Surgeon- and System-Based Influences on Trauma Mortality

Elliott R. Haut, MD; David C. Chang, PhD, MPH, MBA; Awori J. Hayanga, MD, MPH; David T. Efron, MD; Adil H. Haider, MD, MPH; Edward E. Cornwell III, MD

Hypothesis: The mechanism by which trauma systems improve mortality is unknown. Outcomes may be influenced by experienced trauma surgeons treating more patients (surgeon effect) or improving the overall system of care (system effect). We hypothesized that mortality is lower in patients treated by a fellowship-trained senior trauma program director (experienced) vs first-year general surgery attending surgeon (novice) and that patient mortality for novice surgeons would improve after adding a new senior trauma director.

Design: Retrospective cohort study.

Setting: Academic level I trauma center.

Patients: Individuals who had experienced trauma.

Main Outcome Measures: We concurrently compared mortality in trauma patients treated by an experienced trauma surgeon with those admitted by novice surgeons during 1½ years. We also compared mortality in patients treated by novice surgeons before vs after implementation of a more structured trauma program. The χ² test and multiple logistic regression analysis were used to compare the groups. Odds ratios (95% confidence intervals) for death were examined.

Results: Concurrent comparison of patients treated by novice surgeons vs experienced trauma surgeons demonstrated no difference in mortality (odds ratio, 1.33; 95% confidence interval, 0.82-2.15). At unadjusted univariate analysis, mortality in patients treated by novice surgeons significantly improved over time in the blunt trauma group and all emergency department survivor subgroups. Multivariate analysis demonstrated significantly improved mortality over time in patients treated by novice surgeons (odds ratio, 0.56; 95% confidence interval, 0.37-0.85).

Conclusions: In a structured trauma program, there is no mortality difference between novice surgeons and their experienced trauma director. The organized trauma program and senior surgical mentoring overpower any influence of individual surgeon inexperience.

Arch Surg. 2009;144(8):759-764

TRAUMA CARE IN THE UNITED States is provided by surgeons with vastly different training and experience. It is assumed that after general surgery residency training, surgeons are competent to provide trauma care. Trauma fellowships exist for additional training in trauma surgery but are not a prerequisite at most medical centers. This has resulted in a relative scarcity of experienced fellowship-trained trauma surgeons. Less-experienced surgeons are associated with worse outcomes in certain patient subpopulations such as those undergoing complex alimentary tract or prostate cancer surgery; however, this effect has not been noted in trauma care. Richardson et al examined patient outcomes based on surgeon-specific variables (including years in practice) and concluded that the severity of the injury predicted mortality more accurately than surgeon experience or annual case volume per surgeon.

See Invited Critique at end of article

The association between individual surgeon patient volume and outcome has been examined in several surgical subspecialties. High-volume surgeons produce better outcomes in vascular, gastrointestinal tract, oncologic, cardiac, and other...
types of surgery. This surgeon-volume effect has fast permeated the decision making that governs surgeon selection, remuneration, and health policy. Within the subspecialty of trauma, there are disparate results in studies that evaluated this relationship. Some researchers have concluded that there are no statistically significant differences in outcomes between high- and low-volume trauma surgeons or trauma centers. Other investigators have described an inverse relationship between trauma hospital volume and outcomes. These studies have, in turn, been criticized for failing to demonstrate surgeon-specific results as distinct from hospital-related outcomes. We have previously shown improved outcomes for trauma patients treated by full-time trauma surgeons compared with part-time trauma surgeons. Clearly, patient factors alone do not determine eventual outcomes.

Both structural changes and increased resource commitment at trauma centers improve patient survival. However, the role of individual surgeon experience in achieving these outcomes is unclear. The improvements may possibly be the result of either the concentration of care with experienced trauma surgeons or the benefit of greater emphasis on education and the application of evidence-based protocols and guidelines. We hypothesized that the surgeon effect and the system effect are key factors in improving overall trauma outcomes. The first hypothesis that mortality is lower in patients treated by a fellowship-trained senior trauma program director (experienced) vs first-year general surgery attending surgeons (novice) addresses the potential surgeon effect. The second hypothesis that patient mortality for novice surgeons may improve over time after the implementation of enhanced institutional commitment to standardized trauma care examines the system effect.

METHODS

Before 1998, trauma care at The Johns Hopkins Hospital, Baltimore, Maryland, was principally the responsibility of the assistant chiefs of service. These junior first-year surgical attending surgeons joined the surgical staff after their general surgery residency for an additional year of experience in oncologic, hepatobiliary, and pancreatic surgery. They performed some operations with senior academic surgical faculty while maintaining independent attending and admitting privileges. They spent most of their time in trauma and emergency surgical patient care. Each July there was a new group of these first-year attending surgeons who were considered novice trauma surgeons.

In 1998, a seasoned fellowship-trained trauma surgeon (E.E.C.) was recruited and appointed to be the trauma program director. It is difficult to define explicitly an experienced trauma surgeon. Therefore, we assumed that a surgeon is experienced after completing a 2-year trauma/critical care fellowship and 10 additional years (as of the beginning of the study) as a full-time busy trauma clinical surgeon. This trauma program director, considered the experienced trauma surgeon, led and supervised the direction of structural changes designed to enhance the commitment to trauma patient care. These changes included the following: (1) in-house attending trauma surgeon presence 24 hours a day; (2) written evidence-based algorithms, protocols, and guidelines for trauma patient management; (3) a dedicated trauma admitting unit with use and triage solely under the control of the trauma team; (4) regularly scheduled multidisciplinary trauma core curriculum conferences; (5) enhanced quality improvement processes; and (6) a daily morning report in which all new trauma contacts and inpatient management decisions for the previous 24 hours were discussed in a learning forum.

We conducted a retrospective cohort review of prospectively collected data from the Johns Hopkins trauma registry using commercially available software (Collector; TriAnalytics, Inc, Bel Air, Maryland) for 10 years (July 1, 1994, to June 30, 2004). The early (July 1, 1994, to December 31, 1997) and late (January 1, 1998, to June 30, 2004) periods were defined to allow a comparison between differences before and after the structural changes in trauma care were instituted. Patients were assigned to 1 of 2 groups depending on their primary trauma attending surgeon (novice or experienced).

The first analysis concurrently compared patients treated by novice surgeons vs the experienced surgeon during the late period. The second analysis compared patients in the novice group over time (early vs late period). By study design, no patients were treated by the experienced trauma surgeon in the early group. The primary outcome of interest was in-hospital deaths. Standard unadjusted bivariate analyses were performed in the population as a whole and in predetermined subgroups based on injury mechanism, injury severity, need for immediate surgery, and emergency department (ED) survival. Comparisons of means were performed using the t test, and comparisons of percentages were performed using the χ2 test. Standard multiple logistic regression methods were then used to enable comparison of outcomes of disparate populations and to identify risk factors (ie, attending surgeon status, patient age and sex, and severity of injury) for outcome parameters (mortality). Adjusted odds ratios were calculated using multiple logistic regression analyses including the following variables: attending surgeon status (novice vs experienced), patient age and male sex, Injury Severity Score (ISS) higher than 15, hypotension, severe head injury, and penetrating injury mechanism. Hypotension was defined as systolic blood pressure less than 90 mm Hg on arrival at the trauma center. Severe head injury was defined as a Glasgow Coma Scale score of 8 or less and a head Abbreviated Injury Scale score of at least 1. Immediate surgery was defined as direct admission from the trauma bay to the operating room. Statistical analysis was performed using commercially available software (Intercooled Stata version 8.0; StataCorp LP, College Station, Texas). The Institutional Review Board of Johns Hopkins Medical Institutions granted exempt status for this retrospective review.

RESULTS

A total of 13,894 patient contacts were evaluated during the 10-year study. In the early period, novice surgeons treated 4499 patients. Of the 9395 patients in the late period, novice surgeons evaluated 5783 patients (61.6%), and the experienced surgeon treated 3612 patients (38.4%).
Table 1. Demographic Data for Trauma Patients for Comparison According to Surgeon Experience: Late Study Perioda

<table>
<thead>
<tr>
<th>Variable</th>
<th>Novice Surgeons</th>
<th>Experienced Surgeon</th>
<th>P</th>
<th>Value, ( \chi^2 ) Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of trauma patients</td>
<td>5783</td>
<td>3612</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, mean, y</td>
<td>34.5</td>
<td>36.5</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Male sex, %</td>
<td>70.7b</td>
<td>67.8</td>
<td>.002</td>
<td></td>
</tr>
<tr>
<td>Hypotension (SBP &lt;90 mm Hg), %</td>
<td>4.2b</td>
<td>3.1</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Penetrating injury, %</td>
<td>31.1b</td>
<td>21.9</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Severe head injury, %</td>
<td>2.7</td>
<td>2.6</td>
<td>.80</td>
<td></td>
</tr>
<tr>
<td>Injury Severity Score, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;15</td>
<td>10.2b</td>
<td>8.8</td>
<td>.02</td>
<td></td>
</tr>
<tr>
<td>&gt;25</td>
<td>4.2</td>
<td>3.4</td>
<td>.05</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviation: SBP, systolic blood pressure.


b \( P < .05 \).

Table 2. Trauma Patient Mortality by Surgeon Experience: Late Study Perioda

<table>
<thead>
<tr>
<th>Variable</th>
<th>% (No. of Patients/ Total No. of Patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Novice Surgeons</td>
</tr>
<tr>
<td>All trauma patients</td>
<td>3.4 (199/5783)</td>
</tr>
<tr>
<td>Trauma patients, ED deaths excluded</td>
<td>1.2 (69/5652)</td>
</tr>
<tr>
<td>Blunt trauma</td>
<td>1.0 (38/3956)</td>
</tr>
<tr>
<td>Penetrating injury</td>
<td>8.5 (151/1782)</td>
</tr>
<tr>
<td>Immediate surgery</td>
<td>7.1 (35/491)</td>
</tr>
<tr>
<td>Hypotension (SBP &lt;90 mm Hg)</td>
<td>61.2 (148/242)</td>
</tr>
<tr>
<td>Severe head injury, %</td>
<td>51.3 (81/157)</td>
</tr>
<tr>
<td>Injury Severity Score, %</td>
<td></td>
</tr>
<tr>
<td>&gt;15</td>
<td>27.9 (165/592)</td>
</tr>
<tr>
<td>&gt;25</td>
<td>49.4 (121/245)</td>
</tr>
</tbody>
</table>

Abbreviations: ED, emergency department; SBP, systolic blood pressure.
b All \( P > .05 \) not significant.

NOVICE vs EXPERIENCED TRAUMA SURGEON GROUPS: CONCURRENT ANALYSIS IN LATE PERIOD

The demographic data for the novice surgeons vs the experienced trauma surgeon were significantly different. Patients treated by novice surgeons were younger and more likely to be male and to have a penetrating injury, an ISS higher than 15, and hypotension (Table 1). At unadjusted bivariate analysis, there was no statistically significant difference in overall mortality between the 2 surgeon groups as a whole or in any subgroup analysis (Table 2). At multiple logistic regression, age, ISS higher than 15, hypotension, severe head injury, and penetrating injury mechanism were significantly associated with mortality (Table 3). There was no statistically significant survival difference for patients treated by the experienced trauma surgeon compared with those managed by the novice surgeons (odds ratio for death, 1.33; 95% confidence interval, 0.82-2.15).

Table 3. Logistic Regression for Trauma Patient Mortality According to Surgeon Experience: Late Study Perioda

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value, ( \chi^2 ) Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experienced surgeon vs novice</td>
<td>1.33 (0.82-2.15)</td>
</tr>
<tr>
<td>attending surgeon</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>1.05 (1.04-1.07)</td>
</tr>
<tr>
<td>Male sex</td>
<td>1.09 (0.57-2.09)</td>
</tr>
<tr>
<td>Hypotension (SBP &lt;90 mm Hg)</td>
<td>7.81 (4.34-14.0)</td>
</tr>
<tr>
<td>Severe head injury</td>
<td>11.2 (6.40-19.6)</td>
</tr>
<tr>
<td>Penetrating injury</td>
<td>4.38 (2.34-8.22)</td>
</tr>
<tr>
<td>Injury Severity Score &gt;15</td>
<td>32.9 (17.0-63.4)</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; OR, odds ratio; SBP, systolic blood pressure.
b \( P < .05 \).

NOVICE SURGEON OVER TIME: EARLY VS LATE PERIODS

The demographic data for patients treated by novice surgeons were significantly different between the early and late periods. The cohort in the late period was slightly older and less likely to be male and to have a penetrating injury and an ISS higher than 15 (Table 4). At unadjusted bivariate analysis, there was no statistically significant difference in overall mortality between the 2 groups (Table 5). However, when ED deaths were excluded, mortality was lower in the late period (1.8% vs 1.2%; \( P = .01 \)). Patients with blunt trauma injury were more likely to survive in the late period (1.8% vs 1.0%; \( P = .01 \)). Patients managed by novice surgeons in the late period were more likely to survive than those in the early period (odds ratio of death, 0.56; 95% confidence interval, 0.37-0.85).
Within a structured trauma program, there is no difference in mortality between patients treated by novice surgeons and those treated by the experienced fellowship-trained trauma director. Mortality in patients managed by these novice surgeons improved with increased structural changes and commitment to improved trauma care between the early and late periods. Together, these data support the belief that in a structured trauma program, surgeons with vastly different levels of training can safely provide care and obtain equivalent outcomes. System effects outweigh any potential benefits of individual surgeon experience in the care of trauma patients. The implementation of an organized trauma program with evidence-based protocols and senior surgical guidance may have a greater effect on mortality than individual surgeon experience alone.

The survival improvement of 1.8% to 1.2% may seem small, but the improved outcomes identified in our study in the late period may, in part, be the result of standardization of care using the newly emphasized evidence-based guidelines. Evidence-based medicine has been defined as the “conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients.”24 The use of evidence-based guidelines within all fields of medicine continues to grow. Trauma surgeons have led this charge within the surgical community, embracing and acknowledging the benefits of protocols and guidelines.25,26 Perhaps the premier example of guideline use is the well-structured algorithmic approach to trauma care taught in the American College of Surgeons Advanced Trauma Life Support course.27 The Eastern Association for the Surgery of Trauma has also promulgated the use of guidelines for the care of injured patients for well over a decade. Their website (http://www.east.org) offers 30 trauma practice guidelines, which are often regarded as the definitive resource for trauma management.28 Individual guidelines directed at prevention of venous thromboembolism,29 aggressive enteral nutrition,30 treatment of pelvic fracture with hemorrhage,31 and blood transfusion32 are examples that improve resource use, decrease complications, and improve outcomes.

The improved survival rates we identified in the period after our hospital dedicated more resources and committed to enhanced efforts for trauma care mirrors similar findings from other trauma centers.17,20 We agree with other authors that these improvements are the result of a better trauma system; however, the specific factors that affect care cannot be defined. One likely pathway is standardization of care. However, the improved survival is likely multifactorial through a combination of mechanisms. Perhaps conversion to a coverage model with 24-hour presence of an in-house trauma attending surgeon produced the results, as has been noted in other studies.33,34 or perhaps it is simply that all medical care should improve over time. It may not matter which specific pathway produced the results. The trauma system as a whole is improving care for injured patients and saving lives.
As with all fields in general surgery, trauma surgery has become substantially more specialized, requiring a broad array of surgical and other patient-management skills. Other areas of general surgery have also grown, potentially diminishing the amount of time available for surgical residents to learn trauma care. These facts may lead graduating surgical chief residents to feel uncomfortable handling certain trauma situations. A large multi-institutional trial has shown that surgical residents perform relatively few trauma procedures and operations and that their experience on most trauma services is heavily weighted toward nonoperative management.33 Brooks et al33 published data that demonstrate that a substantial number of British general surgeons do not have the surgical confidence to deal with many traumatic injuries. Reilly et al37 have shown that surgeon comfort in managing patients with complex multiple traumas was relatively low after a general surgery residency but increased substantially after a 2-year trauma/critical care fellowship.

The article by Reilly et al emphasizes the role of ongoing, concurrent mentorship of junior surgical attending surgeons in the trauma setting. This group at the University of Pennsylvania used a comparable daily morning report to review and analyze the care rendered by a group of trauma fellows who were also credentialed as attending surgeons. They showed that in their highly structured program, mortality was the same for patients treated by fellows and the academic faculty trauma attending surgeons, although complication rates may be slightly higher for fellows during training.37 Similar models of training in trauma and acute-care surgery occur at institutions across the United States.38 Even at institutions without formal trauma or acute-care fellowship programs, the informal approach is common. Senior surgeons are often available to help with difficult decision making and operations and for the ongoing education of junior faculty.39,40 There is now an established senior visiting surgeon program sponsored by the American Association for the Surgery of Trauma and the American College of Surgeons Committee on Trauma that enables senior civilian trauma surgeons the opportunity to help guide military personnel treating injured soldiers at Landstuhl Regional Medical Center, Landstuhl, Germany. These surgeons can “contribute to education at the center through lectures, serve as scientific mentors, and provide expert commentary during performance-improvement activities.”41(p2723)

The present study has potential limitations and strengths. Limitations include the inherent problems of a nonrandomized retrospective analysis from a single institution that may not be directly applicable to other institutions. We also used historical controls for the comparison of novice surgeons over time, although this is a well-replicated and accepted method.17,20 Because of the study design, we had only a single experienced trauma surgeon against whom to compare the many novice surgeons. This individual may or may not be truly representative of all experienced trauma surgeons. We also chose to look at mortality alone. Although death is a clinically relevant well-defined end point, perhaps some other measure such as functional outcomes, length of stay, or limb salvage rates would show differences between the novice and experienced groups.

A major strength is the study’s simplicity; the only management difference for the novice vs experienced concurrent comparison is the admitting surgical attending surgeon. The system in which the novice surgeons and the experienced trauma surgeon cared for patients was the same. Many care providers in addition to the primary surgical attending surgeon are crucial to ensure the best outcomes. All attending surgeons had the benefit of the same surgical residents, ED staff, surgical intensive care unit and surgical floor nurses, and operating room, laboratory, blood bank, and radiology personnel, who performed all patient care equally for both groups. There are no effects of referral bias because patients are assigned to a particular surgeon depending only on the predetermined call schedule (as opposed to personal preference and insurance status, for example).

In conclusion, in a structured trauma program, there is no difference in mortality between patients treated by novice surgeons and those treated by an experienced trauma director. Mortality in patients managed by novice surgeons improved with the increased structural changes and commitment to trauma care between the early and late study periods. Implementation of an organized trauma program with protocols and senior surgical guidance may have a greater effect than individual surgeon experience.

Accepted for Publication: July 8, 2008.
Correspondence: Elliott R. Haut, MD, Department of Surgery, The Johns Hopkins University School of Medicine, 600 N Wolfe St, Osler Bldg, Room 625, Baltimore, MD 21287 (ehaut1@jhmi.edu).

Author Contributions: Dr Haut had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Haut, Chang, and Cornwell. Acquisition of data: Haut and Cornwell. Analysis and interpretation of data: Haut, Chang, Hayanga, Efron, Haider, and Cornwell. Drafting of the manuscript: Haut, Chang, Hayanga, and Cornwell. Critical revision of the manuscript for important intellectual content: Haut, Chang, Efron, Haider, and Cornwell. Statistical analysis: Chang. Administrative, technical, and material support: Chang. Study supervision: Haut and Cornwell.

Financial Disclosure: None reported.
Previous Presentation: This study was presented as a poster at the American Association for the Surgery of Trauma; Atlanta, Georgia; September 22-24, 2005; and as part of the 2007 American College of Surgeons Committee on Trauma Resident Paper Competition, where it won first prize in both Maryland and Region 3.

REFERENCES


H aut et al are to be congratulated for a comprehensive analysis of the changes that occurred in their trauma center after the introduction of new leadership and structure in 1998. The experience of the in-house trauma attending surgeon did not have an effect on overall patient mortality, whereas the change in leadership and structure decreased mortality when novice surgeons were the caregivers. The use of mortality as an end point in analyzing trauma care does have some limitations. For example, it would be helpful to know the actual percentages of blunt vs gunshot wound vs stab wound mechanisms of injury in all groups. Patients with hypotension in the former 2 groups have significant mortality compared with the latter group when the admission base deficit exceeds –15. It would be expected that the greatest advantage of having an experienced surgeon available would be in the performance of index abdominal trauma operations, that is, those involving repair of complex injuries to the liver, pancreaticoduodenal complex, and major abdominal vascular structures. The