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COMPLICATIONS IN LOW-RISK OLDER ADULT TRAUMA PATIENTS: A CASE-CONTROL STUDY

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Abstract

Background: Although some geriatric trauma patients may be low-risk for complications, poor outcomes are pronounced if complications do occur. Prevention in this group decreases the risk of excess morbidity and mortality.

Methods: We performed a case-control study of trauma patients 65 years or older treated from January 2015 to August 2016 at a level I trauma center with a Trauma Quality Improvement Program (TQIP) predicted probability of complication < 20%. Cases had one of the following complications: unplanned admission to the intensive care unit (ICU), unplanned intubation, pneumonia, or unplanned return to the operating room. Two age-matched controls were randomly selected for each case. We collected information on comorbidities, home medications, and early medical care and calculated odds ratios using multivariable conditional logistic regression.

Results: Ninety-four patients experienced unplanned admission to ICU (N=51), unplanned intubation (N=14), pneumonia (N=21), and unplanned return to OR (N=8). The 188 controls were

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EB contributed to the study design and provided critical feedback on the manuscript
MSV contributed to the study design and provided critical feedback on the manuscript
SA conceptualized the study, contributed to the study design and provided critical feedback on the manuscript.

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more frequently intubated and had higher median ISS but were otherwise similar to cases. The adjusted odds of complication were higher for patients on a home beta blocker (aOR=2.2 [95%CI 1.2, 4.0]) and home anticoagulation aOR=2.2 [95%CI 1.2, 4.1]). Patients with diabetes (aOR 2.0 [95%CI 1.1, 3.7] and dementia (aOR=2.0 [95%CI 1.0, 4.3]) also had higher odds of complication. The adjusted odds of complication for patients receiving geriatrics consultation was 0.4 (95%CI 0.2, 1.0, p=0.05). Pain service consultation and indwelling pain catheter placement may be protective but confidence intervals included one. There was no association between opiates, benzodiazepines, fluid administration, or blood products in the first 24 hours and odds of complication.

Conclusions: Geriatrics consultation was associated with lower odds of unplanned admission to the ICU, unplanned intubation, pneumonia, and unplanned return to the operating room in low-risk older adult trauma patients. Pathways that support expanding co-management strategies with geriatricians are needed.

Keywords

Geriatric trauma; TQIP; Complications; Geriatric consultation

BACKGROUND

From 2001 to 2015, the annual rate of non-fatal injury for ages 65 years and older in the US increased from 7,558 per 100,000 population to 9,976 per 100,000 population, or by nearly 32%.[1] In this age group, there were 2.7 million non-fatal injuries in 2001 and 4.8 million in 2015 with blunt mechanisms such as unintentional fall and collisions (e.g. pedestrians with motor vehicles, etc.) leading the list of causes.[1] In 2015, the estimated costs for treating patients 65 years and older for falls alone was roughly $50 billion dollars.[2]

In addition to the greater risk of mortality, older adult trauma patients are uniquely susceptible to complications after trauma due to comorbid conditions, medications, and frailty.[3,4] The proportion of in-hospital complications may be nearly 30% for older adult trauma patients, and frailty, in particular, is known to correlate with higher risk.[5,6] Pneumonia and other infections are among the most common complications.[5] While frailty is clearly an important factor for risk-stratification, there is no single agreed-upon measure, and currently this information is not routinely documented in trauma registries or in patient records.[5,7,8]

Older adult trauma patients with lower severity of injury, no significant comorbidities, and good functional status are at low risk for complications. However, when complications occur, there are subsequent impacts on in-hospital outcomes, discharge disposition to skilled nursing facilities, and mortality.[9–11] The low-risk geriatric trauma patient cohort is, therefore, an excellent subgroup for performance improvement to reduce poor outcomes from in-hospital complications. Furthermore, this group of geriatric patients usually does not reach the threshold of concern that triggers added resources. For example, in one report, only 11% of geriatric trauma patient underwent evaluation by a geriatrician.[12]

While there is no universally agreed upon definition for low-risk geriatric trauma patients, data compiled through the American College of Surgeons and the Trauma Quality Improvement Program (TQIP) readily provide predictive risk percentages based on patient and injury characteristics.[13] These percentages can be used to define groups of risk for the purposes of study. The TQIP approach incorporates population-averaged hierarchical multivariable models. Using the TQIP complication risk model to select low-risk older adult patients only, our aim was to determine which patient characteristics and aspects of early medical care among this select group are associated with greater risk of, or protection from, complications in low-risk geriatric trauma patients.

METHODS

Setting, Study Design, and Data Source.

We performed a case-control study among trauma patients from Harborview Medical Center (HMC) in Seattle, Washington, the only regional level I trauma center among four northwestern states (Washington, Alaska, Montana, and Idaho). HMC participates in the American College of Surgeons Trauma Quality Improvement Program (TQIP).[14] TQIP collects data from over 700 participating trauma centers and provides biannual feedback on performance using multivariable risk adjusted benchmarking to estimate national comparisons.[13] TQIP provides patient-specific estimated probabilities for a variety of outcomes including individual complications (Supplementary Table 1), any complication, and death. This probability is based on population-averaged hierarchical multivariable modeling based on patient and injury characteristics (Supplementary Table 2).[13] We collected data on patients from January 2015 through August 2016 corresponding to the most recent available TQIP report at the time of project initiation. Data from the HMC Trauma Registry was merged with the TQIP generated patient-specific report to supplement a manual chart review.

Subjects.

The exact age at which the risk for poor outcomes increases likely varies by complication, and prior data suggest this may happen earlier than age 65.[15,16] Nonetheless, TQIP defines older adults at the age of 65 years. Few data exist on the specific pattern of complications in older adult trauma patients, however pulmonary complications are likely to be the most common.[15] Risk for unplanned return to the ICU also increases with age.[17] We identified cases as trauma patients 65 years or older with a TQIP predicted probability of any complication less than 20% who later developed any of the following non-fatal complications: unplanned admission to the intensive care unit (ICU), unplanned intubation, pneumonia, or unplanned return to the OR

To our knowledge, there are no data to guide a specific cutoff value for the TQIP complication probability that delineates low versus high risk. Overall, the probability of complication is left-skewed with most patients having a 10% or lower probability. Preliminary data exploration demonstrated that the median probability of complication for patients 65 years or older was roughly 14%. This was extended up to 20% in order to capture adequate number of patients and improve power with minimal change to the risk profile.

Two randomly selected age-matched controls were chosen for every case from among the remaining patients 65 years or older with a less than 20% TQIP complication probability who did not experience a complication.

Variables and Chart Review.

Two authors (MMR and MLR) reviewed all selected charts and one author (RT) performed unannounced intermittent audits. Material abstracted from the charts included detailed information on: home medications; specific comorbidities; admission and consulting services; crystalloid and blood product administration in the first 24 hours; opioid (morphine equivalents) and benzodiazepine administration (lorazepam equivalents) in the first 24 hours; all surgical procedures; and all complications. The HMC trauma registry includes variables for demographics, Injury Severity Score (ISS), traumatic brain injury, chest injury, intubation, and injury mechanism. Traumatic brain injury (TBI) and chest injury were coded as "Yes" when the Abbreviated Injury Scale was one or higher for the head or chest, respectively. Frailty assessment was not routinely collected in the chart, TQIP data, or trauma registry and was not included.

Quantities of opioids and benzodiazepines administered to the patient were collected from patient electronic Medication Administration Record (eMAR) and converted to IV morphine or lorazepam equivalents (rounded to the nearest hundredth milligram and summed) based on route of administration (oral, IV or transdermal). Data collection for first twenty-four hour variables (crystalloid, blood products, morphine equivalents, lorazepam equivalents) began with initial time in the emergency room.

The following conversion factors were used to convert to intravenous (IV) morphine equivalents in milligrams: 0.1 IV fentanyl (mcg), 2.39 transdermal fentanyl (mcg), 0.4 oral (PO) hydrocodone (mg), 4 IV hydromorphone (mg), 0.8 PO hydromorphone (mg), 0.4 PO morphine (mg), 0.4 PO oxycodone (mg), 0.04 PO tramadol (mg), 0.4 PO methadone (mg). The following conversion factors were used to convert benzodiazepines to lorazepam equivalents: 2 PO/IV clonazepam (mg), 2 PO/IV alprazolam (mg), 0.05 IV/PO chlordiazepoxide (mg), 0.25 IV/PO diazepam (mg), and 0.5 IV midazolam (mg) and 0.25 PO midazolam (mg). Conversion factors were obtained from two online opiate equivalence calculators.[18,19] Transdermal patches were treated as a full duration dose.

Fluid administration data were collected from patient electronic medical records including continuous infusions of medications, solutions (with and without dextrose) of Lactated Ringer's, normal saline, and Plasmalyte. Blood products included red blood cells, platelets, fresh frozen plasma, and prothrombin complex.

Exposures.

We evaluated a combination of non-modifiable patient factors and aspects of early medical care as potential exposures. Patient factors included prior beta blocker usage, prior anticoagulation/anti-platelet agents, history of type II diabetes mellitus, history of dementia, history of chronic obstructive pulmonary disease (COPD), history of atrial fibrillation, history of asthma, history of myocardial infarction, and history of cerebrovascular accident (CVA) or transient ischemic attack (TIA) as documented in the electronic medical record. We evaluated factors of early medical care including totals for the first 24 hours of IV fluids, blood products, morphine equivalents, and lorazepam equivalents. We used the first 24 hours, as opposed to total hospitalization, to avoid confounding by outcome where patients with a complication may have longer time in the hospital and therefore receive more medication. While dividing totals by hospital day may provide some protection against this bias, longer time in the hospital may also drive larger per-day opiate and sedation requirements.

We also considered admitting service (General/Trauma Surgery, Orthopedic Surgery, Neurosurgery or Medicine), presence of a geriatric consult prior to the complication (for cases; any consultation for controls), and time from admission to geriatrics consult (among those patients seen by the geriatrics team). We only considered geriatrics consultation occurring *prior* to the complication in order to ensure that we did not erroneously detect an association with consultation *following* complication which might occur as a result of an unforeseen negative outcome. With regards to pain management, we also evaluated consultation of the pain service before the complication (for cases; any consultation for controls) and placement of an indwelling catheter for pain control (for cases before complication; any placement for controls).

Statistical Analysis.

Standard descriptive statistics were performed for categorical and continuous variables where appropriate. We performed conditional logistic regression to estimate the odds of being a case given exposed status. We constructed crude models (among age-matched groups) and multivariable models adjusting for age (continuous), sex, intubation during hospitalization, surgery during hospitalization, presence of TBI, presence of a chest injury, and ISS for exposures related to prior medical history. We added the admitting service as a covariate to regression models considering aspects of medical care because certain patterns of care provided (pain medication, consults, etc.) and the risk profile of admitted patients may be associated with the admitting service. We also compared average day of complication across admitting services among the cases using linear regression (controls had no complication by definition). All analyses were performed in Stata/SE version 14.2 (StataCorp, LLC, College Station, Texas). Age-matched controls were generated in RStudio version 1.0136 (Affero General Public License). Statistical significance was set at $\alpha=0.05$.

The study was approved by the University of Washington Institutional Review Board (STUDY00003426) in November of 2017.

RESULTS

From January 2015 through August 2016, the TQIP database for our center included 1,211 patients 65 years or older. Of this group, 983 (81.2%) had a TQIP probability of any complication less than 20%. From the group of 112 patients coded as having any complication (Supplementary Table), 94 unique patients had either unplanned admission to

ICU (N=51), unplanned intubation (N=14), pneumonia (N=21), and/or unplanned return to OR (N=8). Of the remaining 889 low risk patients 65 years or older, 188 (2-to-1 controls-to-cases) age-matched controls were randomly selected.

Groups of cases and controls were comparable in terms of age, sex, TBI, chest injury, need for operation, and mechanism (Table 1). The case group was more frequently intubated (34.0% vs 22.3%, chi-squared $p<0.05$), had higher median ISS (17 IQR: 10–25 vs. 14 IQR: 10–19, Wilcoxon Rank-Sum, $p<0.05$), and a higher proportion died (16.0% vs 4.3%, chi-squared p-value <0.01). Over 70% of both groups were admitted after falls.

Cases were more frequently on a home beta blocker and anticoagulation than matched controls (39.4% vs. 24.5% and 68.1% vs. 54.8%, respectively) (Table 2). In adjusted models, the odds of complication were over two times higher for patients on a home beta blocker (aOR=2.2 [95%CI 1.2, 4.0]) and home anticoagulation aOR=2.2 [95%CI 1.2, 4.1]). Patients with a history of diabetes (aOR 2.0 [95%CI 1.1, 3.7], and history of dementia (aOR=2.0 [95%CI 1.0, 4.3]) also had higher odds of complication. Of the 81 patients on beta blockers at home 97.1% of cases and 84.8% of controls were restarted on their home beta blocker at or before the 2nd complete hospital day (Fisher's exact p=0.13). Although history of myocardial infarction and cerebrovascular disease were associated with complication in unadjusted models, the association did not persist in adjusted models (Table 2). There was no significant association between a history of asthma or COPD and complication in these data.

General Surgery/Trauma was the most common admitting service in both cases and controls (Table 3). In unadjusted models, admission to the orthopedics or medicine service were associated with lower odds of complication. However, in adjusted models, there was no association between admitting service and risk of complication (Table 3). Among 94 cases with at least 1 complication, the mean hospital day of complication was 6.1 (SD=7.6). This was similar across admitting services (general surgery/trauma = 6.5 (SD=9.5), orthopedics = 4.3 (SD=4.4), neurosurgery = 7.1 (SD=7.1), medicine = 3.9 (SD=3.3), p = 0.52). A smaller proportion of cases than controls received geriatrics consultation (26.6% vs. 37.8). For patients admitted to the orthopedics service, 87.1% received geriatrics consultation (total including both cases and controls) (Supplementary Table 3). The adjusted odds of complication for patients receiving geriatrics consultation was 0.4 (95%CI 0.2, 1.0, p=0.05). Similar proportions of cases and controls underwent pain consultation and a higher proportion of cases underwent placement of catheter (epidural and paravertebral) for pain control (Table 3). Point estimates for the adjusted odds of complication for pain consultation and pain catheter placement were both less than one however the confidence intervals were wide due to few observations. There was no association between morphine equivalents or lorazepam equivalents in the first 24 hours and odds of complication.

Median intravenous fluid administration in the first 24 hours was higher for cases than controls (1.1 L vs. 1.0 L, Table 3) and the point estimate for odds of complication for each additional liter of fluid in adjusted and unadjusted models was above one. The confidence interval in the unadjusted model included one. Few patients received blood in the first 24 hours and there was no association with blood product administration in the first 24 hours and risk of complication.

DISCUSSION

This is the first time, to our knowledge, that geriatrics consultation has been identified as protective against complications in low-risk older adult trauma patients. Using the TQIP-calculated probability of complication to identify low-risk older adult trauma patients, our findings suggest that geriatrics consultation is associated with a lower odds of unplanned return to ICU, unplanned intubation, pneumonia, and/or unplanned return to the OR by 60%. While these data do not specify the exact reason that geriatrics consultation was beneficial, we know the benefits are protective because we defined the exposure as consultations occurring before the complication. Although the unadjusted odds and proportions demonstrate that complications occurred more commonly on the general surgery/trauma service, after adjusting for patient and injury characteristics, these differences were no longer present. This is not surprising as general surgery/trauma routinely admits polytrauma patients where neurosurgery/orthopedics more commonly admit patients with a single injury (intracranial hemorrhage or fracture). Additionally, our analyses provide evidence that home anticoagulation or antiplatelet agents may be a risk factor for non-hemorrhagic complications in low-risk older adult trauma patients. While home beta blocker usage is associated with higher odds of complication, history of MI or CVA/TIA did not show an association. This combination of results may suggest that beta blockade in older adult trauma patients may confer some risk beyond surrogacy for cardiovascular disease.

The TQIP Geriatric Trauma Management Guidelines recommend "developing criteria for early geriatric consultation and geriatric expertise on the multidisciplinary trauma care team."[20] Currently, the Identification of Seniors at Risk (ISAR) screening tool is one such measure. Routine geriatrics consultation for older adult trauma patients is an area of active study to determine optimal utilization and timing. There are insufficient numbers of geriatricians to assist with the growing numbers of older hospitalized patients. Defining who will benefit most and effective implementation of the consultation recommendations remains to be determined.[21] Geriatric medicine involvement can range from one-time consultation to full co-management with the surgical team.[22] Admission to a geriatrics service with consultation by a trauma team may be another model to consider related to the evolving comfort of surgical residents caring for more medically complex patients. There is also an increasing focus on training surgeons and surgical subspecialties on the key geriatric principles needed to provide high quality care to older adults. [23]

In one prospective study, routine geriatrics consultation for all trauma patients over 65 years old was associated with improvements in geriatric quality of care markers such as mobility, function, dementia, delirium, and pressure ulcers.[12] The particular quality markers studied by Min et al may suggest some pathways for prevention of complications that occur via geriatrics consultation. For instance, our findings suggest that history of dementia was an independent risk factor for complication and Min et al reported higher quality marks for a variety of cognition-focused processes of care in patients with a geriatrics consultation than those who did not receive a consultation.[12] A different study suggested lower intensive care unit readmission rates after a policy of mandatory geriatrics consultation in patients over 70 years old was implemented; however, the study sample may have been underpowered. [24] Improved documentation of code status, medications, and pre-injury level of care was associated with implementation of a combined geriatrics/trauma collaborative team in another recent investigation.[25] Few evaluations of geriatrics consultation have investigated in-hospital morbidity specifically. In the older adult population where patients and families may focus on quality (as opposed to quantity) of life, measures that prevent in-hospital complications may be a more meaningful measure of success compared to in-hospital or 30-day survival.

Consideration of age-appropriate dosages, patient-controlled analgesia, non-opiate medications, and an avoidance of benzodiazepines are the current practice recommendations for pain management in older trauma patients.[20] These recommendations stem from data that may not be specific to trauma, older adults, or may only consider mortality as the outcome of interest.[26–28] Our point estimates for a pain service consultation, and pain catheter placement (epidural or paravertebral) suggest a protective effect to avoid complication. While the confidence intervals are wide and include one for both estimates, the total counts for these exposures were among the lowest observed and power to detect statistical significance may be an issue. The protective impact of appropriate pain management specifically may be difficult to detect because of overlapping services with interventions by other consulting services, in particular, the geriatrics service. Further, given the lack of empiric data on geriatric trauma patients, pain service consultation, and pain catheter placement, calculating the necessary sample size is challenging without anticipation of the effect size the analysis should be able to detect. Nonetheless, while these results are null, the suggestion that a multidisciplinary and multimodal approach to pain management in older adult trauma patients would be protective of complication resonates as warranting directed and further investigation. This sort of inquiry requires variables specific to older adults and may be best suited using panel (longitudinal) data structures; a departure from most trauma registries and the National Trauma Data Bank.[29]

Few data exist on fluid resuscitation in geriatric trauma patients. Factors related to the physiology of aging, medications, and comorbidities make certain endpoints of resuscitation (urine output, heart rate, lactate, blood pressure) in older adult trauma patients challenging to interpret.[3,30] In our analysis, on average case received roughly 100mL more than controls in the first 24 hours and the unadjusted odds of complication were 20% higher for every additional liter of IV fluid, although the estimate was attenuated in adjusted models and did not reach statistical significance. Further study on crystalloid resuscitation in older trauma patients is necessary to evaluate ideal strategies for fluid administration in this population. Few patients received blood products in either cases or controls leading to wide confidence intervals in adjusted and unadjusted models with limited interpretability.

This study has limitations. These data come from a single center and practice patterns among the different services at this center may impact the results. Many elements of trauma care in the geriatric population are understudied and calculating adequate sample sizes is challenging without an expectation of an anticipated effect size. To that end, our sample size is likely underpowered to detect some differences. We did not have data on frailty, a critical variable when studying older adults.[5,7,31] We focused our study population using a low TQIP probability of complication to identify patients where complications may be more likely to be unanticipated and potentially preventable. Data do not exist to support or refute this approach as a basis for identifying unanticipated complications in older trauma patients and deserves further study. Also, while our multivariate analyses controlled for injury severity score and intubation during hospitalization, unmeasured confounding is a possibility with more severe injuries. However, this potential bias should be minimized be restricting to a low-risk group of patients. Additional studies are necessary to unpack the critical elements of inpatient geriatrics consultation associated with improved outcomes in low-risk older trauma patients. Also, the multivariable model used by TQIP may stand to benefit from rigorous comparisons to other tools to predict complications in older adult trauma patients.

CONCLUSION

In older adult trauma patients who are predicted as low-risk for complications using TQIP modeling, geriatrics consultation is associated with lower odds of in-hospital complication including: an unplanned return to the ICU, pneumonia, unplanned intubation, or unplanned return to the OR. Pain management strategies and fluid resuscitation in the first 24 hours were not associated with complications but require further study and may require developing more robust institutional, interdisciplinary, and national data systems that include frailty measures and options for analysis in panel formats.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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REFERENCES

1. Nonfatal Injury Report, 2000–2015. WISQARS, Centers for Disease Control and Prevention 2018.
2. Florence CS, Bergen G, Atherly A, Burns E, Stevens J, Drake C. Medical Costs of Fatal and Nonfatal Falls in Older Adults: Medical Costs of Falls. J Am Geriatr Soc [Internet]. 2018 3 7 [cited 2018 Apr 11]
3. Reske-Nielsen C, Medzon R. Geriatric Trauma. Emerg Med Clin North Am. 2016 8;34(3):483–500. [PubMed: 27475011]
4. Hashmi A, Ibrahim-Zada I, Rhee P, Aziz H, Fain MJ, Friese RS, Joseph B. Predictors of mortality in geriatric trauma patients: A systematic review and meta-analysis. J Trauma Acute Care Surg. 2014 3;76(3):894–901. [PubMed: 24553567]
5. Joseph B, Pandit V, Zangbar B, Kulvatunyou N, Hashmi A, Green DJ, O'Keeffe T, Tang A, Vercruysse G, Fain MJ, et al. Superiority of frailty over age in predicting outcomes among geriatric trauma patients: a prospective analysis. JAMA Surg. 2014 8;149(8):766–72. [PubMed: 24920308]
6. Min L, Ubhayakar N, Saliba D, Kelley-Quon L, Morley E, Hiatt J, Cryer H, Tillou A. The vulnerable elders survey-13 predicts hospital complications and mortality in older adults with traumatic injury: a pilot study. J Am Geriatr Soc. 2011 8;59(8):1471–6. [PubMed: 21718276]
7. Maxwell CA, Mion LC, Mukherjee K, Dietrich MS, Minnick A, May A, Miller RS. Preinjury physical frailty and cognitive impairment among geriatric trauma patients determine postinjury

functional recovery and survival. J Trauma Acute Care Surg. 2016 2;80(2):195–203. [PubMed: 26595712]

8. Joseph B, Pandit V, Zangbar B, Kulvatunyou N, Tang A, O'Keeffe T, Green DJ, Vercruysse G, Fain MJ, Friese RS, et al. Validating trauma-specific frailty index for geriatric trauma patients: a prospective analysis. J Am Coll Surg. 2014 7;219(1):10–17.e1. [PubMed: 24952434]
9. Balentine CJ, Naik AD, Berger DH, Chen H, Anaya DA, Kennedy GD. Postacute Care After Major Abdominal Surgery in Elderly Patients: Intersection of Age, Functional Status, and Postoperative Complications. JAMA Surg. 2016 01;151(8):759–66. [PubMed: 27144881]
10. Davidson GH, Hamlat CA, Rivara FP, Koepsell TD, Jurkovich GJ, Arbabi S. Long-term survival of adult trauma patients. JAMA. 2011 3 9;305(10):1001–7. [PubMed: 21386078]
11. Ayoung-Chee P, McIntyre L, Ebel BE, Mack CD, McCormick W, Maier RV. Long-term outcomes of ground-level falls in the elderly. J Trauma Acute Care Surg. 2014 2;76(2):498–503; discussion 503. [PubMed: 24458057]
12. Min L, Cryer H, Chan C-L, Roth C, Tillou A. Quality of Care Delivered Before vs After a Quality-Improvement Intervention for Acute Geriatric Trauma. J Am Coll Surg. 2015 5;220(5):820–30. [PubMed: 25840534]
13. TQIP Benchmark Report Cycle References. American College of Surgeons; 2017 Fall p. 1–42.
14. American College of Surgeons, Trauma Quality Improvement Program [Internet]. [cited 2018 4 2]. Available from: https://www.facs.org/quality-programs/trauma/tqip
15. Adams SD, Cotton BA, McGuire MF, Dipasupil E, Podbielski JM, Zaharia A, Ware DN, Gill BS, Albarado R, Kozar RA, et al. Unique pattern of complications in elderly trauma patients at a Level I trauma center. J Trauma Acute Care Surg. 2012 1;72(1):112–8. [PubMed: 22310124]
16. MacKenzie EJ, Rivara FP, Jurkovich GJ, Nathens AB, Frey KP, Egleston BL, Salkever DS, Scharfstein DO. A national evaluation of the effect of trauma-center care on mortality. N Engl J Med. 2006 1 26;354(4):366–78. [PubMed: 16436768]
17. Fakhry SM, Leon S, Derderian C, Al-Harakeh H, Ferguson PL. Intensive care unit bounce back in trauma patients: an analysis of unplanned returns to the intensive care unit. J Trauma Acute Care Surg. 2013 6;74(6):1528–33. [PubMed: 23694883]
18. Equivalent Opioid Calculator [Internet]. ClinCalc. [cited 2018 4 10]. Available from: http://clincalc.com/Opioids/
19. Opioid Dose Calculator [Internet]. Agency Medical Directors' Group. [cited 2018 4 10]. Available from: http://www.agencymeddirectors.wa.gov/opioiddosing.asp
20. ACS TQIP Geriatric Trauma Mangement Guidelines [Internet]. American College of Surgeons, Trauma Quality Improvement Program; [cited 2018 4 24]. Available from: https://www.facs.org/~/media/files/quality%20programs/trauma/tqip/geriatric%20guide%20tqip.ashx
21. Warshaw GA, Bragg EJ, Fried LP, Hall WJ. Which patients benefit the most from a geriatrician's care? Consensus among directors of geriatrics academic programs. J Am Geriatr Soc. 2008 10;56(10):1796–801. [PubMed: 19054198]
22. Van Grootven B, Flamaing J, Dierckx de Casterlé B, Dubois C, Fagard K, Herregods M-C, Hornikx M, Laenen A, Meuris B, Rex S, Tournoy J, et al. Effectiveness of in-hospital geriatric co-management: a systematic review and meta-analysis. Age Ageing. 2017 11 1;46(6):903–10. [PubMed: 28444116]
23. Lee AG, Burton JA, Lundebjerg NE. Geriatrics-for-Specialists Initiative: An Eleven-Specialty Collaboration to Improve Care of Older Adults. J Am Geriatr Soc. 2017 10;65(10):2140–5. [PubMed: 28513887]
24. Olufajo OA, Tulebaev S, Javedan H, Gates J, Wang J, Duarte M, Kelly E, Lilley E, Salim A, Cooper Z. Integrating Geriatric Consults into Routine Care of Older Trauma Patients: One-Year Experience of a Level I Trauma Center. J Am Coll Surg. 2016 6;222(6):1029–35. [PubMed: 26968324]
25. Southerland LT, Gure TR, Ruter DI, Li MM, Evans DC. Early geriatric consultation increases adherence to TQIP Geriatric Trauma Management Guidelines. J Surg Res. 2017 8;216:56–64. [PubMed: 28807214]
26. Mohta M, Verma P, Saxena AK, Sethi AK, Tyagi A, Girotra G. Prospective, randomized comparison of continuous thoracic epidural and thoracic paravertebral infusion in patients with

unilateral multiple fractured ribs--a pilot study. J Trauma. 2009 4;66(4):1096–101. [PubMed: 19359920]

27. Harrington DT, Phillips B, Machan J, Zacharias N, Velmahos GC, Rosenblatt MS, Winston E, Patterson L, Desjardins S, Winchell R, et al. Factors associated with survival following blunt chest trauma in older patients: results from a large regional trauma cooperative. Arch Surg Chic Ill 1960. 2010 5;145(5):432–7.
28. Demeure MJ, Fain MJ. The elderly surgical patient and postoperative delirium. J Am Coll Surg. 2006 11;203(5):752–7. [PubMed: 17084339]
29. National Trauma Data Bank [Internet]. American College of Surgeons [cited 2018 4 24]. Available from: https://www.facs.org/quality-programs/trauma/ntdb
30. Scher CS. Trauma and transfusion in the geriatric patient. Curr Opin Anaesthesiol. 2018 4;31(2): 238–42. [PubMed: 29389749]
31. Chen X, Mao G, Leng SX Frailty syndrome: an overview. Clin Interv Aging. 2014;9:433–41. [PubMed: 24672230]

Table 1.

Patient Charateristics

Variable	Cases (N=94) N (%)	Controls (N=188) N (%)
Age, median (Interquartile Range)	78 (71, 85)	78 (70, 84)
Sex		
Female	40 (42.6%)	83 (44.1%)
Male	54 (57.4%)	105 (55.9%)
Mechanism		
Cut/pierce	0 (0.0%)	4 (2.1%)
Fall	74 (78.7%)	136 (72.3%)
Firearm	1 (1.1%)	1 (0.5%)
Motorcycle crash	1 (1.1%)	5 (2.7%)
Motor Vehicle Crash (Occupant/Others)	4 (4.3%)	20 (10.6%)
Other	3 (3.2%)	5 (2.7%)
Overexertion	1 (1.1%)	0 (0.0%)
Pedestrian Pedal	4 (4.3%)	9 (4.8%)
Struck by, against	6 (6.4%)	8 (4.3%)
Intubated *	32 (34.0%)	42 (22.3%)
Surgery Done	64 (68.1%)	120 (63.8%)
Traumatic Brain Injury (Yes)	47 (50.0%)	94 (50.0%)
Chest Injury (Yes)	30 (31.9%)	59 (31.4%)
ISS, median (Interquartile Range) **	17 (10, 25)	14 (10, 19)
Died ***	15 (16.0%)	4 (4.3%)

* chi-squared p = 0.04

** Wilcoxon-Rank Sum p = 0.02

*** chi-squared p<0.01

ISS = Injury Severity Score

Table 2.

Non-Modifiable Patients Factors

Variable	Cases (N=94) N (%)	Controls (N=188) N (%)	Unadjusted OR (95% CI)	Adjusted** OR (95% CI)
Home Beta Blocker	35 (37.2%)	46 (24.5%)	1.8 (1.1, 3.2)	2.2 (1.2, 4.0)
Home Anticoagulation*	64 (68.1%)	103 (54.8%)	1.9 (1.1, 3.3)	2.2 (1.2, 4.1)
History of diabetes	29 (30.9%)	40 (21.3%)	1.7 (0.9, 2.9)	2.0 (1.1, 3.7)
History of COPD	14 (14.9%)	21 (11.2%)	1.4 (0.7, 2.9)	1.5 (0.7, 3.4)
History of dementia	20 (21.3%)	25 (13.3%)	1.8 (0.9, 3.5)	2.0 (1.0, 4.3)
History of Atrial Fibrillation	25 (26.6%)	37 (19.7%)	1.5 (0.8, 2.7)	1.5 (0.8, 2.9)
History of Asthma	6 (6.4%)	10 (5.3%)	1.2 (0.4, 3.3)	1.4 (0.4, 4.1)
History of myocardial infarction	13 (13.8%)	12 (6.4%)	2.6 (1.1, 6.5)	1.5 (0.5, 4.6)
History of CVA/TIA	18 (19.1%)	20 (10.6%)	2.1 (1.0, 4.4)	1.9 (0.8, 4.2)

* Anticoagulants include aspirin, plavix, coumadin, direct thrombin, and Xa inhibitors

** Covariates include sex, age, presence of any intubation, presence of any surgical procedure, presence of TBI, presence of a chest injury, and ISS

COPD = Chronic obstructive pulmonary disease, CVA = Cerebrovascular accident, TIA = Transient ischemic attack, OR = Odds ratio

Table 3.

Medical Care Prior to Complication

Variable	Cases (N=94)	Controls (N=188)	Unadjusted OR (95% CI)	Adjusted* OR (95% CI)
Admitting Service, N (%)				
General Surgery/Trauma	40 (42.6%)	62 (33.2%)	Ref	Ref
Orthopedics	17 (18.1%)	45 (24.1%)	0.4 (0.1, 0.9) ‡	0.7 (0.2, 1.8)
Neuorsurgery	29 (30.9%)	52 (27.8%)	0.8 (0.4, 1.7)	0.8 (0.3, 2.0)
Medicine	8 (8.5%)	29 (15.0%)	0.3 (0.1, 0.9) ‡	0.5 (0.2, 1.5)
Geriatrics Consult ** (Yes), N (%)	25 (26.6%)	71 (37.8%)	0.5 (0.3, 0.9) ‡	0.4 (0.2, 1.0)‡
Days to Geriatrics Consult, median (IQR)	1 (1, 3)	1 (1, 2)	1.1 (0.8, 1.4)	0.5 (0.2, 1.4)
Pain Consult *** (Yes), N (%)	11 (11.7%)	19 (10.1%)	1.2 (0.5, 2.8)	0.7 (0.2, 2.1)
Pain Catheter Placed ***, N (%)	7 (7.5%)	12 (6.4%)	1.2 (0.4, 3.5)	0.5 (0.1, 2.4)
IV Fluid in the first 24 hours **** (L), median (IQR)	1.1 (0.5, 2.2)	1.0 (0.2, 1.7)	1.2 (1.0, 1.5) ‡	1.1 (0.9, 1.4)
Blood products in the first 24 hours (L), median (IQR)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.8 (0.3, 2.2)	0.5 (0.1, 1.8)
Morphine equivalents in first 24 hours, median (IQR)	11.4 (3.9, 26.2)	12 (3.6, 24.35)	1.0 (1.0, 1.0)	1.0 (1.0, 1.0)
Lorazepam equivalents in the first 24 hours, median (IQR)	0 (0, .25)	0 (0, 0)	1.0 (0.9, 1.2)	0.9 (0.7, 1.1)

* Covariates include sex, age, presence of any intubation, presence of any surgical procedure, presence of TBI, presence of a chest injury, primary service, and ISS

For medications, OR reflects the odds of complication for every additional L of fluid, single Morphine equivalent (mg), and single lorazepam eq (mg)

** Only Geriatrics Consults for cases occurring prior to complication

*** Only Pain Consults/Catheter placement for cases occurring prior to complication

**** Includes infusions of medications

‡ p=0.05

IQR = interquartile range, L= liters, OR = Odds ratio