Clinical Science

The differential effects of surgical harm in elderly populations. Does the adage: “they tolerate the operation, but not the complications” hold true?


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KEYWORDS:
Elderly; Harm; Outcomes; Cost

Abstract

BACKGROUND: Elderly patients are thought to tolerate surgical complications poorly because of low physiologic reserve. The purpose of the study was to evaluate the differential effects of surgical harm in patients over 80 years old.

METHODS: Three years of data from a harm-reduction campaign were used to identify inpatient surgeries performed on patients older than 50. The rates of harm, death, cost, and length of stay (LOS) were analyzed using SPSS 21 (IBM, New York, NY).

RESULTS: A total of 22,710 patients were identified. Rates of harm and mortality increased with increasing age. Harmed patients over age 80 had increased mortality (9.5% vs 7%), but lower cost, intensive care unit days, and LOS versus those aged 50 to 80. Linear regression showed increased cost with harm ($24,000) and decreased cost with age above 80 ($7,000).

CONCLUSIONS: In the elderly surgical population, there is more harm and harm events are associated with higher mortality rates, but less additional cost and LOS. Differing goals or aggressiveness of care may explain cost avoidance in the elderly.

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There is an adage in surgery that says of the extreme elderly “they tolerate the operation, but not the complications.” Elderly patients are felt to have limited physiologic reserve; therefore, a 2nd physiologic insult after an operation, in the form of a complication, is likely to result in much more devastating consequences than in younger patients. This lack of reserve is especially prevalent in patients over age 80 and is extreme after age 90.1 Elderly surgical patients are counseled that they have a higher expected mortality based on their age, but if they can get through their operation and early recovery without a complication, they can expect a good outcome. From the providers’ perspective, vigilant early postoperative care and avoidance of complications are felt to be essential. Unfortunately, only 44% of adverse events in hospitals are
likely avoidable. The population of Americans over age 85 is expected to increase from 6 million to 14 million from 2015 to 2040, so surgeons are likely to see more and more patients at the high extreme of age in our hospitals and clinics.

There are several studies that estimate the cost of adverse medical events and several studies which quantify the incidence of adverse events in elderly populations, but to our knowledge, no study has directly compared the differential effects of harm, including cost, in elderly surgical patients versus younger patients. The Department of Health and Human Services has reported that 13.5% of Medicare inpatients experience an adverse event and 1.5% suffers a fatal adverse event. The Agency for Healthcare Research and Quality estimates the rate of hospital-acquired conditions at 145 per 1,000 admissions. They estimate the total cost attributable to medical errors at $19.5 billion or $13,000 per error. Ackroyd-Stolarz et al found that patients over age 65 admitted to acute care Canadian hospitals who experienced an adverse event had twice the hospital length of stay (LOS) (20.2 vs 9.8 days) at a cost of approximately $7,500 per patient. Ecinosa and Hellinger used claims data to identify surgical admissions that included at least one potentially preventable adverse event. They found that surgical admissions with an adverse event had a mortality of 6.3% compared with 0.6% without adverse events. Total cost was $66,879 versus $18,284 and total inpatient days were 21.5 versus 5.1. Hamel et al used the Veterans Affairs National Surgical Quality Improvement Project dataset for noncardiac surgery and found that patients aged 80 and older had a 30-day mortality of 8% versus 3% for younger patients, although for many commonly performed operations the mortality rate for those aged 80 and older was less than 2%. Patients aged 80 and older had a complication rate of 20% and those who suffered a complication had a mortality rate of 26% versus 4% for those who did not.

Surgical patients and the elderly are at higher risk of adverse events in hospitals, which makes the elderly surgical patient particularly vulnerable. With reimbursement models shifting toward outcome-based payment, adverse events are likely to become very expensive for providers.

### Patients and Methods

Our healthcare system is a nonprofit integrated system in southeast Michigan with 7 hospitals, including a large, urban flagship hospital. In 2008, the system launched its global No Harm Campaign with the goal of reducing or eliminating 27 sources of harm. From 2008 to 2011, the program reduced harm events by 31% and inpatient mortality by 18% systemwide. The data from this campaign are ideal for analyzing the differential effects of harm. Assuming the adage “they tolerate the operation, but not the complications” is true, we hypothesized that harm events in surgical patients over age 80 would be associated with significantly higher mortality, LOS, and cost than in younger patients. In addition, unharmed elderly patients should have outcomes similar to younger patients.

#### Patients and Methods

Data compiled from a large Midwestern health system’s global No Harm Campaign from 2009 to 2011 was used to identify inpatient surgical patients 50 years or older at a single hospital. The system’s flagship hospital is an urban, 802-bed tertiary care center, Level 1 trauma center, and education and research complex staffed by an employed medical group. The data were compiled prospectively as part of an ongoing quality assurance and improvement program. Occurrences of harm were tracked for reporting purposes and linked to demographic and care-related variables, as well as financial claims data. Data were obtained under the supervision of our Institutional Review Board. Analysis was performed using SPSS 21 statistical software (IBM, New York, NY).

Patients were considered surgical if their hospitalization included at least one visit to the main operating room. Harm was defined as “any unintended physical injury resulting from or contributed to by medical care (including the absence of indicated medical treatment) that requires additional monitoring, treatment, or hospitalization or results in death. Such injury is considered harm whether or not it is considered preventable, resulted from a medical error, or occurred within a hospital.” The campaign included all types of harm that could be routinely measured. Harm occurrences were placed in the major

### Table 1 Major Categories of Harm

<table>
<thead>
<tr>
<th>Medication</th>
<th>Procedural</th>
<th>Infection</th>
<th>Employee</th>
<th>Care delivery</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypoglycemia</td>
<td>Coded complications</td>
<td>BSI</td>
<td>Back injury</td>
<td>Falls</td>
<td>Renal failure</td>
</tr>
<tr>
<td>Anticoagulation</td>
<td>NSQIP</td>
<td>VAP</td>
<td>Sharps</td>
<td>Pressure ulcers</td>
<td>Blue alert</td>
</tr>
<tr>
<td>Narcotics</td>
<td>Pneumothorax</td>
<td>UTI</td>
<td>Assaults</td>
<td>DVT</td>
<td>OB harm</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>C-Diff</td>
<td>SSI</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sepsis</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For purposes of structure, reporting, and review, 6 broad categories, covering 27 different types of harm, were used in the No Harm Campaign. BSI = bloodstream infection; C-Diff = Clostridium difficile; DVT = deep vein thrombosis; NSQIP = National Surgical Quality Improvement Program; OB = obstetrics; SSI = surgical site infection; UTI = urinary tract infection; VAP = ventilator-associated pneumonia.
categories of medication harm, procedural harm, infection, employee harm, care delivery harm, or other. The constituent variables of the major categories are listed in Table 1. The categories employee harm and obstetric harm were excluded, as they were not applicable to the study population.

Patients younger than 50 years were excluded to increase the homogeneity of the group. All categories of harm were included to demonstrate the true overall rate of healthcare-associated harm and to show an average effect.

Harm occurrences and outcomes occurring during hospitalization were identified in the dataset. The primary outcome was the rate of harm in elderly surgical patients and the mortality and technical cost associated with harm. Technical cost was used rather than total cost because most institutions do not include professional fees in their reports of total cost. Additional outcomes included LOS and intensive care unit (ICU) days. To determine whether high mortality in the elderly was driving down LOS, analysis of LOS and ICU days was repeated excluding deceased patients from the dataset.

The study group of patients 80 years or older was compared with those less than 80 years using the variables LOS, ICU days, ventilator days, and blood transfusions. The groups were compared using Levene’s test for equality of variances.

The rates of harm and mortality events were analyzed in comparison with age group using univariate analysis with the chi-square test. The total technical cost of care, ICU days, and LOS for harmed versus unharmed patients by age group was analyzed with analysis of variance.

Multivariate logistic regression was used to compare the mortality odds ratio of harm with age 80 years or older, American Society of Anesthesiologists (ASA) class, emergency surgery, Elixhauser comorbidity index. ASA class was treated as an ordinal rather than categorical variable for ease of analysis and interpretation. The Elixhauser index is a comorbidity index which summarizes a patient’s disease burden by tallying 30 comorbid conditions. It has been found to be independently associated with inpatient hospital mortality.\(^{18}\)

Linear regression was used to quantify drivers of technical cost as compared with harm. The additional cost associated with harm was compared with death, ASA class, emergency surgery, Elixhauser index, African American race, and age 80 years or older.

### Results

There were 22,710 inpatients aged 50 years or older who underwent operations over the 3-year period. The mean age was 65.62 (standard deviation [SD] 10.51) and ranged from 50 to 105 years. A total of 2,833 patients, or 12.5%, were aged 80 or older. Forty percent of the patients were male and 39.8% were African American. About 10.3% underwent emergency operations.

Mean LOS, ICU days, ventilator days, and packed red blood cells transfusions for patients aged 80 or older as compared with those aged 50 to 79 are shown in Table 2. The groups differed significantly only in LOS, which was 8.03 (SD 8.04) days for those aged 80 or older versus 7.32 (SD 9.94) days for younger patients.

The rates of harm by major category are shown in Table 3. The overall rate of harm for the study sample was 22.2%. The most common major category was procedural (9%) harm, followed by other (8.9%), medication (6.6%), infection (4.2%), and care delivery (1.4%). The table also compares the rates of harm by category for patients aged 50 to 79 with those aged 80 or older. The older group trended toward higher rates in all categories, but the difference was only significant for infection (6.5% vs 3.9%, \(P < .001\)) and other (11.1% vs 8.6%, \(P < .001\)).

The overall mortality rate was 2.3%. The rates of harm and mortality by age group are shown in Fig. 1. The rate of harm increased in a stepwise fashion from 18.7% in ages 50 to 79 to 26.4% in ages 80 to 105 years. Mortality increased from 1.7% in ages 50 to 79 to 3.1% in ages 80 to 105 years.
to 59 to 26.4% in ages 80 to 99. The mortality rate increased similarly, from 1.9% in ages 50 to 59 to 3.4% in ages 80 to 99. Results were significant with \( P \) value less than .001.

The mortality rates of harmed versus unharmed patients by age group are shown in Fig. 2. The mortality rate for all unharmed patients was .8% versus 7.5% for harmed patients. The mortality rate for unharmed patients aged 50 to 59 and 60 to 69 was equal at .7%, but the rate increased to 1.1% after age 70 and 1.2% after age 80. The mortality rate of harmed patients was 7% for patients aged 50 to 59 and increased to less than .5% through age 79, with a sharp increase to 9.5% after age 80. Results were significant with \( P \) value less than .001.

Fig. 3 shows the mean total technical cost of hospitalization for harmed patients versus unharmed patients. Harm in patients under age 80 was associated with approximately $33,000 in additional cost versus an additional $18,700 for harmed patients 80 years or older. Median total technical costs showed a similar relationship. Harmed younger patients were associated with approximately $18,000 ($29,443 vs $11,306) in additional cost versus an additional $12,000 ($24,487 vs $12,021) for harmed patients 80 years or older. The patients under age 80 are grouped into age deciles in Fig. 4. Patients aged 50 to 59 had approximately $36,500 increased mean cost when harmed and those aged 60 to 69 had approximately $35,500. The cost for those patients aged 70 to 79 was significantly less, with harmed patients costing $25,800 more than unharmed. Results were significant with \( P \) value less than .001.

Mean ICU days and LOS for harmed and unharmed patients are shown in Fig. 5. ICU days and LOS for unharmed patients 80 years or older were greater than for unharmed patients younger than 80 (.82 vs .64 and 6.04 vs 4.93) years, but there were significantly less ICU days and hospital days for older harmed patients as compared with younger harmed patients. Harmed patients aged 80 and older had 1.26 less ICU days (3.58 vs 4.84) and 2.38 days shorter LOS (13.58 vs 15.96) than harmed patients under age 80. Median LOS was 3 days for unharmed younger patients and 5 days for unharmed older patients versus 11 days for harmed patients in both groups. Median ICU days were 0 for all groups. These results were similar when only surviving patients were included. Surviving

\[ \text{Figure 1} \quad \text{Harm and mortality by age. Overall mortality rate} = 2.3\% \text{ and overall harm rate} = 22.2\%. *\text{All } P < .001. \]

\[ \text{Figure 2} \quad \text{Mortality by harm status and age. Overall mortality rate for no harm patients is} .8\% \text{ versus 7.5\% for harmed patients.} *\text{All } P < .001. \]

\[ \text{Figure 3} \quad \text{Mean total technical cost by harm status; age over 80 versus age 50 to 79. Cost in US dollars from the year of admission.} \]

\[ \text{Unharmed age 50 to 79 (SD} = 16,863), \text{harmed age 50 to 79 (SD} = 57,445). \text{Unharmed age over 80 (SD} = 24,302), \text{harmed age over 80 (SD} = 31,485). *\text{All } P < .001. \]

\[ \text{Figure 4} \quad \text{Mean total technical cost by harm status and age. Cost in US dollars from the year of admission.} \]

\[ \text{Unharmed age 50 to 59 (SD} = 18,561), \text{harmed age 50 to 59 (SD} = 63,392). \text{Unharmed age 60 to 69 (SD} = 16,287), \text{harmed age 60 to 69 (SD} = 59,731). \text{Unharmed age 70 to 79 (SD} = 14,465), \text{harmed age 70 to 79 (SD} = 44,852). \text{Unharmed age over 80 (SD} = 24,302), \text{harmed age over 80 (SD} = 31,485). *\text{All } P < .001. \]
harmed patients in the older group had fewer ICU days (3.12 vs 4.22) and a shorter LOS (13.4 vs 15.37 days) than those in the younger group. Results were significant with $P$ value less than .001.

Multivariate logistic regression predicting death showed a relative odds ratio of 3.37 for harm. This was similar to the relative odds ratio for ASA class (3.41) and greater than the odds ratios for emergency surgery (1.94), age over 80 (1.52), ventilator days (1.17), and Elixhauser index (1.06).

These data are shown in Table 4. All results were significant with $P$ value less than .001.

Linear regression comparing total technical cost including the variables harm, death, ASA class, emergency surgery, Elixhauser Index, African American race, and age above 80 is shown in Table 5. Associated cost increases with harm ($24,087$), death ($21,993$), ASA class ($10,468$), emergency surgery ($5,435$), and Elixhauser index ($584$) and decreases with age above 80 ($7,086$) and African Americans ($3,070$) and Elixhauser index ($600$).

**Comments**

There are a significant number of patients at the high extreme of age undergoing surgical operations. At a single institution, we were able to identify over 2,800 inpatient surgical patients aged 80 and older in a 3-year study period. With the increasing size of this cohort of the population in the United States, this number will continue to grow. These patients are known to be at high risk for complications. As the emphasis on providing high quality, cost-effective surgical care increases, it is essential to understand how the rates of harm and the effects of harm differ in elderly versus younger populations.

In our study population, acuity of care as estimated by mean LOS, ICU days, ventilator days, and blood transfusions showed little difference between patients aged 50 to 79 compared with those aged 80 and older. The groups were also similar in types of harm, with only infections and other (renal failure, blue alert, and deep vein thrombosis) occurring significantly more frequently in the older group. Physiologic derangements in immune function, coagulation, and the renal system may contribute to increased susceptibility to these types of harm in the extreme elderly.

Both mortality and harm gradually increased with age, but mortality for unharmed patients increased after age 70, whereas mortality for harmed patients increased significantly after age 80. This suggests that the increased mortality in 60 to 69-year olds is because of increased rates of harm rather than increased lethality of harm.

There is an increased mortality in 70 to 79-year olds in unharmed patients but not in harmed patients, which may be because of patient factors such as increased frailty or increased deaths attributable to natural causes. There are likely more patients with do not resuscitate orders in this group, allowing them to avoid harm events at the end of life such as blue alerts. The mortality rate of unharmed patients older than 80 is similar to those aged 70 to 79, but the mortality rate of harmed patients is increased by 2.3%. The high mortality of patients over age 80 is likely because of a combination of both increased rates of harm and increased lethality of harm.

When we looked at the cost of care for harmed versus unharmed patients, we found similar added cost in harmed patients aged 50 to 59 and 60 to 69, but there was dramatically less added cost in patients aged 70 to 79 and even less for those patients aged 81 to 100. Patients over age 70 may receive less aggressive care or their families

**Table 4 Multivariate logistic regression: death**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds ratio (95% CI)</th>
<th>$P$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASA class</td>
<td>3.410 (2.821–4.122)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Harm</td>
<td>3.371 (2.646–4.295)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Emergency surgery</td>
<td>1.943 (1.518–2.486)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Age 80+</td>
<td>1.522 (1.174–2.052)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Ventilator days</td>
<td>1.174 (1.142–1.208)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Elixhauser index</td>
<td>1.063 (1.047–1.080)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

ASA = American Society of Anesthesiologists; CI = confidence interval.

**Table 5 Linear regression: total technical cost**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Additional cost (standard error)</th>
<th>$P$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harm</td>
<td>$24,087 (538)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Death</td>
<td>$21,993 (1,465)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>ASA class</td>
<td>$10,468 (339)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Emergency surgery</td>
<td>$5,435 (710)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Elixhauser index</td>
<td>$584 (37)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>African American</td>
<td>$3,070 (437)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Age 80+</td>
<td>$7,086 (649)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Cost in US dollars from the year of admission. ASA = American Society of Anesthesiologists.
may have differing goals of care versus younger patients. Physicians may be less likely to have timely and appropriate end of life conversations with the families of younger patients. They may also feel less pressure in harmed elderly patients to “do everything” in an attempt to rectify the harm and therefore less likely to offer to older patients tests and treatments with little or no added value. It is also possible that elderly harmed patients and their caregivers are more likely to recognize and accept a need for discharge to a long-term care hospital or skilled nursing facility, resulting in a transference of cost outside the hospital.

In the 70 to 79 age group, harmed patients had dramatically less cost associated with harm than younger patients, but mortality rates were similar. In comparison, patients aged 80 years and older had further decreased cost of harm, but also had significantly increased mortality associated with harm. Harmed patients aged 80 years and older also had fewer additional days in the ICU and in the hospital than younger patients. This suggests that a modest amount of cost avoidance is not harmful, but higher levels may reduce our ability to rescue patients after harm. Removing the deceased patients from the LOS analysis did not increase the LOS for elderly patients, so the reduction in cost is not explained by rapid lethality of harm in the older group. This topic warrants further study.

Our multivariate logistic regression demonstrated that the association between harm and mortality is roughly equal to increasing the ASA score by one level. Harm showed a more powerful association with death than emergency surgery, age 80 or older, ventilator days, and Elixhauser index. Note that the Elixhauser index contains 30 comorbidities, so patients with high levels of comorbidity may have high index scores with predictive value comparable with that of harm and the other indices. In the linear regression predicting total cost, we showed harm to be more costly as well.

Our study was limited by retrospective analysis of prospectively collected data. Also, the database collects postoperative data only during hospitalization, so harm and mortality occurring after discharge are not captured. The database may not be a true national representation as only a single institution is included. We selected all inpatient surgeries and all harm events to better power our study and provide a broad dataset; however, individual procedures and complications are likely to vary widely in their rates of mortality and cost.

Despite these limitations, the “No Harm Campaign” dataset provides a large representative sample of inpatient operations performed at a single institution and our data show a significantly increasing rate of harm with increasing age. Furthermore, there is significant mortality associated with harm which increases after age 80.

Harm was identified as a powerful driver of increased cost. However, harm in the extreme elderly was associated with less added cost and it was not associated with protracted ICU or hospital stays. There was significant cost avoidance after age 70, increasing further after age 80, which may reflect less aggressive care from providers and/or differing goals of care from patients and their families.

It does seem that the adage “(the elderly) tolerate the operation, but not the complications” has some truth. While even unharmed patients over age 80 had some increased mortality versus younger patients, harm is significantly more lethal in extremely elderly populations. It is important, however, to recognize that harm is associated with greatly increased mortality, LOS, and cost among all age groups. This highlights the importance of global harm reduction efforts and provision of high-quality care to all patients.

References

