Journal of the American College of Clinical Wound Specialists (2017) 9, 24–31

RESEARCH PAPER

Pressure Ulcer in Trauma Patients: A Higher Spinal Cord Injury Level Leads to Higher Risk

Areg Grigorian, MD*, Megumi Sugimoto, BS, Victor Joe, MD, Sebastian Schubl, MD, Michael Lekawa, MD, Matthew Dolich, MD, Eric Kuncir, MD, Cristobal Barrios Jr., MD, Jeffry Nahmias, MD, MHPE

University of California, Irvine, Department of Surgery, Division of Trauma, Burns and Surgical Critical Care, Orange, CA, USA

KEYWORDS:
Spinal cord injury;
Pressure ulcer;
Trauma

Abstract

BACKGROUND: In a systematic review, the level of spinal cord injury (SCI) was not associated with risk for pressure ulcer (PU). We hypothesized that in the acute trauma population, upper-SCI (cervical/thoracic) has greater risk for PU when compared to lower-SCI (lumbar/sacral). We additionally sought to identify risk factors for development of PUs in trauma.

METHODS: A retrospective analysis of the NTDB (2007–2015) was performed. Covariates were included in a multivariable logistic regression analysis to determine risk for PU.

RESULTS: Of 62,929 patients (0.9%) with SCI, most had an upper-SCI (83%). The overall rate of PUs in patients with SCI was 5.1%. More patients with upper-SCI developed PUs compared to lower-SCI (5.8% vs. 2.2%, $p < 0.001$). SCI was the strongest predictor for PU (OR = 13.77, CI = 13.25–14.31, $p < 0.001$). Upper-SCI demonstrated greater risk compared to lower-SCI (OR = 2.81, CI = 2.45–3.22, $p < 0.001$).

CONCLUSIONS: Contrary to previous reports, a higher SCI level is associated with a three-fold greater risk for PU compared to lower SCI.

Introduction

Trauma patients hospitalized for more than two days are at risk for developing a pressure ulcer (PU), with an incidence ranging from 0.4% to 30.6%.[1–3] PUs have been shown to be associated with increased healthcare costs (up to $11 billion annually), pain, and mortality, as well as impaired social and psychological well-being.[4–7] Several well known risk factors for PUs include immobility, medical comorbidities (e.g. diabetes), malnutrition, skin moisture, and age.[8] The development of PUs during the index hospitalization of trauma patients is not uncommon. Ham et al. studied PUs in 254 trauma patients and found nearly half the patients with PUs (45.8%) developed it within 48 h of admission, which demonstrates the importance of identifying at-risk patients and instituting prophylactic measures early in the hospital course.[9]

The authors report no conflicts of interest, financial or otherwise.
No funding was received for this work.
This work was presented at the 70th Annual Meeting for Southwestern Surgical Congress, April 8–11, 2018 at Napa, California.

* Corresponding author. Division of Trauma, Burns and Surgical Critical Care Department of Surgery University of California, Irvine Medical Center 333 The City Blvd West, Suite 1600; Orange, CA, USA 92868-3298.
E-mail address: agrigori@uci.edu

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https://doi.org/10.1016/j.jccw.2018.06.001

Several scoring systems are available to determine risk for PUs in hospitalized patients, including the widely used Braden scale.[10] However, its validity in the trauma population has been brought into question.[11] Risk factors known to cause PUs in non-trauma populations have been extensively studied[8] but may not be the most pertinent risk factors for trauma patients.[9] Spinal cord injury (SCI) occurs in up to 7.5% of trauma patients[12] and can result in paralysis or tetraplegia, increasing the risk for the development of PU.[13] Based on a prior study, SCI patients with the highest risk for PUs include those with immobilizing devices for a prolonged period of time, intensive care unit (ICU) admission, high injury severity score (ISS), mechanical ventilation and intracranial pressure monitoring.[14] Tetraplegics, with a higher neurological level of SCI, are more likely to be immobile, compared to paraplegics and thus may be at higher risk for PUs. However, in a large systematic review, the neurological level of injury (paraplegia or tetraplegia) in patients in acute and subacute stages of rehabilitation were not associated with risk for PUs.[15] We hypothesized that in the acute trauma population, an upper (cervical or thoracic) SCI has a greater risk for PU when compared to a lower (lumbar or sacral) SCI. We additionally sought to identify significant risk factors for development of PUs in trauma patients during their index hospitalization.

Methods

This was a retrospective analysis using data from the National Trauma Data Bank (NTDB).[16] All patients admitted during years 2007–2015 were included. Patients with a SCI (cervical, thoracic, lumbar and sacral) were identified by the International Classification of Diseases (ICD) version-9 diagnosis codes listed in Appendix-A. The primary endpoint was the incidence of PU during the index hospitalization. PU is one of the 32 mandated reportable complications in the NTDB. Patients with an upper SCI (cervical or thoracic) were compared to those with a lower SCI (lumbar or sacral), and patients with PUs were compared to patients without PUs. Secondary outcomes included total hospital length of stay (LOS), ICU LOS, ventilator days, acute kidney injury (AKI), acute respiratory distress syndrome (ARDS), myocardial infarction (MI), pulmonary embolism (PE), deep vein thrombosis (DVT), severe sepsis, urinary tract infection (UTI), unplanned intubation, unplanned ICU admission and mortality.

Demographic variables included age and gender. Prehospital comorbidities included end-stage renal disease (ESRD), hypertension, cerebrovascular accident (CVA), smoking, congestive heart failure (CHF), peripheral vascular disease (PVD), MI, malnutrition and chronic obstructive pulmonary disease (COPD). The injury profile included the ISS and severe grade (>3) for abbreviated injury scale (AIS) by body region. An associated traumatic brain injury (TBI), upper extremity fracture, lower extremity fracture and pelvic fracture were also included. All variables were coded as present or absent.

Descriptive statistics was performed for all variables. A Student's *t*-test was used to compare continuous variables and chi-square was used to compare categorical variables for bivariate analysis. Categorical data was reported as percentages, and continuous data was reported as medians with interquartile range or as means with standard deviation.

We performed a univariable logistic regression analysis for risk of PUs in all trauma patients. Covariates were chosen based on a review of the literature and included smoking, TBI, age ≥ 65, hypertension, steroid use, diabetes, CVA, obesity, pelvic fractures, PVD, severe AIS for lower extremity and malnutrition.[8,17–20] These covariates were controlled for using a hierarchical multivariable logistic regression model to identify the adjusted risk for PU in all adult trauma patients with SCI versus no SCI. In addition, we used a similar multivariable model to report the adjusted risk for PU with upper (cervical/thoracic) versus lower (lumbar/sacral) levels of SCI. This was reported with an odds ratio (OR) and 95% confidence intervals (CI). Differences with $p < 0.05$ were considered statistically significant for all analyses. All statistical analyses were performed with IBM SPSS Statistics for Windows, Version 24. (Armonk, NY: IBM Corp).

Results

Demographics of trauma patients with SCI and primary outcome

Out of 6,774,260 trauma patients, 62,929 (0.9%) had SCI with a higher proportion having upper SCI (83%). Compared to patients with lower SCI, those with upper SCI were older (mean age, 44.7 vs. 38.7, $p < 0.001$), less likely to be a smoker (13.3% vs. 15.1%, $p < 0.001$), had a higher median ISS (25.0 vs. 17.0, $p < 0.001$), higher rate of TBI (31.4% vs. 18.7%, $p < 0.001$) and more likely to be involved in a blunt mechanism (88.0% vs. 81.4%, $p < 0.001$) (Table 1). When compared to cervical SCI, those with thoracic SCI had a higher median ISS (26.0 vs. 22.0, $p < 0.001$) and a higher rate of lower extremity fractures (13.7% vs. 7.9%, $p < 0.001$). The overall rate of PUs in patients with SCI was 5.1%. More patients with upper SCI developed PUs compared to those with lower SCI (5.8% vs. 2.2%, $p < 0.001$).

Demographics of trauma patients with and without pressure ulcers

Out of 6,774,260 trauma patients, 29,666 (0.4%) developed PUs and among patients with SCI, the highest proportion of PUs developed in patients with cervical spine

injury (59.7%). Compared to patients without PUs, those with PUs were older (mean age, 53.6 vs. 43.1, $p < 0.001$), more likely to have malnutrition (2.4% vs. 0.1%, $p < 0.001$), COPD (10.2% vs 6.0%, $p < 0.001$) or PVD (0.9% vs. 0.3%, $p < 0.001$), and had a higher median ISS (19.0 vs. 5.0, $p < 0.001$). Patients with PUs also had higher rates of SCI (10.9% vs. 0.4%) and TBI (44.2% vs. 30.9, $p < 0.001$) (Table 2).

Univariable analysis for risk of pressure ulcers in trauma

On univariable analysis, the strongest risk factors for PU, in order, were malnutrition (OR 20.39, 95% CI 18.88–22.02, $p < 0.001$), SCI (OR 13.73, 95% CI 13.22–14.25, $p < 0.001$), severe AIS for the lower extremity (OR 7.08, 95% CI 6.14–8.16, $p < 0.001$) and PVD (OR 3.27, 95% CI 2.89–3.70, $p < 0.001$). Other risk factors are shown in Table 3.

Multivariable analysis for risk of pressure ulcers in trauma

After adjusting for covariates in a multivariable logistic regression analysis, we found SCI to be the strongest predictor for the development of PUs in adult trauma patients (OR 13.77, 95% CI 13.25–14.31, $p < 0.001$), followed by malnutrition (OR 11.77, 95% CI 10.84–12.76, $p < 0.001$). Upper SCI was associated with a significantly higher risk for PU compared to lower SCI (OR 2.81, 95% CI 2.45–3.22, $p < 0.001$). The SCI level with the strongest association for PUs in trauma patients was thoracic (OR 15.96, 95% CI 15.01–16.97, $p < 0.001$) (Table 4).

Secondary outcomes for patients with spinal cord injury or pressure ulcers

Compared to patients with lower SCI, those with upper SCI had a longer median LOS (10.0 vs. 9.0 days,

Table 1 Demographics and injury profile of patients with lower (lumbar and sacral) and upper (cervical and thoracic) spinal cord injury.

Characteristic	Lower SCI (n = 12,166)	Upper SCI (n = 52,246)	p-Value
Age, year, mean (SD)	38.7 (19)	44.7 (21)	<0.001
Male, n (%)	7579 (71.3%)	38,833 (74.6%)	<0.001
Comorbidities, n (%)			
Congestive heart failure	123 (1.2%)	989 (1.9%)	<0.001
Hypertension requiring medication	1595 (14.9%)	10,719 (20.5%)	<0.001
Peripheral vascular disease	16 (0.1%)	98 (0.2%)	0.40
Myocardial infarction	58 (0.5%)	437 (0.8%)	<0.05
Smoking	1616 (15.1%)	6932 (13.3%)	<0.001
End-stage renal disease	37 (0.3%)	242 (0.5%)	0.10
Cerebrovascular accident	86 (0.8%)	735 (1.4%)	<0.001
COPD	472 (4.4%)	2620 (5.0%)	<0.05
Malnutrition	25 (0.2%)	412 (0.8%)	<0.001
ISS, median (IQR)	17.0 (17)	25.0 (17)	<0.001
Blunt mechanism, n (%)	8693 (81.4%)	46,002 (88.0%)	<0.001
Spinal cord injury, n (%)			
Cervical	–	32,925 (63.0%)	–
Thoracic	–	21,026 (40.2%)	–
Lumbar	9567 (87.3%)	–	–
Sacral	1241 (11.6%)	–	–
Additional Injuries, n (%)			
Traumatic brain injury	2002 (18.7%)	16,399 (31.4%)	<0.001
Upper extremity fracture	1687 (15.8%)	9599 (18.4%)	<0.001
Lower extremity fracture	1701 (15.9%)	4844 (9.3%)	<0.001
Pelvic fracture	1649 (15.4%)	3125 (6.0%)	<0.001
AIS (severe)*, n (%)			
Head	601 (5.6%)	6160 (11.8%)	<0.001
Thorax	596 (5.6%)	5023 (9.6%)	<0.001
Abdomen	484 (4.5%)	1203 (2.3%)	<0.001
Lower extremity	31 (0.3%)	58 (0.1%)	<0.001

SCI = spinal cord injury, SD = standard deviation, COPD = chronic obstructive pulmonary disease, ISS = injury severity score, IQR = interquartile range, AIS = abbreviated injury scale.

* = (grade>3)

Table 2 Demographics and injury profile of trauma patients with and without pressure ulcer.

Characteristic	− Pressure Ulcer (n = 6,744,594)	+ Pressure Ulcer (n = 29,666)	p-Value
Age, year, mean (SD)	43.1 (25)	53.6 (22)	<0.001
Male, n (%)	4212759 (62.7%)	19,942 (67.3%)	<0.001
Comorbidities, n (%)			
Congestive heart failure	185,717 (2.8%)	2337 (7.9%)	<0.001
Hypertension requiring medication	1,549,766 (23.0%)	10,958 (36.9%)	<0.001
Peripheral vascular disease	17,980 (0.3%)	257 (0.9%)	<0.001
Myocardial infarction	76,895 (1.1%)	883 (3.0%)	<0.001
Smoking	727,639 (10.8%)	3538 (11.9%)	<0.001
End-stage renal disease	44,907 (0.7%)	674 (2.3%)	<0.001
Cerebrovascular accident	124,212 (1.8%)	1318 (4.4%)	<0.001
COPD	404,935 (6.0%)	3024 (10.2%)	<0.001
Malnutrition	8252 (0.1%)	723 (2.4%)	<0.001
ISS, median (IQR)	5.0 (6)	19.0 (5)	<0.001
Blunt mechanism, n (%)	5,604,335 (83.1%)	26,194 (88.3%)	<0.001
Spinal cord injury, n (%)			
Cervical	30,992 (0.5%)	1933 (6.5%)	<0.001
Thoracic	19,815 (0.3%)	1211 (4.1%)	<0.001
Lumbar	10,690 (0.2%)	267 (0.9%)	<0.001
Sacral	1338 (0.02%)	30 (0.1%)	<0.001
Additional Injuries, n (%)			
Traumatic brain injury	2,082,278 (30.9%)	13,110 (44.2%)	<0.001
Upper extremity fracture	1,265,810 (18.8%)	7751 (26.1%)	<0.001
Lower extremity fracture	1,528,172 (22.7%)	10,497 (35.4%)	<0.001
Pelvic fracture	416,420 (6.2%)	5217 (17.6%)	<0.001
AIS (severe)*, n (%)			
Head	746,408 (11.1%)	7066 (23.8%)	<0.001
Thorax	191,880 (2.8%)	3463 (11.7%)	<0.001
Abdomen	87,469 (1.3%)	1298 (4.4%)	<0.001
Lower extremity	6391 (0.1%)	198 (0.7%)	<0.001

SD = standard deviation, COPD = chronic obstructive pulmonary disease, ISS = injury severity score, IQR = interquartile range, AIS = abbreviated injury scale

* = grade>3

$p < 0.001$) and higher rates of ARDS (6.3% vs. 2.2%, $p < 0.001$), unplanned intubation (3.1% vs. 1.0%, $p < 0.001$), pneumonia (15.1% vs. 4.7%, $p < 0.001$) and mortality (14.5% vs. 4.7%, $p < 0.001$) (Table 5). Compared to patients without PUs, those with PUs had a significantly longer median LOS (10.0 vs. 3.0 days, $p < 0.001$), and higher rates of all in-hospital complications analyzed including a higher mortality rate (9.6% vs. 3.9%, $p < 0.001$) (Table 6).

Discussion

This retrospective report, analyzing data from 2007 to 2015 in the NTDB, found 62,929 SCI patients with an incidence of 0.9%, with the majority having upper SCI. The incidence of PUs during the index hospitalization of trauma patients was 0.4%, and in patients with SCI, the highest proportion of PUs developed in those with cervical spine injury (59.7%). Patients with SCI have nearly a 14-fold increased risk of developing PUs, with the strongest association to be in those with thoracic SCI (16-fold higher risk). Patients with upper SCI have nearly a three-fold greater risk of developing PUs, compared to those with lower SCI.

While risk factors for PUs in non-trauma populations have been well studied, evidence to substantiate increased risk in trauma patients is sparse.[8] The incidence of PUs in trauma patients depends on the severity of the trauma endured.[1,2,19] Additionally, in trauma patients that develop PUs, up to 45.8% develop them within 48 h of admission.[9] Several vulnerabilities in trauma patients may help explain the increased risk for PUs. One particularly common disability in the trauma population is impaired mobility, which can increase risk for PUs.[8,17] In addition, trauma patients uniquely have injuries resulting in decreased sensation, malperfusion of tissue (e.g. shock), need for devices (e.g. cervical collar, casts), malnutrition and soft tissue injury, which may all impair wound healing and increase

Table 3 Univariable logistic regression analysis of predictors for pressure ulcer in trauma patients.

Outcome	OR	CI	p value
Smoking	1.12	1.08–1.16	<0.001
Traumatic brain injury	1.77	1.73–1.81	<0.001
Age≥65	1.81	1.76–1.85	<0.001
Hypertension	1.96	1.92–2.01	<0.001
Steroid use	2.21	1.94–2.52	<0.001
Diabetes	2.34	2.28–2.42	<0.001
Cerebrovascular accident	2.48	2.34–2.62	<0.001
Obesity	2.74	2.62–2.85	<0.001
Pelvic fracture	3.24	3.15–3.34	<0.001
Peripheral vascular disease	3.27	2.89–3.70	<0.001
AIS-lower extremity*	7.08	6.14–8.16	<0.001
Spinal cord injury	13.73	13.22–14.25	<0.001
Malnutrition	20.39	18.88–22.02	<0.001

AIS = abbreviated injury score
* = severe (grade>3)

risk for PUs.[8,18–20] In addition to SCI, we found trauma patients with malnutrition, pelvic fractures or a severe AIS for the lower extremity to have a three to fourteen-fold increased risk of developing PUs. Therefore, we propose that all trauma patients with SCI (especially upper SCI) or one of these other significant risk factors should be screened daily for skin breakdown and PUs. Future prospective studies can use the high-risk features we uncovered to develop a scoring system to better identify at-risk trauma patients.

Table 4 Adjusted* odds ratio for risk of pressure ulcer in trauma patients.

Outcome	OR	CI	p value
Spinal cord injury	13.77	13.25–14.31	<0.001
Upper vs. lower spinal cord injury	2.81	2.45–3.22	<0.001
Cervical spinal cord injury	15.55	14.81–16.33	<0.001
Thoracic spinal cord injury	15.96	15.01–16.97	<0.001
Lumbar spinal cord injury	6.86	6.06–7.77	<0.001
Sacral spinal cord injury	3.26	2.26–4.70	<0.001
Malnutrition	11.77	10.84–12.76	<0.001
Severe AIS-lower extremity	3.62	3.12–4.20	<0.001
Pelvic fracture	3.17	3.07–3.27	<0.001
Obesity	2.09	2.00–2.19	<0.001
Peripheral vascular disease	1.90	1.67–2.15	<0.001
Traumatic brain injury	1.87	1.83–1.91	<0.001
Diabetes	1.65	1.59–1.70	<0.001
History of cerebrovascular accident	1.61	1.52–1.71	<0.001
Steroid use	1.61	1.41–1.83	<0.001
Hypertension	1.41	1.37–1.56	<0.001
Age≥65	1.39	1.35–1.43	<0.001
Smoker	1.18	1.13–1.22	<0.001

* = controlled for covariates in univariable analysis

SCI resulting in immobility and lack of protective sensation contributes to a high rate of PUs within this population. In SCI patients that survive the initial trauma and continue receiving care at subacute facilities, the incidence of PUs ranges between 25 and 66%.[21,22] In the acute hospitalization setting, the incidence ranges between 0.4 and 38%.[23] This figure is concerning when considering that state and federal initiatives have defined PUs as avoidable or "never-events" that are to be reported to the Department of Public Health.[24] In our study using a national database, SCI patients developed PUs at a rate of 5.1% during their index hospitalization. This data confirms the importance of the risk factors (i.e. SCI, malnutrition, severe AIS for the lower extremity) we uncovered and the need for ongoing studies regarding novel preventative measures to help make this truly a "never-event."

The level of SCI, and the resulting motor deficits, may influence the initial development of PUs in trauma patients. However, the association between the level of SCI and the subsequent development of a PU has not been consistently reported. In Canadian patients with SCI, 44.9% of complete paraplegics self-reported the development of PUs, compared to 42.7% of complete tetraplegics.[13] In contrast, Arsh et al. reported a higher rate of PUs in complete tetraplegics (72.8%) admitted to a SCI care-facility, compared to complete paraplegics (66.6%).[25] In a large systematic review, the level of SCI was not found to be a risk factor for PUs in the acute stage.[15] This was attributed to the fact that most SCI patients receive immobilization and vertical stabilization, regardless of the neurologic level. However, our study found the risk of PU development in upper SCI to be nearly three-fold greater than in patients with lower SCI. These patients are subject to a loss of muscle mass and bone density with an increase in fat mass below the level of injury.[26] This metabolic disturbance may predispose patients with a higher level of SCI to a higher risk of nutritional deficiencies.[27] Our study corroborates prior reports demonstrating a higher rate of malnutrition in patients with upper SCI, compared to those with lower SCI.[28,29] Additionally, functional ambulation is dependent on the spinal roots beginning at the T-12 level. Therefore, patients with injuries above this level may not be able to walk in the acute period, even while assisted, increasing periods of immobility and contributing to risk for PU.[30] Tetraplegia occurs in patients with cervical SCI and results in paralysis of all four limbs. Patients with thoracic SCI have variation in the paralysis and weakness of the limbs effected. However, we found thoracic SCI patients to have the highest risk for PU, followed by cervical SCI. This can partly be explained by the fact that patients with thoracic SCI were involved in more severe trauma (i.e. ISS) and had a higher rate of lower extremity fractures, compared to patients with cervical SCI, both of which would result in longer periods of immobility and higher risk for PU. Future studies directly evaluating PU and immobility in trauma patients appears warranted.

Table 5 Outcomes and complications of patients with lower (lumbar and sacral) and upper (cervical and thoracic) spinal cord injury.

Outcomes	Lower SCI (n = 12,166)	Upper SCI (n = 52,246)	p-value
LOS, days, median (IQR)	9.0 (10)	10.0 (15)	<0.001
ICU, days, median (IQR)	4.0 (6)	6.0 (12)	<0.001
Ventilator, days, median (IQR)	3.0 (7)	8.0 (16)	<0.001
Complications, n (%)			
Pressure ulcer	231 (2.2%)	3008 (5.8%)	<0.001
Acute kidney injury	168 (1.6%)	1132 (2.2%)	<0.001
ARDS	230 (2.2%)	3282 (6.3%)	<0.001
Myocardial infarction	20 (0.2%)	241 (0.5%)	<0.001
Pulmonary embolism	129 (1.2%)	765 (1.5%)	<0.001
Deep vein thrombosis	321 (3.0%)	2249 (4.3%)	<0.001
Unplanned ICU	92 (0.9%)	693 (1.3%)	<0.001
Unplanned intubation	102 (1.0%)	1628 (3.1%)	<0.001
Pneumonia	506 (4.7%)	7875 (15.1%)	<0.001
rinary tract infection	350 (3.3%)	2408 (4.6%)	<0.001
Severe sepsis	61 (0.6%)	565 (1.1%)	<0.001
Mortality, n (%)	487 (4.7%)	7382 (14.5%)	<0.001

LOS = length of stay, IQR = interquartile range, ICU = intensive care unit, ARDS = acute respiratory distress syndrome.

A higher SCI may result in altered physiology, which may contribute to PU development. Tetraplegics have more pulmonary ailments (e.g. increased aspirations, pneumonia) in the acute period, which lead to a lower physical condition and more bed rest, contributing to the development of PUs.[31,32] Our study supports this as the rates of pneumonia and unplanned intubation were more than three-fold greater in upper SCI when compared to lower SCI patients. Additionally, tetraplegics have a four-fold increased risk of abnormal blood pressure (hypertension or hypotension) compared to paraplegics, likely due to a deranged sympathetic nervous system.[33] Persistently elevated blood pressure or hypoperfusion impairs the delivery of oxygen, nutrients and removal of wastes in patients with compromised skin and subcutaneous tissue, impairing wound healing and placing patients at risk for PU.[34,35] This may be heightened by pre-hospital comorbidities such as diabetes and obesity.

An important component in the daily care of trauma patients admitted to the hospital is prevention of a PU. Timely prophylactic interventions such as position changing, keeping the head of the bed at the lowest safe elevation

Table 6 Outcomes and complications of trauma patients with and without pressure ulcer.

Outcomes	− Pressure ulcer (n = 12,166)	+ Pressure ulcer (n = 52,246)	p-value
LOS, days, median (IQR)	3.0 (5)	10.0 (15)	<0.001
ICU, days, median (IQR)	3.0 (4)	6.0 (12)	<0.001
Ventilator, days, median (IQR)	2.0 (6)	8.0 (16)	<0.001
Complications, n (%)			
Acute kidney injury	41,338 (0.6%)	3085 (10.4%)	<0.001
ARDS	56,623 (0.8%)	4033 (13.6%)	<0.001
Myocardial infarction	13,913 (0.2%)	740 (2.5%)	<0.001
Pulmonary embolism	18,833 (0.3%)	992 (3.3%)	<0.001
Deep vein thrombosis	43,777 (0.6%)	3531 (11.9%)	<0.001
Unplanned ICU	19,981 (0.3%)	1169 (3.9%)	<0.001
Unplanned intubation	29,445 (0.4%)	2045 (6.9%)	<0.001
Pneumonia	123,487 (1.8%)	10,623 (35.8%)	<0.001
Urinary tract infection	53,221 (0.8%)	3233 (10.9%)	<0.001
Severe sepsis	11,059 (0.2%)	1243 (4.2%)	<0.001
Mortality, n (%)	244,958 (3.9%)	2840 (9.6%)	<0.001

LOS = length of stay, IQR = interquartile range, ICU = intensive care unit, ARDS = acute respiratory distress syndrome

and using pressure reducing surfaces may help avoid the development of PUs.[36] Once a SCI patient develops a PU, immediate management is recommended, starting first with local wound care and if required, surgical treatment.[23] Although treating professionals (e.g. doctors, nurses, physical therapists, etc.) are tasked with providing care to help avoid this complication, the patient and family bear some responsibility and should be educated appropriately. Patients may make behavioral decisions (e.g. participate in physical therapy), even in the acute period that may alter their risk for PU development. Lifestyle choices, such as change/disruption in routine and using a cushion, have been demonstrated to influence the rate of PU development in SCI patients.[37,38] Although most hospitals subscribe to nursing practices and prophylactic interventions aimed at reducing PUs, a recent Cochrane systematic review concluded that the effects of most of these practices in SCI patients are highly uncertain.[39] As such, prospective randomized-controlled trials investigating the role of modifiable patient behaviors and preventative measures to decrease the risk of PU development in patients with SCI are needed.

Our study is a retrospective analysis of a large national trauma database and so reporting bias is present. Data fields in the NTDB are subject to coding and input error. Relevant data fields missing in the NTDB include location and stage of the PU, American Spinal Injury Association (ASIA) impairment scale (including complete versus incomplete neurologic injury), preventative interventions utilized (i.e. frequency of turns, position of the head of bed, type of bed) as well as frequency of physical therapy sessions and timing of when the patient was ordered to be out of bed and actually was out of bed. Finally, the NTDB does not provide long-term follow-up data and so we were unable to capture patients developing PUs after their index hospitalization.

Conclusion

Using a large national database, we found SCI to be a strong predictor for risk of PU in the acute trauma setting. Contrary to previous reports, higher level of SCI (cervical or thoracic) is associated with nearly a three-fold greater risk for development of PU, compared to a lower SCI level (lumbar or sacral). Additional risk factors for PU development in trauma patients include malnutrition, pelvic fractures and a severe AIS for the lower extremity. Future prospective studies can use the high-risk features we uncovered to develop a scoring system to identify at-risk patients and study prophylactic interventions aimed to decrease risk of PU in the trauma population.

Disclosure and funding statement

The authors report no proprietary or commercial interest in any product mentioned or concept discussed in this article.

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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Appendix A ICD-9 diagnosis codes for spinal cord injury.

Cervical	Thoracic	Lumbar	Sacral
806–806.19	806.2–806.39	806.4–806.5	806.6–806.9