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ORIGINAL ARTICLE

Acute respiratory distress syndrome and acute lung injury in patients with vertebral column fracture(s) and spinal cord injury: a nationwide inpatient sample study

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Study design: Retrospective Nationwide Inpatient Sample (NIS) study.
Objectives: To determine national trends in prevalence, risk factors and mortality for vertebral column fracture (VCF) and spinal cord injury (SCI) patients with and without acute respiratory distress syndrome/acute lung injury (ARDS/ALI).
Setting: United States of America, 1988 to 2008.
Methods: The NIS was utilized to select 284 612 admissions for VCF with and without acute SCI from 1988 to 2008 based on ICD-9-CM. The data were stratified for in-hospital complications of ARDS/ALI.
Results: Patients with SCI were more likely to develop ARDS/ALI compared with those without (odds ratio (OR): 4.9, 95% confidence interval (CI) 4.7–5.2, $P<0.001$). Compared with patients with lumbar fractures, those with cervical, thoracic and sacral fractures were more likely to develop ARDS/ALI ($P<0.001$). ARDS/ALI was statistically more prevalent ($P<0.01$) in VCF/SCI patients with epilepsy, sepsis, cardiac arrest, congestive heart failure (CHF), hypertension, chronic obstructive pulmonary disease and metabolic disorders. Patients with female gender, surgery at rural practice setting, and coronary artery disease and diabetes were less likely to develop ARDS/ALI ($P<0.001$). VCF/SCI patients who developed ARDS/ALI were more likely to die in-hospital than those without ARDS/ALI (OR 6.5, 95% CI 6.0–7.1, $P<0.001$). Predictors of in-hospital mortality after VCF/SCI include: older age, male sex, epilepsy, sepsis, hypertension, CHF, chronic obstructive pulmonary disease and liver disease. Patients who developed ARDS/ALI stayed a mean of 25 hospital days (30–440 days) while patients without ARDS/ALI stayed a mean of 6 days (7–868 days, $P<0.001$).
Conclusion: Our analysis demonstrates that SCI patients are more at risk for ARDS/ALI, which carries a significantly higher risk of mortality.
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Keywords: NIS; respiratory failure; ARDS; ALI; spinal cord injury; vertebral column fracture

INTRODUCTION

Acute spinal cord injury (SCI) often occurs following traumatic vertebral column fractures (VCFs). SCI remains an important cause of disability, morbidity and mortality, with an estimated 11000 new cases per year in the United States.[1] Patients with SCI are at high risk for severe medical complications during their hospitalization including decubitus ulcers, deep venous thrombosis and respiratory complications. Rates of post-injury pulmonary events may range from 35 to 95% in those with cervical level SCI.[2–4]

SCI is associated with respiratory muscle weakness and paralysis, which leads to a tendency for ventilation insufficiency and impaired airway clearance.[1] As a result, respiratory complications are the most common cause of death in patients with SCI, with mortality rates of 20–50%.[2,5,6] SCI patients are particularly prone to acute respiratory distress syndrome (ARDS) as a complication of neurological weakness leading to aspiration. Both ARDS and its less severe counterpart, acute lung injury (ALI), are characterized by parenchymal inflammation, diffuse alveolar damage and impaired gas exchange leading to respiratory failure.[7] The diagnostic criteria for ARDS/ALI are based on the American-European Consensus Conference (AECC) on ARDS published in 1994.[8] For ARDS, criteria include hypoxia, partial arterial content of oxygen (PaO_2) to fraction of inspired oxygen (FiO_2) ratio of $\leqslant 200$, and evidence of bilateral pulmonary infiltrates on chest imaging. ALI is defined with all of the above criteria with the exception of a PaO_2/FiO_2 ratio of $\leqslant 300$. In order to diagnose ARDS/ALI, cardiogenic pulmonary edema must be excluded; the absence of left ventricular failure can be seen if a pulmonary artery occlusion pressure via pulmonary artery catheterization is <18 mm Hg, or normal echocardiography.

ARDS/ALI have significant impacts on public health in the United States, with an estimated annual incidence of 75–85/100 000 and an in-hospital mortality of 39%.[9] Limited observational and institutional studies exist about the epidemiology and risk factors of ARDS/ALI in SCI patients, however, the specific relationship between ARDS/ALI and SCI has not been previously reported in large database assessments. This study used the Nationwide Inpatient Sample (NIS) to identify ARDS/ALI in patients admitted for SCI, with and without traumatic VCF. The purpose of the study is to determine national trends in the prevalence, risk factors and mortality for

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VCF/SCI patients with ARDS/ALI using a robust administrative database to examine patterns on an epidemiological level.

MATERIALS AND METHODS

Study design

Data for this study were obtained from the NIS, a database maintained as part of the Healthcare Utilization Project of the Agency for Healthcare Quality and Research. The NIS is the nation's largest all-payer inpatient care database and contains data on approximately 8 million annual hospital stays from 1056 hospitals in 42 states representing a 20% stratified sample of US hospital discharges. Non-federal hospitals encompass the majority of hospitals in the United States including those operated by city and state governments and for-profit and not-for-profit organizations. Detailed information on the design and validation of the NIS is available at http://www.hcup-us.ahrq.gov.

Inclusion criteria

We searched the 1988 through 2008 NIS database for patients age >18 years with primary diagnosis code of (1) fracture of vertebral column without SCI (ICD-9-CM 805.1–805.7); (2) fracture of vertebral column with SCI (806.1–806.7); and (3) SCI without spinal bone injury (952.1–952.4). A total 284 612 cases were identified and further stratified. Other demographics such as age, gender and race were also obtained.

Our methods and criteria for selecting ARDS/ALI were derived from Reynolds and Thomsen.[10,11] Briefly, ICD-9-CM codes 518.5 and 518.82 were first used to identify patients with ARDS/ALI and procedural codes 96.70, 96.71 and 96.72 were then used to select the patients.[10,11] Taken together, these ICD-9-CM codes queried for the descriptors: pulmonary insufficiency following trauma and surgery, ARDS, and continuous mechanical ventilation. Other in-hospital complications and/or comorbidities associated with SCI or ARDS/ALI were also identified and include epilepsy, sepsis, cardiovascular dysfunction, hepatic pathologies, renal dysfunction and metabolic disorders.[12–15] A complete list of ICD-9-CM codes can be found in the Supplementary Appendix.

Hospitals were divided by type into urban-academic, urban-private and rural. Hospital sizes were categorized as small to medium ($\leqslant 300$ beds), large (301–499 beds) and extra large (>500 beds).[16] Patients were excluded from the analysis if no disposition was recorded. The exposure variable of interest was ARDS/ALI, coded in binary. The primary outcome measure was in-hospital mortality.

ICD-9-CM validation

We have previously validated the methodology for ARDS/ALI ascertainment as described by Rincon *et al.*[17] in a prior NIS study on ARDS/ALI in traumatic brain injury patients. Briefly, cases of ARDS/ALI admitted to a sea-level hospital in 2011 with ARDS/ALI ICD-9-CM coding were matched with controls without ARDS/ALI ICD-9-CM codes in their discharge records. ARDS/ALI was deemed to be present when the AECC definitions were met.

Statistical analysis

The NIS is based on a complex survey design that includes discharge weights, stratification over various hospital and regional factors, and clustering around individual hospitals; the purpose of this complex survey design is to achieve more accurate national estimates from the 20% sample of US hospital discharges. The χ^2 test and the Wilcoxon-rank tests were used to determine differences in demographics, hospital characteristics, comorbidities, in-hospital complications and outcomes. Multivariate analysis was first used to identify significant risk factors from candidate variables. Then, multivariable logistic regression modeling was used to calculate odds ratios (OR) and 95% confidence interval (CI). In all multivariate analyses, all factors of interest were included and systematically removing the least significant factor and recalculating the model found parsimonious models. For the validation study we calculated: sensitivity, positive predictive value and receiver operator characteristic curve. The analysis was conducted using structured query language and the LME-4 package (ver. 0.99, R Foundation for Statistical Computing, GNU Open Source, http://CRAN.R-project.org/package=lme4) in the R programming language for statistical computing (ver. 2.11, R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, http://www.R-project.org/). Statistical significance was judged when $P<0.05$.

RESULTS

Between 1988 and 2008, there were >750 million hospitalizations nationwide; 284 612 fulfilled our primary inclusion criteria. Among those admissions, 247 019 were VCFs without SCI. A total of 12 439 were SCI without evidence of fracture and 25 154 were SCI with either open or closed fractures. ARDS/ALI was observed in 32% (standard error 1.2%) of SCI patients with open fracture, 21% (s.e. 0.26%) in SCI patients with closed fracture, 9% (s.e. 0.26%) in SCI patients without fracture and only 2.4% (s.e. 0.03%) in patients with closed fracture but no SCI (Figure 1). Overall, ARDS/ALI was observed in 17% of patients with SCI and 2.5% in patients without. Patients with SCI were more likely to develop ARDS/ALI than patients without SCI (OR 4.9, 95% CI 4.7–5.2, $P<0.001$). Independent of SCI, patients with open VCF were more likely to develop ARDS than those without (OR 8.1, 95% CI 6.9–9.5, $P<0.001$; Table 1).

The prevalence of ARDS/ALI in thoracic, lumbar and sacral fractures were 3.2%, 1.3% and 1.6% respectively. The prevalence of ARDS/ALI was 11% in patients with cervical fractures, increasing from 8.1% in 1993. Annual trends are in Figure 2. Compared with patients with lumbar fractures, those with cervical (OR 4.8, 95% CI 4.5–5.2, $P<0.001$), thoracic (OR 1.9, 95% CI 1.7–2.0, $P<0.001$) and sacral fractures (OR 1.2, 95% CI 1.0–1.5, $P<0.01$) were more likely to develop ARDS/ALI (Table 1).

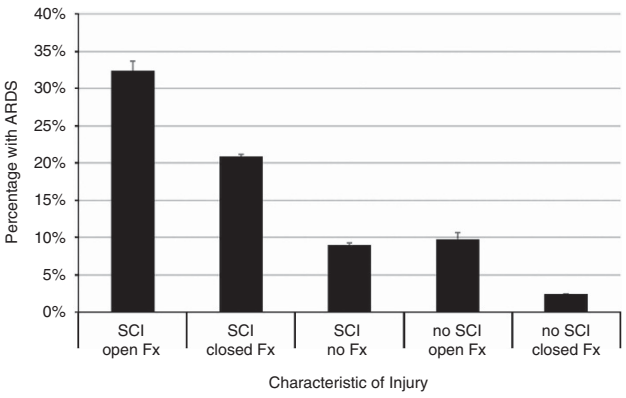

Figure 1 Prevalence of ARDS in patients with SCI or no SCI, stratified by fracture status, demonstrating that ARDS is most common in patients with open fracture and SCI and least common in patients with closed fracture without SCI. Fx, fracture.

Table 1 Multivariate analysis of the risk of VCF and SCI on ARDS/ALI

	OR	*95% Low*	*95% Upper*	P-*value*
SCI (vs no SCI)	4.91	4.65	5.19	<0.001
Open fracture (any level)	8.12	6.93	9.52	<0.001
Closed fracture (any level)	3.36	3.07	3.68	<0.001
Cervical fracture/SCI (vs lumbar)	4.85	4.51	5.21	<0.001
Thoracic fracture/SCI (vs lumbar)	1.86	1.71	2.01	<0.001
Sacral fracture/SCI (vs lumbar)	1.23	1.03	1.45	<0.01
Cadua equina/SCI (vs lumbar)	1.03	0.142	7.47	<0.001

Abbreviations: ALI, acute lung injury; ARDS, acute respiratory distress syndrome; OR, odds ratio; SCI, spinal cord injury; VCF, vertebral column fracture.
Patients with SCI were 4.9 times more likely to develop ARDS/ALI while those with open fractures were 8 times more likely than those without fractures.

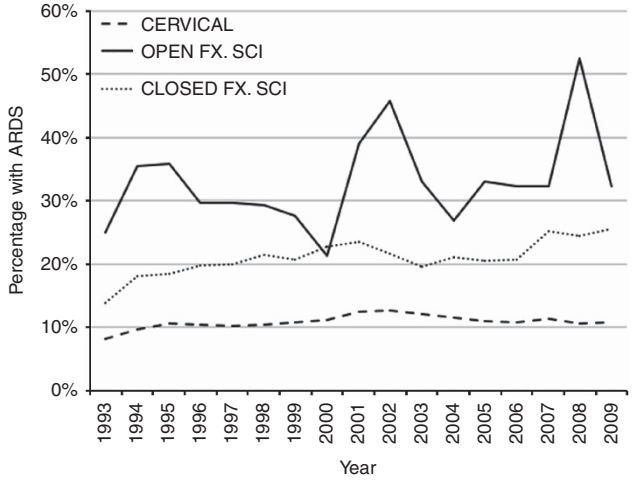

Figure 2 National trends from 1993 to 2009 of ARDS in patients with cervical fracture, open fracture with SCI or closed fracture with SCI. Fx, fracture.

ARDS/ALI was statistically more prevalent ($P<0.01$) in VCF/SCI patients who are Hispanic or native American or treated in a medium/large urban-private hospital (Table 2). This relationship was also found in conjunction with comorbidities such as epilepsy, congestive heart failure (CHF), hypertension, chronic obstructive pulmonary disease and hospital complications such as sepsis, cardiac arrest, renal insufficiency, liver disease and hematological disorders ($P<0.001$). Patients with female gender (OR 0.63, 95% CI 0.59–0.67, $P<0.001$), elective procedure (OR 0.49, 95% CI 0.43–0.55, $P<0.001$), treatment at rural practice setting (OR 0.53, 95% CI 0.47–0.61, $P<0.001$), and interestingly, comorbidities such as coronary artery disease (OR 0.61, 95% CI 0.55–0.68, $P<0.001$) and diabetes (OR 0.84, 95% CI 0.77–0.91, $P<0.001$) were less likely to develop ARDS/ALI (Table 2).

VCF/SCI patients with ARDS/ALI were much more likely to expire in-hospital than those without ARDS/ALI (OR 6.5, 95% CI 6.0–7.1, $P<0.001$). Patients with cervical vertebral fractures with and without SCI were more likely to expire in-hospital (OR 3.1, 95% CI 2.8–3.4, $P<0.001$) than those with thoracic, lumbar and sacral lesions. Independent of VCF or ARDS/ALI, patients with SCI were more likely to die in-hospital compared with those without SCI (OR 3.5, 95% CI 3.2–3.8, $P<0.001$; Table 3, Figure 3). Comorbidities and hospital complications such as epilepsy (OR 17, 95% CI 7.5–42, $P<0.001$), cardiac arrest (OR 22, 95% CI 19–26, $P<0.001$), sepsis (OR 3.6, 95% CI 3.1–4.1, $P<0.001$), hypertension (OR 3.5, 95% CI 2.9–4.1, $P<0.001$) and liver disease (OR 5.8, 95% CI 3.9–8.4, $P<0.001$) were positively associated with increased mortality in patients with VCF/SCI without ARDS/ALI. As was the case for ARDS/ALI, patients with female gender, elective procedure, coronary artery disease and diabetes were less likely to die after VCF/SCI ($P<0.001$; Table 4).

Patients who developed ARDS/ALI had a mean hospital stay of 25 days (30–440 days) while patients without ARDS/ALI stayed a mean of 6 days (7–868 days, OR 2.4, 95% CI 2.36–2.44, $P<0.001$). Patients with SCI, open fracture and closed fracture were 2.2 (95% CI 2.19–2.25, $P<0.001$), 1.7 (95% CI 1.66–1.79, $P<0.001$) and 1.6 (95% CI 1.55–1.62, $P<0.001$) times more likely to have longer length of stay, respectively (Table 5). Those with open fracture and SCI stayed a mean of 22 ± 8 days while patients with closed fracture and no SCI stayed a mean of $5.6\pm$ days.

Table 2 Multivariate analysis of predictors of ARDS/ALI after admission for VCF/SCI

	OR	*95% Low*	*95% Upper*	P-*value*
Demographics				
Age (year)	0.996	0.995	0.998	<0.001
Female	0.633	0.599	0.669	<0.001
Elective procedure	0.488	0.434	0.549	<0.001
Black (vs White)	0.976	0.901	1.06	NS
Asian (vs White)	1.01	0.827	1.22	NS
Hispanic (vs White)	1.13	1.04	1.24	<0.001
Native American (vs White)	1.44	1.09	1.88	<0.01
Other (vs White)	1.02	0.883	1.19	NS
Hospital characteristics				
Rural (vs urban-academic)	0.535	0.467	0.611	<0.001
Urban-private (vs urban-academic)	1.49	1.42	1.59	<0.001
Medium (vs small)	1.59	1.39	1.81	<0.001
Large (vs small)	1.85	1.64	2.10	<0.001
Comorbidities				
Epilepsy	9.14	3.15	26.6	<0.001
Diabetes	0.838	0.769	0.912	<0.001
Hypertension	4.33	3.62	5.19	<0.001
COPD	1.44	1.32	1.58	<0.001
CHF	1.69	1.53	1.86	<0.001
Coronary artery disease	0.612	0.552	0.678	<0.001
Hospital complications				
Sepsis	8.59	7.65	9.66	<0.001
Cardiovascular dysfunction	2.69	2.46	2.97	<0.001
Renal dysfunction	2.06	1.87	2.27	<0.001
Hepatic dysfunction	2.39	1.64	3.51	<0.001
Hematological dysfunction	2.92	2.58	3.30	<0.001
Neurological dysfunction	3.72	3.35	4.14	<0.001
Cardiac arrest	14.0	11.8	16.7	<0.001

Abbreviations: ALI, acute lung injury; ARDS, acute respiratory distress syndrome; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; NS, not significant; OR, odds ratio; SCI, spinal cord injury; VCF, vertebral column fracture.

Table 3 Multivariate analysis of the risk of VCF, SCI and ARDS on mortality

	OR	*95% Low*	*95% Upper*	P-*value*
SCI (vs no SCI)	3.45	3.15	3.78	<0.001
ARDS (vs no ARDS)	6.55	6.03	7.11	<0.001
Open fracture (any level)	2.79	2.04	3.84	<0.001
Closed fracture (any level)	2.09	1.83	2.39	<0.001
Cervical fracture/SCI (vs lumbar)	3.08	2.82	3.37	<0.001
Thoracic fracture/SCI (vs lumbar)	1.09	0.991	1.21	NS
Sacral fracture/SCI (vs lumbar)	1.05	0.864	1.27	NS
Cadua equina/SCI (vs lumbar)	5.56	1.29	24.0	<0.05

Abbreviations: ARDS, acute respiratory distress syndrome; NS, not significant; OR, odds ratio; SCI, spinal cord injury; VCF, vertebral column fracture.
In-hospital diagnosis of ARDS was associated with 6.5-fold increase in risk of death.

DISCUSSION

Respiratory complications contribute significantly to the mortality of patients who have suffered SCI.[2,5] Although atelectasis and pneumonia have been cited as the most common of these

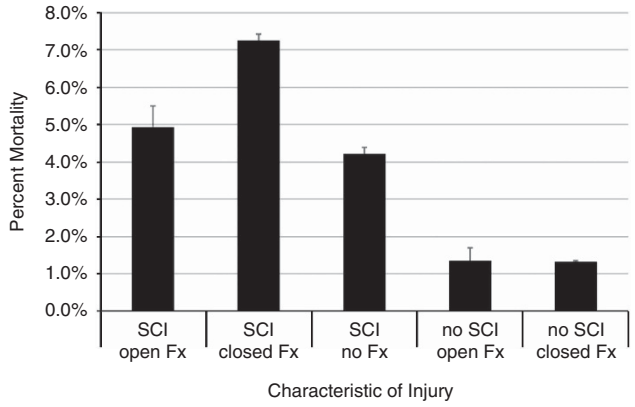

Figure 3 Mortality rates based on characteristic of injury, illustrating that patients with SCI and closed fracture had highest rates of mortality. Fx, fracture.

Table 4 Predictors of mortality after admission for VCF/SCI stratified by demographics, hospital characteristics, comorbidities and in-stay complications

	OR	*95% Low*	*95% Upper*	P-*value*
Demographics				
Age (year)	1.06	1.05	1.06	<0.001
Female	0.685	0.639	0.736	<0.001
Elective procedure	0.618	0.538	0.709	<0.001
Hospital characteristics				
Rural (vs urban-academic)	0.964	0.856	1.09	NS
Urban-private (vs urban-academic)	1.13	1.05	1.22	<0.001
Comorbidities				
Epilepsy	17.8	7.51	42.1	<0.001
Hypertension	3.47	2.91	4.13	<0.001
COPD	1.49	1.36	1.64	<0.001
CHF	2.13	1.953	2.32	<0.001
Coronary artery disease	0.849	0.772	0.934	<0.001
Hospital complications				
Sepsis	3.56	3.12	4.06	<0.001
Cardiovascular dysfunction	2.49	2.23	2.79	<0.001
Renal dysfunction	2.86	2.59	3.15	<0.001
Hepatic dysfunction	5.76	3.96	8.37	<0.001
Hematological dysfunction	1.92	1.65	2.23	<0.001
Neurological dysfunction	2.98	2.65	3.36	<0.001
Cardiac arrest	22.4	19.1	26.2	<0.001

Abbreviations: CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; NS, not significant; OR, odds ratio; SCI, spinal cord injury; VCF, vertebral column fracture.

pulmonary complications, ARDS/ALI is often considered the most deleterious. This study details a high prevalence of ARDS/ALI in patients with SCI compared with VCF patients without SCI. This prevalence has increased gradually from 1993 to 2009, a trend that mirrors that of the general population. This may be secondary to the publication of AECC diagnostic criteria on ARDS in 1994 and by better diagnostic definitions, epidemiologic variables, comorbid conditions and changing economic incentives for better coding and billing.

Table 5 Multivariate analysis of the risk of VCF, SCI and ARDS on length of hospitalization

	OR	*95% Low*	*95% Upper*	P-*value*
SCI (vs no SCI)	2.22	2.19	2.25	<0.001
ARDS (vs no ARDS)	2.40	2.36	2.44	<0.001
Open fracture (any level)	1.73	1.66	1.79	<0.001
Closed fracture (any level)	1.59	1.55	1.62	<0.001
Cervical fracture/SCI (vs lumbar)	1.08	1.06	1.09	<0.001
Thoracic fracture/SCI (vs lumbar)	1.01	0.993	1.02	NS
Sacral fracture/SCI (vs lumbar)	1.12	1.09	1.15	<0.001
Cadua equina/SCI (vs lumbar)	0.883	0.666	1.17	NS

Abbreviations: ARDS, acute respiratory distress syndrome; NS, not significant; OR, odds ratio; SCI, spinal cord injury; VCF, vertebral column fracture.

In our cohort, Hispanic and native American males were at a higher risk of developing ARDS/ALI. This national trend is not exclusive to SCI. For instance, a recent study on traumatic brain injury victims demonstrated that African-American race had a negative association with regards to ARDS/ALI and Hispanic race was associated with a higher mortality and case fatality.[18] For both traumatic brain injury and SCI, these ethnicity/gender differences could be related to genetic or hormonal factors that predispose to ARDS/ALI, discrepancies in susceptibility to risk factors for ARDS/ALI or because of disparities in the access to specific therapies for ARDS/ALI.[19] More detailed investigations will be required to improve our understanding of this risk factor.

Most studies have demonstrated that respiratory complications are not only more prevalent but also more severe in patients with cervical level SCI, with incidences as high as 90% in one report.[2–5] These findings were summarized and re-iterated in the 2002 Guidelines for the Management of Acute Cervical Spine and Spinal Cord Injuries.[20] Subsequent reports have indicated that high thoracic SCI have an increased risk of pneumonia and death compared with low thoracic, lumbar and sacral SCI.[5] Our nationwide cohort demonstrated that the prevalence of and the risk for developing ARDS/ALI were higher in both cervical and thoracic lesions. Pathophysiologically, cervical and thoracic SCI causes loss of sympathetic innervations to the airway, leading to cholinergic hyper-activation and bronchoconstriction. The need for intubation in patients with SCI has been cited to be as high as 87% in those with C1–C4 involvement.[6] In our data, cervical fractures/SCI still represent the most concerning cohort and were linked with a threefold higher risk for mortality compared with all other vertebral levels. Our study confirms the national consensus that among SCI patients, those with cervical and thoracic injuries should warrant intensive and aggressive monitoring as well as treatment.

In clinical trials and cohort studies, most of the cases of ARDS/ALI are related to pneumonia, sepsis and trauma.[19] A small subset of aspiration events could be due to dysphagia stemming as a complication of anterior cervical decompression and fusion procedures, which are utilized to stabilize VCF. Other risk factors for ARDS/ALI that have been reported in the literature include: drug reactions, burns, inhalation injuries, pancreatitis, amniotic fluid embolism and blood transfusions. Although patients with SCI are predisposed to deep vein thrombosis and subsequent pulmonary embolus, a direct etiological relationship between PE and ARDS/ALI is rarely seen.[21,22] Although limited by the administrative nature of the NIS database, an interesting avenue of further study could be to

examine whether the prevalence of pulmonary embolus/deep vein thrombosis is higher in SCI with ARDS versus SCI without ARDS. Risk factors associated with ARDS/ALI in our SCI cohort included epilepsy, hypertension, CHF and hypertension, whereas coronary artery disease and diabetes were less associated with ARDS/ALI. In-hospital complications such as sepsis and cardiac arrest were associated with significant ARDS/ALI and much higher mortality. It is possible that hypertension and CHF may have confounded the association with ARDS/ALI, since some of these patients present with cardiogenic or hydrostatic pulmonary edema. The resulting injury on the lungs could be misdiagnosed as ARDS/ALI, which is strictly defined after ruling out cardiogenic edema. ARDS/ALI were less likely to develop in patients with diabetes and coronary artery disease, a statically significant but possibly clinically irrelevant finding, given the retrospective nature of this study and other confounding factors.

There also appears to be a negative association between rural hospitals and the development of ARDS/ALI. This association is likely the result of selection bias, because the urban-academic centers act as referral centers for severely ill patients from these smaller and less resource-intensive hospitals. Therefore, the majority of patients diagnosed and treated for ARDS/ALI will be within the urban-academic cohort. With this particular finding, studies able to capture the severity of burn patients at each hospital type will contribute significantly to elucidating the reasons for our finding.

Limitations

Although the size and breadth of our sample allow for improved understanding of VCF/SCI and ARDS/ALI, our data are limited to the NIS database. The NIS database represents a 20% stratified sample of US hospital discharges and as such, does not capture the full yearly incidences of SCI (estimated ~11 000 per year overall in the United States, calculated to be ~1200 per year in the NIS sample set). The NIS is unable to identify individual patients and re-admissions for complications were not included in this study. The study design was retrospective and observational and does not include prospective interventions. There is also considerable debate regarding the accuracy of using ICD-9-CM codes to identify ARDS/ALI patients for large database studies. There may be an underestimation of the true prevalence of ARDS/ALI within VCF/SCI admissions. There are also other factors that may influence true outcomes that were not well captured by ICD-9 coding, such as multiple trauma, ASIA impairment scale, temporal changes in care/diagnostics and multiple trauma. The authors are aware that the lack of specific granularity for accuracy of diagnosis through an administrative database is the most concerning limitation, however, our study does provide insight into the relationship between VCF, SCI and ARDS/ALI and summarized national trends in morbidity and mortality.

CONCLUSION

Our analysis demonstrates that ARDS/ALI is a common complication in patients with VCF/SCI. In particular, patients with cervical VCF/SCI, open VCF with and without SCI, and those with comorbidities such as CHF and epilepsy are more at risk for ARDS/ALI, which carries significantly higher risk of mortality. A high suspicion of ARDS/ALI should be maintained in these particular patients who present with SCI, and thus aggressive and meticulous care should be exercised in the management of these patients given their propensity for rapid clinical decline and high rate of mortality.

DATA ARCHIVING

There were no data to deposit.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Supplementary Information accompanies this paper on the Spinal Cord website (http://www.nature.com/sc)