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Cervical spinal cord injury after blunt assault: Just a pain in the neck?

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ABSTRACT

Background: We aimed to determine the incidence, risk factors, and outcomes of cervical spinal cord injury (CSCI) after blunt assault.

Methods: The ACS National Trauma Data Bank (NTDB) 2012 Research Data Set was used to identify victims of blunt assault using the ICD-9 E-codes 960.0, 968.2, 973. ICD-9 codes 805.00, 839.00, 806.00, 952.00 identified cervical vertebral fractures/dislocations and CSCI. Multivariable analyses were performed to identify independent predictors of CSCI.

Results: 14,835 (2%) out of 833,311 NTDB cases were blunt assault victims and thus included. 217 (1%) had cervical vertebral fracture/dislocation without CSCI; 57 (0.4%) had CSCI. Age ≥55 years was independently predictive of CSCI; assault by striking/thrown object, facial fracture, and intracranial injury predicted the absence of CSCI. 25 (0.02%) patients with CSCI underwent cervical spinal fusion.

Conclusions: CSCI is rare after blunt assault. While the odds of CSCI increase with age, facial fracture or intracranial injury predicts the absence of CSCI.

Summary: The incidence, risk factors, and outcomes of cervical spinal cord injury (CSCI) after blunt assault was investigated. 14,835 blunt assault victims were identified; 217 had cervical vertebral fracture/dislocation without CSCI; 57 had CSCI. Age ≥55 years was found to independently predict CSCI, while assault by striking/thrown object, facial fracture, and intracranial injury predicted the absence of CSCI.

Introduction

Blunt trauma patients, especially patients with trauma to the head and neck or with an altered level of consciousness, are at risk for cervical spine injury (CSI). CSI may be devastating if accompanied by cervical spinal cord injury (CSCI). Thus, it is of great importance to maintain cervical spine stabilization of patients with a potentially unstable injury, and clinicians often go to great lengths to avoid potential secondary injury. Stabilization of the cervical spine using a cervical collar is recommended until the cervical spine can be adequately assessed by physical exam, computerized tomography (CT) scan, or magnetic resonance imaging (MRI).[1–4] However, unnecessary and prolonged use of the cervical collar can also cause harm, as cervical collar treatment has been associated with an increased risk of complications such as increased intracranial pressure, delirium, swallowing dysfunction, and pressure ulceration.[5,6]

When evaluating a trauma patient with a potential injury to the cervical spine and deciding on possible protection measures to be taken (e.g. cervical collar), it may be highly relevant to consider the mechanism of injury. The reported rates of CSI and CSCI following blunt trauma range from 2 to 5%.[7–10] However, the incidence of CSI and CSCI vary significantly depending upon the mechanism of injury. Higher rates are typically seen after high-energy transfers such as motor vehicle or motorcycle crashes,[11,12] whereas other

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blunt mechanisms of injury are much less likely to result in CSI or CSCI. The aim of this study was to determine the incidence and describe the outcome of CSI and CSCI after blunt assault (hands, feet or blunt instruments) to the neck, head, or face using the American College of Surgeons' (ACS) National Trauma Data Bank (NTDB).

Materials and methods

The NTDB contains data from over 900 registered U.S. trauma centers. This study was approved by the ACS Committee on Trauma and was granted exemption from review by our local institutional review board. The NTDB remains the full and exclusive copyrighted property of the ACS. The ACS is not responsible for any claims arising from works based on the original data, text, tables, or figures. We used the 2012 NTDB Research Data Set (Version: October 2013, issued in March 2014) to identify incidents of blunt assault using the following ICD-9-CM E-codes: 960.0 ('unarmed fight or brawl'), 968.2 ('assault by striking by blunt or thrown object'), 973 ('injury due to legal intervention by blunt object'). Cases with additional mechanisms of injuries and those with Glasgow Coma Score (GCS) qualifiers were excluded from analysis. ICD-9-CM codes were used to identify cervical vertebral fractures (805.00–805.18), cervical vertebral dislocations (839.00–839.18), and CSCI with or without cervical vertebral fracture (806.00–806.19, 952.00–952.09) for the included cases of blunt assault. Associated injuries to the face and/or head were identified as fractures of the skull or face (800–804), cervical ligamentous injury (847.0), intracranial injury (850–854), and injury to blood vessels of the head or neck (900). Additionally, data on demographics, vital signs on admission, intoxication, injury severity, emergency department (ED) disposition, and cervical injury related procedures were extracted for all included cases. Cervical spinal fusion or refusion (ICD-9-CM procedure codes 81.01–81.03, 81.31–81.33) and external cervical spinal traction (93.41, 93.42) were considered related procedures. Data on hospital discharge disposition, length of stay (LOS), and mortality were also extracted.

Cases of blunt assault were compared according to assault type, i.e. unarmed versus blunt object, and according to injury outcome, i.e. no cervical vertebral fracture, dislocation, or CSCI versus cervical vertebral fracture and/or dislocation without CSCI versus CSCI.

Univariate analyses were performed to compare cases of unarmed and armed assault, and to identify predictors of cervical vertebral fracture and/or dislocation without CSCI and CSCI, respectively. Multivariable regression analyses were performed to identify independent predictors of any cervical injury, cervical vertebral fracture and/or dislocation without CSCI, and CSCI, respectively. Cases with missing key data were excluded from analysis.

The statistical analyses were performed using the STATA Software (Version 13.1). Numerical variables were summarized as means and standard deviations or as medians with 25th and 75th interquartile range and compared using two-sample *t*-test, or one-way ANOVA. Categorical variables were summarized as frequencies and percentages, and compared using Chi-squared test. A p-value of less than 0.05 was considered statistically significant.

Results

Out of 833,311 unique trauma cases in the 2012 NTDB dataset, 14,835 (2%) victims of blunt assault were identified and included in the analysis. The characteristics for the entire study population are displayed in Table 1. There were 9914 (67%) cases of unarmed assault, and 4921 (33%) victims of assault with blunt objects. Blunt assault (unarmed and with blunt object) resulted in cervical injury in 274 (2%) cases, of whom 217 (1%) had a cervical vertebral fracture and/or dislocation without CSCI, and 57 (0.4%) were found to have CSCI. 24 of the cases with CSCI had an associated cervical vertebral fracture and/or dislocation.

Table 1 also presents the univariate analysis stratified according to the presence and type of cervical injury. Cases with cervical injury (cervical vertebral fracture and/or dislocation without CSCI or CSCI) were older (41.4 (14.5) and 45.6 (13.0), vs. 37.3 (13.6) years, $p < 0.001$), and had a higher rate of vascular injuries (5 (2%) and 2 (4%), vs. 69 (0.5%), $p < 0.001$), but had a lower incidence of facial fractures (74 (34%) and 9 (16%), vs. 7444 (51%), $p < 0.001$) than cases without cervical injury. Five cases with cervical vertebral fracture and/or dislocation without CSCI were treated with external traction compared to none of the cases with CSCI. There was no difference in time to cervical spinal fusion/re-fusion between the two groups (43 [28–83] vs. 40 [24–131] hours, $p = 1.000$). Cases with CSCI had longer intensive care unit (ICU) and hospital LOS compared to cases with cervical fracture/dislocation and cases without cervical injury, respectively (ICU LOS: 2 [0–5] days vs. 0 [0–2] days and 0 [0–1] days, $p < 0.001$; hospital LOS: 7 [4–13] days vs. 3 [2–5] days and 3 [2–4] days, $p < 0.001$). In terms of hospital discharge disposition, 51% of cases with CSCI were discharged home compared to 84% of cases with cervical fracture and/or dislocation and 90% of cases without cervical injury ($p < 0.001$).

In the multivariable regression analysis (Table 2) age $\geq$55 was an independent predictor of CSCI (OR 2.23 [95% CI: 1.21–4.12], $p = 0.010$), whereas assault with blunt object (OR 0.49 [95% CI: 0.26–0.93], $p = 0.030$), associated facial fracture (OR 0.17 [95% CI: 0.08–0.34], $p < 0.001$), and intracranial injury other than concussion (OR 0.21 [95% CI: 0.08–0.59], $p = 0.003$) predicted the absence of CSCI.

Two (0.01%) cases without cervical vertebral fracture and/or dislocation without CSCI or CSCI ($n = 14,561$) underwent cervical spinal fusion. One (0.007%) of the two had a cervical ligamentous injury. A detailed presentation of these two patients is provided in Table 3.

Discussion

In this large, nationwide study we found that following blunt assault, cervical vertebral fracture and/or dislocation is uncommon and CSCI is extremely rare. For the group of patients sustaining cervical vertebral fracture and/or dislocation operative intervention or external traction is very rare. While almost half of the patients with CSCI received surgical stabilization, most operations were performed in a delayed fashion. Additionally, we found that the odds of a blunt assault resulting in CSCI increases with increasing age, but is decreased when associated facial fracture or intracranial injury is present.

When comparing our findings with previous studies of CSI following blunt assault, our study reports a slightly higher incidence of cervical vertebral fracture and/or dislocation and CSCI.[13–18] The most recent study of a similar patient population is a retrospective case review by Hadjizacharia et al., where 3286 patients from a single institution were reviewed. Only 11 patients (0.003%) were found to have a cervical vertebral fracture and/or dislocation and none sustained a CSCI.[14] In another study by Rhee et al., 18 (0.41%) and 6 (0.14%) patients out of a total of 4390 patients from three institutions sustained cervical vertebral fracture and/or dislocation and CSCI, respectively.[17] Three additional smaller studies reported rates of cervical vertebral fracture and/or dislocation between 0 and 1%, and none identified patients with CSCI following blunt assault.[13,16,18]

When studying rare injuries it is necessary to study a large cohort in order to obtain a sufficiently large sample size of cases. One of the strengths of our study in comparison with previous

Table 1
Demographics, emergency department characteristics, assault type, injury characteristics, injury-related procedures, and outcomes for all cases of blunt assault and separated by presence and type of cervical injury.

	Total (n = 14,835) n (%)	No cervical vertebral fracture or CSCI (N = 14,561) n (%)	Cervical vertebral fracture and/or dislocation (N = 217) n (%)	CSCI (N = 57[a]) n (%)	p-value
Male gender (%)	13,040 (88)	12,806 (88)	183 (84)	51 (89)	0.251
Age (years), mean (SD)	37.4 (13.6)	37.3 (13.6)	41.4 (14.5)	45.6 (13.0)	<**0.001**
Age ≥ 55		1722 (11.8)	47 (21.7)	14 (24.6)	<**0.001**
Race					**0.010**
White	7625 (51)	7487 (51)	108 (50)	30 (53)	
Black or African American	3915 (26)	3820 (26)	72 (33)	23 (40)	
Other race/not known	2669 (18)	2636 (18)	30 (14)	3 (5)	
American Indian/Asian/Native Hawaiian/Pacific Islander	626 (4)	618 (4)	7 (3)	1 (2)	
Payment					0.365
Self pay	4986 (34)	4899 (34)	66 (30)	21 (37)	
Government	4805 (32)	4700 (32)	82 (38)	23 (40)	
Private	3025 (20)	2977 (20)	41 (19)	7 (12)	
Other or Unknown	2019 (14)	1985 (14)	28 (13)	6 (11)	
Emergency Department					
SBP (mm Hg), mean (SD)	137 (22)	137 (22)	136 (21)	132 (31)	0.361
HR, mean (SD)	91 (19)	91 (19)	90 (20)	87 (22)	0.381
RR, mean (SD)	18 (5)	18 (5)	18 (6)	17 (4)	0.517
Oxygen Saturation, mean (SD)	98 (6)	98 (6)	97 (7)	97 (3)	1.000
Mechanical and/or external support of respiration	790 (6)	768 (6)	19 (9)	3 (5)	0.107
GCS					0.883
3-12	1693 (12)	1657 (12)	31 (14)	5 (9)	
13	418 (3)	410 (3)	8 (4)	0 (0)	
14	1451 (10)	1426 (10)	17 (8)	8 (14)	
15	10,819 (75)	10,617 (75)	158 (74)	44 (77)	
ISS, median (IQR)	6 (4–12)	6 (4–12)	9 (5–13)	16 (10–21)	<**0.001**
≤ 15	12,271 (83)	12,074 (83)	172 (79)	25 (44)	<**0.001**
>15	2564 (17)	2487 (17)	45 (21)	32 (56)	
Alcohol Intoxication	6431 (43)	6300 (43)	103 (47)	28 (49)	0.315
Drug Intoxication	4224 (28)	4130 (28)	74 (34)	20 (35)	0.096
ED Disposition					<**0.001**
Floor bed/Telemetry/step-down unit/ Observation unit	9703 (65)	9570 (66)	112 (52)	21 (37)	
Intensive Care Unit	3993 (27)	3867 (27)	95 (44)	31 (54)	
Operating room	1139 (8)	1124 (8)	10 (5)	5 (9)	
Assault					0.137
Unarmed fight or brawl	9914 (67)	9727 (67)	142 (65)	45 (79)	
Assault by striking or by blunt or thrown object (incl. legal intervention)	4921 (33)	4834 (33)	75 (35)	12 (21)	
Associated injuries					
Skull fracture	3100 (21)	3051 (21)	44 (20)	5 (9)	0.076
Facial fracture	7527 (51)	7444 (51)	74 (34)	9 (16)	<**0.001**
Intracranial injury	6225 (42)	6119 (42)	88 (41)	18 (32)	0.256
Concussion	2883 (19)	2828 (19)	41 (19)	14 (25)	0.087
Other	3342 (23)	3291 (23)	47 (22)	4 (7)	
Vascular injury, head or neck	76 (0.5)	69 (0.5)	5 (2)	2 (4)	<**0.001**
Related procedures					
Cervical spinal fusion or refusion	44 (0.3)	2 (0.01)	17 (8)	25 (44)	<**0.001**
Hours to procedure, mean (SD)	–	121 (61)	70 (89)	69 (72)	1.000
Hours to procedure, median (IQR)	–	121 (78–164)	43 (28–83)	40 (24–131)	
External spinal traction	7 (0.05)	2 (0.01)	5 (2)	0 (0)	<**0.001**
Hours to procedure, mean (SD)	–	1 (2)	305 (400)	N/A	0.396
Hours to procedure, median (IQR)	–	1 (0.1–2.4)	305 (22–587)	N/A	
Hospital discharge disposition					<**0.001**
Discharged home	13,283 (90)	13,071 (90)	183 (84)	29 (51)	
Transferred to rehabilitation/skilled nursing facility/intermediate care facility	950 (6)	902 (6)	24 (11)	24 (42)	
Left against medical advice or discontinued care	422 (3)	415 (3)	5 (2)	2 (4)	
Expired	165 (1)	158 (1)	5 (2)	2 (4)	
Discharged/Transferred to hospice care	15 (0.1)	15 (0.1)	0 (0)	0 (0)	
Hospital LOS (days), median (IQR)	3 (2–4)	3 (2–4)	3 (2–5)	7 (4–13)	<**0.001**
ICU LOS (days), median (IQR)	–	0 (0–1)	0 (0–2)	2 (0–5)	<**0.001**
Ventilator days, median (IQR)	–	0 (0–0)	0 (0–0)	0 (0–0)	<**0.001**

CSCI, cervical spinal cord injury; SD, standard deviation; SBP, systolic blood pressure; HR, heart rate, RR, respiratory rate; GCS, Glasgow Coma Scale score; ISS, injury severity score; IQR, interquartile range; ED, emergency department; LOS, length of stay; ICU, intensive care unit.
P-values below 0.05 are marked in bold.
[a] 24 cases in this group also had a cervical vertebral fracture and/or dislocation.

Table 2
Independent predictors of cervical spinal cord injury for patients with blunt assault (multivariable regression analysis).

Independent variable	CSCI Odds Ratio (95% CI)	p-value
Age ≥ 55	2.23 (1.21–4.12)	**0.010**
Race (reference: White)		
Black or African American	1.48 (0.85–2.58)	0.161
Other race/not known	0.31 (0.10–1.03)	0.056
American Indian/Asian/Native Hawaiian/Pacific Islander	0.42 (0.06–3.13)	0.401
Emergency Department		
Alcohol Intoxication (reference: Not intoxicated)	1.30 (0.76–2.20)	0.337
Drug Intoxication (reference: Not intoxicated)	1.32 (0.76–2.30)	0.326
Assault (reference: Unarmed fight or brawl)		
Assault by striking or by blunt or thrown object (incl. legal intervention)	0.49 (0.26–0.93)	**0.030**
Associated injuries		
Skull fracture	0.62 (0.24–1.57)	0.312
Facial fracture	0.17 (0.08–0.34)	<**0.001**
Intracranial injury other than concussion	0.21 (0.08–0.59)	**0.003**

CSCI, cervical spinal cord injury; CI, confidence interval.
P-values below 0.05 are marked in bold.

studies is the large sample size and broad geographic representation. This may also explain our slightly higher incidence of both cervical vertebral fracture and/or dislocation and CSCI, as former studies may suffer from too small sample sizes to determine the true incidence of cervical vertebral fracture and/or dislocation and CSCI following blunt assault.

The results of the present study, as well as previous studies, clearly indicate that CSCI is extremely rare after blunt assault. While cervical fracture is more common, it is detectable on a high resolution CT scan. A CT scan is performed for most patients with head and/or neck trauma, and a fracture/dislocation is an injury that is unlikely to be missed. In the absence of fracture or other abnormalities on the CT scan and no clinical evidence of spinal cord injury, the clinician should feel comfortable removing the cervical collar for patients with a blunt assault mechanism of injury. Additional imaging (i.e. MRI) should be reserved for patients with risk factors (e.g. high age) or abnormal cervical spine CT findings.[19] Furthermore, unlike CSCI from high-energy mechanism injuries (e.g. diving accidents, motor vehicle collisions), we found that the majority of CSCI after blunt assault are *not* devastating. This is inferred from the low mortality rate and high rate of home discharge reported in the CSCI-group in this study.

With this study we have taken one more step towards identifying specific predictors of CSCI after blunt assault. We have identified the presence of intracranial injury and facial fracture to be predictive of the absence of CSCI following blunt assault. It may be that the vector of the force applied in the assault is different in assaults resulting in intracranial injury or facial fracture than assaults resulting in CSCI. Another potential explanation for this finding is that the face acts as a "crumple zone" for the neck, i.e. absorbing a significant part of the energy of impact and thereby protecting the neck from injury.

Our study is limited by its retrospective design and the use of a large national trauma database, which, by its very nature, has several limitations. First, the data that was available to us is only as accurate as the original data submitted by the individual hospitals supplying data to the NTDB. For example, we only identified two cases (out of 14,561; 0.01%) of cervical spinal fusion without a diagnosis of cervical vertebral fracture or CSCI, and one of those two (out of 14,561; 0.007%) had a ligamentous injury. At such a low event rate, it is entirely possible that these cases represent coding/data entry errors rather than true cases of ligamentous injury without fracture or CSCI. Additionally, we cannot rule out the possibility that the underlying mechanism for CSCI sustained in patients without an associate cervical vertebral fracture and/or dislocation is ligamentous injury that had not been identified or recorded in the NTDB, or because of a cervical collar that had been removed too early. Second, the NTDB misses a considerable amount of data, which cannot possibly be accounted for by chart review as is possible in single institution studies. For example, we do not have details about physical exam findings (such as neurological deficits) upon ED presentation. Radiographic details such as type of cervical fracture (body, facet, spinal process, etc.) are also not available. This limitation of our dataset may explain the discrepancy between the incidence rates of CSI reported in our study compared to those from single institutions.[14,15,17] Third, data in the NTDB is subject to selection bias as participation in the NTDB is voluntary, and thus the data may not be representative of all U.S. trauma hospitals. Having determined the incidence of cervical spine injury and overall outcomes on a national level, the next step could be to use regional

Table 3
Detailed presentation of two cases, who underwent cervical spinal fusion/re-fusion without having a cervical fracture and/or dislocation without CSCI or CSCI.

Assault	Demographics	Prehospital vitals	ED vitals	Injuries	Outcomes
Blunt object	69 y.o. male Not intoxicated (alcohol or drugs)	HR: 70 SBP: 105 RR: 16 O_2 SAT: 91% RA GCS: 14	HR: 72 SBP: 106 RR: 16 O_2 SAT: 95% RA GCS: 15	- Cervical ligamentous injury. - Open wound of gum. - Open wound of forehead.	Discharge to rehabilitation Hospital LOS: 9 days ICU LOS: 0 days Ventilator days: 0
Unarmed	35 y.o. male Not intoxicated (alcohol or drugs)	HR: n/a SBP: n/a RR: n/a O_2 SAT: n/a GCS: n/a	HR: 92 SBP: 140 RR: 16 O_2 SAT: 100% RA GCS: 15	- Closed fracture of mandible. - Closed fracture of base of skull.	Discharged to home. Hospital LOS: 7 days ICU LOS: 0 days Ventilator days: 0

CSCI, cervical spinal cord injury; SBP, systolic blood pressure; HR, heart rate, RR, respiratory rate; O_2 SAT, oxygen saturation; GCS, Glasgow Coma Scale score; ISS, injury severity score; ED, emergency department; LOS, length of stay; ICU, intensive care unit.

trauma databases containing more detailed information on management and outcomes to describe in more detail the nature of these potentially devastating injuries.

Despite these limitations, we feel our results are important and interesting, because they provide further evidence to support clinicians when removing cervical collars in the absence of fracture or other abnormalities on the CT scan of patients sustaining blunt assault. This helps minimize the time spent in a cervical collar and reserves additional imaging to patients with risk factors or abnormal CT scan findings. Future high quality observational studies on this rare injury will be prohibitively difficult or expensive to perform. Randomized interventional studies on this high-stakes injury will be even more difficult to design and execute.

Conclusions

The incidence of cervical vertebral fracture and/or dislocation after blunt assault is low. CSCI is even more uncommon, has a low mortality, and discharge home occurs in more than half of affected patients. In the absence of fracture/dislocation or spinal cord injury, cervical ligamentous injury requiring operative stabilization after blunt assault is extraordinarily uncommon.

Conflicts of interest

None of the authors have conflicts of interest.

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