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The Relationship Between Processes and Outcomes for Injured Older Adults: A Study of a Statewide Trauma System

Noelle Saillant, MD,

Department of Surgery, Perelman School of Medicine at the University of Pennsylvania, Philadelphia, PA. Noelle.Saillant@uphs.upenn.edu

Emily Earl-Royal, BA,

Perelman School of Medicine at the University of Pennsylvania, Philadelphia, PA, eearl@mail.med.upenn.edu

Jose L Pascual, MD PhD,

Department of Surgery, Perelman School of Medicine at the University of Pennsylvania, Philadelphia, PA, Jose.Pascual-Lopez@uphs.upenn.edu

Steven R Allen, MD,

Department of Surgery, Perelman School of Medicine at the University of Pennsylvania, Philadelphia, PA, Steve.Allen@uphs.upenn.edu

Patrick K Kim, MD,

Department of Surgery, Perelman School of Medicine at the University of Pennsylvania, Philadelphia, PA, Patrick.Kim@uphs.upenn.edu

M Kit Delgado, MD MS,

Department of Emergency Medicine, Perelman School of Medicine at the University of Pennsylvania, Philadelphia, PA, Mucio.Delgado@uphs.upenn.edu

Brendan G Carr, MD MSHP,

Department of Emergency Medicine, Perelman School of Medicine at the University of Pennsylvania, Philadelphia, PA, Brendan.Carr@jefferson.edu

Doug Weibe, PhD, and

Corresponding Author/ Reprints: Emily Earl-Royal, 2400 Chestnut St., Apt 1907, Philadelphia, PA 19103, eearl@mail.med.upenn.edu.

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This study was conducted in accordance with the ethical standards of the Perelman School of Medicine at the University of Pennsylvania and was approved by the Institutional Review Board.

Department of Emergency Medicine, Perelman School of Medicine at the University of Pennsylvania, Philadelphia, PA, dweibe@exchange.upenn.edu

Daniel N Holena, MD
Department of Surgery, Perelman School of Medicine at the University of Pennsylvania, Philadelphia, PA, Daniel.Holena@uphs.upenn.edu

Abstract

Purpose—Age is a risk factor for death, adverse outcomes, and health care use following trauma. The American College of Surgeons' Trauma Quality Improvement Program (TQIP) has published "best practices" of geriatric trauma care; adoption of these guidelines is unknown. We sought to determine which evidence-based geriatric protocols, including TQIP guidelines, were correlated with decreased mortality in Pennsylvania's trauma centers.

Methods—PA's level I and II trauma centers self-reported adoption of geriatric protocols. Survey data was merged with risk-adjusted mortality data for patients ≥ 65 from a statewide database, the Pennsylvania Trauma Systems Foundation (PTSF), to compare mortality outlier status and processes of care. Exposures of interest were center-specific processes of care; outcome of interest was PTSF mortality outlier status.

Results—26 of 27 eligible trauma centers participated. There was wide variation in care processes. Four trauma centers were low outliers; three centers were high outliers for risk-adjusted mortality rates in adults ≥ 65. Results remained consistent when accounting for center volume. The only process associated with mortality outlier status was age-specific solid organ injury protocols (p=0.04). There was no cumulative effect of multiple evidence-based processes on mortality rate (p=0.50).

Conclusions—We did not see a link between adoption of geriatric best-practices trauma guidelines and reduced mortality at PA trauma centers. The increased susceptibility of elderly to adverse consequences of injury, combined with the rapid growth rate of this demographic, emphasizes the importance of identifying interventions tailored to this population.

Keywords

Geriatric; Trauma Quality Improvement Program (TQIP); Outcomes Assessment; Mortality; Treatment Protocols

BACKGROUND

Traumatic injury is a leading cause of death and disability in patients over the age of sixty-five (1). Over 43 million United States residents are considered elderly, an age demographic that will represent over 20% of the population by the year 2030 (1). The surge in the elderly demographic has been paralleled by an increase in traumatic injury in this age group (2). In itself, age is an independent risk factor for death, adverse outcomes, and disproportionate health care utilization following traumatic injury (2, 3, 4). Despite advances in trauma care, geriatric trauma-associated fatality rates continue to rise (4, 5).

Recent literature has suggested that system based modifications may improve geriatric trauma outcomes. For instance, use of a geriatric care team may decrease rates of delirium, functional decline, and discharge to long-term acute care facilities (5–7). Additionally, a lower trauma activation threshold for elderly patients can lead to improvements in mortality (8).

The American College of Surgeons' Trauma Quality Improvement Program (TQIP®) has consolidated much of the available evidence in a consensus paper in their publication of the *Geriatric Trauma Management Guidelines*. These recommendations are considered "best practices" in the care of injured older adults (Table 1). However, the extent of utilization of these guidelines and other evidence based geriatric protocols across the US is unknown.

The purpose of this study was to determine which geriatric practice patterns were associated with optimal management of geriatric trauma patients. We sought to associate processes of care with risk-adjusted mortality. We hypothesized that high performing centers also had high levels of adherence to "best practices" for injured older adults as described by TQIP guidelines. We further hypothesized that there would be significant center-to-center variability in the application and adoption of the TQIP guidelines.

METHODS

To characterize existing processes in place for older adult trauma care at Pennsylvania's level I and II trauma centers, a survey instrument based on the TQIP "best practices" guidelines for geriatric trauma patients was developed. The survey domains included threshold for trauma system activations, use of CT scanning, assessment for and reversal of anticoagulation, use of geriatrician consultation, medication prescribing practices, involvement of the primary care provider, and discussion of advanced directives. We also we sought to determine if each center had a definition for 'elder' or 'geriatric' or 'older adult.' Each domain began with topically directed questions followed by open-ended questions to allow for elaboration on processes of care. Likert scales were used to evaluate the extent of specific practices. The survey instrument was piloted among a local cohort of trauma nurses and trauma surgeons to ensure ease of use and construct validity. After revision of the survey instrument, we sought to interview the trauma medical directors and/ or trauma program managers all 27 adult Level I and Level II trauma centers in the state of Pennsylvania. Trained interviewers used a standardized script to administer the survey and captured responses in an online database constructed for the purpose of this study (REDCap™).

This survey data was then merged with risk-adjusted mortality data from a statewide database in order to ascertain the association between mortality outlier status and processes of care. The statewide database, Pennsylvania Trauma Systems Foundation (PTSF), is a non-profit corporation that establishes trauma center accreditation standards in the state of Pennsylvania. In addition, the PTSF models risk-adjusted outcomes data from trauma centers across the state using its Pennsylvania Trauma System Foundation Risk-Adjusted Model (PTSF-RAM). Full details of the PTSF-RAM model are published elsewhere but, briefly, this multivariable logistic regression model uses data from 101,477 patients collected between 2011–2013. The model generates risk-adjusted mortality rates using the following

covariates: age, injury severity, comorbidities, admission physiology, mechanism of injury, and transfer status. The model also generates observed to expected (O: E) ratios for each center and compares those ratios using caterpillar and funnel plots.

For this study, data from our process surveys were merged with PTSF-RAM risk-adjusted mortality rankings that used a subgroup analysis of patients ≥ 65 years of age. All center-level identifiers were stripped from the dataset prior to the PTSF-RAM merge to ensure that participating centers could not be identified and linked to their mortality data.

The primary of exposures of interest were the center-specific processes of care, which were identified via the survey of trauma center directors and managers. The primary outcome of interest was mortality outlier status (low, average, or high) as determined by the PTSF-RAM. Due to the overall small sample size, Likert data were dichotomized by combining ‘never’ and ‘sometimes’ to indicate low intensity and combining ‘often’ and ‘always’ to indicate high intensity. Descriptive statistics were generated for each of the processes of care and Fisher’s exact test was used to compare categorical variables with a two tailed significance set at p=0.05. All statistical analysis was performed using Stata 13.1 (College Station, TX).

RESULTS

In total, 26 of the 27 level I and level II trauma centers participated in the survey. Participating centers were evenly split between level I and level II centers and were predominantly located in metropolitan areas.

The definition of older adult was age ≥65 years of age at 77% of the surveyed centers. Overall, there was significant variation in the use of TQIP “best-practice” guidelines across participating centers, with rates of individual process adoption ranging from 4–85% (Figure 1). Only one center incorporated all of the TQIP guidelines into routine trauma care of the elderly. This center was not a mortality outlier.

The most common process in place was the routine discussion of code status on admission, which was practiced by 22/26 (85%) centers surveyed. Other processes widely used in widespread use were a high frequency of involvement of primary care (58%) and palliative care providers (58%).

Processes for assessment and reversal of anticoagulation assessment and reversal processes varied between centers. While all centers reported using prothrombin time (PT) and partial thromboplastin time (PTT) as standard admission measures of anticoagulation, 9/26 (35%) centers used thromboelastography as an additional assessment measure. Another 35% of centers reported using various other studies, which were predominantly targeted at platelet function. Use of fresh frozen plasma and vitamin K for reversal of anticoagulation was nearly ubiquitous, occurring in 96% and 81% of centers, respectively. Approximately two-thirds of centers reported the use of prothrombin complex concentrate as a reversal agent, while roughly 46% used recombinant factor VII. Administration of platelets in patients taking antiplatelet agents, such as aspirin or clopidogrel, varied substantially between

centers, with 54% of centers reporting that they always or almost always gave platelets and the remainder reporting a selective approach.

The PTSF-RAM analysis identified four trauma centers as low outliers and three trauma centers as high outliers for risk-adjusted mortality rates in older adults. Caterpillar plots illustrating the results of this model can be seen in Figure 2.

To control for individual center trauma volume, funnel plots were used to compare O: E mortality ratios for each center. These results were concordant with the PTSF-RAM data and revealed the same four low outliers and three high outliers in center mortality rates (Figure 3).

The association between the processes we surveyed and outlier status in mortality based on the PTSF-RAM can be seen in Table 2. When considered as dichotomous variables in univariate analysis, only the presence of age-specific solid organ injury protocols was found to be associated with mortality low-outlier effect. To assess for a possible cumulative effect of multiple processes, each center was assigned a score by summing the results across all best-practice processes; scores were not significantly different between low, average, and high outlier status for mortality (8 (IQR 7–10.5) vs. 7(IQR 5–9) vs. 8 (IQR 6–14), p=0.50).

As an exploratory query, we asked trauma center leaders what characteristics they perceived to be important to improving geriatric trauma outcomes and what characteristics they perceived to be barriers to improving those outcomes.

Representative quotations from these open-ended questions may be seen in Table 3. Two themes strongly emerged as perceived keys to improvement. First, many expressed the belief that multidisciplinary care (often involving a geriatric specialist) in the care of injured older adults was critical for improving outcomes. Second, center representatives stressed the importance of recognizing that injured older adults represent a distinct cohort of patients, with unique physiologic reserve, response to injury, and pharmacological requirements. The strongest theme that emerged in assessing barriers to care was a perceived lack of available resources to care for injured older adults, specifically lack of access to geriatricians.

DISCUSSION

Our study confirmed that there was center-to-center variation in the adoption of TQIP guidelines and in each center's definition of geriatric-specific care.

We found no universal age definition of the "elderly" patient group across Pennsylvania trauma centers. The vast majority of centers (77%) defined elderly as > 65 years old. However, one out of five centers used a different age threshold. This finding may reflect the lack of uniformity as to the definition of elderly in the literature and the notable absence of an age definition within TQIP guidelines (9).

While there is no agreement about at what age a patient becomes "elderly," age has been identified as a risk factor for under-triage (10, 11). Chang et al. reported that patients ≥ 65 years old had a significantly higher risk of under-triage as compared to their younger

counterparts (49.9% vs. 17.8%, respectively). Severely injured geriatric patients often do not manifest the physiologic markers for trauma team activation. Demetriades showed that 63% of geriatric patients with Injury Severity Scores > 15 did not meet the trauma team activation threshold. Even when the ISS was >30, almost a quarter of elderly patients would have been under-triaged (10). Appropriate triage is essential to lowering mortality in geriatric trauma patients: a lowered trauma activation threshold for elderly patients led to 30% improvement in mortality (12, 13). For these reasons, TQIP has proposed that age be an independent criterion for trauma activation and has gone so far as to recommend elevating activation level by one tier based on age. Despite this seemingly robust evidence, our survey of statewide trauma centers demonstrated only 36% used age as a trauma activation criterion.

The most common TQIP process adopted by trauma centers was the clarification of code status upon admission, which was routinely practiced by 85% of centers surveyed. The widespread practice of this TQIP guideline may be related to the ascertainment of code status as a standard part of the admissions order set. Given that geriatric trauma patients are at greater risk for mortality early determination of code status is particularly pertinent in this population. Mosenthal and colleagues found that implementation of a structured communication between physicians and families resulted in earlier consensus regarding goals of care (14). Other authors have suggested that DNR status of elderly trauma patients may skew trauma-center outcomes towards a higher observed to expected mortality rates (15, 16). This highlights the potential limitation of using mortality as a primary outcome measure. Aggressive pursuance of DNR status, combined with liberal use of hospice and palliative care, both recommended practices by the American College of Surgeons, may elevate the mortality rate but would not reflect the quality of care of the elder trauma patient. For this reason, mortality rate may not be the best outcome measure in this patient population. Other quality indicators such as failure to rescue, functional status, and disposition status may be better-suited outcome measures for future research.

Another important, geriatric-centered problem is that of anticoagulation. Anticoagulated elderly patient account for 25% of all trauma related deaths and have higher rates of traumatic brain injury (17). Systematic awareness and management of anticoagulation and resuscitation in geriatric patients improved outcomes after trauma (18, 19). The monitoring of PT and PTT was universally practiced across surveyed trauma centers. However, use of thromboelastography (TEG) was used in only 9/26 (35%), with similar frequency in level one and level two trauma centers. TEG has been associated with improved trauma outcomes, likely due to improved matching of blood product need to each individual's coagulopathy (20) but whether this association also exists in geriatric trauma care has yet to be determined. A 2005 study by Coimbra and colleagues reported wide variations in the anticoagulation-reversal protocols of various trauma centers (21). This finding was echoed in our 2014 survey data set. Although use of fresh frozen plasma and vitamin K for reversal of anticoagulation was nearly ubiquitous (96% and 81% of centers), only two-thirds of centers reported the use of prothrombin complex concentrate as a reversal agent, and 46% reported the use of recombinant factor VII. Platelet assays were administered in 35% of centers. Transfusion of platelets in patients taking antiplatelet agents, such as aspirin or clopidogrel, varied substantially between centers, with 54% of centers reporting that they always or almost always gave platelets and the remainder reporting a selective approach. To date, there

is no evidence to support a mortality benefit with platelet transfusion in patients taking antiplatelet drugs (22, 23).

In addition to ascertaining which centers employed TQIP guidelines, we inquired whether centers used non-TQIP practices that have been demonstrated to affect geriatric outcomes. Examples of such practices include management protocols for solid organ injuries (24) and rib fractures (25), fall protocols (26), and traumatic brain injury management strategies (27). The only significant relationship we found between care protocols and improved mortality was presence of geriatric-specific protocols for solid organ injury.

Centers that had better than expected mortality ratios were statistically more likely to have had a protocol in place for the management of geriatric solid organ injury (50% for low outliers vs. 5 % and 0% of average performing and poor performing centers respectively, p= 0.04). Although age-specific solid organ injury protocols are not part of the TQIP guidelines, use of these guidelines was associated with improved outcomes.

Ultimately, we were not able to demonstrate a relationship between utilization of TQIP guidelines or other geriatric-specific practices with outlier performance in geriatric mortality. This result was unexpected. Evidence-based guidelines from TQIP and our literature search have demonstrated improvement in outcomes in other series (8, 12, 13, 28, 29). However, the current study has certain limitations that must be discussed. Given the small sample size, for a statistically significant difference to be detected between high, average, and low outlier for mortality centers, a given process would have to have been used at all low outlying centers and extremely few of the other centers. Secondly, we used survey data to approximate the prevalence of processes of care in place, which creates the possibility of reporter bias. We attempted to minimize this bias by interviewing trauma center agents in positions of power, such as managers and directors, as they would best be able to identify and communicate their center's respective care protocols. If reporter bias were present, we would expect it skew the results away from the alternative hypothesis, since we hypothesize that centers with fewer geriatric-specific processes in place would tend to over-report their use. It is also possible that care-processes may vary not just between institutions but also within them, and we have no way to discern whether positive responses represent the practices of all providers at a center. Site visits to more objectively ascertain processes of care for older adults may have been of benefit. Lastly, the TQIP best practices for the older injured adult are published as a result of the efforts of the American College of Surgeons, which is the accrediting body for the vast majority of trauma centers in the United States. As Pennsylvania trauma centers are accredited by the PTSF and not by the ACS, there may be decreased impetus to adopt TQIP guidelines.

In conclusion, we did not see a link between adoption of best-practice geriatric trauma guidelines and reduced mortality at PA trauma centers. The increased susceptibility of elderly to adverse consequences of injury combined with the projected rapid growth rate of the elderly population emphasizes the importance of identifying interventions to improve care quality and distribution to this population.

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Lower the threshold trauma activation for elderly patients
Liberal use of computed tomography (CT) scanning for injured, elderly patients
Assess for the presence of anticoagulation and develop a rapid anticoagulation reversal protocol based on the availability of products, local costs, and preferences
Develop criteria for early geriatric consultation and geriatric expertise on the trauma care teams
Following geriatric medication recommendations: -Use Beers Criteria in decision making about pharmacotherapy in the elderly. -Discontinue nonessential medications. -Continue medications with withdrawal potential -Continue β-blocker or start if indicated -Continue statins when appropriate. -Adjust medication doses for renal function based on glomerular filtration rate.
Establish past medical history and medication history. -Attempt to communicate with the patient's immediate family and physician.
Discuss advanced directives and/or living wills
Make liberal use of palliative care options
Develop a plan for transition to post-hospital care or special unit care in the immediate post-injury period.

Figure 1.
SYNOPSIS OF INPATIENT TQIP GERIATRIC TRUMA GUIDELINES

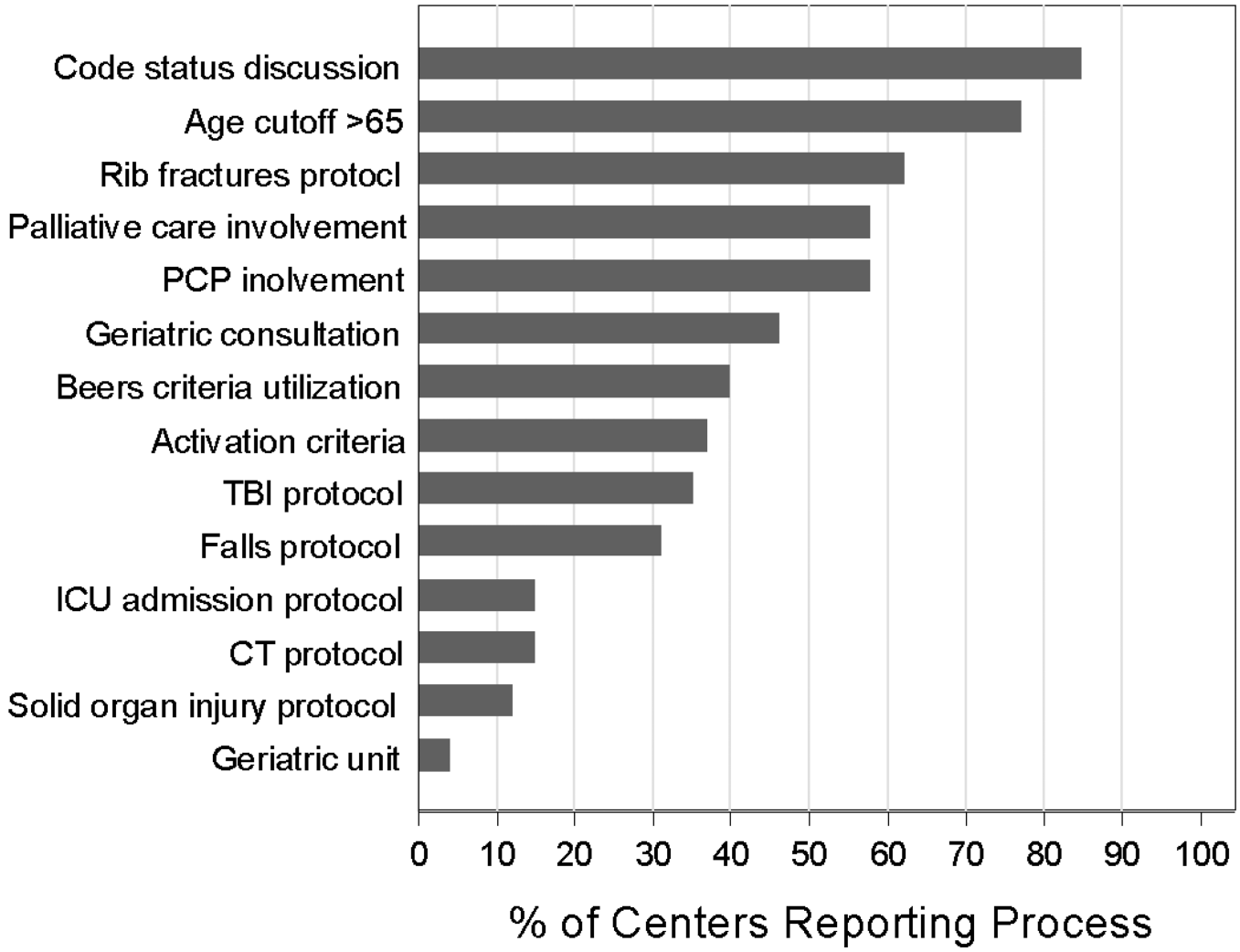

Figure 2.
Percentages of trauma centers in the state of Pennsylvania reporting use of geriatric best practice guidelines.

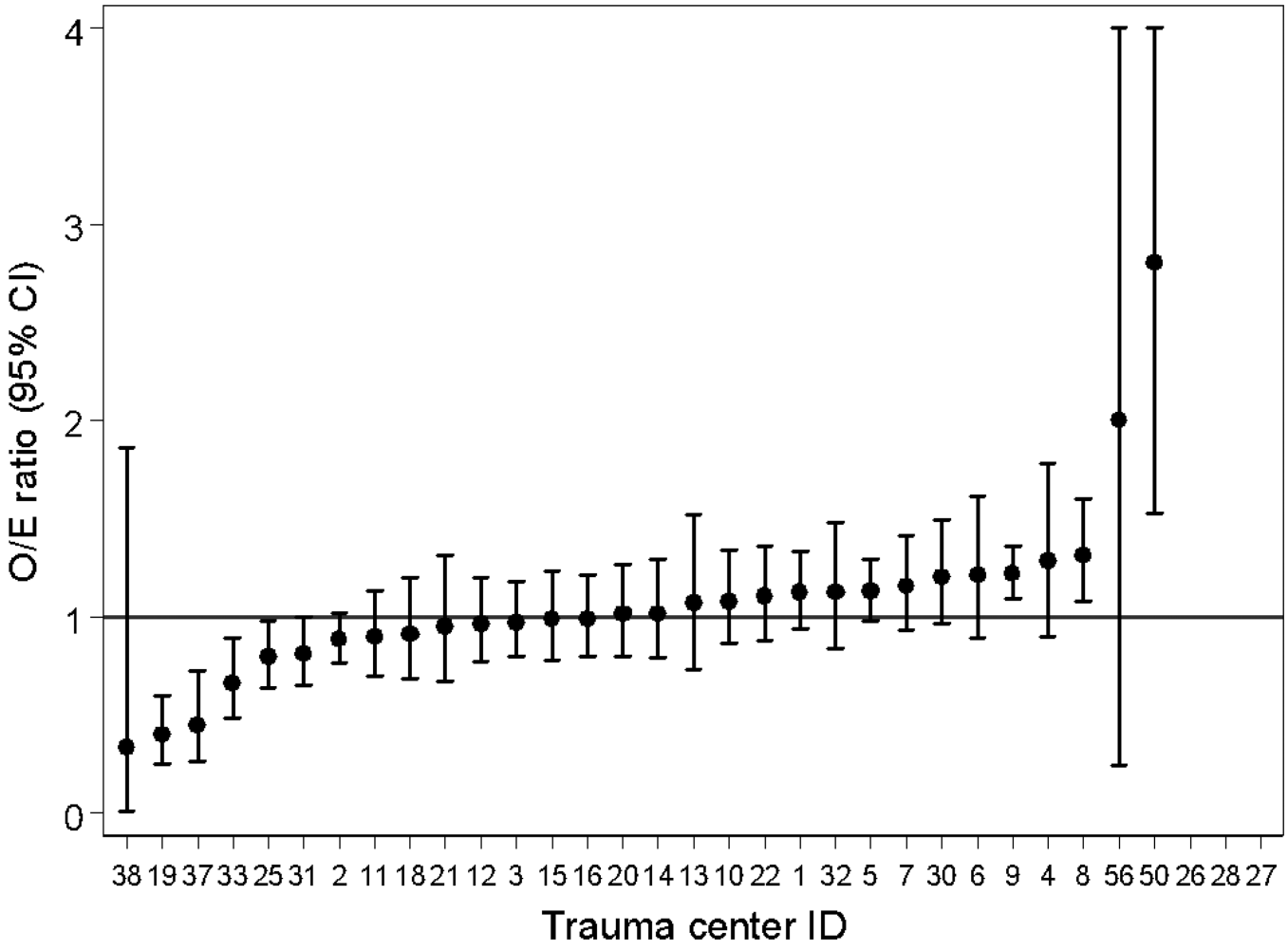

Figure 3.

Risk-adjusted observed to expected mortality ratios for older adult injury trauma patients across level I and level II trauma centers in Pennsylvania.

Figure 4: Funnel plot comparing observed

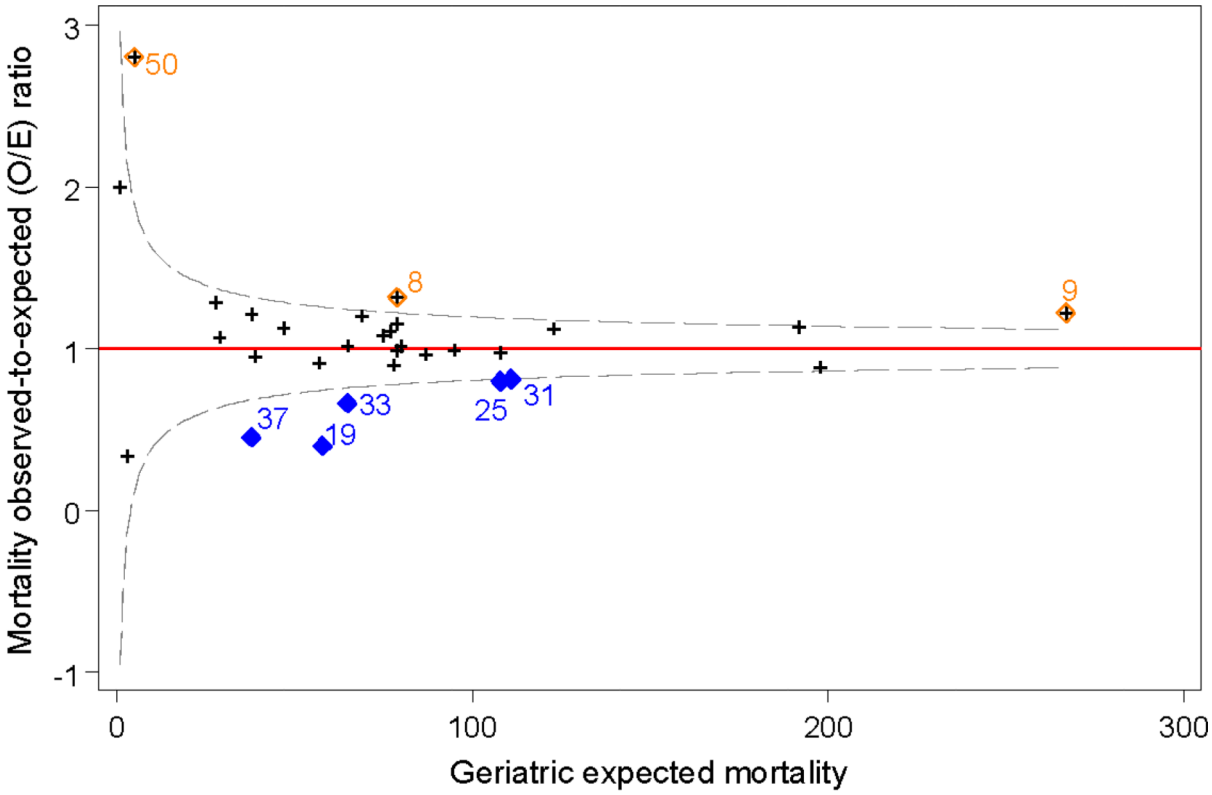

Figure 4.

Funnel plot comparing observed to expected mortality for injured older adults against expected mortality. Dashed lines indicate upper and lower 95% confidence intervals; outliers tagged by center number.

Table 1

Characteristics of surveyed centers in the state of Pennsylvania. Teaching hospital status a based on ACGME accreditation; region based on core-based statistical areas as defined by the US Office of Management and Budget.

Characteristic	n (%)
Level	
I	13 (50%)
II	13 (50%)
Region	
Metropolitan	15 (58%)
Divisional	9 (35%)
Micropolitan	2 (8%)
Bedsize	
1–299	4 (15%)
300–499	10 (38%)
>500	12 (46%)
Teaching hospital	24 (92%)

Table 2

Processes of care in place for injured older adults at the trauma center across the state of Pennsylvania and associations with low, average, and high O:E ratios.

	O:E mortality outlier status			
Process	**Low (n=4)**	**Average (n=19)**	**High (n=3)**	**p**
Age Cutoff ≥65	4 (100%%)	15 (79%%)	1 (33%%)	0.11
Older-adult specific protocols				
Activation Criteria	2 (50%)	3 (32%)	1 (33%)	0.87
CT scans	0 (0%)	3 (16%)	1 (33%)	0.48
Falls	2 (50%)	7 (37%)	1 (33%)	0.35
ICU admission	1 (25%)	3 (16%)	0 (0%)	0.66
TBI	1 (25%)	8 (42%)	0 (0%)	0.33
Rib Fractures	2 (50%)	11 (58%)	3 (100%)	0.33
Solid organ injury*	2 (50%)	1 (5%)	0 (0%)	0.04
Geriatric unit	0 (0%)	1 (5%)	0 (0%)	0.83
Geratric consultation	1 (25%)	10 (53%)	1 (33%)	0.54
Beers Criteria utilization	2 (50%)	7 (37%)	1 (33%)	0.96
PCP involvement	1 (25%)	2 (11%)	0 (0%)	0.57
Palliative care involvement	4 (100%)	10 (53%)	1 (33%)	0.15
Code status discussion on admission	4 (100%)	15 (79%)	3 (100%)	0.42
Summary score	8 (IQR 7–10.5)	7 (IQR 5–9)	8 (IQR 6–14)	0.50

TBI = Traumatic Brain injury; IQR = interquartile range.

Values expressed as n(%) for categorical variables, median(IQR) for continuous variables.

P values are for Fishers' exact test for categorical variables and Kruskal-Wallis test for continuous variables.

Table 3

Representative quotations from trauma team leaders on key ideas for improving geriatric trauma care and barriers to improvement

Ideas for improvement:
"Have an open mind to what they [geriatric patients] want and what their families want…as medical teams, we can get so used to…the kind of knee jerk response and forget to sit back or stand back and look at the broader picture."
"Dealing with complications. Looking at trends and physiology of older adults. Just taking everything into account and looking at patterns…and because of that, developing guidelines surrounding those issues."
"A real dedication to this patient population, from everybody on the team…geriatrics needs to be looked at as a special entity that has special requirements. A 45 year-old has totally different requirements than an 85 year-old. And I think we need to look at that."
Perceived barriers to care:
"Budgeting and adding personnel. And resources."
"Dedication…the younger population of healthcare workers and physicians, unless they've gone through it with a parent or a grandparent, don't understand…"
"Resources…getting geriatricians to see these patients especially is a barrier."