]. The reduced sensory nerve action caused by WNV infection has been demonstrated [30]. In addition, pathological data showed that WNV causes dorsal root ganglia lesions. The lesions might be severe enough to produce sensory deficits and correlate with the severity of the poliomyelitis [31,32].

The case fatality rate among hospitalized patients in Ohio was 6.3%, similar to that reported in Romania (4.3%) but lower than that reported in New York and New Jersey (11.0%) and in Israel (14.1%) [6,15,19,20]. The reasons for the observed differences are not apparent. Among them may have been differences in the length of the follow-up periods of hospitalized patients, the criteria for WNV-related death, completeness of the ascertainment of encephalitis cases, changes in WNV virulence [19,21], the immunological background in a population, the prevalence of comorbid conditions, age distribution of the population, and others.

This study had limitations. First, in Ohio, only hospitalized patients presenting with neurological symptoms of infection were tested for WNV without charge. Nonhospitalized patients with WNV infection were not studied. Consequently, the full spectrum of symptoms of WNV illness, especially mild disease, could not be discovered, and the total burden of disease might have been underestimated. Second, the information on symptoms was obtained from ED medical charts, which vary in completeness and accuracy of clinical details. We were not able to validate the data provided by each hospital. In addition, 28 recorders conducted chart reviews. Although we gave them specific instructions on how to complete the survey, interabstractor agreement was not determined and differences in completeness and quality of data likely occurred. Also, for analysis purposes, we assumed that signs and symptoms not recorded on the chart were not present, resulting in potential misclassification. Moreover, because of financial, time, and legal constraints, we were able to collect data on only about 60% of the reported WNV cases from 27 (48%) of 56 counties. West Nile virus cases in other counties might differ from those that we analyzed.

Our study demonstrated that WNV infection begins with nonspecific symptoms, making early clinical diagnosis challenging. Diagnosis is based mainly on serological tests for the presence of anti–WNV IgM, which can be demonstrated either in serum or in CSF. Nevertheless, the results have to be interpreted with caution because cross-
reactivity with other members of the genus Flavivirus is possible. Because no effective therapy is known, patients with WNV infection can be offered only supportive care. Physicians should maintain a high index of suspicion for WNV infection during the epidemic season, particularly when evaluating elderly patients with neurological or gastrointestinal symptoms.

Acknowledgments

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We are grateful to Dr Amy Bode (Division of Vector-Borne Infectious Diseases, National Center for Infectious Diseases) and Dr Matthew Zack (Division of Adult and Community Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention) for their thoughtful comments.

References


Early symptoms of WNV infection


Emergency diagnosis of Fournier’s gangrene with bedside ultrasound

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Abstract Fournier’s gangrene is a life-threatening infection of the scrotal skin. Although originally thought to be an idiopathic process, Fournier’s gangrene has been shown to have a predilection for patients with diabetes as well as chronic alcohol abuse; however, it can also affect patients with nonobvious immune compromise. Because of potential complications, it is important to diagnose the disease process as early as possible. Ultrasound has been previously described to aid in the diagnosis of Fournier’s gangrene. In patients with low to moderate suspicion of Fournier’s gangrene, it may provide a rapid and reliable diagnosis and differentiate the pathological process from mimicking entities such as scrotal edema or cellulitis. We present 6 cases of Fournier’s gangrene diagnosed in the ED at the patient’s bedside using ultrasound. None of the patients had a history of diabetes, and 5 had sources of infection determined. © 2005 Elsevier Inc. All rights reserved.

1. Introduction

Fournier’s gangrene was originally described in 1883 and was thought to be an idiopathic process. J.A. Fournier, a Parisian venereologist, noted the disease process to be a rapidly progressing fasciitis of the scrotum and penis that was without a known source [1]. Since then, Fournier’s gangrene has been identified as having a polymicrobial origin with causative agents including Escherichia coli, Proteus, Pseudomonas, Staphylococcus, Streptococcus, Bacteroides, Clostridium, Salmonella, Klebsiella, Enterococcus, Peptostreptococcus, Corynebacterium, and Fusobacterium [2-9]. Fournier’s gangrene is commonly thought to be more frequent in men with impaired immune function such as those with diabetes mellitus.

Fournier’s gangrene may be easily diagnosed solely on clinical grounds when advanced, and morbidity and mortality are quite high. However, early detection is essential to decreasing the morbidity and mortality of this life-threatening disease. Because Fournier’s gangrene is a disease on the far end of a spectrum of infection severity, in many cases, it is difficult to distinguish mild Fournier’s gangrene from scrotal cellulitis. This distinction, however, is important because the treatment and ultimate outcome differ between these entities. Any delay in diagnosis of Fournier’s gangrene such as misidentification as simple cellulitis or idiopathic scrotal edema can significantly delay treatment and lead to an increased morbidity and mortality. We present 6 cases of Fournier’s gangrene diagnosed at the bedside with ultrasound in patients without diabetes or other known...
immunologic disturbance. All presented with complaints of scrotal pain, swelling, and redness.

2. Case 1

J.T., a 44-year-old man with a history of hypertension, presented to the ED with complaints of scrotal swelling. The patient had been seen 5 days before arrival in an urgent care facility and diagnosed with and treated for a urinary tract infection. The patient stated that he noticed scrotal swelling 2 days prior, but it did not alarm him until the day of evaluation. He denied nausea, vomiting, or fever at home but noted burning sensation upon urination. The patient was febrile in the ED with a temperature of 101.5°F. His remaining vital signs were unremarkable. The physical examination was significant for diffuse scrotal swelling and bilateral testicular tenderness (Fig. 1). The epididymides were enlarged and tender bilaterally. A bedside ultrasound revealed diffuse scrotal edema and increased flow on color Doppler to both testicles with mildly enlarged epididymal heads bilaterally. In addition, a small collection of soft tissue gas was noted in the scrotal midline (Fig. 2). Laboratory values included an elevated white blood cell count of 14,700 cells per microliter and presence of urinary tract infection. Surgical consultation was obtained, and the patient was admitted to the hospital for intravenous antibiotics and surgical debridement. The patient was eventually discharged with moderate loss of tissue.

3. Case 2

I.O., a 56-year-old man with no significant medical history, presented to the ED with complaints of lower abdominal pain for 1 day. The patient was obviously intoxicated and stated that he was drinking to ease the discomfort. His blood pressure was 100/55 mm Hg, heart rate was 95 beats per minute, respiratory rate of 18 breaths per minute, and a temperature of 95.5°F. Physical examination revealed a thin patient with a smell of alcohol on his breath. He had mild to moderate lower abdominal pain and a significantly swollen scrotum with diffuse erythema. Rectal examination revealed an enlarged and tender prostate. Bedside ultrasound examination showed a large collection of soft tissue gas in the scrotal wall. Abdominal and pelvic computed tomography showed gas tracking into the lower abdominal wall. The patient was admitted to the surgical service with intravenous antibiotics. The patient underwent extensive surgical debridement but did not survive to discharge from the hospital.

4. Case 3

T.K., a 48-year-old man with no significant medical history, presented to the ED with a complaint of scrotal swelling and discomfort for 2 days. The patient stated that a similar event occurred approximately 2 years ago and was self-limited. Physical examination revealed an afebrile man with unremarkable vital signs. His scrotum was diffusely swollen; however, there was no obvious erythema. The right testicle was tender. Laboratory values were significant for a normal urine analysis and a low white blood count at 3200 cells per microliter. A bedside ultrasound examination revealed diffuse scrotal edema with soft tissue gas on the right side of the patient’s scrotum. The patient was admitted to the surgical service and was taken to the operating room for debridement. He left the hospital approximately 2 weeks later with moderate tissue loss.

5. Case 4

G.O., a 58-year-old man with a history of hypertension and mild chronic obstructive pulmonary disease, presented to the ED with a complaint of lower abdominal pain for several days. He had been seen 5 days previously and treated for presumptive diverticulitis by his primary care physician. The patient’s vital signs were unremarkable except for a temperature of 100.6°F. The physical examination was significant for mild suprapubic tenderness and an erythematous swollen scrotum. The scrotum, as well as both...
testicles, was diffusely tender. No focal areas of mass or swelling were noted. The patient alleged that this was his baseline and continued to complain of lower abdominal pain only. A bedside ultrasound examination revealed bilateral epididymo-orchitis and a focal area of abscess in the left hemiscrotum. On further evaluation, a small area of soft tissue gas was noted in the left hemiscrotum. Abdominal and pelvic computed tomography looking for a link to possible diverticulitis or abdominal abscess confirmed a small area of scrotal soft tissue gas and focal scrotal abscess, but no intra-abdominal abscess was located. The patient was admitted for surgical debridement and antibiotics. The patient recovered with limited tissue loss and was discharged from the hospital.

6. Case 5

P.J., a 40-year-old male with a history of renal stones and hypertension, presented to the ED with a complaint of testicular pain and swelling for 12 hours. The patient denied any scrotal trauma or risk factors for sexually transmitted diseases. He was afebrile and had unremarkable vital signs. His physical examination was significant for diffuse scrotal edema and mild erythema. The patient was uncomfortable with scrotal manipulation. Although he indicated that the right hemiscrotum was most painful, he could not lateralize the discomfort on palpation. A pelvic x-ray was read out as having no evidence of subcutaneous gas. A bedside ultrasound was then performed for evaluation of possible orchitis or epididymitis. The ultrasound showed diffuse scrotal edema with a small area of soft tissue gas in the posterior midline scrotum. The patient was seen by surgical consultants and admitted for antibiotics and surgical debridement. The patient had a protracted hospital course with complicating infections, not directly related to his primary illness, to which he eventually succumbed.

7. Case 6

L.B., a 44-year-old man with no significant medical history except for a recently treated sexually transmitted disease, presented to the ED with a complaint of scrotal pain for 5 days. The patient had been seen in 3 EDs over the previous 2 weeks and had been treated for gonorrhea and urinary tract infection. He denied any fever, nausea, or vomiting. On physical examination, the patient had unremarkable vital signs and was afebrile. Physical examination was normal except for a tender and enlarged prostate and an edematous, mildly erythematous scrotum which was diffusely tender. Bilateral inguinal lymph node enlargement was noted as well, but there was no abdominal tenderness or rebound. Initially thought to be consistent with idiopathic scrotal edema, the laboratory values showed a normal urinalysis and complete blood count. A bedside ultrasound examination was performed to evaluate for the presence of epididymitis or orchitis. However, the scan showed diffuse scrotal edema with areas of subcutaneous gas. No focal abscess was noted. The soft tissue edema and gas were traced posteriorly toward the patient’s rectum. The general surgery service was consulted regarding the patient and admitted him with a diagnosis of Fournier’s gangrene for surgical debridement. The patient had significant tissue loss but survived to hospital discharge.

8. Discussion

There have been an estimated 750 cases of Fournier’s gangrene described in the literature since 1883 [10]. Once thought to be an idiopathic process, studies have revealed that the majority of cases have a primary source. These
sources include rectal abscesses, urinary sources such as strictures or catheters, testicular infections (epididymo-orchitis), and skin infections (hidradenitis, abscesses of the scrotal wall, and infected varicella pustules). In addition, blunt trauma to the penis, postsurgical complications, and injection of intravenous drugs into the superficial penile vein have been associated with Fournier’s gangrene [2,5,8,11]. The disease process typically affects men in their 50s, and whereas it was originally thought to have a higher incidence in patients with diabetes, recent research has indicated a stronger association with alcohol abuse [2,5,8,11,12].

Patients with Fournier’s gangrene typically have a delayed presentation with the interval between symptoms and diagnosis ranging from 1 to 30 days [2,5,8,12]. The disease process can have significant morbidity, including prolonged hospitalizations, loss of testicles, and need for colostomies or cystostomies, and mortality which can reach 25% [2-5,8,11,12]. As a result, it is important to differentiate Fournier’s gangrene from other presentations of acute scrotal complaints such as scrotal cellulitis, idiopathic scrotal edema, testicular torsion, testicular fracture, hemorrhage or necrosis of a testicular tumor, strangulated or incarcerated hernia, and other inflammatory or infectious processes.

Findings on physical examination typically include scrotal swelling and tenderness. In addition, crepitus can be identified in up to 64% of patients because of the subcutaneous air produced by the growing bacteria [8]. The radiographic detection of subcutaneous air is more sensitive than that of physical examination with up to 89% of patients demonstrating what is sometimes described as a “honeycomb scrotum” (Fig. 3) [7,8,11]. Ultrasonographic findings typically include marked thickening of the scrotal skin, as well as discrete focal regions of high-amplitude echoes with posterior acoustic shadowing indicative of subcutaneous gas which is pathognomonic for Fournier’s gangrene (Fig. 2). Hernias in the scrotum are another pathological process which may also demonstrate gas on ultrasound examination; however, this process is easily differentiated from the scrotal subcutaneous gas seen in Fournier’s gangrene as the air of a hernia is within bowel and contained within the scrotum (Fig. 4). Additional ultrasonographic signs seen in Fournier’s gangrene include peritesticular fluid and possible signs of epididymo-orchitis [6,9].

Ultrasound is the radiographic method of choice if history and physical examination are not diagnostic in suspected Fournier’s gangrene. Subcutaneous air on plain films is not universally identified, and computed tomography does not visualize the scrotal structures as well as ultrasound. Furthermore, computed tomography requires intravenous contrast, and patients with Fournier’s gangrene often have renal impairment [2,8,11]. Testicular ultrasound can be performed at the patient’s bedside, can evaluate the scrotal contents, does not subject a patient to radiation, does not require intravenous access or contrast, and although operator-dependent, can be easily replicated. Furthermore, ultrasound is able to evaluate for other possible diagnosis such as torsion or epididymitis.

As in the cases presented, Fournier’s gangrene can have a variety of presentations, and in fact, this diagnosis is often not considered when the presentation is in the early stages which can lead to the delay in diagnosis. Frequently, the infection suspected is epididymitis or orchitis; however, sometimes, only the scrotum is tender and not the testicles or epididymides. In all the cases presented, subcutaneous scrotal gas noted on the ultrasound examination yielded the diagnosis of Fournier’s gangrene. Several of these cases were early in the disease progression, and the amount of gas was small. Therefore, a high index of suspicion must be used when evaluating an edematous scrotum for the presence of small pockets of gas. Like previously published cases, the patients in this series had often seen other physicians before the presentation to the ED and frequently carried a different diagnosis. The use of ultrasound by an experienced sonologist, in conjunction with a thorough history and physical examination, was integral in making the diagnosis of Fournier’s gangrene and commencing the appropriate treatment.

References

Therapeutics

Open endotracheal tubes may be safely left on an ED airway cart for 48 hours

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Abstract

Objective: To determine if endotracheal tubes (ETTs) that are opened, prepared, and stored in an ED airway cart are prone to bacterial contamination.

Methods: A prospective study conducted in the ED of a level 1 trauma center. A study group of 50 endotracheal tubes were opened, preloaded with a stylet, the cuff checked for integrity by air inflation, and then stored in an ED airway cart. The study group was subdivided into 5 groups of 10 ETTs each, cultured at different time intervals. The ETTs were cultured at 6, 12, 24, 36, and 48 hours for the presence of bacterial contamination. The control group consisted of 10 ETTs that were left in their sterile packing in the ED airway cart and then removed at 48 hours and cultured.

Results: In the study group, 7 (14%) ETTs resulted in a positive culture; 43 ETTs cultured negative for bacteria. In the control group, 2 (20%) ETTs cultured positive, the remainder was all negative. There was no statistically significant difference between the 2 groups (\( P = .63 \)). If only clinically significant bacteria are considered, defined as a culture with 5 or more colony-forming units, 3 ETTs in the study group cultured positive; there were no clinically significant bacteria cultured in the control group. Once again, there was no statistically significant difference between the 2 groups, with a \( P \) value of .57.

Conclusion: It appears that opening, preparing, and storing ETTs in an ED airway cart for up to 48 hours does not increase the risk of bacterial contamination of the ETTs.

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1. Introduction

In the ED, it is not uncommon for emergency medicine (EM) physicians to “set up” the airway cart for the day. Often, this involves preparing endotracheal tubes (ETTs) by placing a stylet, checking the integrity of the cuff, and molding the ETT into the preferred shape. When this is done, the sterile packing is violated. While intubation is not a sterile procedure, this preparation could potentially lead to bacterial contamination. Although the majority of these ETTs are used in a timely manner, on occasion, they may be left in the cart for longer periods before use.

The potential for contamination of ETTs in the ED has not been studied. A thorough Medline search performed to identify similar studies yielded no match. However, the contamination of other medical devices has been docu-
mented in the literature [1-5]. Jones et al [2] demonstrated that *Staphylococcus* species could be cultured from the diaphragm of stethoscopes of ED workers. Moreover, the number of colonies correlated with the cleaning practices of the providers. While *Staphylococcus* species are by far the most common organisms isolated, studies have also demonstrated colonization by gram-negative organisms, such as *Acinetobacter* and *Enterobacter* [4]. Other researchers have demonstrated that health care equipment, such as otoscopes, can carry pathogenic bacteria [3].

Our study was designed to determine the incidence of bacterial contamination of ETTs after preparation and storage in an airway cart in a level 1 trauma center ED. We used a model similar to the one used with stethoscopes to determine if the preparation and storage of ETTs in an airway cart lead to colonization with bacteria over time [2].

This study was considered exempt from review by the Eastern Virginia Medical School institutional review board.

## 2. Methods

This study was conducted in the trauma bay of the ED in Sentara Norfolk General Hospital from April 13 to April 15, 2004. This hospital is a tertiary-care, level 1 trauma center, with an annual ED volume of approximately 48,000 patients. It is the primary training site for our fully accredited post-graduate year (PGY)-1 through PGY-3 EM residency program. Airway management for all ED patients is performed by the EM residents and faculty.

A total of 60 new sterile Hi-lo Evac ETTs (Nellcor/Tyco Healthcare), all adult size 7.5 mm, donated by Nellcor/Tyco Healthcare, were used for the study. These ETTs are the same type used in our hospital ED, intensive care units, and operating rooms. A total of 50 ETTs were used in the study group; this was subdivided into 5 groups of 10 ETTs each. The 3 EM physicians participating in this study washed their hands before handling all ETTs. The sterile package was opened at the adapter end of the ETT, a 10-mL syringe was placed onto the cuff port and inflated to test cuff integrity. A rigid stylus was then inserted into the ETT lumen. Finally, the provider molded the ETT by adjusting it (while still in its packaging), into the preferred shape, which for our study was the “hockey stick.” At no time during the procedure was the packing opened more than half-way down the ETT. The 3 physicians did not directly touch the distal portion of the ETT at anytime; this was intended to prevent direct hand contact with the portion of the ETT that enters the airway.

The 50 study ETTs were then placed into the airway cart in the trauma bay of the ED at Sentara Norfolk General Hospital in the same area as all of the other ETTs used for intubation. The study ETTs were clearly marked “not for patient use” on the outside packaging. The airway cart was used in its normal manner (i.e., ETTs prepared, removed for use, etc) throughout the study period.

From the study group, 1 set of 10 ETTs were removed from the cart and cultured at each of the following time intervals: 6, 12, 24, 36, and 48 hours. Each ETT was cultured by rolling the distal cuff portion across the blood agar, and then a sterile swab was used to sample the distal portion of the tube and rolled onto the agar. Great care was taken by the authors to perform this in a sterile manner. The cultures were hand-carried to the laboratory and incubated at 37°C. All cultures were examined for the presence of microbes and the number of colony-forming units (CFUs) for a total of 48 hours. This was performed by the Sentara Norfolk General Microbiology laboratory personnel. Laboratory personnel were blinded to which group of ETTs was being cultured.

The control group consisted of 10 ETTs that were placed in the airway cart at the same time as the study ETTs (0 hour), but were not opened. The ETTs in the control group were removed at 48 hours and cultured in the same manner as the study ETTs.

The study group and the control group were then compared for the presence of bacteria and the number of CFUs. Statistical analysis was performed using the Fisher exact test to determine if there was a statistically significant difference in the presence of bacteria on ETTs from the study groups versus the control group. The 2 groups were also compared regarding the presence of clinically significant bacteria, defined as those cultures with 5 or more CFUs.

A statistically significant difference was considered to be present if \( P < .05 \).

## 3. Results

In the study group, 7 (14%, 95% CI 0.08-0.28) ETTs cultured bacteria; the remaining 43 were negative. Two
of the 10 control-group ETTs cultured bacteria. Using the Fisher exact test to compare the 2 groups, there was no statistically significant difference ($P = .63$). See Table 1.

If only clinically significant bacteria cultures are considered, there were 3 (6%; 95% CI 0.02-0.51) positive cultures in the study group and none in the control group. Once again, using the Fisher exact test, there was no statistically significant difference between the 2 groups ($P = .57$). See Table 2.

Although there was a trend for an increase in the incidence of bacterial contamination of ETTs with increasing time in the airway cart, this difference did not reach statistical significance.

Table 3 lists the bacteria and number of CFUs cultured for each contaminated ETT.

Table 3  Bacteria cultured and number of CFUs for each contaminated ETT

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<thead>
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* Clinically significant bacterial contamination, defined as 5 or more CFUs.

4. Discussion

Nosocomial infections are a significant source of morbidity and mortality in hospitalized patients [6]. Approximately 2 million nosocomial infections occur in the United States each year [7]. Population-based surveillance studies of nosocomial infections in US hospitals indicate a 5% attack rate [8]. For many larger institutions, the nosocomial infection rate is probably closer to 10% [8].

Several studies have examined bacterial contamination of hospital and medical equipment. Jones et al [2] found that the stethoscopes used in ED practice were often contaminated with staphylococci, and therefore a potential vector of infection. Other studies have demonstrated that contaminated blood pressure cuffs [9], electronic thermometers [5], and white coats [10] have resulted in hospital endemics [2]. Recently, an unpublished study presented at the annual meeting of the American Society for Microbiology in New Orleans in May 2004 demonstrated that neckties worn by physicians are a potential carrier of bacterial pathogens. In this study, the neckties of 42 physicians, medical students, and physician assistants were swabbed and cultured. Nearly 50% of the neckties tested positive for bacteria, including staphylococcus; no methicillin-resistant strains were cultured. Although this study was widely disseminated in the national press, it has yet to undergo the rigorous process of peer review necessary for publication.

Bacterial contamination of ETTs could be a potential cause or contributing factor to ventilator-associated pneumonia (VAP). VAP is a cause of significant morbidity and mortality in critically ill patients [11]. It has been postulated to start by colonization of the ETT and entry of the pathogenic bacteria into the lower respiratory tract [12]. The contribution of initial contamination of the airway device to the development of VAP has not been well studied.

This study was designed to determine if the common practice of preparing ETTs for future use and storing them in an airway cart in the ED is a potential cause of bacterial contamination. Our results show no statistically significant increase in the incidence of bacterial contamination of ETTs prepared and stored in an airway cart for up to 48 hours. Although the study size was limited, we conclude that it is safe to continue this practice and use ETTs that have been prepared less than 48 hours prior.

Similar to other studies examining the bacterial contamination of medical equipment, our study has several limitations. We cannot prove that simply culturing bacteria on medical equipment leads to actual infection and disease. For our particular study, we did not show that ETTs contaminated with bacteria lead to VAP. It is not an unreasonable assumption, however, that such contamination probably plays some role in nosocomial infections. Second, because of the study design, we were not able to make a specific identification of the bacteria cultured from the ETTs. We could have determined the degree of risk for significant nosocomial infection (ie, methicillin-resistant...
Staphylococcus aureus vs Staphylococcus epidermidis) with identification of specific bacteria. However, this lack of specific bacterial identification in no way changes the results or conclusion of our study. In addition, there is a possibility that bacterial contamination occurred at the time of plating the cultures, rather than from the preparation and storage of the ETTs in the ED airway cart. Great care was taken, however, by the authors to prevent this occurrence.

Finally, this study was conducted in only 1 ED; it is possible that the results would be different in another hospital ED. It would be interesting to repeat this study using multiple institutions.

5. Conclusion

The preparation of ETTs for use in emergent intubation and their storage in an ED airway cart for up to 48 hours in the ED are not associated with an increased incidence of bacterial contamination.

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References

Use of gum elastic bougie for prehospital difficult intubation

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Abstract The objective of this study was to assess effectiveness of gum elastic bougie (GEB) in case of difficult intubation occurring in the prehospital settings. After manikin training to GEB handling, physicians were recommended to use GEB as first alternative technique in case of difficult intubation. Intubating conditions and details of patients requiring GEB-assisted laryngoscopy were recorded over 30 months. Among the 1442 extrahospital intubations performed, 41 patients (3\%) required GEB. Gum elastic bougie allowed successful intubation in 33 cases (78\%) and 8 patients sustained a second alternative technique. One patient was never intubated, another 1 required rescue cricothyroidotomy. Twenty-four (60\%) GEB patients had associated factors for difficult intubation such as reduced or limited cervical spine mobility, morbid obesity, cervicofacial trauma, and ears, nose, and throat neoplasia. The success rate of GEB was 75\% and 94\%, respectively, depending on whether associated factors for difficult intubation are present or not. No adverse events associated to GEB use were noted. © 2005 Elsevier Inc. All rights reserved.

1. Introduction

The gum elastic bougie (GEB) is an old tool widely used in European countries in case of difficult tracheal intubation occurring in the operating room [1-4]. Gum elastic bougie is a 60-cm-long tracheal tube introducer fabricated from a braided polyester base with a resin coating and a smooth angled distal tip. During direct laryngoscopy, when glottis is not visualized, GEB is passed blindly behind the epiglottis. Progression of the bougie within the trachea is confirmed by clicks felt (due to distal tip of the bougie stumbling over tracheal rings) and distal holdup (bronchus tree) limiting insertion at 30 to 40 cm from dental arcades. The tracheal tube is then railroaded over the GEB while direct laryngoscopy is maintained. Several studies performed at induction of general anesthesia have reported its effectiveness when optimal laryngeal landmarks could not be obtained under direct laryngoscopy [2,5,6]. This device has been exported outside the operating room and has become a cornerstone for difficult airway management in...
some EDs [7,8]. Recently, we have validated the efficiency of a simple algorithm to manage unanticipated difficult airway occurring in anesthetized patients using GEB as first alternative technique in case of difficult laryngoscopy [9]. We have demonstrated 80% success rate of GEB. Because airway management of prehospital emergency patients resembles that of unanticipated difficult airway anesthetized patients, we have hypothesized that GEB might be of similar interest out of the hospital. We have conducted an observational study to determine the success rate and safety of GEB as first-line alternative technique in case of difficult intubation occurring in prehospital intensive care medicine.

2. Methods

This monocenter study was performed in the suburbs of Paris (Val de Marne, population 1 300 000) by our local prehospital emergency medical unit (SMUR) between February 2001 and July 2003, according to French ethic laws. Our SMUR is equipped with 5 mobile intensive care units (MICUs) and its annual activity is about 10 000 medical emergency out-of-hospital interventions.

A MICU unit is composed of a vehicle driver, a nurse anesthetologist, and either a senior emergency physician (>90% of cases) or a senior anesthesiologist. In France, extrahospital tracheal intubation is always performed by or under the control of a physician.

Forty-five intubators (23 emergency physicians, 5 anesthesiologists, and 17 nurses specialized in anesthesia) were involved in this study. Before joining the MICU team, specialized nurses were requested to have an experience of more than 4 years of intubation in operating room conditions and emergency physicians had at least 3 years of prehospital and in-hospital emergency medicine experience (with a mean of 30 intubations per year). During the study period, a senior anesthesiologist was always on call in case of severe airway management difficulties encountered by the emergency physicians. This senior anesthesiologist was motorized to rapidly assist airway management on the scene of difficult intubation.

Before introducing GEB in the prehospital emergency medicine, the medical team of our SMUR adhered to an intense theoretical and practical formation (training manikin, Laerdal) with GEB handling. After completion of this initial formation, GEB (Eschmann tracheal tube introducer; Sims Portex, Hythe, UK) was available in all medical vehicles of the SMUR. The standard airway equipment on vehicles comprises laryngoscope with Macintosh blades (cold light) of different sizes, a GEB, a retrograde intubation kit, a cricothyrotomy kit, and an intubating laryngeal mask airway (ILMA).

As integral part of our local prehospital difficult airway management, GEB was recommended as the first-line alternative technique in case of difficult intubation defined by a number of failed tracheal access attempts under direct laryngoscopy (>2) with optimal head position (head extension in the absence of cervical immobilization) and external laryngeal manipulation (backward, upward, and right pressure). One intubation attempt under direct laryngoscopy was defined by an advancement of the tracheal tube toward the glottis followed by its removal from oral cavity. If 2 successive insertions of GEB failed at trachea intubation, the difficult airway management algorithm recommended second-step alternative techniques of intubation depending on physicians’ preference and experience. A call for help to a senior anesthesiologist was mandatory in case of difficult ventilation scenario or if GEB-assisted intubation failed.

Before starting the study, all emergency care providers of the SMUR received an oral formation on the study’s design, query form completion, and the algorithm of airway management. Cormack and Leane laryngeal view classification drawing was photocopied on each data sheet (grade 1, whole larynx visible; grade 2, partial view of vocal cords; grade 3, only epiglottis visible; grade 4, no part of larynx visible). All anesthetized (rapid sequence) or cardiac arrest patients in the care of our SMUR who requested rescue intubation and for whom tracheal access failed after 2 direct laryngoscopy attempts were included with the query form available in all vehicles systematically completed immediately after the airway management process.

Circumstances and clinical conditions of the airway management, characteristics of difficult laryngoscopy patients, intubation difficulty score, and details of the intubating process were recorded (Table 1). The success rate of GEB was calculated [10].

Airway care providers had to document the following parameters for all patients: estimated or known height and weight, history of ears, nose, and throat (ENT) disease, objective cervical mobility, cervical immobilization, and history of maxillofacial disease.

The relative position of the intubator and the patient and occurrence of complications, such as macroscopic inhala-

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<td>Parameter</td>
<td>Score</td>
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<tr>
<td>No. of attempt &gt;1</td>
<td>N1</td>
</tr>
<tr>
<td>No. of operators &gt;1</td>
<td>N2</td>
</tr>
<tr>
<td>No. of alternative techniques</td>
<td>N3</td>
</tr>
<tr>
<td>Cormack grade 1</td>
<td>N4</td>
</tr>
<tr>
<td>Lifting force required</td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>N5 = 0</td>
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<tr>
<td>Increased</td>
<td>N5 = 1</td>
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<tr>
<td>Laryngeal pressure</td>
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<td>Not applied</td>
<td>N6 = 0</td>
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<td>Applied</td>
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<td>Vocal cord mobility</td>
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<tr>
<td>Abduction</td>
<td>N7 = 0</td>
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<tr>
<td>Adduction</td>
<td>N7 = 1</td>
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<td>IDS = sum of scores</td>
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tion, dental trauma, arterial oxygen desaturation, and hemodynamic instability, were recorded.

3. Results

During the study period, 1442 patients required intubation. Six hundred forty were cardiac arrest patients and 802 had a spontaneous cardiac activity the moment of airway management. Of the 802 patients with persistent cardiac activity, 771 (95%) received succinylcholine. Among the 1442 emergency cases, 186 were trauma patients, the remaining (1266) were medical patients.

Forty-one (3%) patients required GEB-assisted tracheal intubation challenge. Difficulties at laryngoscopy were encountered by 28 of 45 potential intubator of our SMUR emergency team. Three airway care providers were concerned 3 times, 7 twice, and 18 once. Median (SD) intubation difficulty score and Cormack grade for these 41 patients were 8 (2.2) and 4 (0.2), respectively. Twenty-eight patients (68% of GEB patients and 2% of all patients) were classified as Cormack grade 4. Gum elastic bougie allowed rapid successful intubation in 33 cases (78%); 24 at the first attempt, and 9 at the second. Rescue oxygenation was mandatory for 2 difficult mask ventilation patients after failed GEB challenge. Cricothyroidotomy was performed in 1 patient because of an allergic laryngeal angioedema and the resuscitation process was conducted while the second patient was ventilated then intubated through the ILMA.

A potential difficult airway management was anticipated in 24 (60%) of GEB patients that demonstrated associated factors for difficult intubation (AFDI) such as reduced cervical spine mobility (n = 7), morbid obesity (n = 7), ENT neoplasia (n = 7), cervicofacial trauma (n = 2), and allergic angioedema (n = 1). Seven patients with failed GEB that were intubated with a second-step alternative technique (ILMA [n = 1], retrograde intubation [n = 1], blind nasal intubation [n = 1], or by the rescue senior anesthesiologist under direct laryngoscopy [n = 4]) were among the 24 patients with AFDI.

The success rate of GEB was 75% and 94%, respectively, depending on whether AFDI are present or not. Most failed GEB-assisted intubation occurred in patients suffering from ENT neoplasia, with 95% GEB success rate in other patients with AFDI. All but 1 difficult laryngoscopy patients free from AFDI (n = 17) were intubated with GEB demonstrating a 95% (16/17) success rate. Clinical conditions, characteristics of difficult laryngoscopy patients, and details of the intubating process are reported in Table 2. No specific complication associated with GEB was noted.

4. Discussion

We observed about 3% difficult intubation requiring more than 2 laryngoscopic attempts in our emergency out-of-hospital patients. We demonstrated the effectiveness and safety of the GEB proposed as the first-line alternative technique in difficult laryngoscopy patients; 80% of these patients were rapidly intubated with this device.

We have chosen GEB to facilitate tracheal intubation of emergency difficult airway patients because of its simplicity of use, convenience, efficiency, and low cost. In addition, we have observed on manikin a very short learning process of this pocket-sized ready-to-use airway device. Although popular in the United States, we preferred to challenge GEB rather than the stylet because it was demonstrated in hospital studies to be systematically more efficient at assisting intubation [5,11]. Moreover, a recent report has demonstrated more than 95% success rate of tracheal intubation associated with the use of the GEB in case of unpredicted difficult laryngoscopy, which contrasts with our results [12].

Several factors can explain the lower efficiency of GEB to facilitate tracheal intubation in our emergency out-of-hospital difficult laryngoscopy patients. First, most of operating room studies that have demonstrated the interest of GEB included selected patients. Anticipated difficult airway and emergency patients were excluded from these trials. None of the patients included in these studies had factors that were shown to increase the risk of difficult intubation such as 60% (24/41) of the difficult laryngoscopy patients that we have managed. Interestingly, we demonstrated a 94% (16/17) success rate of the bougie in difficult laryngoscopy patients that were free (n = 17) from AFDI. All but 1 (7/8) bougie failure was observed which occurred in difficult laryngoscopy patients that were free (n = 17) from AFDI. In the 24 difficult laryngoscopy patients with AFDI, we demonstrated a 75% success rate of bougie. Surprisingly, both groups of difficult laryngoscopy patients, with (n = 24) or without (n = 17) AFDI, were similar in mean Cormack score (3.5 and 3.6, respectively), suggesting that AFDI are determining factors for more difficult GEB-assisted intubation. Among difficult laryngoscopy patients with AFDI, most failed bougie-assisted intubation (3/7) occurred in patients suffering from ENT neoplasia, with 95% (16/17) success rate of bougie in morbidly obese patients and those

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<th>Table 2</th>
<th>Characteristics of patients with or without AFDI</th>
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<td>Patients with evident AFDI (n = 24)</td>
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<tr>
<td>H/F</td>
<td>17/7</td>
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<tr>
<td>Age</td>
<td>52 ± 15</td>
</tr>
<tr>
<td>Cormack 3/4</td>
<td>3/4/17</td>
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<tr>
<td>IDS</td>
<td>8 ± 2</td>
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<td>Failure GEB</td>
<td>7</td>
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<td>AFDI</td>
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<tr>
<td>Morbid obesity</td>
<td>7</td>
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<tr>
<td>Reduced cervical mobility</td>
<td>7</td>
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<tr>
<td>Upper airway distortion</td>
<td>8</td>
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<td>Maxillofacial trauma</td>
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with reduced cervical spine mobility and cervicofacial trauma. Our results confirm a recent prospective study conducted in similar conditions. Gum elastic bougie efficiency was challenged in elective anesthetized patients as a first alternative technique in case of unexpected difficult laryngoscopy. The authors demonstrated that GEB allowed rapid tracheal intubation in 80% of difficult laryngoscopy patients [9]. We believe that unexpected difficult airway management of elective anesthetized patients is somehow comparable to that of prehospital anesthetized or cardiac arrest patients.

The second factor that may have influenced overall GEB success rate is related to environmental intubation circumstances. Indeed the interaction between the patient and the operator body positions at intubation seems to be of particular importance. The lying position of the patient on the ground, such as we experienced in almost half of our difficult laryngoscopy patients, was demonstrated to be an independent risk factor for prehospital difficult intubation [13]. This specific interplay between the operator and the patient, directly linked to prehospital emergency medicine, might have induced additional difficulties at laryngoscopy. The third factor that could explain a lower success rate than previously reported with GEB may be the high incidence of Cormack grade 4 reported in our study. Gum elastic bougie is classically attended to facilitate intubation in difficult laryngoscopy Cormack grade 2 and 3 patients. In our prehospital population, 27 of 41 patients were classified as Cormack grade 4 at the first laryngoscopy, and blind (with regard to laryngeal landmarks) tracheal intubation was attempted. Finally, the last factor that has probably influenced our results concerns the experience of the physicians that performed initial laryngoscopy. In the present study, most of the physicians in charge of the intubation were emergency physicians whose experience in difficult airway management is certainly less accurate than that of experienced anesthesiologist. Surprisingly, when a rescue senior anesthesiologist was requested (4/41), its success rate we report may not be completely exportable to other system of prehospital care using less educated care providers. We are aware that specialized physician aboard emergency ambulance is relatively uncommon out of European countries. However, we recommend using GEB as the first strategy in case of difficult intubation because this simple device is very easy to use. Although efficiency of GEB has not been evaluated in non medical personal, our educational program of medical student and paramedics has showed us that the learning curve of GEB was extremely short on the dummy and clinical acquisition of the technique of GEB-assisted tracheal intubation was immediate. Because of these reasons we recommend GEB handling to be taught to any care provider performing laryngoscopy.

In summary, our prehospital study outlines the major interest and safety of GEB to assist tracheal intubation of emergency patients. We have demonstrated that this simple device allowed rapid intubation of nearly 80% of prehospital patients with difficult direct laryngoscopy.

References

Controversies

Emergency medicine and older adults: continuing challenges and opportunities

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1. Introduction

The treatment of older adults in the emergency department (ED) has been a part of emergency medicine (EM) since its inception. Nationwide, older adults represent an important and growing patient population representing about 18% of ED admissions annually [1]. Although geriatric EM has attracted limited clinical and research attention, there continues to be significant challenges, needs, as well as opportunities in pursuit of providing high-quality care to older adults.

Over the next 25 years, the US population of older adults (65 years and older) will double from 34 million in 2000 to more than 69 million by the year 2030 [2]. Because these individuals have already been born and are aging, there is little doubt in the veracity of these projections. This dramatic aging of the US population will significantly affect a range of social institutions from education to health care including hospital EDs. Currently, EDs nationally report an estimated 18.5 million older ED admissions annually [1,3]. Despite the tremendous projected growth of older adults, there are very limited, if any, projections specifically regarding the numbers of older patients EDs can anticipate serving. Nonetheless, it is reasonable to assume any increases in the older adults will likely exacerbate the current overcrowding conditions experienced by many ED nationwide [4-6]. At the same time, the size of the older ED population represents just one dimension of the issue, because we also know that older adults (65 years and older) represent a highly heterogeneous population in terms of health status, function, and presenting diagnosis.

2. Initial efforts in geriatric emergency medicine

Clinical and scholarly attention to geriatric EM has been sporadic during EM’s history. The most recent effort was a 1992 collaboration between the John Hartford Foundation and the Society for Academic Emergency Medicine (SAEM). It was designed to develop a comprehensive educational program for training EM residents and physicians. Led by Sanders, the group published a series of journal articles and a textbook and developed an educational training manual distributed by SAEM [7-9]. In addition, a model of geriatric EM was proposed to guide the clinical approach to treating older adults in the ED [7].

Findings from Sanders and colleagues documented higher ED use rates among older adults compared with younger patients [7-9]. Clinically, older adults were also shown to present with: nonstandard disease presentations, altered laboratory values, multiple comorbid diseases, extensive medical histories, communication problems, and potentially altered mental status [7]. In some cases, classic symptoms for diagnosis were absent in the older ED patient [10,11]. In addition, 30% to 50% of older adults ED patients were hospitalized, in sharp contrast to just a 12%
hospitalization rate for younger patients [7]. These issues can make health-care delivery to this population much more challenging and time consuming. The lack of training and educational programs in geriatric EM was documented as challenging and time consuming. The lack of training and commitment. Despite the increasing prevalence of cognitive impairment, it is widely recognized that the training, commitment, and call for more research and intervention projects targeting at-risk older adults.

Overall, it appears that clinical and scholarly work in geriatric EM appears to have lost momentum since the efforts of Sanders [7-9]. The early work characterized the population and provided a model, however, the pace of work has diminished despite rapidly increasing older adults ED populations. The research has been dominated by descriptive studies of use rates and issues such as acuity levels, repeat visits, and 6-month mortality rates [4,12]. Research considering the impact that the older adult population has on the practice of EM is much more limited in scope [13].

3. Continuing and emerging challenges

Despite the absence of sustained scholarly attention regarding older patients, emergency physicians (EPs) continue to face challenges in providing care to this population. The realities of clinical practice and the existing literature on older adults suggest at least 4 areas that would benefit from renewed attention by EM professionals.

3.1. Managing cognitive impairment in the emergency department

Currently, 4.5 million older adult are cognitively impaired, and estimates suggest that by 2050, these numbers could be as high as 16 million [14]. Cognitively impaired older adults are a specific patient population that will continue to demand new and innovative patient care strategies from EM on several levels. First, EPs need the skills and instruments to accurately diagnose and screen this population. Recent findings suggest EPs fail to identify nearly 50% of older patients with cognitive impairment [15]. Second, cognitively impaired patients are a heterogeneous population presenting with a wide range of diagnoses, impairment levels, comorbidities, and medical histories. Third, cognitively impaired patients in the ED also exhibit a range of challenging behavior patterns including non-responsiveness, combative, and/or wandering. Such characteristics complicate rapid diagnosis and patient management. Fourth, cognitively impaired older adults may present to the ED for evaluation solely because of the unavailability, inadequacy, or failure of other support services, which inappropriately ties up resources [16,17].

These challenges are illustrated in the case of a 79-year-old female patient transferred to a county ED from a local nursing home for evaluation of increased temperature and increasing lower extremity edema. She had a history of moderate dementia and was not oriented to person or place. She was unaccompanied and transported via private ambulance. In the ED, she resisted lying down and continuously attempted to get down from the cart in an attempt to exit the area. After a few minutes of persistent struggle and combative with several ED nurses, the patient was loosely tied to the cart with a bedsheet across her chest. In addition, the cart was strategically placed near the nursing station so she could be closely observed. Within minutes she used a “Houdini” maneuver to release herself and climbed down from the cart. The staff returned her to the cart; however, she immediately set about the task of struggling to free herself, oblivious to the pleadings of the staff. Again, she freed herself and the frustrated staff applied soft Velcro restraints. Her examination continued, with some difficulty, as she was combative and uncooperative. Her care required additional staff support during every phase of the examination. Eventually, the patient was diagnosed with an acute urinary tract infection and was transferred to a medical ward for continued therapy.

Appropriate management of cognitive impairment in the ED requires substantial staff time, training, resources, and commitment. Despite the increasing prevalence of cognitive impairment, it is widely recognized that the training, policies, and resources for handling this population remain inadequate [17].

3.2. Assisted-living facilities and emergency departments

Assisted-living facilities (ALFs) are a residential environment broadly guided by a social model of care designed to maximize the independence of older adults by providing assistance and services to maintain an individual’s ability to age-in-place. Although regulations vary by state, in general, these facilities generally house 3 or more unrelated adults (although some purpose-built facilities have over 200 units); provide shelter (room), food (board), and 24-hour supervision/protective oversight and personal care services; and can respond to unscheduled needs for assistance. There are as many as 35,000 AL facilities nationwide [18], and the total number of residents is as high as 1.5 million. ALFs are considered an intermediate between home and nursing home care [19-22].

The rapid expansion and saturation by the ALF industry presents a number of challenges to EDs. First, ALFs typically do not employ trained medical staff and consequently rely on community physicians and EDs for medical
care. Second, older adults typically move into an ALF because of some health, functional, or cognitive decline that compromises their ability to live independently and increases their likelihood of ED use. Third, residents of ALFs may lack family involvement or other caregivers to provide health histories and support, which may make emergency care more challenging. On a structural level, the presence of multiple large ALFs (>100 units) in a catchment area has the potential to overwhelm the resources of an ED particularly during a public health epidemic (eg, influenza outbreak).

In response to the rise of ALFs as a living environment for older adults, EDs may consider taking proactive steps to address some of the challenges ALF present. EDs may want to assess the number and type of ALFs and nursing homes that fall into their catchment area. Based on this evaluation, EDs may encourage large ALFs to develop primary medical coverage for their residents to avoid overreliance on area EDs. In addition, EDs could encourage ALFs to use consistent medical records in the event their residents are transferred to an ED. An ED may also wish to initiate a dialogue with area ALFs to educate them about the appropriate use of EDs and the services that can and cannot be offered.

3.3. Emergency physician satisfaction treating older patients

Examining EPs attitudes about their patients is important because patient encounters have been identified as a key source of professional satisfaction and dissatisfaction across specialties [23]. EP practice dissatisfaction has been associated with abusive and demanding patients, anger on the part of patients or relatives, and difficult or violent patients [24]. Considering these dimensions of EP satisfaction and dissatisfaction, older adult patients admitted from long-term care settings or presenting with cognitive impairment overlays are at risk of being considered particularly unsatisfying patients. Research comparing satisfaction between EPs and internists reported EPs were less satisfied than internists regarding current and preferred conditions of their practice. A source of this gap was suggested to be the discontinuity for EPs between being trained to treat urgent, emergently ill patients while frequently treating patients with nonurgent problems [25]. Issues of practice satisfaction/dissatisfaction among EPs are important because low levels of satisfaction are predictive of decisions to leave the field [24]. In addition, leaving the field is also associated with work-related stress and burden.

EM has been described as a high-stress work environment due to its unpredictability and the need for rapid action and decision making [25]. Increasing numbers of encounters with older ED patients has the potential to add to physician stress because these patients may be more time-consuming, perceived as less satisfying, and EPs report less confidence in their treatment [8]. Research indicates that EPs agreed that older adults required more time and resources than other patients and that their training in geriatric EM was not sufficient [8]. EPs have also been shown to highly overestimate the percentage of older patients they treat in the ED. In one study, EPs estimated the mean percentage of older adults they treated was near 40%, which is more than double the actual national average of 18% (J Schumacher, unpublished manuscript, 2004). Such overestimation may indicate feelings of burden, particularly, if these patients also are considered to be unsatisfying and/or time-consuming cases. Despite a decade-old call for research into factors associated with occupational stress among EPs, few studies examine this issue and none has focused on the impact of older adult patients [25].

3.4. Geriatric emergency medicine education and training

The EM training curriculum is overfilled and consistently challenged to incorporate new and emerging information. Geriatric EM content represents another curriculum pressure. To date, it has not been a formal part of the residency training with core competencies or explicit skills testing. However, with the projected demographic transition fueled by Baby Boomers, geriatric instruction may rapidly need to become a core part of training. In a recent survey, EM residents reported lower levels of confidence treating older adults (>65 years) compared with adults (age 18-64 years) (J. Schumacher, unpublished manuscript, 2004). One quarter of these residents indicated that their training experience “avoided” instruction in geriatric EM. At the same time, three quarters agreed that more training in geriatric EM is necessary to provide better care to older adults. These results suggest that efforts by professional organizations to develop and disseminate educational programs in geriatric medicine are warranted.

4. Innovations and future directions of geriatric emergency medicine

Several challenges have been described above regarding older adults and EM. In response to these challenges, the following subsections suggest 3 thematic areas to renew attention to issues of older adults in the ED.

4.1. Emergency department case finding, assessment, and referral projects

In response to the complexity of older adult cases presenting to the ED, several innovative case finding, assessment, and community referral projects have been implemented. The case finding and assessment projects are designed to screen older patients to identify at-risk older adults who would benefit from comprehensive geriatric assessment by a geriatric nurse specialist [26-28]. Early identification of these at-risk patients also facilitates their
management because appropriate ED resources can be directed earlier in the admission. Some programs extend the screening function into the prehospital setting by training paramedics in intermediate care and assessment of older patients [29]. These programs are frequently coordinated with a referral network comprised of a coalition of community-based service providers. Evaluations of the programs find high levels of support from staff; however, improvements in reported outcomes such as repeat ED visits, hospitalizations, nursing home admissions, and costs have been modest [30]. Such programs are one way to begin to address the challenges of cognitive impairment, ALF, and EP provider burden by providing EPs with information and resources to improve their management of this patient population.

4.2. Evaluating the structure and process of emergency department care

Responsive ED management requires continuous evaluation of their structure and processes of care to appropriately accommodate the needs of older patients. Structurally, the typical design/layout of EDs with many open bays, curtain dividers, and extraneous noise may interfere with the clinical examination of older patients with hearing loss. Tracking these patients to quieter examination rooms may be good clinical practice as well as a priority in future ED architectural design and renovations. ED observation units or 23-hour beds represent another structural resource in the appropriate clinical evaluation of older patients [31].

Processes of care issues in the ED include evaluating patient flow and supportive services. Older adults waiting for hours, without food/fluids, and sitting in hard chairs are poor processes that may lead to the patients’ diminished physiological capacity. Cognitively impaired older adults may require innovative support services and treatment protocols that accommodate their needs. Some EDs have partnered with local Alzheimer disease associations to develop collaborative arrangements providing staffing or volunteer support for cognitively impaired patients. In addition, EDs could work more closely with nursing facilities to develop procedures for handling cognitively impaired patients. Many nursing homes have developed “special care units” specifically designed to accommodate cognitively impaired patients. The techniques and treatment protocols developed for use in these special care units may be successfully applied in the ED setting. One thing remains clear—the population of cognitively impaired older adults presenting to EDs will increase in the future. An organized response by EM would benefit the patients, families, and ED staff.

4.3. Focusing national efforts regarding geriatric emergency medicine

Educating EPs at all training levels about geriatric EM remains a critical need. Leadership by professional organizations (eg, American College of Emergency Physicians, SAEEM) and national health agencies and organizations (eg, Agency for Healthcare Research and Quality, the National Institute on Aging) is needed to promote geriatric EM as an educational and research priority. Despite the growing older population, a lack of geriatric EM educational opportunities persists, particularly on the national level (eg, few national conferences). In addition, funded research opportunities in the area have been limited or nonexistent. The professional EM societies need to provide critical leadership and advocacy in establishing priorities, convening workgroups, developing position statements, setting and funding research goals, and fostering the growth of the area of geriatric EM.

5. Conclusions

Older adults are a heterogeneous and rapidly growing population in the ED. Responding to their unique care needs requires a sustained, focused effort by the EM profession. Consistent clinical and scholarly themes suggest the need for innovation, increased geriatric education, and systematic research about older adults. The challenges facing EM related to older adults will continue building particularly in the areas of cognitive impairment and ALFs. EM has the opportunity to prepare and respond to these challenges if it takes the initiative to address the issues associated with providing quality care to older adults in the ED.

References

We present a case of patient with chronic digoxin toxicity with minimal evidence of heart failure, but a significantly elevated B-type natriuretic peptide (BNP) levels.

A 78-year-old woman was brought to an ED by her daughter with complaints of nausea, increasing dyspnea on exertion, and lower extremity edema for approximately 2 weeks. The patient denied chest pain, fevers, chills, vomiting, diarrhea, or abdominal pain.

The patient’s medical history was significant for moderate to severe congestive heart failure, coronary artery disease status after bypass graft in 1994, diabetes mellitus, hypertension, hypothyroidism, dementia, depression, dyspepsia, and osteoarthritis. The patient was taking a significant number of medications including 0.125 mg of digoxin daily, with which she was reportedly compliant.

Physical examination revealed a thin elderly woman in moderate distress. Vital signs were significant for a bradycardia with a rate of 50 beats per minute and tachypnea with a rate of 30 breaths per minute. The patient was afebrile, had a normal blood pressure, and normal room air oxygen saturation by pulse oximetry. Head, eyes, ears, neck, and throat examination was unremarkable except for mild jugular venous distension. Lung examination revealed mild crackles at the bases, tachypnea without retractions, and good air exchange. Cardiac examination revealed a bradycardia, which was regular, and a systolic murmur. There were no rubs or gallops. The remainder of the examination was unremarkable except for mild bilateral lower extremity pitting edema. Peripheral pulses were normal.

Diagnostic studies included an electrocardiogram, which demonstrated a sinus bradycardia with a left bundle-branch block and no other ST-T wave changes. Portable chest radiograph showed cardiomegaly, surgical clips, and no frank infiltrates. Initial laboratory data included hyperkalemia with a potassium of 7.0 mmol/L, elevated blood urea nitrogen/creatinine over baseline at 105/2.5 mg/dL, a metabolic acidosis with respiratory compensation, an unremarkable complete blood count, normal cardiac enzymes, and an elevated digoxin level at 4.2 ng/mL. The BNP level was reported as greater than 1300 pg/mL (the upper limit of the assay at the time).

Given the apparent chronic digoxin toxicity from which the patient was symptomatic, the decision was made in consultation with a cardiologist to administer Digibind. Shortly after administration, the patient experienced a brief run of ventricular tachycardia which was spontaneously terminated before any antiarrhythmic agents could be given. The patient was then transferred to the cardiac intensive care unit.

The patient was started on intravenous (IV) rehydration in the cardiac intensive care unit for her acute renal insufficiency and received treatment for hyperkalemia. The patient proceeded to have a complicated hospital course demonstrating signs of fluid overload despite later attempts at diuresis. She developed multiple right upper extremity deep venous thromboses secondary to an indwelling
peripherally inserted central catheter line. A transthoracic echocardiogram showed severely depressed left ventricular function, increased left ventricular end-diastolic pressure, moderate pulmonary hypertension, and elevated right atrial pressure. This represented a worsening of findings when compared with a transthoracic echocardiogram done 7 months prior, which showed moderate to severe left ventricular dysfunction. Because of the extremely poor prognosis, end-of-life issues were discussed, and she elected to sign a “do not resuscitate”/“do not intubate” order. The patient died 10 days after this admission.

As the echocardiogram was not performed at the time of the initial ED evaluation, it is unclear whether objective findings consistent with worsening congestive heart failure were present on arrival.

A review of the medical literature reveals no previous case reports of digitalis toxicity (acute or chronic) and elevated BNP levels. However, there have been a few studies demonstrating a direct effect of digitalis on BNP. One such project was completed at the Shiga University of Medical Science in Otsu, Japan [1]. This study measured BNP and atrial natriuretic peptide levels in patients with CHF after therapeutic administration of digitalis. Although this was a small population (total of 13 patients), the study showed an increase from 628 to 689 pg/mL at 1 hour after receiving IV digitalis versus placebo. This increase was despite a decrease in pulmonary capillary wedge pressure, which the authors concluded suggests a possible direct action of digitalis on cardiac natriuretic peptides.

A second study published in 2001 measured BNP, atrial natriuretic peptide, and cGMP (cyclic guanosine 3c, 5c-monophosphate) levels in CHF patients after therapeutic IV followed by oral administration of digoxin [2]. The population for this study consisted of 25 patients, and again, the authors demonstrated a statistically significant increase in BNP levels in digoxin patients versus placebo (130 vs 227 both 3 hours after IV and 3 days after oral administration).

As the role of BNP as a marker for congestive heart failure continues to evolve, it will become increasingly important to identify factors which could affect an accurate interpretation [3]. This case highlights a possible confounding variable of digitalis toxicity when interpreting the results of BNP levels during the evaluation of patient with signs and symptoms suggestive of a heart failure exacerbation. Given preliminary research suggesting an independent effect of digitalis administration on serum BNP concentration, a future study examining BNP levels in patients presenting with digitalis toxicity would be useful. Caution should be exercised in interpretation of BNP levels in patients with heart failure on digoxin.

References

Speed bump–induced spinal column injury

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Abstract

Introduction: Compression fracture of the vertebral body is common, especially in older adults. Injuries to the spinal column are one of the most frequent injuries by accidents and falls from heights. Vertebral fracture associated with minor trauma, however, is a rare occasion.

Case Report: Five cases were injured in the inner city buses after passing onto speed bumps are presented. On presentation, four patients complained of severe pain in the thoracolumbar region, while in the other patient, physical examination revealed pain and tenderness on the neck. No neurologic deficit was noted except for one patient with tenderness on thoracic spines. Examination of the thoracolumbar X-ray and computed tomography displayed compression fractures in four patients. Other laboratory data obtained on admission were within normal limits. Posterior instrumentation was applied to three patients. All patients recovered well except for the one with cervical fracture.

Conclusion: Drivers should be strongly warned and educated on the potential hazards of traversing past such bumps in roads too fast and such barriers should be built regarding tested standards.

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1. Compression fractures due to speed bumps

 Authorities apply a wide array of precautions to cut down the relatively high rate of in-city motor vehicle accidents. For instance, speed bumps are built on roads in a number of countries to limit intraurban speed of vehicles at a point well below the legal speed limits [1]. These are designated to eliminate motor vehicle accident and diminish the resultant death toll involving especially pedestrians and are placed predominantly on minor roads, which are both crowded by pedestrians and where vehicles are likely fast cruising. Spinal column injury is an unintended result of these safety measures, as illustrated by the following 5 cases.

Two patients (cousins), 50 and 57 years old, walked into the university-based emergency department (ED) complaining of severe pain in the thoracolumbar region, which appeared during the bus ride they had nearly an hour before. The bus has passed a speed bump over the speed limit in the city, which caused the bus to jump up high injuring the passengers at the back seats. The speed bump was nearly 15 cm in height, which was beyond the standard...
The men were not wearing safety belts during the event. Both patients were placed onto spine board. On arrival, the victims’ vital signs were normal. A complete physical examination revealed pain and tenderness in the thoracolumbar region; however, no neurological deficit was noted. Examination of other organ systems was unremarkable. Examination of the thoracolumbar plain radiographs displayed compression fractures in both patients. Thoracolumbar computed tomography images confirmed the presumptive diagnoses in the plain x-rays. Laboratory data (including serine calcium to rule out metastatic disease) obtained on admission were within normal limits. The patients denied any history of osteoporosis, degenerative bone disease, and malnutrition. The patients were admitted to the hospital for operative repair. Posterior instrumentation was performed in both patients in the same day. Both patients were discharged within 15 days after an uneventful follow-up.

Within nearly 5 months after the first 2 cases, 2 other patients, 48 and 43 years old, were brought to ED because of severe pain in the thoracolumbar region, which appeared during an urban bus ride. Both patients complained of severe back pain. It was learned that the bus passed a speed bump without slowing, which caused the bus to jump up high.

The women were not wearing safety belts during the event. Both patients were placed onto spine board. On arrival, the victims’ vital signs were normal, and physical examination revealed pain and thoracolumbar tenderness. One of these patients was noted to have motor neurological deficit, including hypoesthesia and 3/5 motor deficit in the right leg. Examination of other organ systems was unremarkable. Thoracolumbar plain radiographs displayed compression fractures in both patients. Thoracolumbar magnetic resonance imaging confirmed the presumptive diagnoses in the plain x-rays. Laboratory data (including serine calcium to rule out metastatic disease) obtained on admission was within normal limits. The patients denied any history of osteoporosis, degenerative bone disease, or malnutrition. The patients were admitted to the hospital for operative repair. Posterior instrumentation was performed in one of these patients in the same day. This patient was discharged after 13 days of follow-up, which was uneventful. The other patient wore a corset and was suggested to rest. Follow-up was uneventful and full recovery was achieved.

A 28-year-old woman was brought to ED because of severe pain in the neck region. She reported that 30 minutes ago, the bus she was traveling in passed a speed bump with its usual speed. The unexpected event caused a sudden back and forth movement of her neck. On arrival, the patient’s vital signs were normal and a cervical collar was immediately applied. On examination, her neck was tender, with no apparent neurological deficit. There was no fracture on lateral and anterior-posterior cervical x-rays. Cervical magnetic resonance imaging disclosed minimal posterior dislocation at C3 and C4. The patient was discharged with cervical collar. The patient was still complaining of neck pain in her follow-up visits at 1, 3, and 6 months.

In developed countries, traffic accidents appear to be the most common cause of spinal fractures and spinal cord injuries, whereas in developing countries, the most common mechanism is falling from heights. Osteoporosis, malignancy, inflammatory diseases, other metabolic bone diseases, and hematological diseases are known risk factors for the development of spinal compression fractures [2,3]. A high percentage of lumbosacral fractures occur in individuals younger than 30 years. Nearly 60% of patients have serious disabling deficits. The most common types of acute vertebral fractures are compression fractures or vertebral endplate fractures caused by sudden axial loading, transverse process avulsion by the origin of the psosas muscle, spinous process avulsions, and acute fracture of the pars interarticularis from hyperextension [4,5]. Sudden axial loading, which our patients were exposed to, could be the underlying mechanism in the resultant thoracolumbar compression fractures seen in the present cases.

Speed bumps to enforce 50-km/h speed limit in the city are built in areas with intense pedestrian population, such as schools, parks, and residential areas, where cruising at a higher speed could be too dangerous to afford.

In bus routes, the speed bumps should be 7.5 to 10 cm high and a warning sign should be placed 10 m before the bump [1]. The speed bumps could be effective if only the drivers obeyed the rules. However, if the speed bumps are not built with respect to the standards and if the drivers do not obey the rules, these bumps can be harmful, causing property damage, injuries, and even death. According to statistics, in year 2002, 400 000 traffic accidents caused 5000 deaths and 110 000 injuries in Turkey.

In conclusion, drivers should be strongly warned and educated against the potential hazards of traversing too fast on speed bumps. Another point to mention is that such barriers should be constructed according to tested standards. The pros and cons of various types of precautions to limit speed of motor vehicles should be taken into account by the local authorities before deciding which one should be chosen.

References

[1] Speed control humps built on the roads. Institution of Turkish Standards. TS 6283/ December 1988 [in Turkish].
Multiple organ failure as initial presentation of pheochromytoma

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A 50-year-old woman presented to the emergency department complaining of recent cephalalgias with sudden onset of palpitations, abdominal, and thoracic pain followed by nausea and vomiting. She had no medical history, but she reported a case of rhinitis treated for 2 days with a nonsteroidal anti-inflammatory agent. On examination, she was afebrile, with cold peripheries and discreet cyanosis, and abdominal palpation was normal and painless. There were no signs of heart failure, blood pressure was 164/114 mm Hg, and heart rate was 150 beats per minute, but she was oliguric. Electrocardiogram showed a sinusual tachycardia, an ST-segment elevation, Q waves in leads V1 and V2, and an ST-segment depression of more than 2 mm in leads V4 to V6. Chest radiograph showed bilateral interstitial infiltrates with right lower lobe consolidation. Echocardiography showed global alteration of left ventricular systolic function and grade II mitral regurgitation. Troponin Ic on admission was 66.8 µg/L (NR < 0.5); creatine kinase, 634 U/L (NR < 175); and creatine kinase-MB, 144 U/L (NR < 6). She had a severe lactic acidosis (ie, pH, 7.17; HCO3−, 8.8 mmol/L; lactate, 8.6 mmol/L) but without hypoxemia. C-reactive protein level was 9 mg/L (NR < 5); urea nitrogen, 7 mmol/L; creatinine, 172 µmol/L; protein, 92 g/L; amylase, 423 IU/L; and lipase, 190 IU/L. Her leukocytes count was 18 × 109/L. The clinical and biologic findings suggested a viral infection with acute myocarditis, pancreatitis, and pneumonia. Because of severe dehydration, the patient received intravenous rehydration and an antivomiting agent and was rapidly transferred to the intensive care unit (ICU).

On admission to ICU, she presented worsening dyspnea, extended marbling, and anuria despite a blood pressure of 124/84 mm Hg. The new biologic findings confirmed rapid evolution toward multiorgan-failure syndrome with shock, rhabdomyolysis, hepatic cytolysis (alanine aminotransferase, 9490 IU/L), acute pancreatitis (amylase, 3050 IU/L), anuric renal failure (creatinine, 343 µmol/L), and intravascular disseminated coagulation (fibrin degradation products, 160 µg/mL; prothrombin time, 30%). Less than 24 hours after her admission at the hospital and a few hours after the initial treatments, the patient’s clinical condition deteriorated and she was promptly intubated and ventilated. Continuous venovenous ultrafiltration was rapidly initiated.

The echocardiographist noted an abnormal image of the liver under diaphragmatic view. An abdominal ultrasound...
scan examination made by an experienced physician revealed a 7 × 6 × 6-cm hepatic mass in segment VI, suggesting a collected abscess. The patient was finally treated as a probable case of severe septic shock of hepatic and pulmonary origin, and after collection of blood and urine specimens and tracheal suction for culture, antimicrobial therapy was administered. Despite multiple organ failure, the hemodynamic state was stable, without any need for vasopressor or inotropic support. Immediately after intubation, she had an atrioventricular block followed by asystole. The patient died despite a long resuscitation, including external and intraventricular artificial cardiac pacing.

Autopsy showed a normal macroscopic liver with no mass (Fig. 1). A 9 × 7-cm (216-g), right retroperitoneal, hemorrhagic and necrotic mass involving the adrenal gland was found. Histological examination diagnosed a typical encapsulated pheochromocytoma with extensive necrotic changes and no signs of malignancy (Fig. 2). Systematic sampling of organs also revealed in the left heart ventricle a subacute inflammatory infiltrate with numerous eosinophilic polymorphonuclear cells associated or not with unicellular necrotic muscular cells corresponding to adrenergic myocarditis.

Pheochromocytoma is a rare cause of hypertension and is known to have a potentially fulminant course [1,2], especially after massive hemorrhagic and necrotic changes. The majority of patients report headache, sweating, palpitations, and pallor. Other less frequent symptoms are nervousness, tremor, nausea, fatigue, acute abdominal pain, visual disturbances, weight loss, and dyspnea [3]. In our case, initial symptoms (cephalalgias, palpitations, tachycardia, nausea and vomiting, and abdominal and chest pain) could have been suggestive elements of etiologic orientation. Second, the continuous presence of sustained blood pressure despite shock is another element suggesting pheochromocytoma. However, the lack of hypertension, the report of a recent rhinitis, and the erroneous echographic diagnosis of liver abscesses were probably the most confounding elements, leading to a false diagnosis.

Surgical management is the appropriate treatment of pheochromocytoma, together with preoperative medical management using α- and β-blocking agents to limit the adverse effects of catecholamine excess, which is mediated by α- and β-adrenergic receptors [3]. Earlier diagnosis would have led us to consider this treatment despite shock, leading to adrenalectomy.

Pheochromocytoma is often lethal when unsuspected [4]. Although uncommon, this condition should be considered early in patients with unexplained shock, multiorgan-failure syndrome, and preserved blood pressure because it is be potentially curable by surgical removal [5].

References

Carbon dioxide asphyxiation caused by special-effect dry ice in an election campaign

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During an election campaign held in a mansion hall, a previous healthy 33-year-old man was discovered unconscious in a wooden coverless box. The young man was a worker of a public relations company and was assigned to hide in a 7-ft-long, 2-ft-wide and 2.5-ft-deep topless wooden box. According to the designed scenario, he was made to help rise a big Taiwan-map slogan out of the box, symbolic of “Taiwan on the rise.” He lay at the bottom of the box and a 3-in pipe was pouring dry ice near his right arm. Because of the fog, the inner side of the box soon became invisible. At least 20 minutes had elapsed before the young man was discovered cyanotic and unconscious. Without palpable pulse and spontaneous respiration, the victim was resuscitated with mouth-to-mouth artificial ventilation and cardiac massage by a surgeon at the scene. Emergency medical technicians arrived 9 minutes later, when weak pulse was felt and irregular spontaneous respiration was restored. Laryngeal mask airway was established and he was sent to our ED for further evaluation and management.

On arrival, physical examination revealed a comatose consciousness with a Glasgow Coma Scale of E1M1V1. Neurologic examination revealed bilateral 4-mm-sized, fixed, nonreactive pupils, and an elevated muscle tone with a decorticate posture. Some skin wounds with intact or ruptured clear blisters were noted on his right elbow (Fig. 1). The location of the lesions was compatible with the site of the outlet of the dry ice pipe. Witness reported that there were no signs of struggle before the accident. The victim had no history of psychiatric disorders, recent personal crises, or medical illnesses. Later investigation of the scene of the accident also revealed a normal functioning air-conditioning and ventilation system.

Series of laboratory results on ED admission were within reference range (Table 1). Electrocardiography and chest radiograph were unremarkable. Computed tomography showed diffuse brain edema. His consciousness level improved to E1M3VT 20 minutes later. Under the impression of hypoxic encephalopathy, he was cared in the neurologic intensive care unit. Two months later, he still remained vegetative.

Dry ice is widely used in various public activities as special-effect fog. However, even in open space, its safety is still questionable. The molecular weight of dry ice is 44, which means it is heavier than air and easily accumulates in the bottom of a box, pool, or building. According to the Occupational Safety and Health Administration and American Conference of Governmental Industrial Hygienists, the exposure limit of carbon dioxide is 5000 parts per million (9000 mg/m³) or 0.5% for an 8-hour time-weighted
average [1]. The Occupational Safety and Health administration considers a 10% carbon dioxide concentration potentially lethal [2].

From a toxicologic standpoint, carbon dioxide simply resembles asphyxants [3]. However, it has direct toxic effect in high concentration despite normal atmospheric oxygen concentrations [4]. It causes hypercapnia, increased heart rate, cardiac output, mean pulmonary artery pressure, and pulmonary vascular resistance [5,6] and therefore imposes excess load on the myocardium [3]. The predominant mechanism for hypercapnia is decreased hypoxic ventilatory drive [7]; this aggravates the hypoxia and eventually causes brain damage.

The chest radiograph of the victim was normal, compatible with previous observations [3,8,9]. In fact, reports of fatal cases of carbon dioxide exposure [8,9] indicate that the lungs were normal on postmortem examination. The rate of excretion of carbon dioxide is very rapid with hyperventilation. Blood partial pressure of carbon dioxide returns to normal within a few minutes [10]. This explained the normal arterial gas profile after intensive resuscitation minutes later.

Contradictory to general belief, respiratory arrest usually occurs without any warning signs like cough, strenuous breathing, or struggle, preventing early recognition and rescue. In our case, the evaporating dry ice yielded carbon dioxide, accumulated in the bottom of the box, and displaced much of the oxygen; thus, unconsciousness developed silently. Without timely resuscitation, prolonged hypoxia may lead to hypoxic encephalopathy and even death. Besides, loss of consciousness predisposed the victim to the frostbite because he had no reactions to pain or coldness upon dry ice contact.

Dry ice should be used cautiously in public activities. Its odorless, nonirritant characteristics may cause asphyxiation silently even in an open space, if regional accumulation is possible. Once carbon dioxide intoxication occurred, the victim should be evacuated and resuscitated immediately. The general public should be made aware of the potential hazard of dry ice and the silent nature of asphyxiation, which is the most effective way to prevent the next tragedy.

References

Correspondence

Emergency department procedural sedation formularies

To the Editor,

The ideal procedural sedation agent for any patient may be less a function of pharmacology and more a function of physician access. This study was undertaken to profile ED procedural sedation formularies and define which agents are available for use by emergency physicians (EPs) within their departments. Relationships between medication availability and ED characteristics were also examined.

A survey was conducted of emergency physicians attending a national meeting of community ED directors regarding their access to various procedural sedation medications. The specific information collected in the survey included ED annual census, medications available to emergency physicians, ED procedural sedation policy development, and credentialing of EPs for specific levels of sedation. Medications available only for endotracheal intubations were differentiated from those used for non-endotracheal intubations procedures. Statistical analysis was through \( \chi^2 \) and regression modeling.

A total of 76 completed surveys were returned out of a possible 155 hospital sites (49%). Annual ED censuses ranged from 6000 to 111000 visits with a median of 28 200 visits. Procedural sedation policies were created solely by emergency medicine in 9 (12%) sites, anesthesia only in 22 (29%) sites, and by both in 40 (53%) sites. Five sites (6%) had no written or an unknown policy. Emergency physicians were credentialed for deep sedation at 16 (21%) sites and moderate sedation at 48 (63%) sites. Twelve sites (16%) did not specify the level of credentialing. The percentage of departments with described access to medications are listed in Table 1.

The median number of unrestricted medications per site was 4, whereas 3 sites had unrestricted access to all 11 medications, and 8 sites had unrestricted access to no medications.

There were no statistically significant differences between access to individual medications and ED census, policy development, or credentialing for moderate or deep sedation. A significant correlation was noted between number of medications with unrestricted access and ED census \( (P < .002) \) and EP credentialing \( (P < .002) \).

To our knowledge, this report represents the first published multi-site study on ED procedural sedation formularies. Our findings demonstrate a marked degree of variability between institutions with regard to emergency physician access to these agents. It is surprising to note the number of community hospitals with unrestricted access to agents such as propofol (34%), etomidate (46%), ketamine (43%), and droperidol (42%), considering the recent controversies surrounding these agents [1-3]. The finding that almost half the sites have access to at least one of the agents indicates the successful relationship that emergency and anesthesia departments can develop.

Unfortunately, no useful correlation between ED characteristics and procedural sedation formularies could be determined from this study. Future prospective studies of actual patient outcomes will be needed to assess EP’s performance with these agents.

Table 1 Emergency physician medication access

<table>
<thead>
<tr>
<th>Drug</th>
<th>Unrestricted (%)</th>
<th>Adult only (%)</th>
<th>Child only (%)</th>
<th>RSI only (%)</th>
<th>Not available (%)</th>
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<td>0</td>
<td>13</td>
<td>0</td>
<td>36</td>
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<tr>
<td>Droperidol</td>
<td>42</td>
<td>8</td>
<td>0</td>
<td>1</td>
<td>49</td>
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<tr>
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<td>46</td>
<td>4</td>
<td>0</td>
<td>17</td>
<td>33</td>
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<tr>
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<td>12</td>
<td>0</td>
<td>3</td>
<td>23</td>
</tr>
<tr>
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<td>43</td>
<td>3</td>
<td>9</td>
<td>4</td>
<td>41</td>
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<tr>
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<td>0</td>
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<td>76</td>
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<tr>
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<td>0</td>
<td>3</td>
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<td>90</td>
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<td>1</td>
<td>1</td>
<td>3</td>
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</tr>
</tbody>
</table>

Abbreviation: RSI, rapid sequence intubation.

References

To the Editor,

Although upper gastrointestinal (GI) bleeding has an overall annual incidence of 100 per 100,000 in the general population, bleeding secondary to Dieulafoy’s lesion is rare and likely underdiagnosed. This vascular malformation can present with massive and catastrophic hemorrhage that can be fatal if not managed aggressively. We present the case of an unusual presentation of upper GI bleeding secondary to Dieulafoy’s lesion.

A 45-year-old woman presented to our ED by ambulance after feeling fatigue, malaise, and indigestion all day while at work as a nurse in a pediatrician’s office. She stated she felt hot, sweaty, and lightheaded most of the day. Upon arriving home at the end of a very busy day, she “collapsed” into a chair and had diminished level of responsiveness but did not lose consciousness. She had been lowered to the floor by her husband who instructed his son to call 9-1-1. She was found by paramedics to be awake but poorly responsive with a blood pressure of 90/54 and a heart rate of 80. She became more conscious during transport and arrived in the ED alert and oriented. On initial questioning, she states she ate what she thought was bad fish the night before and attributed her symptoms to food poisoning. She denied nausea, vomiting, diarrhea, or abdominal pain. She had a past medical history significant for migraine headaches, depression, and lactose intolerance, and took only Prozac daily and Lactaid as needed. The patient’s social history was significant for occasional tobacco and alcohol use, but she denied drug use.

On physical examination, she was noted to be pale but was awake, alert, oriented, and conversant. Her vital signs are recorded as follows: blood pressure, 103/64; heart rate, 84; respiratory rate, 18; O₂ saturation, 100%. She was noted to be orthostatic, but the capillary refill was less than 2 seconds. The patient’s abdomen was soft, nontender with normoactive bowel sounds. There was no distention observed, no tympany elicited on percussion, no masses palpated, and no hepatosplenomegaly appreciated. The rectal examination was initially deferred as the clinician was acquainted with the patient and her family.

After IV rehydration, the patient was no longer orthostatic and felt much better, although still quite tired as she ambulated to the rest room. Laboratory results revealed the following: hematocrit of 30.3; blood urea nitrogen and creatinine of 38 and 0.9, respectively. A nasogastric tube was inserted and 350 mL of maroon blood was aspirated.

Gastroenterology consultation was requested and the patient underwent immediate endoscopy at which time she was found to have a Dieulafoy’s lesion in the gastric mucosa. The patient was treated with sclerotherapy and on follow-up has been asymptomatic for 2 years.

Dieulafoy’s lesion is an arterial malformation in the submucosal layer that can lead to GI hemorrhage. Although the majority of these lesions are found in the proximal stomach within 6 cm of the gastroesophageal junction [1], there are documented cases of Dieulafoy’s lesion elsewhere in the GI tract as well [2-4]. The site of bleeding is usually a 2- to 5-mm mucosal defect, and clinical presentation in one study showed 28% of patients developed hematemesis alone, 51% with hematemesis and melena, and 18% with melena alone [5]. Hemorrhage, shock, and death can occur with severe bleeding. Initial stabilization is the same as that for other causes of GI bleeding, with 2 large bore peripheral IV lines and infusion of crystalloid. Although the initial management of Dieulafoy’s lesion historically has been surgical, endoscopic treatment is now the preferred means of management [6-9].

This case report presents an interesting presentation of a rare cause of GI bleeding. Emergency physicians must remain cognizant that GI bleeding has a spectrum of possible presentations and etiologies, some of which have the potential to be extremely surreptitious but rapidly progressive and life-threatening.

References

Effects of diabetes on the ED presentation of acute intermittent porphyria

To the Editor,

Whether diabetes could prevent attacks of acute intermittent porphyria (AIP) remains incompletely understood. Lithner described 16 AIP patients who had complete remission of AIP attacks after onset of diabetes [1]; however, a correlation between blood glucose level and frequency/severity of AIP attacks was not mentioned. Can AIP be excluded in a diabetic patient who visits ED for severe abdominal pain? AIP is a very rare hereditary metabolic disorder in Taiwan; herein, we reported a patient who had diabetes antedated AIP.

A 68-year-old Taiwanese man took herbal medications for the treatment of hyperglycemia in 1980s. He had visited our ED because of severe abdominal pain with vomiting and dark urine on 30 occasions since August 1992 (when he was 56 years old) to December 1999. AIP was diagnosed according to the typical symptoms and positivity of Watson-Schwartz test for 4 times. No significant change was found on radiographic, panendoscopic, or laboratory examinations except for hyperglycemia (190-250 mg/dL). He has received glibizide 2.5 mg BID since June 1993, and his glycosylated hemoglobin (HbA1c) level was 8.3% (upper limit of normal, 6%) in November 1998. The number of AIP attacks declined to less than 3 times a year since 2000 (Table 1) and his HbA1c level increased to 9.2% in December 2002. In November 2003, he was admitted with abdominal pain and dark urine. His symptoms subsided after parenteral use of glucose with negative Watson-Schwartz test. Meanwhile, his porphobilinogen deaminase activity was 44.6 nmol·h⁻¹·mL⁻¹ red blood cell, which was the lower limit of the age-matched healthy Taiwanese subjects (44.2-55.4 nmol·h⁻¹·mL⁻¹ red blood cells) [2]. His HbA1c was 9.6% during this admission, and there was no more AIP attack until September 2004.

Although diabetes is shown to decrease the risk of AIP attacks [3,4], 3 patients with diabetes antedating AIP for 3 to 20 years have been reported [5]. Usually, AIP affects persons in their 30s [6]; however, patients having diabetes-antedated AIP may experience relevant symptoms after 50 years, as is shown in our case. Of particular note is that our patient had fewer AIP attacks when his glycemic control worsened in recent years. Perhaps, a higher blood glucose level could suppress aminolevulinic acid synthase and then ameliorate the frequency and/or severity of AIP attacks, yet it still cannot elicit a complete remission of AIP in some patients. On the other hand, these discrepant observations between previous reports may be reasoned by the different ethnic populations studied. Further large comparative studies with prospective design are therefore needed to examine this interesting and important issue. In conclusion, although diabetes may have beneficial effects on patients with AIP, AIP should still be considered as a differential diagnosis in a diabetic patient with severe abdominal pain at the ED.

References


Table 1 The relation of serum glucose and episodes of AIP

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<thead>
<tr>
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<tbody>
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<td>4</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>8</td>
<td>11</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>HbA1c (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.3</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Sugar (mg/dL)*</td>
<td>200-250</td>
<td>200</td>
<td></td>
<td></td>
<td></td>
<td>250-360</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>260-300</td>
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</table>

* Serum glucose level was recorded upon arrival at the ED.
Training emergency physicians to perform out-of-hospital ultrasonography

To the Editor,

We read with interest the paper from Jang et al [1] on training for ultrasonography in emergency cases. Training is a crucial matter when ultrasonographic examination is performed by a nonradiologist operator [2]. Our experience could contribute to this issue as we recently evaluated initial training for emergency physicians performing out-of-hospital ultrasonography.

A 4-hour tutorial on focused abdominal sonography for trauma included theoretical lecture, demonstration, and practice. Eight experimented emergency physicians attended 1 to 6 tutorials. Then, ultrasonography was routinely used by emergency physicians in out-of-hospital settings. Patients were followed up to validate out-of-hospital diagnosis. Indeed, it should be noted that, because of out-of-hospital settings, patients’ follow-up was indispensable for the physicians to validate their out-of-hospital diagnosis.

Two hundred twenty-two examinations were analyzed to evaluate initial training. Diagnostic performance (sensitivity, specificity, and positive and negative predictive values) increased for emergency physicians after attending 2 tutorials (Table 1). Diagnostic performance according to the number of examinations performed using a receiver operator curve showed a cutoff point of 25 examinations. Then, we validated the following training protocol associating at least 8 hours of initial tutorial and at least 25 examinations including patients’ follow-up. According to our results, performance reached with such training was similar to the performance reached by hospital emergency physicians. The results we reported are consistent with those of Jang et al whereas ultrasonography indications are different. In both studies, the minimal training seemed to involve 25 examinations or less. Despite the lack of strong evidence, as Jang et al, we concluded that the recommendations of the American College of Emergency Physicians were pertinent as the suggested number of examinations required (25 for each indication) is similar to our results [3]. Such attitude seems to be adequate for emergency physicians willing to reach a high level of performance. It should be noted that, in particular indications, a much shorter tutorial has been proposed with satisfactory results [4,5]. This point illustrates the need to validate tutorials and practical training according to a specific indication, as Jang et al and we undertook.

![Table 1](image-url)

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>NPV</th>
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<tr>
<td>&lt;2 formations</td>
<td>20</td>
<td>98</td>
<td>67</td>
<td>83</td>
</tr>
<tr>
<td>&gt;2 formations</td>
<td>92</td>
<td>98</td>
<td>89</td>
<td>99</td>
</tr>
</tbody>
</table>

PPV indicates positive predictive value; NPV, negative predictive value.

References


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Spontaneous pneumothorax presenting as epigastric pain

To the Editor,

Spontaneous pneumothorax is a common disease encountered in hospital practice. It usually occurs in young men and presents with sudden onset of respiratory distress and chest pain. We report on a patient with spontaneous pneumothorax, who presented with epigastric pain,
mimicking peptic ulcer disease or acute pancreatitis. The pain subsided after chest tube thoracostomy.

A 41-year-old man, smoking for 20 years, had gradual onset of epigastric pain 2 weeks before visit to our hospital. He had no history of heavy alcohol intake. Reviewing his history, the respiratory symptoms, such as cough, dyspnea, chest or shoulder pain, did not occur after the onset. No trauma history was noted. He had no medical history of peptic ulcer disease and pancreatobiliary disease. On arrival, he was clear and ambulatory. The vital signs were stable: blood pressure was 130/80 mm Hg, pulse rate 84 beats per minute, respiratory rate 16 breaths per minute, and body temperature 37.0°C. Blood gas analysis at room air was $P_{O_2}$ 71.4 mm Hg and $P_{CO_2}$ 40.1 mm Hg, and his peripheral oxygen saturation was 94%. Physically, auscultation of the lung revealed clear breath sounds except over the left lung field where breath sounds were diminished. The abdomen was soft but with epigastric tenderness. The remainder of the physical examination was unremarkable. The differential diagnoses were peptic ulcer disease and acute pancreatitis. A peripheral white cell count showed 7100 cells per microliter without a left shift. Serum amylase and lipase were within normal limits. Abdominal ultrasound revealed normal a pancreas without pancreatobiliary tract dilatation. In gastric endoscopy, neither gastric nor duodenal ulcer was found. Posterior-anterior chest radiograph disclosed a left pneumothorax (around 80%) without a mediastinal shift (Fig. 1). Pleural effusion was not observed on the radiograph. Soon after chest tube thoracostomy, his epigastric pain subsided. Full reexpansion of the left lung was achieved, and he was discharged uneventfully 4 days later. No more epigastric pain was reported after discharge.

Primary spontaneous pneumothorax is a common disease encountered in hospital practice. It is defined as pneumothorax without underlying lung disease and typically occurs in tall thin boys and men between the ages of 10 and 30 years [1-4]. It results from rupture of subpleural bullae and air leaks into pleural cavity. Practically, all patients have ipsilateral pleural chest pain or acute dyspnea because reduction of lung volume results in respiratory distress [1-4]. Other minor symptoms include cough and general malaise [5]. However, our patient presented with epigastric pain, mimicking acute peptic ulcer disease or pancreatitis and, surprisingly, without respiratory symptoms. It is a very rare manifestation for spontaneous pneumothorax. In English literature, we found only one report on tension pneumothorax presenting with epigastralgia and epigastric tenderness described by Hollins et al [5]. Very recently, Lien et al [6] reported pneumothorax presenting with right upper quadrant pain and a positive Murphy sign, mimicking acute cholecystitis. The mechanism by which spontaneous pneumothorax causes epigastric pain is still uncertain. In the patients reported by Hollins et al [5], epigastric pain might be elicited by tension pneumothorax that depressed the right hemidiaphragm of the affected side. In the patient reported by Lien et al [6], no tension pneumothorax was found, and therefore, they speculated that right upper quadrant pain might be caused by a small pleural effusion. In our patient, however, there was neither tension pneumothorax nor pleural effusion. We suspected that other mechanism such as influence on diaphragm of the affected side by highly collapsed lung toward pulmonary ligament would be concerned with the epigastric pain. It would be possible in our case rather than tension pneumothorax and pleural effusion. In addition, Lien et al [6] suggested that young age and high pain tolerance were the reason why the patient had no respiratory symptoms. With this phenomenon, we suppose that very slow progression of pneumothorax would be concerned in our patient.

In a patient with epigastric pain, an intra-abdominal pathology, especially gastrointestinal and pancreatobiliary diseases, should be sought initially. However, consider a spontaneous pneumothorax if there are negative findings on abdominal sonography and gastric endoscopy.

References

To the Editor,

The prevalence of clinically significant methemoglobinemia (MHb) is unknown among previously healthy infants presenting to the emergency department (ED) with diarrhea and dehydration. However, it is well described in these infants and, when present, can be associated with significant morbidity [1-4]. Nevertheless, it may not be clinically apparent until levels reach almost 7 times normal levels [5]. Based on this, we hypothesized that dehydrated infants younger than 3 months with diarrhea would commonly have MHb levels above normal but below that causing cyanosis and obvious distress.

We conducted a cross-sectional study of MHb in acyanotic dehydrated infants with diarrhea and a comparison group of well-hydrated febrile infants, all 3 months old or younger, presenting to an urban pediatric ED. The age group and severity of illness of the dehydrated patients were chosen for the highest likelihood of MHb [3]. A sample size of 10 was needed in each group, with a one-tailed α level of .05 and power of 80% to detect a mean group MHb level of 5% ± 5%. (An MHb level of 5% was chosen as a cutoff level for which symptoms are likely to occur but clinical signs will not be evident.)

A convenience sample was enrolled during 1 year from among age-appropriate patients with diarrhea and diagnosis of dehydration as determined by the on-duty attending pediatric emergency physician. Diarrhea was defined as 3 or more loose or watery stools in the prior 24 hours. Degree of dehydration was established by the use of a generally accepted pediatric emergency dehydration scale [6]. Well-hydrated comparison patients were selected from a convenience sample of well-hydrated infants in the same age range undergoing a fever evaluation. Patients were excluded if they had a history of MHb, an acidemia-inducing illness (eg, metabolic disorder), or received oxidizing medication via breast milk or direct ingestion.

The research was approved by the hospital’s institutional review board. Written informed consent was obtained from the parents of all infants. The study was conducted at the Children’s National Medical Center General Clinical Research Center.

Thirty patients were approached for enrollment and 3 parents refused (1 in the dehydration group and 2 in the fever group). We enrolled a total of 27 subjects: 10 with dehydration and 17 febrile patients. The mean age of the entire study population was 59 ± 29 days; 70% were boys. The 2 groups were demographically similar (Table 1). The prevalence of subclinical MHb (sMHb) (ie, MHb >1.5%) was 2 of 10 (20%; 95% CI, 2.5-55.6) dehydrated subjects and 1 of 17 (5.9%; 95% CI, 0.2-28.7) well-hydrated comparison patients (P = NS). It is noteworthy that of the patients with sMHb, the 2 dehydrated patients had levels of 5.9% and 6%, whereas the single well-hydrated patient had a level of 1.9%.

None of the potential risk factors for sMHb were significantly associated with group designation. Among all 27 patients enrolled, χ2 analysis and the Student t test revealed the following factors significantly associated with sMHb: lower mean body weight percentile (P = .027) and higher mean chloride level (P = .033) (Table 2).

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Presented in part at the Clinical Research 2003 National Meeting (March 23, 2003), the National Meeting of the Pediatric Academic Societies (May 3, 2003), and the National Meeting of the Society for Academic Emergency Medicine (May 29, 2003).

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Table 1 Demographics and clinical variables by group

<table>
<thead>
<tr>
<th></th>
<th>Dehydrated</th>
<th>Febrile</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male sex [n (%)]</td>
<td>7 (70)</td>
<td>12 (71)</td>
<td>RR = 0.99 (0.59 to 1.64)</td>
</tr>
<tr>
<td>Breastfed [n (%)]</td>
<td>4 (40)</td>
<td>13 (76)</td>
<td>RR = 0.53 (0.24 to 1.18)</td>
</tr>
<tr>
<td>Median age (d [IQR])</td>
<td>64 [38-84]</td>
<td>52 [32-81]</td>
<td>P = .69</td>
</tr>
<tr>
<td>Mean weight (percentile)</td>
<td>52 ± 36</td>
<td>61 ± 30</td>
<td>P = .55 (−22 to 39)</td>
</tr>
<tr>
<td>Mean temperature (°C)</td>
<td>38.2 ± 1</td>
<td>38.4 ± 1</td>
<td>P = .66 (−1 to 1)</td>
</tr>
<tr>
<td>Mean pulse (beats/min)</td>
<td>175 ± 24</td>
<td>164 ± 16</td>
<td>P = .23 (−30 to 8)</td>
</tr>
<tr>
<td>Mean respiration (beats/min)</td>
<td>41 ± 8</td>
<td>41 ± 10</td>
<td>P = .98 (−7 to 7)</td>
</tr>
<tr>
<td>Mean oxygen saturation (arterial) (%)</td>
<td>99 ± 2</td>
<td>99 ± 1</td>
<td>P = .33 (−1 to 2)</td>
</tr>
<tr>
<td>Median dehydration level (% [IQR])</td>
<td>5 [5-10]</td>
<td>0 [0-0]</td>
<td>P &lt; .001</td>
</tr>
</tbody>
</table>

a The 95% CI of the difference in the means.
Despite the often described MHb etiology of oxidant stress from enteritis, it remains unclear why an otherwise healthy infant with diarrhea develops MHb when another does not. Traditionally, acidemia from dehydration has been thought to be the underlying factor in these children [7-13]. Despite this, a single inciting factor for methemoglobinemia in these patients has not been identified and several factors are thought to play a contributory role. First, by virtue of enzymatic immaturity, infants have only slightly more than half of the functioning MHb of healthy adults [14]. In addition, fetal hemoglobin is more easily oxidized than adult hemoglobin. Finally, the high pH level in an infant’s gut promotes the growth of nitrite-producing flora that can lead to added oxidative stress.

In this investigation, we identified a potentially clinically important, but not statistically significant, difference in the prevalence of sMHb and degree of elevation between an ED group of dehydrated infants and a group of well-hydrated infants. The lack of statistical significance for this finding is prone to type II error given the small sample size. Of note, it is not clear whether the elevated MHb levels in either group are causal for morbidity or merely an indicator of disease status. The lack of a true control group (ie, healthy infants) is an additional limitation.

Previous studies of infantile MHb had included obviously ill or hospitalized patients [12]. These had only limited applicability to ED patients, in whom sMHb is probably more likely to go unsuspected and therefore undetected before disposition. Our data provide a first estimation of the prevalence of elevated MHb levels in dehydrated infants with diarrhea presenting to the ED.

## References


<table>
<thead>
<tr>
<th>Table 2</th>
<th>Clinical and laboratory measurements by presence of sMHb</th>
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<tbody>
<tr>
<td>MHb &gt;1.5%</td>
<td>MHb ≤1.5%</td>
</tr>
<tr>
<td><strong>Breastfed (%)</strong></td>
<td>0 (0)</td>
</tr>
<tr>
<td><strong>Median age (d [IQR])</strong></td>
<td>55 [42-59]</td>
</tr>
<tr>
<td><strong>Mean weight (percentile)</strong></td>
<td>20 ± 9</td>
</tr>
<tr>
<td><strong>Mean temperature (°C)</strong></td>
<td>38.7 ± 0.5</td>
</tr>
<tr>
<td><strong>Median dehydration level (%) [IQR]</strong></td>
<td>10 [0-10]</td>
</tr>
<tr>
<td><strong>Mean anion gap</strong></td>
<td>11 ± 3</td>
</tr>
<tr>
<td><strong>Mean pH</strong></td>
<td>7.25 ± 0.09</td>
</tr>
<tr>
<td><strong>Mean hemoglobin (g/dL)</strong></td>
<td>10.3 ± 1.2</td>
</tr>
<tr>
<td><strong>Mean chloride (mEq/dL)</strong></td>
<td>114 ± 11</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>3</td>
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</table>

$^a$ The 95% CI of the difference in the means.

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Common causes of hemiballism

To the Editor,

Hemiballism is a rare hyperkinetic movement disorder, characterized by irregular, wide amplitude and vigorous involuntary movements of the unilateral limbs. The term *ballismus* is derived from the Greek word meaning “to throw” because the abnormal movements resemble the motions of throwing. The movements are usually continuous but may be intermittent and can be voluntarily restrained by the patient, although only for a few minutes. They are most prominent during periods of rest but are absent during sleep. It may occur with other types of involuntary movements, such as dystonia, myoclonus, or orofacial gestures [1].

Hemiballism is often used interchangeably but distinguished from hemichorea by the fact that hemichoreic movements are slower, more randomly distributed, less violent, and primarily involve distal musculature [2]. Some patients with hemiballism also have choreiform movements; therefore, the “hemiballism-hemichorea” is often used to describe this clinical spectrum [2-5].

We present 2 cases of hemiballism, 1 subthalamic nucleus (STN) infarction and 1 nonketotic hyperglycemia, with a literature review.

A 69 year-old woman was brought to the ED because of right-sided involuntary movements. The medical history included diabetes and hypertension on medications for 10 years. The unintentional, intermittent flinging movements of her arm and leg started several days before admission. The movements were most prominent during periods of rest but were absent during sleep. The arm was more severely involved than the leg. Vital signs on admission included blood pressure of 120/80 mm Hg and pulse rate of 64 beats per minute. She was alert and oriented. There was no other remarkable neurologic abnormality except the involuntary movements. The magnetic resonance imaging (MRI) showed lacunar infarction of the left STN (Fig. 1). The movements were decreased with the administration of oral haloperidol. She was discharged on the sixth hospital day with improved condition. The involuntary movements completely disappeared after 4 months.

A 76 year-old woman presented with left-sided involuntary movement for 7 days. She has known hypertension on intermittent medication for several years, but not known diabetes. She had not taken neuroleptic drugs and there was no family history of movement disorder. The irregular but persistent movements were started on her lips and extended to arm and leg. It resembled rolling and kicking motion, and aggravated when excited, but resolved when sleeping. She was alert and her vital signs included blood pressure of 150/80 mm Hg and heart rate of 84 beats per minute. On neurologic examination there were no other unusual findings. The initial fasting glucose was 177 mg/dL and hemoglobin A1c level was 10.1%. The urinalysis showed glucose 3+ and no ketone. The MRI showed high signal intensity in the right basal ganglia on the T1-weighted image (Fig. 2). She had taken haloperidol orally and insulin infusion. She was referred to the neurology department under the impression of hemiballism associated with
nonketotic hyperglycemia. The involuntary movement was improved within the fifth hospital day.

Hemiballism is reported to be most commonly due to a lesion in the STN on the side contralateral to the involved limbs as seen in case 1. The STN is a lens-shaped structure located along the medial and cephalad margin of the peduncular portion of the internal capsule [3]. The STN has a tonic inhibitory influence on the thalamus by means of excitatory projections onto inhibitory neurons in the medial globus pallidus. Therefore, a destructive lesion in the STN could result in disinhibition of these excitatory pathways, resulting in production of hemiballistic movements [2]. It is usually caused by lacunar infarction but may also result from various conditions such as neoplastic, infectious, traumatic, iatrogenic, or metabolic origin [1,2,6].

The lesion outside the STN is also reported to develop hemiballism, at points along the afferent or efferent pathways connecting the STN to its projection areas, which include the globus pallidus, putamen, thalamus, and brainstem [1,2,7]. Surprisingly, recent review of modern case series has reported that the lesion outside STN accounted for more than half the hemiballism [2]. The striatum (caudate nucleus and putamen) is reported to be the most common non-STN site [8] and usually associated with hyperglycemia as seen in case 2.

The hyperglycemic hemiballism is now regarded as the second most commonest cause of hemiballism [2]. It tends to be more prevalent in Asian elderly women with poorly controlled type 2 diabetes mellitus. The hemiballism may be the only manifestation of hyperglycemia [4]. Most patients have nonketotic hyperglycemia, although a patient with hemiballism associated with ketoacidosis has been reported [9]. The pathogenesis and the unilaterality of the lesion despite of its metabolic origin are uncertain.

The MRI is the imaging study of choice for hemiballism because the STN is a small structure and the sensitivity of computed tomography scan for lacunar infarct is low. It is also useful in the hyperglycemic hemiballism. They have characteristic hyperintense lesion in the contralateral striatum on T1-weighted MR image (Fig. 2). All reported cases show putaminal lesion and similar changes are found variably in the globus pallidus and head of caudate [2]. The nature of high signal intensity in the striatum on the T1-weighted images has been the subject of considerable controversy, including petechial hemorrhage, demyelination, or swollen astrocytosis [10]. The T2-weighted images in the corresponding area are more variable [11,12]. The computed tomography scan is reported to show high densities in some cases [10].

In case 2, the patient has a not so high glucose level of 177 mg/dL, but had confirmed hyperglycemic hemiballism because of the typical striatal hyperintensities on T1-weighted images. The initial glucose levels have been reported variously and appear not to be proportional to the severity of hyperglycemic hemiballism [11-13], whereas the glycosylated hemoglobin A1c, which reflects recent glucose status, is always increased. Even a diabetic patient with hemiballism who have low glucose level has typical lesions on MRI [11]. Therefore, the MRI is useful to differentiate whether the cause of hemiballism is hyperglycemia or not.

The treatment and prognosis of the hemiballism depends on their etiologies. As hemiballism can be life threatening, early recognition of its cause is important. Patients who have severe ballism may injure the affected limbs by striking walls and bedrails. So, padding of the limb may be important to prevent injury in severe cases. The long-term prognosis of vascular hemiballism is similar to that of other stroke patients [5]. In case of hyperglycemic hemiballism, the clinical and radiological abnormalities improved on control of blood glucose levels. Resolution of the lesions on the imaging studies may be slower than the clinical improvement [13]. However, atypical cases have been reported with delayed onset after resolution of the hyperglycemia, unremitting severe movements, and late recurrence [14]. Most patients respond well to the dopamine antagonists, such as haloperidol or phenothiazines, because of their antidopaminergic activity resulting in inhibition of STN neuronal firing [1,2]. However, pharmacologic therapy is not always necessary because some patients have mild and self-limited course.

When an emergency physician encounters a patient with hemiballism, he should keep in mind common causes of hemiballism such as STN infarction and nonketotic hyperglycemia. The MRI should be considered to look for lesions in the contralateral STN or striatal hyperintensity on T1-weighted images. Correction of underlying hyperglycemia with temporary use of haloperidol, if necessary, will lead to clinical improvement.
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Group A streptococcal necrotizing fasciitis: reducing the risk of unwarranted litigation

To the Editor,

Invasive group A streptococcal (GAS) disease is a disease of public health importance in the United States. The annual incidence of invasive GAS disease is 4 times that of meningococcal disease [1]. The case-fatality rates of GAS necrotizing fasciitis (NF) and streptococcal toxic shock syndrome, 2 severe manifestations of invasive GAS disease, are high (20% and 45%, respectively).

Clinicians involved with the treatment of GAS NF are at risk for malpractice claims [2]. The rapidity with which GAS NF can progress from a minor condition to a life-threatening situation may trigger a lawsuit even though the patient has received appropriate care [2]. The rapid diagnosis of GAS NF can be difficult. Unrelenting pain out of proportion to the physical findings is an important symptom of GAS NF [3].

Competent physicians may initially miss the diagnosis of GAS NF because several of the signs and symptoms of GAS NF may mimic those of a muscle strain, influenza [3], or gastroenteritis due to a foodborne pathogen. Another reason why competent physicians may initially miss the diagnosis of GAS NF is self-medication by the patient with nonsteroidal antiinflammatory drugs (NSAIDs). Nonsteroidal antiinflammatory drug may delay presentation to the emergency department.

The goal of this analysis is to provide emergency medicine specialists who have treated patients with GAS NF with data from a population-based study of invasive GAS disease that may reduce the risk of an unwarranted malpractice lawsuit.

Data from a retrospective study of invasive GAS infections conducted in Florida were analyzed. Details of the original study are found elsewhere [4]. These cases were 195 patients who were hospitalized throughout Florida between 1996 and 2000 for invasive GAS disease and reported to the Florida Department of Health, Tallahassee, Fla. Invasive GAS disease is a reportable condition in Florida. For the current analysis, data on 42 patients with GAS NF were extracted from the main database.

Table 1 shows the frequency distribution of the admitting diagnosis listed on the Florida Department of Health
surveillance case report form of 42 cases of GAS NF. Few patients (9.5%) had NF listed as an admitting diagnosis. A total of 13 patients (31%) had an admitting diagnosis of cellulitis noted on the health department case report form.

Twenty-five percent of these patients (8/32) had diarrhea at the time of admission or developed it within 48 hours of admission. (Ten of these patients with GAS NF had missing values for this variable).

Limited data were available on the recent use of NSAIDs by these GAS NF cases. Twenty percent of these patients (5/25) had used NSAIDs after the onset of invasive GAS disease.

Investigators have recently discovered a host genetic factor (a certain human leukocyte antigen class II haplotype) that strongly predisposes certain individuals to develop GAS NF or streptococcal toxic shock syndrome after infection with GAS [5]. In this situation, it is conceivable that rapid and appropriate treatment may do little to reduce the chance of mortality.

If GAS NF is suspected, then rapid consultations with surgeons and infectious disease clinicians are imperative. Even though penicillin and clindamycin are the antibiotics of choice in this setting [4], surgery remains the foundation of treatment for GAS NF [2].

References


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Finally, a paper documenting the delay

To the Editor,

We compliment Adams et al [1] for their elegant use of scintography to verify the commonly held belief that significant delays in gastric emptying occur after intentional overdose. Given that histories obtained from suicidal patients are inherently unreliable and that toxicology screening was not obtained in a standardized manner, we caution readers not to overinterpret the association between the individual drugs categorized in this study and their effects on gastric motility. We agree with the authors’ conclusion that poisoning from drug overdose (in general) results in hypomotility and delayed gastric emptying.

The power of the study would be improved if individual drug categories were eliminated and each patient was used as their own control. In addition, as gastric instrumentation has been shown to delay emptying, the authors should consider publishing the data that compare patients treated with and without gastric lavage [2]. We hope that this work will help advance the discussion of gastrointestinal decontamination and cast doubt on the dogmatic approach in patients presenting more than 1 hour after ingestion [3,4].

References


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Oligoanalgesia in ED patients with isolated extremity injury without documented fracture

To the Editor,

Effective management of pain is a fundamental aspect to the humane provision of emergency care. Multiple studies have identified oligoanalgesia as a significant problem in emergency medicine [1,2]. Pain is a subjective entity that manifests differently based upon specific injury, disease process, and the patients’ physiological and psychological make-up [3]. Therefore, a similar anatomic injury or disease process may produce a very different sensation of pain depending on the host.

In the process of diagnosing injury, physicians seek objective indicators of pain such as the presence of an acute fracture. We hypothesized that in patients with acute extremity injuries, those with radiographically diagnosed fractures would receive more aggressive pain management compared with those with only soft-tissue injuries.

Patients with isolated acute extremity injury were asked by research assistants to rate their pain on a visual analog scale at ED admission and discharge. Demographic data and pain medicines administered in the ED and at discharge were concurrently recorded from the medical record. Patients who received an x-ray of an extremity and who could consent were included.

One hundred three patients with acute extremity injuries were enrolled. Thirty-one had fractures. Initial 10-point visual analogue scale pain scores were not significantly different (P = .68) for the fracture and nonfracture groups at ED admission (6.0 vs 6.2, P = .68) or ED discharge (4.2 vs 4.5, P = .60). The differential between admission pain and discharge was also not significantly different (P = .80).

A higher percentage of patients with fractures received narcotic analgesia in the ED compared with those without fracture (45% vs 36%); however, this did not reach predetermined statistical significance (P = .51). Patients with fractures also received nonnarcotic analgesia more frequently than those without (32% vs 22%, P = .32). Patients with fractures were more likely to receive a narcotic prescription (52% vs 39%, P = .20) at ED discharge.

These data corroborate published reports on pain management in the ED [1,2]. Certain populations are at greater risk for oligoanalgesia such as pediatric patients, critically ill patients, and patients who have an impaired ability to communicate. Ethnicity, age, and sex have also been shown to play a role in the provision of analgesia [4,5]. These data suggest that those with traumatic extremity injury without documented fracture may also be at risk.

Although not a statistically significant result, our study showed that patients with fractures tend to receive more aggressive pain management than those without fractures, despite similar pain scores. This suggests that physicians perceive soft-tissue injuries as less painful than fractures. In fact, in this group of patients, those with soft-tissue injuries reported a slightly higher degree of subjective discomfort. In the search for objective evidence of painful injury, physicians may look to laboratory and x-ray results. The point is that the subjective feeling of pain reported is highly variable upon the physiological and psychological make-up of the host, and patients in pain may have no objective sign of injury or disease.

The data also show that patients are being discharged from the ED in a significant pain. Wilson and Pendleton [1] found that of 198 patients presenting with painful conditions, only 44% of patients received analgesia while in the ED. Our data collected 14 years after this study show an improvement in care, but still 25% of patients with fractures and more than 40% of patients with soft-tissue injury did not receive analgesia while in the ED.

Lessons that can be learned from this study include the reinforcement of the principle of taking patients’ report of pain at face value and to ensure that patients have achieved an adequate level of pain relief before ED discharge. In addition, physicians must be more aware even in the absence of documented injury on x-ray that patients still report significant pain. Also, a determination must be made about the need for ongoing pain control after discharge in the form of a limited narcotic prescription with arrangement for follow-up or at least the recommendation for or prescription of nonsteroidal anti-inflammatory medication.

References


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Slow supraventricular tachycardia in a patient on \( \beta \)-blocker therapy

To the Editor,

A 77-year-old man presented to the emergency room with a heart rate (HR) of 130 beats per minute and a 2-week history of cough that was worse at night. His current medications included metoprolol for hypertension and, although not a current smoker, he did have a 30-year smoking history. He described no exacerbation with exercise, and his physical examination was negative for jugulovenous distension, calf edema, fevers, wheeze, or neck mass. His chest x-ray was negative. The patient’s pulse oximetry was steady at 95\%, and his electrocardiogram demonstrated possible left ventricular hypertrophy, a regular rhythm, a PR interval of 148 milliseconds, a QRS interval of 92 milliseconds, and a HR of 130 beats per minute. He was given 500 mL of normal saline without a change in his pulse rate. Given the pulse oximetry reading, the tachycardia, and the cough, the possibility of pulmonary embolism was entertained. A \( d \)-dimer test and a computed tomography pulmonary angiogram were done, and both were normal. Troponin I was negative, and his chemistry panel was normal except for a slightly elevated blood glucose (117 mg/dL) and blood urea nitrogen (23 mg/dL). After a routine trip to the bathroom, the patient was swinging his legs up onto the gurney, and his HR dropped to 90 beats per minute (see Fig. 1). By exerting an effort to lift his legs and flexing his abdominal muscles, the patient had performed a Valsalva maneuver, which terminated the tachycardia. The diagnosis of supraventricular tachycardia (SVT) was subsequently made.

Sustained tachycardia in the elderly can have many etiologies. Common causes include congestive heart failure, pulmonary embolism, myocardial infarction, alcohol withdrawal, bronchitis, and pneumonia. With a 2-week history of cough, worse at night with no fever or chills, this patient was first worked up for a respiratory illness. After a negative chest x-ray, he was worked up for a pulmonary embolism, which was also eventually ruled out. Tests for myocardial ischemia were negative, and his electrocardiogram failed to give any clues to an etiology as his PR interval and QRS interval were both within the reference range and of normal morphology. The patient also lacked common presenting symptoms of SVT. These include palpitations, dizziness, shortness of breath, syncope, chest pain, fatigue, diaphoresis, and nausea [1,2]. However, the main factor in excluding SVT as a diagnosis initially was the relatively slow HR of 130 beats per minute.

SVT is most often associated with a more rapid HR (>140 beats per minute) [1,3]. We attribute the slow SVT in this patient to his chronic \( \beta \)-blocker therapy. \( \beta \)-Blockers inhibit sympathetic action at the heart by competing at the \( \beta_1 \)-adrenergic receptor and have a negative inotropic and a negative chronotropic effect. The slowing of the reentry mechanism that our patient experienced was enough to disguise itself as a tachycardia caused by some other mechanism. It was not until the patient “cured” himself by crawling into his bed and creating a vagal response to an increase in pressure that the SVT revealed itself. Thus, “slow” SVT should be at least considered in patients with sustained tachycardias of unclear cause who are on \( \beta \)-blocker therapy.

References

Lactic acidosis caused by nucleoside analogues

To the Editor,

Type B lactic acidosis, lactate accumulation without any clinical evidence of tissue hypoxia, occurs because of impairment in lactate use. Type B is further divided into subcategories based on underlying etiology. Type B1 is associated with systemic disease such as renal and hepatic failure, diabetes, and malignancy. Type B3 is associated with inherited metabolic disorders. Type B2 is known to be caused by several classes of drugs including biguanides, alcohols, iron, isoniazid, and salicylates. Since the early 1990s, the nucleoside reverse transcriptase inhibitors (NRTIs) have also been implicated in causing this serious syndrome at a rate of 1.3 per 1000 person-years of drug therapy [1,2]. The mortality rate is high and may be up to 80% in those patients with lactic acid (LA) levels greater than 10 mmol/L [2,3]. The following case presentation and review of the literature will discuss the pathophysiology, clinical features, and potential therapy for this disorder.

A 56-year-old woman HIV-positive for 7 years, with a CD4 cell count of 268 cells/microliter and undetectable viral load, presented complaining of 1 week of vomiting and diffuse abdominal pain; her medications included the NRTIs, stavudine (d4T) and lamivudine (3TC). She was found to have an anion gap of 27 mEq/L, serum bicarbonate of 8 mEq/L, arterial pH 7.20, and LA level of 63 mg/dL (reference range 5-15 mg/dL). Remaining hemodynamically stable, she clinically improved with intravenous fluids and bicarbonate infusions despite her LA continuing to be elevated (50-60 mg/dL); workup was only significant for fatty infiltration of the liver by computed tomography scan. When tolerating a regular diet on day 6, she was discharged, but she returned 4 days later with the same symptoms and was found to have an anion gap of 30 mEq/L, bicarbonate of 5 mEq/L, arterial pH 7.06, and LA of 70 mg/dL. Again, she remained in stable condition and was feeling well after intravenous fluids and bicarbonate therapy, but her LA persisted above 60 mg/dL for 1 week. We then administered riboflavin (50 mg) and thiamine 1 mg intravenously, and her LA subsequently normalized over 2 days, and she was discharged to home. At a follow-up visit 2 weeks later, she remained well.

The NRTIs are nucleotide analogues lacking the 3'-OH group, to which the 5'-OH group of the next nucleotide to be added is joined, so that when they are incorporated into newly transcribed viral DNA, they act as chain terminators, inhibiting viral RNA-directed DNA polymerase (reverse transcriptase). Mammalian DNA polymerase-z is not affected, but DNA polymerase-γ, involved in mitochondrial DNA replication, is inhibited by NRTIs. When the mitochondrial DNA is poisoned, 2 important catabolic pathways become impaired: (1) oxidative phosphorylation, causing a shift in pyruvate metabolism toward lactate, (2) fatty acid β-oxidation, causing triglyceride accumulation in hepatocytes, which are highly dependent on oxidative metabolism [1-4]. The symptoms of this syndrome—anorexia, nausea, vomiting, and abdominal pain—are typically seen after 3 to 15 months of NRTI therapy, but merely discontinuing the drug does not reverse the disorder [3,5]. In addition to the metabolic acidosis that results from elevated LA, abnormal prothrombin time and liver enzymes may be found, but they may be only mildly elevated despite severe hepatic steatosis. Severe pancreatitis and diffuse weakness, caused by myopathy from mitochondrial toxicity in these tissues, are also common features in this syndrome [1,3,5]. Skeletal muscle samples will have pathognomonic features including red-ragged fibers on microscopy, mitochondrial inclusions, and reduced amounts of mitochondrial DNA [6,7].

Underlying nutritional deficiencies in the cofactors required for cellular respiration, other defects in oxidative enzymes, or genetic factors may predispose a subset of patients for this disorder [4]. Therapy thus far has been aimed at attempting to rescue mitochondrial metabolism by supplying necessary cofactors. Riboflavin (B2), the precursor of flavin mononucleotide and flavin adenine dinucleotide, required in the Krebs cycle, electron transport chain, and oxidation of fatty acids, has been reported effective in treating several other cases of NRTI-induced lactic acidosis and has been studied more extensively in pediatric patients with inherited mitochondrial disorders and in animal models [8-12]. Thiamine (B1), a cofactor for pyruvate dehydrogenase, which converts pyruvate to acetyl-CoA (instead of lactate), has also been used in treating congenital mitochondrial disorders and could theoretically be useful in this syndrome [3,11]. Lastly, a deficiency of L-carnitine, an important cofactor for the intramitochondrial transport of fatty acids, is thought to result from NRTIs and may also contribute to the acidosis and steatosis. It has been used previously in treating inherited oxidative disorders, and there was one case report

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Presented as a poster at the 2001 Research Day for the American College of Physicians, Maryland Chapter.
of successfully treating NRTI-induced lactic acidosis with L-carnitine supplementation [3,13].

References


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Detrusor hyporeflexia presents as an early manifestation in encephalitis

To the Editor,

Encephalitis is an emergent condition urgent for rapid and correct diagnosis. However, some patients may present with uncommon manifestations, such as behavioral change, sensorimotor deficit, psychosis, or hallucinosis [1], which make it difficult to establish an accurate diagnosis abruptly. We add an unusual flaccid bladder caused by detrusor hyporeflexia as an early symptom for encephalitis.

A 24-year-old woman caught common cold and had an acute onset of urinary retention 4 days later. Urinary tract infection was diagnosed based on a presence of 8 leukocytes per high-power field in urinalysis. While she was hesitating for further procedure, intermittent fever, neck stiffness, vomiting, and mental change subsequently developed on the following 2 days. On presentation, she was drowsy. Glasgow Coma Scale was E2V2M4. Blood pressure, pulse rate, and respiratory rate were normal, but body temperature was 37.8°C. Neck was stiff. There was no proptosis or conjunctival congestion. Abnormal neurological findings included unreactive pupils, papilledema, generalized brisk tendon reflex, bilateral Babinski sign, and snout reflex. Several episodes of tonic eye deviation to left side were observed. Encephalitis was interpreted. Cranial computer tomography revealed brain edema. Mastoid and paranasal sinuses were clear. Electroencephalogram showed excessive slowing activity in diffuse. Biochemistry, immunology, hematology, serology, VDRL test, Treponema pallidum hemagglutination test, HIV test, and lupus study were normal except for leukocytosis (12 400 cells/mm³) and neutrophilia (78%). Cerebrospinal fluid analysis disclosed an opening pressure to be 250 mmCSF, cytology 141 cells/mm³, neutrophils 4%, glucose 44 mg%, total proteins 190 mg%, and immunoglobulin (Ig) G–link index 0.23. Culture for bacterium, fungus, or tubercle bacillus was sterile. Virology showed an initial increase of IgM antibody but over 4-fold IgG antibody 2 weeks later to respiratory syncytial virus in serum and cerebrospinal fluid. Other viral antibody titer and polymerase chain reaction for Mycobacterium tuberculosis and herpes simplex virus were negative. Viral encephalitis was established. Osmotherapy was initiated. Her fever subsided, and consciousness recovered rapidly, but dysuria still persisted. Urine was sterile, and residual urine was 350 mL. Cystometry revealed a severe decrease of detrusor pressure upon bladder distention and micturition, suggesting detrusor hyporeflexia. No detrusor hyperreflexia was seen. Urethral pressure and detrusor-sphincter synergy were normal. Micturition was relied only on abdominal strain (Fig. 1). Nerve conduction velocity study, F wave, H reflex, and somatosensory evolved potential were normal. Her dysuria spontaneously recovered 1 month later.

In contrast to the previous concept that micturition is a spinal reflex, the pontine micturition center (PMC) is recently found to control micturitional process also [2,3]. An increase in bladder pressure activates the ascending afferent to PMC, from where it sends 2 distinct descending pathways to the lower urinary tract. The first one is parasympathetic pathway that innervates the detrusor...
muscle, contracts, and empties the bladder to excrete urine [3]. The second one is the γ-aminobutyric acid pathway, which relaxes the urethra and external sphincter and facilitates the urine outflow [3].

A high frequency of neurogenic bladder in hemispheric stroke [4] supports a cortical regulation of the PMC [5]. However, bladder dysfunction has not been mentioned as an early manifestation in case of neuroinfection as in our patient. Tonic ocular deviation to left side and presence of snout reflex reflect an involvement of her right frontal lobe. In fact, the right frontal cortex (anterior and medial surface), left sensorimotor cortex, and bilateral supplementary motor area [6] are activated during micturition, suggesting a functional link between PMC and these areas. Descending fibers may travel through the anterior edge of the paraventricular white matter or genu of the internal capsule [4] and are integrated by putamen, thalamus [4], or cerebellum [7]. However, these anatomic sites cannot predict the type of bladder dysfunction, except that detrusor hyporeflexia is more frequent in cerebellar lesion [7]. This confliction is similar to pontine lesion that can provoke detrusor areflexia or hyperreflexia [8], which may eventually be determined by the severity of damage of excitatory or inhibitory pathway.

An involvement of spinal cord may occasionally cause detrusor hyporeflexia, but a negative electrophysiology study and an absence of other urodynamic finding and associated neurological deficit at lower limbs [9] may be argued for her bladder dysfunction by lower spinal involvement.

Preceding bladder disorder may be neglected or underestimated in case of acute brain disease. Our patient reminds us to consider central lesion promptly when the cause for bladder dysfunction is obscure. Early recognition is the rule to reduce the mortality in acute brain disease.

References


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Aripiprazole is a second generation, atypical antipsychotic medication used in the treatment of schizophrenia, schizoaffective disorder, and acute bipolar mania. The mechanism of action of this drug is not entirely known; however, it has been shown to have high affinity agonistic activity at D2 dopamine and serotonin 5-HT1A receptors, and antagonistic activity at serotonin 5-HT2A receptors. Other affinities noted in premarketing studies [1] demonstrated moderate affinities for dopamine D4, serotonin 5-HT2C, histamine H1, and α1-adrenergic receptors. There have been no appreciable affinities for peripheral muscarinic cholinergic receptors.

Aripiprazole toxicity has been reported in a minority of cases. In a premarketing study, of 5500 patients receiving aripiprazole therapy, there were 7 reported overdoses. Two of these patients reportedly ingested 180 mg of aripiprazole. These patients were observed in the hospital and were provided supportive care only. One of the 2 patients who ingested this dose reportedly suffered somnolence as well as nausea and vomiting [1]. No deaths have been reported from aripiprazole overdose in the medical literature.

This was a retrospective chart review study of patients with reported aripiprazole toxicities over 1 year (2003). Data were compiled and reviewed for patient demographics, adverse outcomes, and clinical course associated with either accidental or intentional overdoses.

The inclusion criteria for this study consisted of either accidental or intentional overdose of aripiprazole above the recommended dosage (15 mg/d) and no known congestion. In addition to these criteria, poison control center follow-up finally occurred until a final outcome was documented. Specifically, all patients were followed by the poison center until the cessation of symptoms or for 24 hours if the patients were asymptomatic.

Reviewers received training in systematic chart review. A third reviewer acted as a tiebreaker. Ages, outcomes, signs, and symptoms were recorded.

The study population consisted of 8 patients with an average age of 23.75 years (range, 3-43 years). The most common formulation of aripiprazole ingested was the 15-mg tablet commonly prescribed as initial therapy. There were 4 accidental ingestion and 4 intentional ingestion. The average amount of aripiprazole ingested was 81.66 mg (data from 6 cases; in 2 cases, the dosage was unknown). In the accidental ingestion group, 3 of the 4 patients were observed at home with poison center follow-up conducted at 24 hours. All of these patients had favorable outcomes. The remaining patient of this group was observed in the emergency department (ED) and eventually discharged home also with a favorable outcome. In the group of intentional overdoses, all 4 were observed in the ED. Two of these 4 patients were admitted to the hospital for excessive somnolence. All of these patients in this group demonstrated favorable outcomes (Table 1).

In premarketing studies of the efficacy and safety of aripiprazole, there have been minimal reports of toxic exposures. Among those that did have aripiprazole toxicity, no one succumbed to the adverse effects. Areas of concern associated with aripiprazole toxicity as well as most antipsychotic medications include cardiovascular derangements, central nervous system depression, and autonomic instability. The most concerning of these would be neuroleptic malignant syndrome. In clinical trials with aripiprazole compared to placebo or other antipsychotics, there have not been any cases of neuroleptic malignant syndrome. The most common adverse events associated with aripiprazole overdose included orthostatic hypotension, likely secondary to the drugs action on α1-adrenergic receptors. The cardiovascular effects observed were primarily rhythm disturbances, namely, QTc prolongation. These 2 situations required continuous cardiac monitoring and supportive care. Given the drug’s high protein binding and large volume of distribution (4.9 L/kg), hemodialysis would not be efficacious in treating acute or chronic toxicity [1-3].

Our experience with aripiprazole is similar to that observed with larger clinical trials. Most of our patients had little to no serious consequences associated with the overdose. A common treatment of these patients simply involved supportive care with most patients remaining home as opposed to being admitted. Those patients who were observed in the ED had an uneventful clinical course.

A limitation to this study is the sample size. To make significant conclusions, the sample size should be larger. However, in review of the premarketing trial [1], the sample size of those with aripiprazole toxicity involved 7 patients (n = 5500). Regardless, a larger sample of those with aripiprazole toxicity would yield substantial data to draw significant conclusions. This was a study based solely on data

<table>
<thead>
<tr>
<th>Patient group</th>
<th>Average age (y)</th>
<th>Average dose ingested (mg)</th>
<th>Clinical course</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accidental (n = 4)</td>
<td>23.75</td>
<td>81.66</td>
<td>3/4 Observed at home; 1/4 observed in the ED</td>
<td>All favorable</td>
</tr>
<tr>
<td>Intentional (n = 4)</td>
<td>23.75</td>
<td>81.66</td>
<td>All observed in ED; 2/4 admitted for excessive somnolence</td>
<td>All favorable*M</td>
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</tbody>
</table>
collected from one poison control center (Good Samaritan Regional Poison Control Center, Phoenix, Ariz). The patient population was limited to those residing in this region. When reproducing this study, it would be advantageous to include multiple poison control centers to build the patient population more as well as to sample various populations.

Our outcomes are consistent with the literature on aripiprazole adverse effects. The new second and third generation antipsychotic drugs have proven to be less detrimental to patient outcomes in the setting of overdoses. These newer drugs are not more effective than previous antipsychotics. Rather, they appear to have significantly less adverse effects. Aripiprazole is a promising drug in the treatment of schizophrenia, schizo-affective disorder, and acute bipolar mania. However, in the setting of toxic exposures, this drug does exhibit potentially significant consequences and each overdose should be evaluated individually with appropriate treatment rendered on the basis of these adverse effects.

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Three-year experience with ziprasidone exposures

To the Editor,

Ziprasidone (ZIP) is an atypical antipsychotic medication approved for treatment of schizophrenia, acute psychomotor agitation, and the treatment of bipolar disorder. Although the side effects of ZIP during standard clinical use are well described, there is a relative dearth of information regarding toxicity in either accidental ingestion or intentional overdose.

We conducted a retrospective chart review of isolated ZIP ingestions reported to our Poison Center during 2001 to 2003. After a brief training, reviewers blinded to the purpose of the study completed a standardized data collection sheet. Age, outcomes, and amount ingested were recorded.

Approximately 150,000 human exposures were reviewed. Thirty patients met the criteria. The average amount of ZIP ingested was 205.62 mg (data from 29 cases), and the average patient age was 22.7 years (range, 1-41 years). The most common formulation ingested was the 20-mg tablet. Eight patients accidentally ingested ZIP, and 22 admitted intentional ZIP ingestion. Of the 8 accidental ZIP ingestions, 7 were observed at home with Poison Control Center follow-up in 24 hours, all with good outcomes. The other patient was observed in the ED and discharged home without incident. Nineteen of the intentional ingestions were observed in the ED with good outcomes, 1 patient was lost to follow-up, and 1 patient was evaluated by paramedics and watched at home. One patient ingested an unknown quantity of ZIP and presented to the ED comatose. Endotracheal intubation was performed and the patient recovered after 8 hours.

As an atypical antipsychotic, the efficacy in treating schizophrenia with ZIP is purportedly due to the antagonism of specific serotonin and dopamine receptor subclasses and serotonin and norepinephrine reuptake blockade. Ziprasidone is an a1 adrenergic as well as histamine (H1) antagonist, resulting in the side effects of orthostatic hypotension and somnolence, although these effects are less pronounced with ZIP use than with other atypical antipsychotics. Even in routine use, there is unique concern for corrected QT interval prolongation, which appears dose-related and has been shown to be as much as 10 to 20 milliseconds with the higher standard dosages [1] Although no case has yet been reported, this produces concern for torsades de pointes, especially in an overdose situation. Other complications noted to date include, but are not limited to, neuroleptic malignant syndrome, tardive dyskinesia, mania, and rhabdomyolysis. Often, these cases are difficult to assess given the possibility of mixed ingestion, recent discontinuation of other medication to initiate ZIP therapy, and a history of similar symptoms in patients initially treated with other medications [2-5].
Accidental ingestions were typically a sub- or therapeutic dose, and with the relatively high safety profile of ZIP at normal doses, were without complication. Given the more substantial dosage of ZIP in intentional overdoses, most of these patients were monitored in the ED for adverse effects, as well as for further psychiatric intervention. We report only 1 case requiring significant medical intervention, that being secondary to the sedative properties of ZIP. In our experience, it appears that low-dose accidental ingestions may be monitored at home with close follow-up, whereas overdose situations may continue to benefit from observation in the ED. However, given the relatively recent introduction of ZIP, more information on exposures and management can be expected in the future.

References


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Erratum


Dr Jane Terries, of St. Thomas’s Hospital, London, UK, was inadvertently left off the manuscript as an author when it was submitted to AJEM. The co-authors wish to acknowledge Dr. Terries as a co-author at this time to correct this oversight.

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