Emergency department pericardial drainage for penetrating cardiac wounds is a viable option for stabilization

Teresa S. Jones, M.D., Clay Cothren Burlew, M.D., F.A.C.S.*, Robert T. Stovall, M.D., Fredric M. Pieracci, M.D., Jeffrey L. Johnson, M.D., Gregory J. Jurkovich, M.D., Ernest E. Moore, M.D.

Department of Surgery, Denver Health Medical Center, University of Colorado School of Medicine, 777 Bannock Street, Denver, CO 80204, USA

KEYWORDS: Trauma; Cardiac injury; Pericardial tamponade; Pericardial drain; ED thoracotomy; Penetrating trauma

Abstract

BACKGROUND: Penetrating cardiac injuries (PCI) causing tamponade causes subendocardial ischemia, arrhythmias, and cardiac arrest. Pericardial drainage is an important principle, but where drainage should be performed is debated. We hypothesize that drainage in the emergency department (ED) does not delay definitive repair.

METHODS: Over a 16-year period, patients sustaining PCI were reviewed.

RESULTS: Seventy-eight patients with PCI survived to the operating room (OR), with 39 undergoing ED thoracotomy. An additional 39 patients underwent pericardial drainage, 17 (44%) in the ED and 22 in the OR. Comparing the ED with OR pericardial drainage groups, they had a similar ED systolic pressure (99 ± 25 vs 99 ± 34), heart rate (103 ± 16 vs 85 ± 37), median time to the OR (20 vs 22 min), and mortality (12% vs 23%).

CONCLUSIONS: ED pericardial drainage for PCI did not appear to delay operation and had an acceptably low mortality rate. Pericardial drainage is a viable option for stabilization before definitive surgery when surgical intervention is not immediately available in the hemodynamically marginal patient.

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With improvements in pre-hospital management and early recognition of injuries, patients with penetrating cardiac injuries (PCI) have reported a survival rate of 19%. In those patients undergoing resuscitative thoracotomy in the emergency department (ED), the survival rate is 16% compared to a survival rate of 70% for patients who are stable for transport to the operating room (OR).

The primary cause of death in patients with PCI is not exsanguinating hemorrhage; the associated cardiac tamponade causes subendocardial ischemia, malignant arrhythmias, and cardiac arrest. Drainage of the pericardium can reverse these physiologic changes by decreasing ischemia and preventing subsequent decompensation or cardiac arrest. Reports in the 1970s suggested that pericardiocentesis before resuscitative thoracotomy decreased mortality; however, pericardial drainage seems to have fallen out of favor because of reported inconsistent results and a concern that it delays definitive treatment. The objective of this study was to determine if pericardial drainage has a role in
modern trauma care. We hypothesized that pericardial drainage in the ED does not delay transport to the OR and improves outcomes for patients who sustain PCI.

Methods

All patients sustaining PCI at Denver Health Medical Center from 1996 to 2011 were reviewed. Denver Health Medical Center is a state-certified and American College of Surgeons-verified level I regional trauma center and an integral teaching facility of the University of Colorado Denver. Patients who did not survive to the OR were excluded from the analysis as no patient who underwent pericardial drainage died in the ED. Management protocols at Denver Health Medical Center require patients to have a systolic blood pressure ≥ 70 mmHg, with or without an aortic cross clamp, to be transported to the OR for further intervention. Demographics recorded included age, sex, mechanism of injury, vital signs, and organ injury severity score (OIS). The presence of cardiac tamponade was included if described as such in the trauma team admission note or operative report. Pericardial drainage was categorized as occurring in the ED before transport versus in the operating room. The outcomes analyzed included time to the OR, intensive care unit length of stay, hospital length of stay, and mortality. Statistical analyses were performed using SAS version 9.2 (SAS Inc, Carey, NC). The alpha error level was set at .05, with $P < .05$ being considered statistically significant. Differences in the means of continuous variables were compared using the Student $t$ test, and survival significance was calculated using Fischer’s exact test. The Colorado Multi-Institutional Review Board approved this study.

Results

Over the 16-year study period, 78 patients with PCI survived to the OR. The majority (91%) were men with a mean age of 33 ± 14 years. The predominant mechanism was stab wounds (74%) and the mean OIS was 4.2 ± 1.2. Of the 78 patients, 39 (50%) underwent resuscitative thoracotomy in the ED, and mortality rate in this group was 43% (Fig. 1).

Of the 39 patients undergoing pericardial drainage, 17 (44%) patients had drainage performed in the ED. All patients had a positive pericardial ultrasound demonstrating pericardial fluid. Pericardial drain placement was performed with a percutaneous catheter in all cases; clinicians used the Seldinger technique in the subxiphoid location, with US guidance when available. Drainage was successful in all but 1 patient, with a range of 15 to 200 mL of fluid removed. In 10 (59%) patients, hypotension was recorded to have improved with pericardial drainage; this was documented with numeric evidence in 5 patients and with subjective wording alone in 5 patients. All patients subsequently underwent operative intervention; mortality rate in this group was 12%. There were no drain-related complications and no drain was dislodged in transport.
Compared to the ED pericardial drainage group, only 68% of those undergoing operative drainage (13/19 patients) had a positive focused abdominal sonography for trauma (FAST); 3 patients had no FAST documented. Of the patients who had a negative FAST, 2 were taken to the OR for a massive hemothorax, 3 were taken to the OR for worrisome abdominal examinations, and 2 had additional imaging that suggested PCI. Overall mortality for this operative drainage group was 23%. If the patients with a negative pericardial FAST examination are excluded, then mortality in the OR drainage group was 30%.

Comparing the ED pericardial drainage group with patients who went directly to the OR without intervention, both had a similar ED systolic blood pressure, ED heart rate, and median time to the OR (Table 1). The mean OIS was higher in the ED pericardial drainage group compared to patients who went directly to the OR without intervention. Mortality rate in the OR drainage group was 23% and was not significantly different from the mortality in the ED drainage group (12%, \( P = .25 \)). If the patients with a negative pericardial FAST examination in the OR drainage group are excluded, hence comparing positive pericardial FAST patients with ED drainage versus OR drainage, then mortality in the OR group was 30% versus 12% in the ED drainage group.

### Table 1

<table>
<thead>
<tr>
<th></th>
<th>Pericardial drainage in the ED ((n = 17))</th>
<th>Direct to OR ((n = 22))</th>
<th>(P) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean ED SBP</td>
<td>99 ± 25</td>
<td>99 ± 34</td>
<td>.93</td>
</tr>
<tr>
<td>Mean ED heart rate</td>
<td>109 ± 16</td>
<td>101 ± 37</td>
<td>.40</td>
</tr>
<tr>
<td>Mean organ injury severity score</td>
<td>4.4 ± 0.5</td>
<td>3.4 ± 1.6</td>
<td>.02*</td>
</tr>
<tr>
<td>Median time to OR (min)</td>
<td>20</td>
<td>22</td>
<td>.15</td>
</tr>
<tr>
<td>Mean ICU stay (d)</td>
<td>8.4 ± 16</td>
<td>6.5 ± 12</td>
<td>.68</td>
</tr>
<tr>
<td>Mean hospital stay (d)</td>
<td>11.6 ± 16</td>
<td>11.7 ± 15</td>
<td>.98</td>
</tr>
<tr>
<td>Mortality</td>
<td>12%</td>
<td>23%</td>
<td>.25</td>
</tr>
</tbody>
</table>

*ED = emergency department; ICU = intensive care unit; OR = operating room; SBP = systolic blood pressure.

*\( P \leq .05 \).

The time between injury and definitive care is a critical determinant of survival for patients with PCI. With prehospital mortality of over 90% in PCI, the patient’s physiologic status and mechanism of injury are the primary determinants of survival.\(^2,8\) Having witnessed the untoward effects of cardiac tamponade—ischemia with recalcitrant malignant arrhythmias—in several patients following direct transport to the OR, we became more interested in early drainage of the pericardium while in the ED. After diagnosing a pericardial effusion using bedside US, a percutaneous subxyphoid drain can be placed in less than 5 min. Prepackaged pericardial drain kits are commercially available, and these are placed much like a central venous catheter via Seldinger technique. Once in place, the catheter may be placed to gravity drainage or can be continuously aspirated en route to the OR.

To our knowledge, this is the first reported comparison of pericardial drainage options. In this series, the location of pericardial drainage (ED vs OR) did not appear to significantly delay operative intervention. Additionally and perhaps not surprisingly, drainage improved hemodynamics in the majority of patients. Based on animal models, by the time significant hypotension is experienced, coronary blood flow is one third of normal levels.\(^10\) Upon anesthetic induction, patients with acute tamponade may lose peripheral constriction, further reducing venous return and cardiac output.\(^11\) Relief of pericardial tamponade could alleviate early myocardial ischemia, mitigating malignant arrhythmias to improve outcomes.\(^3\) Finally, patients treated with preoperating room pericardial drainage had an acceptably low mortality rate and short time to OR compared to other management options. In fact, mortality appeared decreased in the ED drainage group, although the study was underpowered to detect statistical significance.

One of the main concerns of pericardial drainage is the potentially high false negative rate.\(^5,12\) These reports appear to come before the common use of US for diagnosis of cardiac tamponade. Reported sensitivity of US is 73% to 100% and specificity is 44% to 99.3%.\(^13,14\) All of the patients who underwent pericardial drainage in the ED demonstrated pericardial effusions on FAST, with only 1 of the 17 patients having a failed attempted drainage. The patient who failed drainage was found in bed after a self-inflicted stab wound to the heart and had significant clot after open evacuation of his pericardium.

There are limitations inherent to any retrospective review. The number of patients with PCI is small, with the majority presenting in extremis requiring a resuscitative thoracotomy in the ED. This small sample size limited power to detect statistical significance in findings that may have been clinically meaningful, most notably the mortality difference of 13% versus 23% in the ED drainage group as compared to the OR drainage group. We chose to make the conservative conclusion that ED drainage is at least not associated with an increase in mortality as compared to OR drainage. The decision for timing of pericardial drainage was determined by the attending trauma surgeon without a predefined algorithm. As such, specifics of patient
management and decision-making rationale cannot be inferred in this retrospective review. In general, however, we use pericardial drainage in the ED for those patients with hemodynamic compromise, unresponsive to crystalloid infusion, who have a significant pericardial fluid stripe on US. Alternatively, patients with a marginally positive pericardial stripe (particularly if the myocardium abuts the pericardium which would risk laceration of the heart) who are hemodynamically normal typically do not undergo ED pericardial drainage.

In this highly selected population, ED pericardial drainage had an acceptably low mortality rate compared to other management options. Pericardial drainage in the ED is a viable option for stabilization before definitive surgery when surgical intervention is not immediately available in the hemodynamically marginal patient. Early pericardial drainage in patients with PCI does not negatively affect patient outcomes.

References