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Clinical Study

Occipitocervical dissociative injuries: common in blunt trauma fatalities and better detected with objective computed tomography-based measurements

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Abstract

BACKGROUND CONTEXT: Occipitocervical injuries (OCIs) are generally not common in blunt trauma victims, but autopsy studies of blunt trauma fatalities consistently report a high prevalence of these injuries. New computed tomography (CT)-based quantitative criteria have recently been developed for use in assessing the occipitocervical spine. The efficacy of these new criteria for detecting OCI would be supported if the high prevalence of OCI in blunt trauma fatalities can also be detected using these objective CT-based criteria.

PURPOSE: To test the hypothesis that the prevalence of OCI in blunt trauma fatalities, determined using objective CT-based measurements and reliable reference data, will be similar to the prevalence reported in prior autopsy studies.

STUDY DESIGN/SETTING: Retrospective assessment of the CT examinations of blunt trauma fatalities at a Level 1 trauma center.

PATIENT SAMPLE: Seventy-four consecutive patients who died within 21 days of blunt trauma and had a CT examination of the cervical spine.

OUTCOME MEASURES: Quantitative measurements from CT examinations of the occiput–C1 and C1–C2 levels.

METHODS: Measurements were made on a Picture Archiving and Communication System (PACS) from the CT images that were originally used for diagnosis and also using imaging software that allowed for precisely reoriented slices that correct for variations in the alignment of the upper cervical spine. The prevalence of abnormal measurements found by each method and the interobserver reliability of the measurements were assessed.

RESULTS: At least one abnormal measurement was found in 50% of cases based on measurements made on the PACS, and in 34% of cases using measurements from carefully reoriented images. At least three abnormal measurements were found in 22% and 14% of patients, respectively. Only one of the patients had been diagnosed as having an OCI before death. Interobserver reliability measurements of more than 80% were found for most measurements.

CONCLUSIONS: Using precise CT-based measurements and reliable reference data for diagnosis of occipitocervical dissociative injuries, the prevalence of injuries in severely injured blunt trauma patients was close to the levels reported in prior autopsy studies (approximately 30%). This supports that with careful measurements, both soft- and hard-tissue OCI can be detected by CT. This study is limited by the fact that a gold standard was not available to confirm the injuries.

Keywords: Occipitocervical injuries; Prevalence; Fatalities; Diagnosis; CT-based measurements

FDA device/drug status: not applicable.

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Introduction

Traumatic occipitocervical dissociation is one of the most common fatal cervical spine injuries [1]. Early recognition and appropriate management of dissociative occipitocervical injuries (OCIs) are associated with improved outcomes [2–6].

Seventy-four blunt trauma victims who arrived alive to a Level 1 trauma center but died less than 21 days later were studied to determine the proportion that had evidence of an OCI based on quantitative computed tomography (CT)-based criteria. This is an important population in that intervention strategies may exist to prevent some of these deaths, and the true incidence and characteristics of OCIs is not well documented.

EVIDENCE & METHODS

Context
Occipitocervical injuries (OCI) are often associated with death from blunt trauma but are also increasingly recognized in survivors. Using previously delineated norms established for reoriented CT, this study aims to assess the prevalence of these injuries in blunt trauma fatalities occurring at one center.

Contribution
In patients with severe blunt trauma, who died within 21 days, 34% of the fatalities demonstrated at least one abnormal measurement suggesting OCI, and 14% demonstrated at least three abnormal measurements using CT reorientation.

Implications
These numbers are similar to those reported in carefully performed autopsy studies, suggesting that reoriented CT might provide accurate detection of OCI. The authors, appropriately, note no postmortem autopsy was performed as a gold standard corroboration of the CT findings.

—The Editors

Methods

This was a retrospective cohort study (Baylor College of Medicine IRB H-24370) of 74 blunt trauma fatalities who died within 21 days of arrival and had CT images available for analysis. Mean age, gender, survival time from initial trauma, and the number of associated injuries are summarized in Table 1. Five of the 74 patients had an upper cervical spine fracture that was noted by a radiologist in the clinical records. Eighteen had fractures in the mid- to lower cervical spine.

All patients had a CT scan obtained with axial slices 0.7- to 1-mm thick and sagittal and coronal plane reconstructions. Measurements were made from the CT examinations using two methods. Measurements were first completed using the conventional DICOM viewer (Synapse Workstation; Fujifilm Medical Systems, Colgate, WI, USA) on the Hospital's Picture Archiving and Communication System (PACS), which does not allow reorienting slices to correct for axial rotation, left-right bending, or flexion/extension of the patient's head and neck. Measurements were then made using a freely available imaging processing software (Microview; GE Medical Systems, London, Ontario, Canada; www.sourceforge.net), which allowed for precise selection of specific planes through the three-dimensional volume.

Eleven measurements were collected, using both measurement methods, on every CT examination. The measurements made were previously described [7], and the thresholds used to classify a measurement as normal or abnormal are summarized in Table 2. Thresholds used in the present study were defined as the upper limit of normal from the previous study PLUS the average interobserver error from the previous study [7]. Measurements classified as

Table 1
Summary description of patients in this study

Description	Number of patients or average value (mean; range)
Total number of patients	74
Men	62
Women	12
Mean age at time of injury (y)	46.3
Survival time (d)	4.96 (5.4; 0–21)
Intracranial hemorrhage	58
Upper cervical spine injuries	5
Subaxial cervical injuries	13
Noncervical spine injuries	2
Abdominal injury mandating laparatomy	15
Orthopedic injuries except spine injuries	46
Average Glasgow Coma Scale	5.4

Table 2
Summary of quantitative CT-based measurements that were first made on the hospital PACS system and then with precise selection of measurement planes

Description	Threshold (mm)
Middle of the occiput–C1 joint in the sagittal plane	1.3
Middle of the occiput–C1 joint in the coronal plane	1.3
Sum of the coronal plane measures for the left and right occiput–C1 joints	4.0
Middle of the C1–C2 joint in the sagittal plane	3.3
Lateral edge of the C1–C2 joint in the coronal plane	1.5
Basiondens interval	9.0
C1–C2 spinolaminar line	11.2

CT, computed tomography; PACS, Picture Archiving and Communication System.

All joint space measurements were made for both the left and right sides.

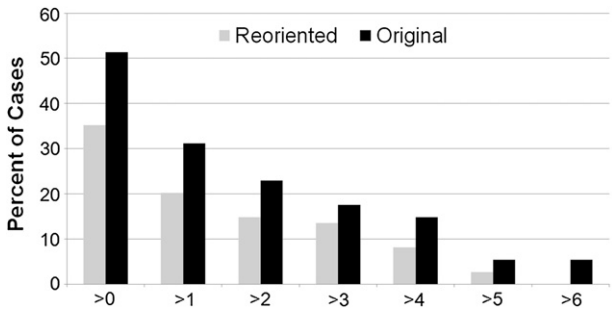

Fig. 1. Proportion of cases with greater than zero to greater than six abnormal quantitative radiographic measurements in the occipitocervical region. The proportions are provided for the measurements made on the Picture Archiving and Communication System (''original'') and for the measurements made using Microview after selecting optimal measurement planes (''reoriented'').

abnormal in the present study were clearly abnormal in comparison to uninjured occipitocervical spines. All measurements were made by a senior orthopedic resident (ND) who had previously worked on the reference data used to define normal [7]. The resident was blinded to the clinical data.

Data were analyzed by descriptive statistics to determine the proportion of the cases where abnormal measurements were found. Based on the assumption that multiple abnormal measurements in a single patient would have greater clinical significance, the proportion of cases with two, three, four, five, or six abnormalities was also calculated.

Fifteen cases were remeasured by a second orthopedic resident (RL) who also had extensive training in making these measurements. This was done to allow calculation of interobserver reliability with respect to classification of the measurements as abnormal. These data were analyzed using adjusted percent agreement and kappa statistics. Measurements for the left and right joints were pooled for the observer agreement calculations.

Results

Fifty-one percent of the 74 blunt trauma fatalities were found to have at least one abnormal measurement based on measurements made on a PACS (35% using Microview measurements) with gradually decreasing percentages to where 5% were found to have six or more abnormalities on PACS (0% using Microview measurements). Fig. 1 details the percent of cases that had between one or more and six or more abnormal measurements.

The percent of cases that had abnormal measurements is shown in Fig. 2 for each of the individual diagnostic measurements. The proportions of cases classified as abnormal were equal to or higher when measurements were made on the PACS versus Microview. However, this difference was statistically significant only for coronal plane measurements of the occiput–C1 and C1–C2 joints. Using the ''sum of condyles'' threshold of 4 mm as the only criteria to identify an OCI, 3% and 5% of patients would have been suspected of having a dissociative OCI using original PACS data and reoriented Microview data, respectively.

Interobserver reliability analysis between two observers revealed an adjusted percent agreement of 60% to 87% for all measurements with a kappa score of more than 53% for all measurements.

All 10 measurements from both the sagittal and coronal images could be made in 100% of cases using either the PACS or Microview. With thin axial CT slices, the reformatted images were sharp enough to allow considerable

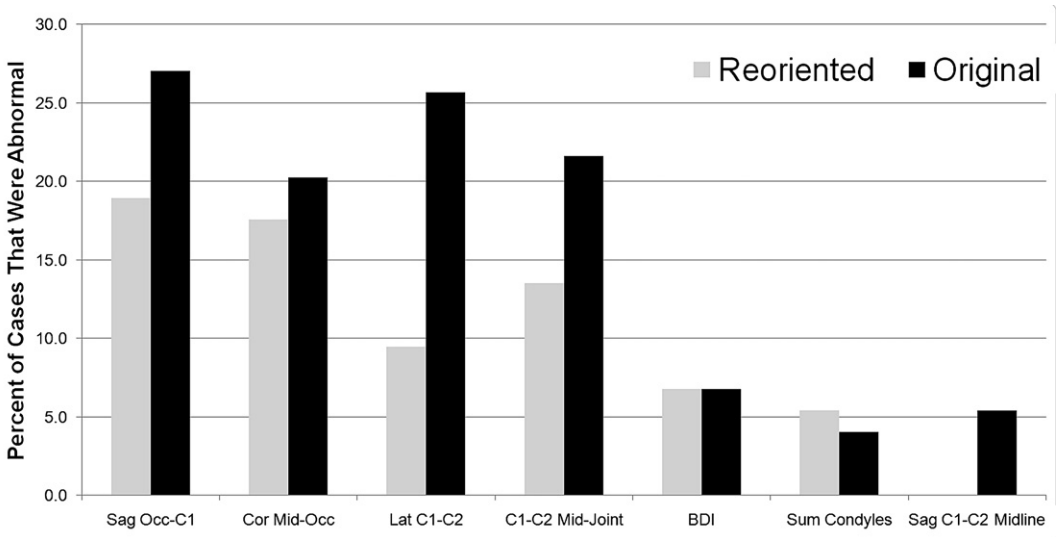

Fig. 2. Proportion of cases with abnormal quantitative radiographic measurements calculated for each of the specific measurements that were made. Measurements for the left and right joints were pooled to create this graph. The proportions are provided for the measurements made on the Picture Archiving and Communication System (''original'') and for the measurements made using Microview after selecting optimal measurement planes (''reoriented''). Sag Occ, sagittal occiput; Cor Mid-Occ, coronal middle occipital; Lat, lateral; BDI, basiondens interval.

magnification to select landmarks for the measurements. Precise triplanar localization of the CT slice and reconstruction of the planes of measurement in any direction could easily be achieved with the Microview software. The best plane for joint space measurements was generally perpendicular to the axis of the joint at the widest cross section through the joint surface. Obtaining the proper triplanar orientation in six degrees of freedom was perceived to be critical to obtaining reliable measurements.

Discussion

Based on the quantitative thresholds applied, and the measurements made from carefully reoriented slices, up to 35% of patients who died within 21 days of blunt trauma had some evidence of an OCI. Approximately 14% had three or more abnormal relationships between the occiput and C1 or between C1 and C2, and this may be an indicator of a more severe dissociative injury to this region.

The data suggest a spectrum of injuries with proportions consistent with previous studies [1,2,8]. Using 35% as the best estimate of the proportion of patients who had a soft-tissue injury, and noting that 7% had a cervical spine fracture per clinical records, these data suggest approximately five soft-tissue injuries for every fracture.

Conclusions

We hypothesized that precise CT-based measurements of the relationships within the occiput–C1–C2 complex, using new reference data, may help to identify an OCI, document the types of injuries to look for, and support that improved assessment of cervical CT examinations may help to identify patients that should have been suspected of having a dissociative injury. The results support this hypothesis. A previously described protocol was used to carefully measure spacing between the occiput and C1 and between C1 and C2 from CT examinations of 74 patients who died within 21 days of blunt trauma. Approximately 35% of patients were found to have evidence of a soft-tissue injury in the occipitocervical region. This proportion is consistent with prior autopsy studies and supports that trauma severe enough to result in death is associated with high rates of injuries in the upper cervical spine. This consistency with injury incidence rates from autopsy studies also supports that careful quantitative measurement from CT examinations of blunt trauma victims, using data from prior studies of uninjured spines to define threshold levels that identify abnormal measurements, can be used to detect abnormal separation between osseous structures. It is not yet known if routine clinical use of these measurements would help to avoid the missed diagnoses that have been reported in many studies of what can be a fatal injury pattern.

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