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Review Article

The association of occipitocervical dissociation and death as a result of blunt trauma

Ran Lador, MD[a], Peleg J. Ben-Galim, MD[a], Bradley K. Weiner, MD[b,*], John A. Hipp, PhD[a]

[a]*Department of Orthopedic Surgery, Baylor College of Medicine, Houston, TX 77030, USA*

[b]*Department of Orthopedic Surgery, The Methodist Hospital, 6550 Fannin St., Suite 2500, Houston, TX 77030, USA*

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Abstract

BACKGROUND CONTEXT: Despite multiple reports of survivability, dissociative occipitocervical injury (OCI) is generally accepted to be fatal in most cases. The actual number of trauma victims where OCI may have made the difference between life and death is unknown because multiple studies have shown that these injuries can be missed with current diagnostic methods. An improved understanding of the relative importance of OCI in blunt trauma mortality may help to refine protocols for the assessment and treatment of patients who arrive alive to the emergency room after severe blunt trauma. One way to improve our understanding is to document the relative frequency OCI relative to brain, liver, aorta, and spleen injuries in blunt trauma fatalities.

PURPOSE: In this study, we aimed to glean a more accurate estimate of the absolute and relative incidence of OCI after death from blunt trauma via a systematic review of data reported in the forensic literature.

STUDY DESIGN: Systematic literature review.

METHODS: A systematic literature search and review were undertaken. The search aimed to answer three primary questions: What is the true incidence of cervical spine injuries in blunt trauma fatalities? What is the incidence of dissociative OCIs specifically? and What is the incidence of these injuries relative to other common injuries associated with blunt trauma fatalities (central nervous system, spleen, liver, etc)? For that, two search protocols were used and included postmortem studies of blunt trauma mechanism in adult population.

RESULTS: The mean reported incidence of cervical spine injuries was 49.7% in blunt trauma fatalities. Dissociative OCIs were found to have a mean incidence of 18.1%. The relative frequencies of injuries were 49.7% for cervical spine, 41.8% for central nervous system, 20.8% for liver, 11.2% for spleen, and 10.8% for aorta.

CONCLUSIONS: In this systematic literature review, cervical spine injuries were found to be the most commonly reported finding associated with blunt trauma fatalities, occurring in nearly 50% of cases with occipitocervical dissociation accounting for nearly 20%. Older pathologic studies suggested a lesser overall and relative frequency and may have underestimated their incidence. Typically, these blunt cervical spine injuries were much more commonly found to disrupt the soft tissue stabilizing restraints (ligaments, facet capsules, etc) as opposed to causing bony fractures and, accordingly, were often not detected on plain radiographs. It is likely that the frequency of this injury is underestimated in patients surviving severe blunt trauma, placing them at risk for death from an occult source in the postinjury period. Additional research is needed to determine if improved methods to diagnose OCI and improved patient management protocols to protect against secondary injuries might reduce mortality in blunt trauma victims.

Keywords: Cervical spine; Trauma; Occiput; Dissociation

FDA device/drug status: not applicable.

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* Corresponding author. Department of Orthopedic Surgery, The Methodist Hospital, 6550 Fannin St., Suite 2500, Houston, TX 77030, USA. Tel.: (713) 441-3595; fax: (713) 441-6614.

E-mail address: bkweiner@tmhs.org (B.K. Weiner)

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Introduction

Despite several recent reports of survivability (and occasional reasonable neurological outcomes) [1–8], dissociative occipitocervical injury (OCI) is most notable as a major cause of mortality. It is generally estimated that OCI accounts for between 8% and 15% of immediate deaths after blunt trauma [9–11]; but it is recognized that an accurate incidence is difficult to obtain [12–14], given that radiographic and pathoanatomic findings may be overlooked during routine autopsies, which fail to specifically/carefully assess the upper cervical spine. A greater understanding of the true incidence would afford a more accurate determination of OCI's contribution and association with death relative to more pathologically obvious sources (brain, liver, aorta, spleen, etc) and might also help guide prioritization during the assessment and treatment of patients surviving severe blunt trauma.

In this study, we aimed to glean a more reliable estimate of the absolute and relative incidence of OCI after death from blunt trauma via a systematic review of data reported in detailed forensic literature.

Materials and methods

A systematic literature review was undertaken. Data from Medline, PubMed, Ovid, and the Texas Medical Center Library databases were collected and assessed. The search aimed to answer three primary questions: What is the true incidence of cervical spine injuries in blunt trauma fatalities? What is the incidence of dissociative OCIs specifically? and What is the incidence of these injuries relative to other common life-threatening injuries associated with blunt trauma fatalities (central nervous system, spleen, liver, etc)?

Two search protocols were used. The first (Protocol 1) focused on articles providing specific details of cervical injuries in blunt trauma. The second (Protocol 2) focused more broadly on articles evaluating multiple organ systems (including the cervical spine). Included studies satisfied the following conditions: blunt trauma mechanism, postmortem studies from the forensic literature detailing careful assessment of the cervical spine (Protocol 1) or other organ systems (Protocol 2), adults only, and English language only. Excluded studies were those with selected subjects, reporting mixed data from blunt and penetrating trauma, providing data that could not be readily quantified, and that failed to detail a careful assessment of the cervical spine or organs. The detailed search protocols used are presented in the Appendix.

Results

Table 1 summarizes the data from the peer-reviewed literature addressing multiple organ involvement in blunt

Table 1
Summary of data from studies assessing multiple organ involvement in fatal blunt trauma

Author, [reference]	No. of blunt trauma autopsies	CNS	C-spine	Head	Liver	Spleen	Aorta	Lung	General neck	General chest	General abdomen
Tonge et al. [19]	1,004	54.5	16.7	48.3	24.9	21.1	11.5	42.6	N/A	N/A	N/A
Hodgson et al. [20]	108	28.7	N/A	N/A	22.2	14.8	7.4	N/A	N/A	N/A	N/A
Rokkanen and Slatis [21]	298		8.3	54	7.7	5	6.8	N/A	N/A	28.8	14.7
Caldwell and McGovern [22]	96	39.5	N/A	69.8 (40.6)	25 (1)	21.8 (1)	17.7 (7.2)	N/A	N/A	63.5	52
Acosta et al. [23]	537	(45.4)	N/A	N/A	(1.8)	N/A	(11) including all great vessels	N/A	N/A	N/A	N/A
Baker et al. [24]	200	(73)	N/A	N/A	(3)	N/A	N/A	(8)	N/A	N/A	N/A
Perry and McClellan [25]	127	N/A	N/A	66 (40)	(3)	N/A	(1.5)	N/A	N/A	37.7 (12.5)	29.9 (9.4)
Turk and Tsokos [26]	68	50	N/A	N/A	N/A	N/A	14.7	N/A	33	N/A	N/A
Toro et al. [27]	664	50.9	N/A	N/A	25.7	N/A	12.8	N/A	N/A	N/A	N/A

N/A, not applicable; CNS, central nervous system; C-spine, cervical spine.

The numbers in each column represent the percent of fatalities in each study that had an injury to the organ or anatomic region described by the column heading. Some studies also estimated the percent of deaths that could be attributed to the injury to the organ or anatomic region. When available, this number is provided in parentheses.

trauma fatalities. Studies that provided the number or percent of fatalities with specific injuries are included in Table 1 and data from articles in which a specific injury was identified as the cause of death. Table 2 summarizes the combined percentages of these general forensic articles. Table 3 summarizes the data from the accepted forensic articles looking specifically at cervical spine involvement in blunt trauma fatalities.

Protocol 1

The initial search generated 1,001 studies, of which 896 were written in English and 834 addressed human subjects. Those that specifically addressed cervical spine injuries numbered 590, and the abstract for each study was assessed for relevance/inclusion. Thirty-one articles were satisfactory (failed exclusion) and were reviewed in detail.

Protocol 2

The initial search generated 4,339 studies of which 3,831 studies were written in English and 3,557 addressed human subjects. One thousand thirty-seven studies focused on blunt trauma. Sixty-four articles met the inclusion criteria and were reviewed in detail for quantitative estimates of the percent of fatalities where injuries to specific organs/anatomic regions were found or where a specific organ/anatomic region was implicated in the cause of death.

The average reported incidence of cervical spine injuries was 49.7% in blunt trauma fatalities. Dissociative OCIs were found to have a mean incidence of 18.1%. The relative frequencies of injuries were 49.7% for cervical spine, 41.8% for central nervous system, 20.8% for liver, 11.2% for spleen, and 10.8% for aorta.

Discussion

In this article—the first in which an extensive review of reported pathologic findings after blunt trauma fatalities has been undertaken—cervical spine injuries were found to be the most commonly reported, occurring in nearly 50% of cases, with occipitocervical dissociation accounting for nearly 20%. Although older pathologic studies suggested a lesser overall and relative frequency, many of these studies failed to include a detailed assessment/dissection of the cervical spine and, accordingly, appear to have underestimated their incidence.

Substantial variability was found in the proportion of fatalities that had each of the specific injuries tabulated. This is most likely because of the variability in methods used to identify injuries, but variability may also occur because of the specific populations studied. The studies that were reviewed addressed a wide range of populations and used a wide range of reporting methods. All the studies attempted to describe the proportion of the population studied that had the injury or injuries they studied. The results reported may not provide the true incidence that may be found in a large population. For most of the organs/anatomic regions tabulated, no method has yet been validated as the ‘‘gold standard’’ for identifying clinically significant injuries. It is also possible that alternative literature search strategies might identify studies with different results.

Our hypothesis is that in major blunt trauma, the upper cervical spine (occiput–C2) is at particular risk of devastating injury. The relatively heavy human skull/head articulates with the highly mobile upper cervical spine that lacks an intervertebral disc and relies solely on ligamentous restraints to resist significant forces [15]. These forces, often in shear and distraction (motor vehicle accident and pedestrian accidents), may result in disruption of the tectorial, alar, and cruciate ligaments—as well as the occiput–C1–C2 articular facet capsules—resulting in occipitocervical dissociation. Subsequent damage to the medulla oblongata or spinomedullary junction results in severe neurological injury or death.

In the current review, such dissociative OCIs were found in 18.1% of blunt trauma fatalities. This is commensurate with findings from our center, wherein 14.4% of 76 consecutive blunt trauma fatalities were found to have radiographic abnormalities consistent with these injuries [12]. Typically, these blunt cervical spine injuries were much more commonly found to disrupt the soft tissue stabilizing restraints (ligaments, facet capsules, etc) as opposed to causing bony fractures and, accordingly, were often not detected on plain radiographs [16–18]. This was also the case in the findings from our center where soft-tissue dissociative injuries were detected on computed tomography scans 7 to 10 times more commonly than fractures of the upper cervical spine [12].

An obvious advantage of using forensic studies as the ‘‘gold standard’’ rests with the fact that carefully performed

Table 2
The overall association with blunt trauma death

Injury group	No. of blunt trauma autopsies	CNS	C-spine	Head	Liver	Spleen	Aorta	Lung	General chest	General abdomen	General neck
Cause of death	960	40.6	N/A	9.3	2.1	0.1	7.1	1.6	1.6	1.2	N/A
Overall injuries	2,365	41.8	8.2	33.7	20.8	11.2	10.8	18.1	8.2	5.6	0.9

N/A, not applicable; CNS, central nervous system; C-spine, cervical spine.

In the second column, Table 2 sums the number of autopsies described in Table 1 and sums the number of autopsies that identified specific injuries as the cause of death. The remaining columns provide the averages from the corresponding columns in Table 1, with the row labeled ‘‘Cause of death’’ providing the averages from studies where specific injuries were identified as a cause of death.

Table 3
Summary of the peer-reviewed studies that specifically addressed the number or percent of fatalities where an injury was found to the cervical spine

Author, [reference]	No. of autopsies	Fractures	Total soft-tissue injuries	Upper cervical injuries	Subaxial injuries	Any cervical spine injury
Adams [17,18]	155	7.7	42.5	30.3 (16.8 dislocations)	12.2	50.2
Bucholz and Burkhead [9]	112	N/A	N/A	18.7	4.5	23.2
Bucholz et al. [28]	100	N/A	N/A	20	4	24
Taylor and Twomey [29]	16	12.5	N/A	31.1	N/A	93.7
Taylor and Taylor [16]	109	N/A	N/A	54.1 (17.4 dislocations)	N/A	94 (including minor injuries)
Overall	476 with any injury and 280 with a dislocation	2.8	—	Total=43.2 and dislocations=18.1	—	49.7

N/A, not applicable.
Some investigators were specific about the type of injury, and these specifics are provided where available.

autopsies often reveal significant injuries undetected via initial clinical imaging. Sharma et al. [13] described more than twice the percentage of missed injuries to the spine or neck compared with the abdomen in 163 autopsies reviewed.

This information, when coupled with increasing reports of survival after dissociative OCIs and the recognition that radiographic findings are often quite subtle, is sobering. It is likely that the frequency of this injury is underestimated in patients surviving severe blunt trauma. Secondary brain stem or spinal cord injuries because of insufficiently stabilized dissociative OCIs may be overlooked as a source of delayed mortality after blunt trauma (in the field, during transport, or during hospitalization). Efforts to improve the early recognition, characterization, external stabilization, and operative treatment of these disorders are to be encouraged.

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Appendix

PubMed Search Protocol 1 for cervical spine injuries

((trauma[Title/Abstract] OR traumatic[Title/Abstract]) AND (blunt[Title/Abstract] OR non penetrating[Title/Abstract]) AND (cervical[Title/Abstract] OR spine[Title/Abstract] OR spinal[Title/Abstract] OR c-spine[Title/Abstract] OR neck[Title/Abstract] OR occipitoatlantal[Title/Abstract] OR atlanto-occipital[Title/Abstract] OR occiput [Title/Abstract] OR atlas[Title/Abstract] OR dislocation [Title/Abstract]) AND (forensic[Title/Abstract] OR fatal[Title/Abstract] OR fatalities[Title/Abstract] OR autopsy[Title/Abstract] OR autopsies[Title/Abstract] OR death[Title/Abstract] OR deaths[Title/Abstract] OR lethal[Title/Abstract] OR pathologic[Title/Abstract] OR cadaver[Title/Abstract] OR cadavers[Title/Abstract] OR epidemiology [Title/Abstract] OR findings[Title/Abstract] OR analysis [Title/Abstract] OR assessment[Title/Abstract] OR pattern [Title/Abstract] OR patterns[Title/Abstract] OR injury[Title/Abstract] OR injuries[Title/Abstract])).

PubMed Search Protocol 2 for severe blunt trauma injuries

((trauma[Title/Abstract] OR traumatic[Title/Abstract]) AND (blunt[Title/Abstract] OR non penetrating[Title/Abstract]) AND (forensic[Title/Abstract] OR fatal[Title/Abstract] OR fatalities[Title/Abstract] OR autopsy[Title/Abstract] OR autopsies[Title/Abstract] OR death[Title/Abstract] OR deaths[Title/Abstract] OR lethal[Title/Abstract] OR cadaver[Title/Abstract] OR cadavers[Title/Abstract] OR epidemiology[Title/Abstract] OR findings[Title/Abstract] OR analysis[Title/Abstract] OR assessment[Title/Abstract] OR pattern[Title/Abstract] OR patterns[Title/Abstract])).