Risk factors for delirium in older trauma patients admitted to the surgical intensive care unit

Sarah B. Bryczkowski, MD, Maeve C. Lopreiato, RN, MPH, Peter P. Yonclas, MD, James J. Sacca, *and* **Anne C. Mosenthal, MD,** *Newark, New Jersey*

AAST Continuing Medical Education Article

Accreditation Statement

This activity has been planned and implemented in accordance with the Essential Areas and Policies of the Accreditation Council for Continuing Medical Education through the joint sponsorship of the American College of Surgeons and the American Association for the Surgery of Trauma. The American College Surgeons is accredited by the ACCME to provide continuing medical education for physicians.

AMA PRA Category 1 Credits™

The American College of Surgeons designates this journal-based CME activity for a maximum of 1 *AMA PRA Category 1 Credit*™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

Of the *AMA PRA Category 1 Credit*™ listed above, a maximum of 1 credit meets the requirements for self-assessment.

Credits can only be claimed online at this point.

American College of Surgeons
Inspiring Quality:
Highest Standards, Better Outcomes

Objectives

After reading the featured articles published in the *Journal of Trauma and Acute Care Surgery*, participants should be able to demonstrate increased understanding of the material specific to the article. Objectives for each article are featured at the beginning of each article and online. Test questions are at the end of the article, with a critique and specific location in the article referencing the question topic.

Claiming Credit

To claim credit, please visit the AAST website at http://www.aast.org/ and click on the "e-Learning/MOC" tab. You must read the article, successfully complete the post-test and evaluation. Your CME certificate will be available immediately upon receiving a passing score of 75% or higher on the post-test. Post-tests receiving a score of below 75% will require a retake of the test to receive credit.

Disclosure Information

In accordance with the ACCME Accreditation Criteria, the American College of Surgeons, as the accredited provider of this journal activity, must ensure that anyone in a position to control the content of *J Trauma Acute Care Surg* articles selected for CME credit has disclosed all relevant financial relationships with any commercial interest. Disclosure forms are completed by the editorial staff, associate editors, reviewers, and all authors. The ACCME defines a 'commercial interest' as "any entity producing, marketing, re-selling, or distributing health care goods or services consumed by, or used on, patients." "Relevant" financial relationships are those (in any amount) that may create a conflict of interest and occur within the 12 months preceding and during the time that the individual is engaged in writing the article. All reported conflicts are thoroughly managed in order to ensure any potential bias within the content is eliminated. However, if you perceive a bias within the article, please report the circumstances on the evaluation form.

Please note we have advised the authors that it is their responsibility to disclose within the article if they are describing the use of a device, product, or drug that is not FDA approved or the off-label use of an approved device, product, or drug or unapproved usage.

Disclosures of Significant Relationships with Relevant Commercial Companies/Organizations by the Editorial Staff:

Ernest E. Moore, Editor: PI, research support, Haemonetics; PI, research support, TEM Systems, Inc. Ronald V. Maier, Associate editor: consultant, consulting fee, LFB Biotechnologies. Associate editors: David Hoyt and Steven Shackford have nothing to disclose. Editorial staff: Jennifer Crebs, Jo Fields, and Angela Sauaia have nothing to disclose.

Author Disclosures:

Sarah B. Bryczkowski: grants (Graduate Medical Education Challenge; Healthcare Foundation of New Jersey). Anne C. Mosenthal: grants (Graduate Medical Education Challenge; Healthcare Foundation of New Jersey). The remaining authors have nothing to disclose.

Reviewer Disclosures:

The reviewers have nothing to disclose.

Cost

For AAST members and *Journal of Trauma and Acute Care Surgery* subscribers there is no charge to participate in this activity. For those who are not a member or subscriber, the cost for each credit is $25.

System Requirements

The system requirements are as follows: Adobe® Reader 7.0 or above installed; Internet Explorer® 7 and above; Firefox® 3.0 and above, Chrome® 8.0 and above, or Safari™ 4.0 and above.

Questions

If you have any questions, please contact AAST at 800-789-4006. Paper test and evaluations will not be accepted.

Submitted: January 15, 2014, Revised: May 31, 2014, Accepted: June 17, 2014, Published online: Sepetember 22, 2014.
From the Department of Surgery, Rutgers New Jersey Medical School, Newark, New Jersey.
This study was presented at the 44th Annual Meeting of the Western Trauma Association, March 2–7, 2014, in Steamboat Springs, Colorado.
Supplemental digital content is available for this article. Direct URL citations appear in the printed text, and links to the digital files are provided in the HTML text of this article on the journal's Web site (www.jtrauma.com).
Address for reprints: Sarah B Bryczkowski, MD, Department of Surgery, Rutgers New Jersey Medical School, Newark, New Jersey; email: Sarahb459@gmail.com; Sarah.Bryczkowski@rutgers.edu.

DOI: 10.1097/TA.0000000000000427

BACKGROUND: Adults (age > 50 years) admitted to the surgical intensive care unit (SICU) are at high risk for delirium. Little is known about the role traumatic injury plays in the development of delirium because these patients have often been excluded from studies. Identification of specific risk factors for delirium among older adults following injury would be useful to guide prevention strategies. We attempted to identify modifiable factors that would predict delirium in an older trauma population admitted to the SICU.

METHODS: Data were collected prospectively from July 2012 to August 2013 at a Level I trauma center on consecutive trauma patients, older than 50 years, admitted to the SICU. Patients who died in the SICU were excluded. Delirium was assessed every 12 hours using the Confusion Assessment Method for the ICU scale. Demographic, injury, social, and clinical variables were reviewed. Bivariate analysis determined significant factors associated with delirium. A multivariate logistic regression model was used to predict delirium risk. After preliminary results, additional analysis compared patients with chest injury (defined as chest Abbreviated Injury Scale [AIS] score ≥ 3) with those without.

RESULTS: A total of 115 patients met criteria, with a mean age of 67 years, Injury Severity Score (ISS) of 19, and Glasgow Coma Scale (GCS) score of 14. The incidence of delirium was 61%. Variables present on admission, which were positive predictors of delirium, were as follows: age, ISS greater than 17, GCS score less than 15, substance abuse, and traumatic brain injury (defined as head AIS score ≥ 3). Chest injury (defined as chest AIS score ≥ 3) was a negative predictor of delirium. Significant risk factors influenced by clinical treatment included doses of opioids and propofol, restraint use, and hours deeply sedated (Richmond Agitation Sedation Scale [RASS] score ≤ −3). Clinical treatments with negative predictability were ventilator-free days/30 (vent-free), benzodiazepine-free days/30 (benzo-free), and restraint-free days/30. In a regression model considering age, vent-free days, chest injury, traumatic brain injury, GCS score, benzo-free days, and hours sedated, only age (odds ratio [OR], 1.1; 95% confidence interval [CI], 1.01–1.1; $p = 0.03$) was a predictor of delirium, while vent-free days (OR, 0.79; 95% CI, 0.65–0.96; $p = 0.02$) and chest injury (OR, 0.3; 95% CI, 0.09–0.83; $p = 0.02$) were significant negative predictors of delirium. Patients with chest injury had lower delirium incidence (44%) versus those without (75%) ($p = 0.002$) despite similar GCS score, ISS, and clinical variables.

CONCLUSION: Delirium is common in older trauma patients admitted to the SICU, and for every year for those older than 50 years, the chance of delirium increases by 10%. While higher ISS increases delirium risk, we identified several modifiable treatment variables including days patients were deeply sedated, mechanically ventilated, and physically restrained. Interestingly, patients with chest injury experienced less delirium, despite similar injury severity and clinical variables, perhaps owing to frequent health care provider interactions. (*J Trauma Acute Care Surg*. 2014;77: 944–951. Copyright © 2014 by Lippincott Williams & Wilkins)

LEVEL OF EVIDENCE: Prognostic/epidemiologic study, level III.

KEY WORDS: Delirium; trauma; SICU; benzodiazepines; mechanical ventilation.

Hospital-acquired delirium is a serious health care issue, especially in older adults (age > 50 years) admitted to the surgical intensive care unit (SICU). The incidence of delirium has been quoted as high as 84% in all patients requiring mechanical ventilation and 92% in mechanically ventilated trauma patients.[1,2] Developing delirium is independently linked with poor outcomes including increased intensive care unit (ICU) and hospital lengths of stay (LOS), fewer ventilator-free days, worse long-term disability and cognitive impairment, as well as increased mortality.[1,3–5] Delirium prevention strategies that target at-risk groups are likely to be the most successful at lowering the incidence of delirium.

Risk factors for delirium in the general medical population have been identified and include the use of physical restraints, malnutrition, prescription of more than three new medications in a day, indwelling bladder catheterization, and any iatrogenic event such as hospital-acquired infection, transfusion reaction, or other complication.[6] In the medical ICU, additional risk factors for delirium have been shown to include intensive smoking, daily alcohol consumption, living alone, preexisting cognitive impairment, use of drains and tubes, absence of visible daylight, need for mechanical ventilation, use of psychoactive medications, use of benzodiazepines, use of opioids, lack of visitors, fever, and sedation/coma.[7,8] When specifically examining postoperative delirium following elective spine and other major noncardiac surgeries, benzodiazepine use, meperidine use, need for blood transfusion, being older than 65 years, alcohol/drug abuse, depression, psychiatric disorder, neurologic disorder, fluid/electrolyte disorder, and weight loss were all predictors.[9–11]

While there is much evidence to determine risk factors for delirium for medical and surgical patients, little is known about the role that injury plays on hospital-acquired delirium. Trauma patients and those with traumatic brain injury (TBI) are frequently excluded from delirium studies because of presumptive complexity of their data collection and interpretation. However, studying this patient population is important because hospitalization following traumatic injury is a frequent event for all ages. According to the National Center for Injury Prevention and Control, unintentional injury is the eighth leading cause of death in adults older than 50 years, and trauma centers are seeing an exponential growth in older trauma patients.[12] Studies evaluating delirium in the trauma ICU found that benzodiazepines (e.g., lorazepam and midazolam) and opioid analgesics (e.g., fentanyl) were associated with delirium.[3,13] In contrast, Pandharipande et al.[14] found that lorazepam, increasing age, and Acute Physiology and Chronic Health Evaluation scores were associated with delirium, but neither opioids (e.g., morphine and fentanyl) nor propofol were. In 2008, Angles et al.[2] prospectively evaluated trauma admissions and found that low Glasgow Coma Scale (GCS) score, blood transfusions, and multiple-organ failure scores were strongest predictors of delirium.

Because age is a known risk factor for delirium and differences in health outcomes between the elderly and the general adult populations exist, identification of specific risk factors for delirium among older adults following injury would be useful to guide prevention strategies. Older adults who experience a fall or other traumatic events are at a greater risk of decreased activities of daily living and return to previous health

state following a traumatic incident compared with younger patients. Therefore, the purpose of this study was to identify both modifiable and nonmodifiable risk factors that predict delirium in an older trauma population admitted to the SICU.

PATIENTS AND METHODS

Study Design and Setting

A prospective observational study at a single academic urban Level I trauma center in Newark, New Jersey, was conducted. Rutgers University–New Jersey Medical School's Institutional Review Board approved the study. No consent was necessary given the observational design.

Selection and Description of Participants

Consecutive trauma patients (age > 50 years) who were admitted to the SICU for 24 hours or longer from July 2012 to August 2013 were included in the study. Patients were excluded if they (1) were 50 years or younger at the time of SICU admission, (2) died in the SICU, (3) had a history of dementia, or (4) were transferred from jail or were in active police custody. The age cutoff of 50 years was selected to define the risk factors for delirium in elderly trauma patients instead of the older cutoff of 65 years based on previous work in the trauma literature. It is known that degenerative changes to all systems occur with age. Previous work by Adams et al.[15] evaluated unique patterns of complications in elderly trauma patients and found that complications such as mortality, decubitus ulcers, and renal failure peaked at the age of 45 years, while infectious complications continued to peak from age 45 years to 65 years. Patients who died were excluded to avoid confounding factors associated with medications. Terminally injured patients often receive very high doses of medications for pain and sedation. In addition, patients whose delirium status were unable to be assessed (UTA) or were undocumented for the entire duration of their SICU stay were excluded from the analysis. The most common reasons for being unable to assess delirium status were prolonged deep sedation or chemically induced paralysis.

Data Collection

All admissions to the SICU were screened daily by research staff to identify older adults eligible for enrollment in the study. Electronic medical records were accessed daily to record data for selected patients. Data obtained included demographics (age and sex) and baseline characteristics (weight [kg], medical history of cardiac disease, pulmonary disease, use of hearing or visual aids, and depression). Specific injury information included GCS score, Injury Severity Score (ISS), presence of orthopedic fracture (yes or no), acute pain on admission assessment (pain ≥ 6 of 10 using the Wong-Baker FACES scale), TBI (defined as intracranial hemorrhage and head Abbreviated Injury Scale [AIS] score ≥ 3, yes or no), and chest injury (defined as rib fracture, pneumothorax, hemothorax, or pulmonary contusion and chest AIS score ≥ 3, yes or no). While the presence of TBI and chest injury were identified prospectively, the AIS score and ISS were collected from the trauma registrar and assigned to patients after discharge. Social variables included active or past substance abuse, history of smoking, living alone, and history of psychotropic drug use. Clinical variables that were collected included daily doses of benzodiazepines (converted to milligram lorazepam equivalents), opioids (converted to milligram morphine) and propofol (recorded in milligram, converted to milligram per kilogram), as well as atypical antipsychotics (in milligram). All routes of administration of opioid analgesics were included in the data collection. The Eastern Metropolitan Region Palliative Care Consortium Opioid Conversion Ratios were used to convert all opioid analgesics to milligram oral morphine.[16] Additional clinical documentations included hours spent in severe pain (≥ 6 of 10 using the Wong-Baker FACES scale, recorded hourly by nursing staff), hours spent deeply sedated (Richmond Agitation Sedation Scale [RASS] score ≤ -3), days mechanically ventilated, and physical restraint use. Delirium risk assessment forms were completed on admission to the SICU (Fig. 1). To evaluate the associations among the onset of delirium and clinical variables, complete daily records were kept. Variables such as mechanical ventilation, restraint use, and atypical antipsychotic use were referenced to first and subsequent episodes of delirium. Variable were then labeled as occurring before, simultaneous to, or after delirium.

Outcome Measures

The primary outcome of the study was delirium. Trained nurses in the SICU used the Confusion Assessment Method for the ICU (CAM-ICU), a validated tool used to document delirium every 12 hours (positive, negative, or UTA).[17,18] When patients were documented delirium positive, the frequency of documentation increased to every 4 hours to help physicians assess the response to treatment. Patients were considered delirium positive for the day if any CAM-ICU record was documented positive at any time. Secondary outcomes collected for this study included ventilator-free days/30 (vent-free days [calculated by subtracting total days ventilated from 30]); SICU LOS; daily doses of medications for pain (opioids), sedation (benzodiazepines and propofol), and agitation (atypical antipsychotics); and time spent in severe pain.

Data Management and Statistical Analysis

Data were manually entered into an electronic database (Microsoft Access, Microsoft Corporation) then analyzed using SAS version 9.2 statistical analysis software (SAS Institute, Inc., Cary, NC). Bivariate analysis determined significant factors present at admission and clinical risk factors associated with delirium using χ^2 analysis or Wilcoxon rank-sum test where appropriate. Data are presented as mean, 95% confidence interval (CI), or number and percentages, unless otherwise noted. A multivariate logistic regression model was used to identify associations between delirium and variables to predict delirium risk. The model included age, ventilator-free days, chest injury, TBI, GCS score, benzodiazepine-free days, and hours sedated. Only records with no missing data were included in the analysis. Odds ratios (ORs) with 95% CI were reported. Since hours sedated was highly collinear with the mean daily doses of propofol and benzodiazepines, it would not be appropriate to combine and include all three variables in a multivariable model. As level of sedation is most amenable to SICU intervention by physicians, it was selected for inclusion in the

model. After preliminary results, additional χ^2 analysis compared patients with chest injury with those without. Data were considered statistically significant when $p < 0.05$.

Sample Size Estimation

The sample size for the study was estimated based on the incidence of delirium in older adults admitted to the SICU from

RUTGERS
New Jersey Medical School

DELIRIUM RISK ASSESSMENT

Pre-Existing Factors:	Yes	No
Use of Visual Aids	☐	☐
Use of Hearing Aids	☐	☐
Age >50	☐	☐
Substance Abuse	☐	☐
Living Single at Home/No Visitors	☐	☐
Smoking	☐	☐
Depression	☐	☐
Psychotropic Drug Use	☐	☐
Medical Factors:	Yes	No
Cardiac Disease	☐	☐
Pulmonary Disease	☐	☐
Orthopedic Fracture	☐	☐
Chest Injury (Chest AIS ≥3)	☐	☐
Traumatic Brain Injury (Head AIS ≥3)	☐	☐
Acute Pain (Pain ≥6 out of 10)	☐	☐

Figure 1. Delirium risk assessment form. It was designed to identify risk factors for delirium, which were present on admission to the hospital after traumatic injury. All patients admitted to the SICU, older than 50 years, had this form filled out by a study team member. Substance abuse referred to alcohol and/or any illicit drugs. Smoking referred to active or history of excessive smoking (e.g., >1 pack per day). Cardiac disease referred to any cardiac diagnosis, from hypertension to myocardial infarction. Pulmonary disease referred to any pulmonary diagnosis from asthma to chronic obstructive pulmonary disease on home oxygen.

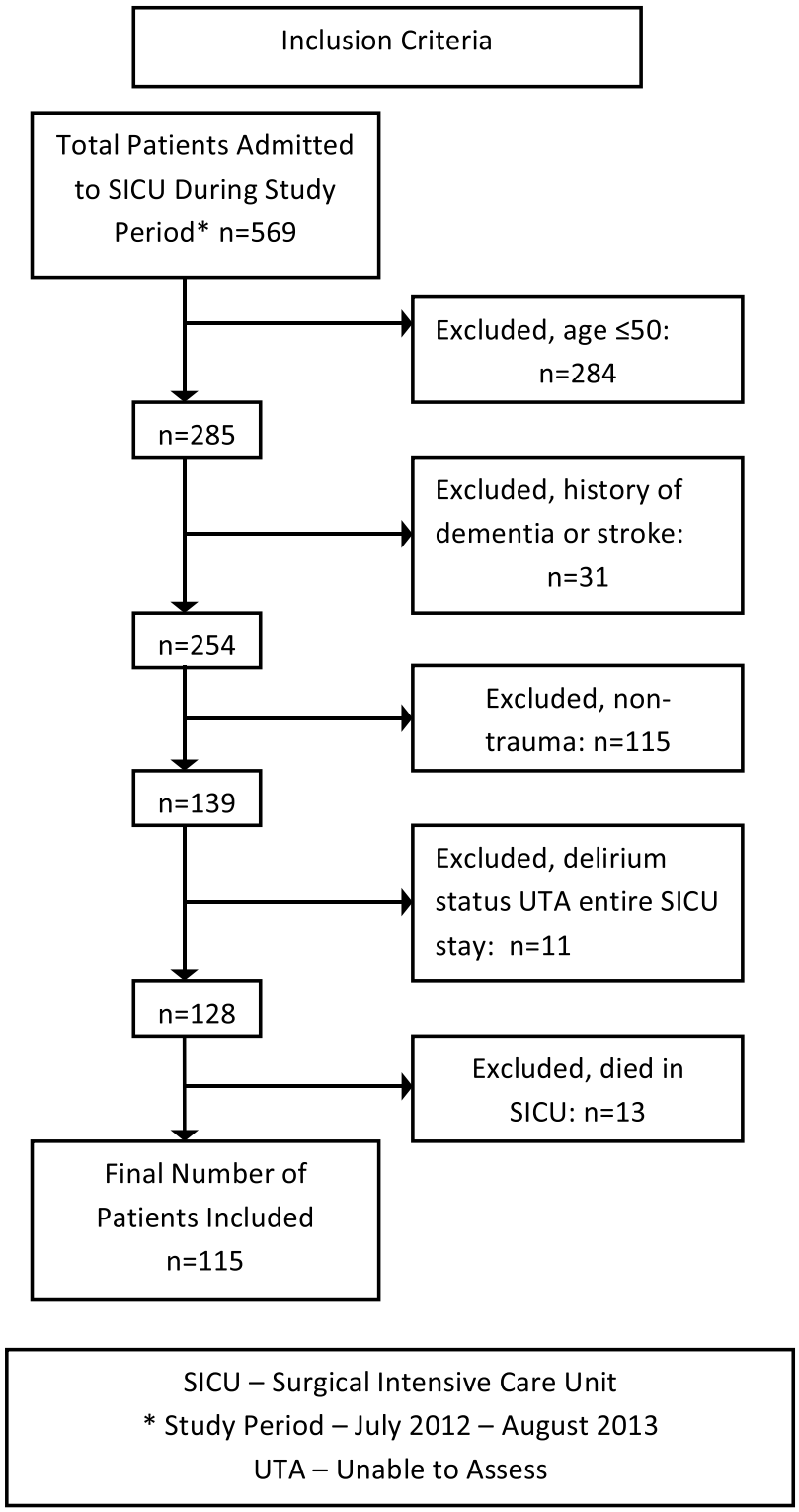

Figure 2. Inclusion criteria. A flow diagram of the process for inclusion in the final analysis of the study. The study period started in July 2012 and ended August 2013. Of 569 patients admitted to the SICU during the period, 115 adults (age > 50 years) were included in the final analysis.

a previous retrospective chart review that showed historical delirium incidence was between 30% and 50% in 2011 to 2012. The number of variables included in the multivariate logistic regression model was limited because of the sample size, following the generally accepted rule of one variable per 10 patients included.[19] We estimated that the final model would include a maximum of 10 variables and therefore estimated the minimum sample size to be 100 patients. Considering the yearly SICU admission numbers are approximately 500 patients, approximately half of them are trauma, and approximately half of those patients develop delirium, we estimated that 1 year of patients would need to be screened for inclusion to reach a large enough sample size. A goodness-of-fit analysis was performed to test the model. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines were referred to for manuscript preparation.[20]

RESULTS

Of 569 patients admitted to the SICU during the 1-year study period, 115 met inclusion criteria and were followed up for the development of delirium over a total of 1,250 SICU days (Fig. 2). The mean age was 67 years, with an ISS of 19 and a GCS score of 14. The overall incidence of delirium was 61%. Variables present on admission, which were positive predictors of delirium, were TBI and history of substance abuse. Of note, the presence of chest injury was a negative predictor of delirium (Table 1).

When considering continuous variables such as age, ISS, GCS score, SICU LOS, and mean daily medication doses, all variables were associated with the development of delirium on bivariate analysis except for age (Table 2). Significant clinical treatments with negative predictability were vent-free days, benzodiazepine-free days/30 (benzo-free days), and restraint-free days/30 (restraint-free days).

In terms of timing of onset of delirium with respect to mechanical ventilation, there were 52 patients who were mechanically ventilated and experienced at least one episode of delirium. Of these, 33 were mechanically ventilated before at least one episode of delirium, 17 had simultaneous onset of mechanical ventilation and delirium, and only 2 patients experienced delirium before mechanical ventilation (noting that both remained delirium positive for the entire SICU LOS). The mean number of days mechanically ventilated before being documented delirium positive was 4 days.

In a multivariate regression model including age, vent-free days, chest injury, TBI, GCS score, benzo-free days, and hours deeply sedated, only age (OR, 1.1; 95% CI, 1.01–1.1; $p = 0.03$) was an independent predictor of delirium, while vent-free days (OR, 0.79; 95% CI, 0.65–0.96; $p = 0.02$) and chest injury (OR, 0.3;95% CI, 0.09–0.83; $p = 0.02$) were significant independent negative predictors of delirium (Table 3). The Hosmer-Lemeshow goodness-of-fit test for the logistic regression model was nonsignificant ($p = 0.16$), suggesting that the

TABLE 1. Delirium Risk Assessment: A Comparison of Known Risk Factors for Delirium Present on Admission to the Observed Incidence of Delirium in Trauma Patients in the SICU

Variable	Yes		No		p
Chest injury	52	(44%)	63	(75%)	0.002
TBI	58	(76%)	57	(46%)	0.002
Substance abuse	31	(74%)	83	(55%)	0.05
Depression	7	(86%)	99	(56%)	0.11
Psychotropic medication use	17	(71%)	92	(57%)	0.28
Severe pain (>6/10)	49	(55%)	66	(64%)	0.36
Visual aid	78	(60%)	31	(52%)	0.41
Cardiac diagnosis	83	(63%)	31	(55%)	0.45
English speaking	100	(62%)	15	(53%)	0.57
Lives alone	38	(63%)	71	(58%)	0.58
Pulmonary diagnosis	20	(55%)	93	(61%)	0.60
Smoker	31	(61%)	83	(59%)	0.83
Hearing aid	10	(60%)	98	(57%)	0.86
Orthopedic fracture	77	(60%)	38	(61%)	0.94

All the factors in the delirium risk assessment form filled out by the study team at admission to the SICU following traumatic injury. Patients diagnosed with chest injury (chest AIS score ≥ 3) had a significantly lower incidence of delirium than those without the diagnosis of chest injury. Patients admitted with TBI (head AIS score ≥ 3) or histories of substance of abuse were more likely to develop delirium than those without TBI or those without histories of substance abuse. Data are presented as n total and (percent delirium positive). Significance at $p < 0.05$.

TABLE 2. Admission Factors and Clinical Variables Associated With Delirium on Bivariate Analysis

Variable	Delirium Positive	Delirium Negative	p
n	n = 69	n = 46	—
Age	68 (65–71)	65 (62–68)	0.44
ISS	22 (19–24)	16 (13–18)	0.005
Initial GCS score	13 (12–14)	15 (14–15)	<0.001
SICU LOS	15 (12–18)	5 (4–6)	<0.001
Benzo-free days	25 (24–27)	29 (28–30)	<0.001
Benzodiazepine, mg/d	1.7 (1–3)	0.5 (0–1)	<0.001
Vent-free days	22 (19–24)	29 (28–30)	<0.001
Propofol, mg/kg/d	6 (4–8)	1 (−5–3)	<0.001
Restraint-free days	23 (22–25)	30 (29–30)	<0.001

Admission factors and clinical variables, which were associated with the development of delirium. Benzodiazepines reported as milligram lorazepam equivalents per day.
Data are presented as mean (95% CI).

TABLE 3. Risk Factors for the Development of Delirium: A Multivariate Logistic Regression

Variable	OR (95% CI)	p
Vent-free days	0.79 (0.65–0.96)	0.02
Chest injury (chest AIS score ≥ 3)	0.28 (0.09–0.83)	0.02
Age	1.1 (1.01–1.1)	0.03
Initial GCS score	0.85 (0.68–1.07)	0.17
Benzo-free days	0.84 (0.66–1.09)	0.19
TBI	0.65 (0.22–1.87)	0.42
Deep sedation, hours RASS low (≤−3)	0.99 (0.98–1.02)	0.77

ORs for the development of delirium are presented here. Age was a significant independent predictor of delirium with a 10% increase in developing delirium with every year for those older than 50 years. In contrast, vent-free days and chest injury diagnosis were protective against the development of delirium. For every extra vent-free day, the risk of delirium decreased by 21%.
Significance at $p < 0.05$.

data fit the model well. The model's overall predictive value was 82% (85% for delirium positive, 78% for delirium negative).

In patients admitted to the SICU with chest injury, the incidence of delirium was significantly lower (44%) compared with those without chest injury (75%) ($p = 0.002$). There were no differences between the cohorts in terms of age, sex, initial GCS score, or SICU LOS (Table 4). Patients with chest injury were less likely to have TBI (33%), compared with patients without chest injury (66%) ($p = 0.001$).

DISCUSSION

Delirium is common in older trauma patients admitted to the SICU. Our study found that the incidence of delirium was 61% and that for every year for those older than 50 years, the chance of delirium increased by 10%. This means that by the age of 60 years, the chance of delirium in trauma patients admitted to the surgical ICU is 100%. The strength of this study was that it focused on a population that has been underrepresented, older adults following trauma, including those sustaining TBI. This study confirmed that higher injury severity increased the risk of delirium, but it also identified several modifiable risk factors associated with delirium including time spent deeply sedated, time spent mechanically ventilated, and time spent restrained.

After comparing the timing of mechanical ventilation to onset of delirium, it was clear that mechanical ventilation either preceded or occurred simultaneous to the onset of delirium in almost all patients. In addition, for each additional vent-free day, the chance of delirium decreased by 21%. There is no question that mechanical ventilation is a significant stressor for patients admitted to the ICU. When mechanically ventilated, patients often receive additional sedation and high-dose opioid administration and are placed in physical restraints. Thus, it is intuitive to conclude that early liberation from mechanical ventilation is a valuable target to decrease the risk of delirium as it impacts many known risk factors for the development of delirium.

Patients admitted with a history of substance abuse should be monitored carefully for the development of delirium. While TBI was associated with delirium on initial bivariate analysis, it was not a significant predictor of delirium in the regression model. One interesting finding of the study was that chest injury seemed to be protective against delirium. Upon further analysis, patients with chest injury were less likely to also have a TBI compared with those without chest injury. This is interesting because while the association of less TBI in patients with chest injury might contribute to less delirium in patients with chest injury, TBI was not a significant predictor in the regression model. Patients with chest injury experienced less delirium than those without chest injury, despite similar severity of injury and nearly identical clinical interventions assessed in this study.

Our study supports many of the risk factors identified in different settings and populations. The findings in our study build on a prospective study in critically ill surgical and trauma patients by Lat et al.,[3] who found that delirium was associated with more time spent mechanically ventilated, longer ICU stay, and higher doses of opioids and benzodiazepines. Like the studies by Inouye et al.[6] and van Rompaey et al.,[7] we also found that physical restraints were a risk factor for delirium.

One study in a similar SICU population also reported a 59% incidence of delirium following trauma.[2] A significant difference was the inclusion of younger patients (age > 18 years) and the exclusion of those with hearing/visual deficits. One weakness of that study, however, was that the CAM-ICU was recorded only once daily, which could potentially miss episodes of delirium, which has a natural fluctuating course. A specific strength of the study reported here compared with previously published data is that ours was one of the first to routinely document the CAM-ICU every 12 hours.[3,6,13] A perceived weakness of our data is that it included patients with TBI. Soja et al.[17] reported that using the CAM-ICU to monitor delirium is reliable for identifying delirium in TBI patients. TBI is a major issue in patients in the SICU, and the pharmacologic management of these patients, including the control of delirium, is an important part of achieving good outcomes. Thus, inclusion of this population is a necessity.

Our patients with chest injury experienced delirium less frequently than other SICU patients, perhaps owing to the lower incidence of TBI; however, additional study is required. One hypothesis is that our trauma service implemented rib fracture guidelines that recommended SICU admission for older patients with significant chest trauma (see Figure, SDC 1 http://links.lww.com/TA/A470). The guidelines were designed to prevent respiratory failure and decrease the need for mechanical ventilation by encouraging aggressive incentive spirometer use, pain control, and early ambulation. As a part of the

TABLE 4. Chest Injury Patients Compared With Non–Chest Injury Trauma Patients

Characteristic	Chest Injury	No Chest Injury	*p*
n (%)	52 (45%)	63 (55%)	0.31
TBI	17 (33%)	41 (65%)	0.001
Delirium incidence	23 (44%)	47 (75%)	0.002
Severe pain hours > 6	0.5 (0–1)	0 (0–0.4)	0.06
Benzodiazepine use	29 (56%)	45 (71%)	0.08
ISS	22 (18–25)	18 (16–20)	0.10
Initial GCS score	14 (13–15)	13 (12–14)	0.14
Age	65 (62–67)	69 (65–72)	0.16
% male	38 (73%)	40 (63%)	0.27
Opioid dose, mg	40 (28–51)	37 (26–49)	0.29
Benzodiazepine dose, mg	1.3 (0.6–2)	1.1 (0.3–2)	0.34
Propofol dose, mg/kg	4 (2–6)	4 (3–6)	0.49
Deep sedation, hours RASS ≤ −3	1 (0–2)	1 (1–2)	0.49
Atypical antipsychotic use	12 (23%)	18 (29%)	0.50
Restraint use	24 (46%)	33 (52%)	0.51
SICU LOS	12 (9–15)	10 (8–13)	0.58
Restraint-free days	26 (23–28)	26 (25–28)	0.86
Vent-free days	24 (21–26)	25 (24–27)	0.99

The variables present in patients admitted with chest injury compared with those without chest injury. There were no significant differences between the groups, except for the presence of TBI and the incidence of delirium. Data are presented as mean (95% CI) or number (percentage). All medication doses refer to the mean daily SICU dose. Benzodiazepine dose is milligram lorazepam equivalents and opioid dose refers to milligram morphine equivalents converted to PO equivalent.

Significance at $p < 0.05$.

rib fracture guidelines, pain medications (including opioids and nonsteroidal anti-inflammatory drugs) get carefully titrated to achieve appropriate pain control without oversedation. The rib fracture guidelines require nursing staff to document incentive spirometer effort every 2 hours during daytime hours. It can be labor intensive, and perhaps, the frequent visits by nurses, physical therapists, and respiratory therapists played a role in orientation and delirium prevention. Another possibility as to why older adults with chest injuries developed delirium less often may be due to other variables that this study did not collect. Aldemir et al.[21] found that risk factors for delirium in the SICU included respiratory disease, infection, hypotension, anemia, and metabolic acidosis.

In summary, the most important predictor of delirium following trauma is age, suggesting that prevention methods should be focused on older patients. We also identified several easily modifiable risk factors for delirium following trauma, which include duration of physical restraint use, duration of deep sedation, and duration of mechanical ventilation. The results of this study show that early liberation from mechanical ventilation is a highly effective method for delirium prevention. The study found chest injury to be a negative predictor or protective against delirium in the SICU. While it possible that the results may be, in part, due to fewer patients having TBI in the chest injury group, interestingly, the logistic regression did not identify TBI as an independent predictor of delirium. Another possibility is that the constant attention given to patients with chest injury actually helped protect against delirium. Further prospective research spurred by these findings is necessary to determine if in fact modifications in clinical care such as scheduled frequent rounding by staff, often referred to as "hello rounds," can be implemented to reduce delirium incidence.

AUTHORSHIP

A.C.M., P.P.Y., M.C.L., and S.B.B. were responsible for the study design. S.B.B., M.C.L., and JS performed the literature search and collected data. M.C.L., P.P.Y., S.B.B., and A.C.M. interpreted the data. S.B.B. wrote the abstract and manuscript, with the help of A.C.M., P.P.Y., M.C.L., and JS who all helped with critical revisions.

ACKNOWLEDGMENT

We thank David H. Livingston, MD, for his guidance and encouragement throughout the project.
We also thank Robert Lavery for his never-ending support with the data analysis and interpretation.

DISCLOSURE

The authors declare no conflicts of interest.

REFERENCES

1. Brummel NE, Jackson JC, Pandharipande PP, Thompson JL, Shintani AK, Dittus RS, Gill TM, Bernard GR, Ely EW, Girard TD. Delirium in the ICU and Subsequent Long-Term Disability Among Survivors of Mechanical Ventilation. *Crit Care Med*. 2013;42(3):1–9.
2. Angles EM, Robinson TN, Biffl WL, Johnson J, Moss M, Tran ZV, Moore EE. Risk factors for delirium after major trauma. *Am J Surg*. 2008; 196(6):864–870.
3. Lat I, McMillian W, Taylor S, Janzen JM, Papadopoulos S, Korth L, Ehtisham A, Nold J, Agarwal S, Azocar R, et al. The impact of delirium on clinical outcomes in mechanically ventilated surgical and trauma patients. *Crit Care Med*. 2009;37(6):1898–1905.
4. Girard TD, Jackson JC, Pandharipande PP, Pun BT, Thompson JL, Shintani AK, Gordon SM, Canonico AE, Dittus RS, Bernard GR, et al. Delirium as a predictor of long-term cognitive impairment in survivors of critical illness. *Crit Care Med*. 2010;38 (7):1513–1520.
5. Ely EW, Shintani A, Truman B, Speroff T, Gordon SM, Harrell FE, Inouye SK, Bernard GR, Dittus RS. Delirium as a predictor of mortality in mechanically ventilated patients in the intensive care unit. *JAMA*. 2004; 291:1753–1762.
6. Inouye SK, Charpentier PA. Precipitating factors for delirium in hospitalized elderly persons: predictive model and interrelationship with baseline vulnerability. *JAMA*. 1996;275:852–827.
7. van Rompaey B, Elseviers MM, Schuurmans MJ, Shortridge-Baggett LM, Truijen S, Bossaert L. Risk factors for delirium in intensive care patients: a prospective cohort study. *Crit Care*. 2009;13(3):R77.
8. Pisani MA, Murphy TE, Araujo KL, Slattum P, Van Ness PH, Inouye SK. Benzodiazepine and opioid use and the duration of intensive care unit delirium in an older population. *Crit Care Med*. 2009;37(1):177–183.
9. Fineberg SJ, Nandyala SV, Marquez-Lara A, Oglesby M, Patel AA, Singh K. Incidence and risk factors for postoperative delirium after lumbar spine surgery. *Spine*. 2013;38(20):1790–1796.
10. Marcantonio ER, Goldman L, Orav EJ, Cook EF, Lee TH. The association of intraoperative factors with the development of postoperative delirium. *Am J Med*. 1998;105(5):380–384.
11. Marcantonio ER, Juarez G, Goldman L, et al. The relationship of postoperative delirium with psychoactive medications. *JAMA*. 1994;272: 1518–1522.
12. National Center for Injury Prevention and Control, WISQARS Leading Causes of Death Reports, 1999–2005. Atlanta, GA: Centers for Disease Control and Prevention National Center for Health Statistics. Available at: http://webappa.cdc.gov/sasweb/ncipc/leadcaus10.html. Accessed January 9, 2014.
13. Pandharipande P, Cotton BA, Shintani A, Thompson J, Truman Pun B, Morris JA, Dittus R, Ely EW. Prevalence and risk factors for development of delirium in surgical and trauma intensive care unit patients. *J Trauma*. 2008;65(1):34–41.
14. Pandharipande PP, Shintani A, Peterson J, Pun BT, Wilkinson GR, Ely EW. Lorazepam is an independent risk factor for transitioning to delirium in intensive care patients. *Anesthesiology*. 2006;104:21–26.
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;72(1):112–118.
16. Eastern Metropolitan Region Palliative Care Consortium. Opioid Conversion Ratios—Guide to Practice. 2010. Available at: http://www.emrpcc.org.au/wp-content/uploads/2013/03/EMRPCC-Opioid-Conversion2010-Final2.pdf. Accessed April 2011.
17. Soja SL, Pandharipande PP, Fleming SB, Cotton BA, Miller LR, Weaver SG, Lee BT, Ely EW. Implementation, reliability testing, and compliance monitoring of the Confusion Assessment Method for the intensive care unit in trauma patients. *Intensive Care Med*. 2008;34(7):1263–1268.
18. Khan BA, Guzman O, Campbell NL, Walroth T, Tricker J, Hui SL, Perkins A, Zawahiri M, Buckley JD, Farber MO, et al. Comparison and agreement between the Richmond Agitation-Sedation Scale and the Riker Sedation-Agitation Scale in evaluating patients' eligibility for delirium assessment in the ICU. *Chest*. 2012;14(1):48–54.
19. Steyerberg EW, Eijkemans MJ, Harrell FE Jr., Habbema JD. Prognostic modelling with logistic regression analysis: a comparison of selection and estimation methods in small data sets. *Stat Med*. 2000;19:1059–1079.
20. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP; STROBE Initiative. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *Lancet*. 2007;370(9596):1453–1457.
21. Aldemir M, Ozen S, Kara IH, Sir A, Bac B. Predisposing factors for delirium in the surgical intensive care unit. *Crit Care*. 2001;5:265–270.

