Diagnosis Errors in the Imaging of Cervical Spine Trauma

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Abstract

Background: Systematic assessment of the multisystem blunt trauma case is the critical step of clearing the cervical spine (C-spine). **Aim:** To evaluate the clinical significance of diagnostic errors in the interpretation of cervical spine for trauma to describe and categorize them. **Patients and methods:** Retrospective analysis of the clinical records of 63 cases who were admitted to a trauma center with cervical spine fractures and/or dislocations has been performed in this investigation. **Results:** False negative cases were found in 90.47%; false positive cases were found in 9.523%; spinal cases were found in 80.95%; and extraspinal cases were found in 19.04%. Rib fractures were found in 25% of cases; lung nodules were found in 25%; hyoid bone fractures were found in 16.67%, cavicular fractures, dental caries, thyroid lobe nodules, and intraluminal tracheal debris were found in single cases. Based on the diagnostic error, does the necessity for surgery or the surgical approach change? In five cases, was it true that nonsurgical immobilization was altered as a result of a diagnostic error? Yes, in 23 patients, needing of a magnetic resonance imaging change has been a result of a diagnostic error. The answer was true in nineteen patients. **Conclusion:** Diagnostic errors were primarily false negatives (90.47%), with spinal fractures prevalent in vertebral bodies and transverse processes. In a variety of patients, extraspinal missed results have been identified.

Key words: diagnosis errors, imaging, cervical spine trauma.

Introduction

In the multisystem blunt trauma case systematic evaluation, (C-spine) clearance is a critical step. Despite the fact that cervical spine injuries have been demonstrated in approximately two to six percent of all cases that were admitted for trauma, they have an association with a great rate of mortality & morbidity. **(1)** .

Due to the absence of universally accepted guidelines for the management of CSI, clinical practice management is predicated on a variety of algorithms that involve information from clinical examination and imaging, including computer tomography & magnetic resonance imaging. In the event that a clinical C-spine examination is not viable due to intubation, distracting injuries, altered mental status, or intoxication, the treatment decision is primarily determined by the results of computer tomography or magnetic resonance imaging. **(2)**.

Following blunt trauma, cervical spine has been extensively applied as an acute imaging modality. In accordance with the subset of cases examined, the sensitivity of cervical spine for CSI varies from 98.5 to 100%. as any diagnostic process, the radiologic interpretation of cervical spine is susceptible to error, & diagnostic errors might lead to death or long-term disability. Radiology is characterized by a prevalence of errors and discrepancies, with an estimated five percent of cases occurring in everyday practice & as great as thirty percent in emergent situations and trauma. **(3,4)**.

Despite the low reported rate, radiographic diagnostic errors account for nearly twenty percent of missed injuries. **(5)**. However, there is a lack of information regarding the clinical significance of the most prevalent types of cervical spine diagnostic errors conducted for trauma. It is essential to be aware of the diagnostic error's types in cervical spine and their clinical significance in order to refine the search pattern & recognize the factors that have been frequently causing misdiagnosis. This will help to reduce the catastrophic consequences of diagnostic errors and their potential number. **(6)**.

The objective of this investigation was to evaluate the clinical significance of diagnostic errors in cervical spine interpretation conducted for trauma and to describe & categorize them**.**

Patients and methods

The clinical records of sixty-three cases who were admitted to a trauma center with fractures and/or dislocations of the cervical spine have been retrospectively analyzed in this investigation.

Inclusion criteria: include cases that were admitted to a trauma center during the investigation and sustained fractures and/or dislocations of the cervical spine.

Methods

All patients have been subjected to the following:

Collecting data: for example, neurologic state, alteration of mental state, sex, mechanism of injury, level of injury, treatment, significant concomitant injuries and age during the initial examination. Any injury that has been identified after the primary trauma evaluation has been classified as delayed or missed diagnosis. The diagnostic algorithm of this unit has been followed to assess the cases for cervical spine injuries, which included a standard set of radiographs and a physical examination. an anteroposterior view, an open-mouth view, and a lateral view of the odontoid comprised of flexion-extension views, the standard set of radiographs. Oblique views and swimmer's views were not frequently applied. The trauma surgeon ordered a magnetic resonance imaging or computer tomography scan at their discretion, as indicated by clinical suspicion or standard views (incomplete or inadequate radiographs) due to neurologic deficits or continuing symptoms. An emergency radiology fellow (X1.X1) and a musculoskeletal fellowship-trained emergency radiologist with fourteen years of clinical experience (X6.X6.) reviewed all reports for discrepancies and categorized all images to identify diagnostic errors. Whenever there was a discrepancy in the categorization of errors by the two readers, it was resolved through consensus. The errors were categorized as either (1) missed finding (false-negative finding), which is a finding that was present on the image but missed, or (2) overcall (false-positive finding that is incorrectly attributed to injury), as per a classification that has been previously published (7). The errors have been categorized as extraspinal and spinal outcomes. Soft tissue, intervertebral disc spaces, osseous, and spinal cord have been the 4 categories into which spinal outcomes have been subclassified. Additionally, they have been classified regarding their level of acuity (age-indeterminate or acute, chronic). The level of each discovery and anatomical site were specified. Other potential contributors to diagnostic error and additional positive outcomes (satisfaction of search) have been documented. Among these factors were osteoporosis, extensive degeneration, artifacts, outcomes situated at the margins of the field of view, and failed comparisons with available prior imaging investigations**.**

CT acquisition

Achieving computer tomography Because of the retrospective nature of the investigation, the protocols and parameters of computer tomography images varied among the cases that have been chosen. Nevertheless, all scans satisfied the institutional standards and technical parameters for suitable diagnostic image quality. To achieve coverage from the skull base to the T1 vertebral body, a helical technique was utilized. The multidetector scanner was provided with 4–128 detectors, a 2 mm or thinner slice thickness, bone and soft tissue reconstruction algorithms, and coronal and sagittal multiplanar reformations. A clinical significance assessment and analysis of images.

Imaging analysis and evaluation of clinical significance

In retrospect, a musculoskeletal fellowship-trained emergency radiologist (X6.X6.) and 2 spine surgeons with over 15 (X2.X2.) and 25 (X4.X4.) years of clinical experience in spine trauma reviewed de-identified CsCT images of spinal diagnostic errors. The radiologist and each spine surgeon independently assessed the CsCT images, aware of the diagnostic error in each case however unaware of any demographic data. The following questions were posed to the spine surgeons for each patient: (1) Would the need for surgery or surgical approach change as a result of the diagnostic missed or misinterpreted finding (yes, no); (2) Would the need for nonsurgical immobilization change as a result of the diagnostic error (yes, no); (3) Would the need for magnetic resonance imaging change as a result of the diagnostic error (yes, no), and (4) Would the need for a computerized tomography angiogram of the neck change as a result of the diagnostic error (yes, no). Discrepancies regarding any of the responses have been resolved in order to accomplish consensus whenever they were present. In accordance with the definition of clinically significant as the smallest change in a results score that would result in an alteration in case treatment ^, results considered clinically significant if the response to any of these 3 questions has been positive. **(8).**

Results

Table (1): Distribution of demographic data in the studied patients.

	Studied patients N=63
Gender	
male	33 (52.38%)
female	30 (47.61%)
Age (years)	
Mean ±SD	39.42 ± 7.19
Range (min. – max.)	22 - 64
Weight (kg)	
Mean ±SD	82.57 ± 8.96
Range (min. – max.)	63.5 – 105
Height (cm)	
Mean ±SD	163.72 ± 5.49
Range (min. – max.)	155 – 179
BMI (kg/m2)	
Mean ±SD	29.91 ± 3.76
Range (min. – max.)	25.15 – 36.8

There have been 52.38% of cases males and other have been women, the mean age of the examined patients has been 39.42 ± 7.19 with range (22 - 64) years, the average Weight (kg) was 82.57 ± 8.96 with range (63.5 – 105), the average height (cm) was 163.72 ± 5.49 with range (155 – 179) and the average BMI was 29.91 ± 3.76 with range (25.15 – 36.8) kg/m2.

Table (2): Distribution of Classification and Location of diagnostic error in the studied patients.

	Studied patients N=63
Classification of diagnostic error	
missed findings (false negative)	57 (90.47%)
incorrectly finding (false positive)	6 (9.523%)
Location of missed finding	
Spinal	51 (80.95%)
Extraspinal	12 (19.04%)

False negative cases were found in 90.47% and false positive cases were found in 9.523%, Spinal were found in 80.95% and extraspinal were found in 19.04%. (Table 2)

Table (3): Distribution of sites of missed finding in Spinal in the studied patients.

	Spinal Location N=51
Fractures	29 (56.86%)
Intervertebral disc protrusion	17 (33.33%)
Atlantooccipital subluxation	3 (5.88%)
Lytic bone lesions	2 (3.92%)
total	**51 (100%)**
Fractures	
Vertebral body	11 (37.93%)
Transverse process	9 (31.03%)
Anterior and posterior arch of C1	2 (6.89%)
Spinous process	7 (24.13%)
total	**29 (100%)**
Spinous process	
Facet	5 (71.42%)
Lamina	2 (28.57%)
total	**7 (100%)**

Fractures were found in 56.86% of cases, intervertebral disc protrusion were found in 33.33%, Atlantooccipital subluxation were found in 5.88% and Lytic bone lesions were found in 3.92%. Spinal fractures were most frequently observed in the vertebral body. (37.93%) and transverse process (31.03%). (Table 3)

Table (4): Distribution of sites of missed finding in Extraspinal in the studied patients.

	Extraspinal Location N=12
Rib fractures	3 (25%)
Lung nodules	3 (25%)
Clavicular fracture	1 (8.33%)
Hyoid bone fracture	2 (16.67%)
Thyroid lobe nodule	1 (8.33%)
Intraluminal tracheal debris	1 (8.33%)
Dental caries	1 (8.33%)

Rib fractures were found in 25%of cases, Lung nodules were found in 25%, hyoid bone fracture were found in 16.67%, Clavicular fracture, Intraluminal tracheal debris, Thyroid lobe nodule and dental caries were found in single cases. (Table 4)

Table (5): Clinically significant diagnostic error and the distribution of surgeons' consensus responses to questions

	Q1	Q2	Q3	Q4
Fractures (29)	2	23	15	27
Intervertebral disc protrusion (17)	0	0	0	0
Atlantooccipital subluxation (3)	2	0	3	3
Lytic bone lesions (2)	1	0	1	0
Total (51)	5	23	19	30

Q1: Would the diagnostic error alter the necessity for surgery or the surgical approach? Q2: Would the necessity for nonsurgical immobilization be altered as a result of the diagnostic error? Q3: Would the necessity of a magnetic resonance imaging be altered as a result of the diagnostic error? Q4 (Would the diagnostic error induce a change in the necessity of neck computer tomography angiogram?

regarding the diagnostic error, does the necessity for surgery or the surgical approach change? In five patients, was it true that nonsurgical immobilization was altered as a result of the diagnostic error? In twenty-three patients, was the need for a magnetic resonance imaging change justified by the diagnostic error? In nineteen, the answer was yes, and the diagnostic error necessitated a neck computer tomography angiogram computer tomography angiogram. In thirty patients, the answer was yes.

Discussion

In the multisystem blunt trauma case systematic evaluation, cervical spine clearance is a critical step. Despite the fact that cervical spine injuries are reported to occur in approximately two to six percent of all trauma cases admitted, they are associated with a great rate of morbidity and mortality. (1).

Our results showed that regarding distribution of demographic data in the studied patients, there were 52.38% of patients' males and others women, the average age of the examined cases has been 39.42 ± 7.19 with range (22 - 64) years, the average weight (kg) was 82.57 ± 8.96 with range (63.5 – 105), the average height (cm) was 163.72 ± 5.49 with range (155 – 179) and the average BMI was 29.91 ± 3.76 with range (25.15 – 36.8) kg/m2.

Khalilzadeh O et al (9) who seek to assess the efficacy of second-opinion radiology consultations in reevaluating the cervical spine computer tomography scans of trauma cases, established our

outcomes. They demonstrated that a total of 301 consecutive cases have been analyzed in their research. The ages of the cases varied from 18 to 97 years (mean: 56.4±23.1 years). Conversely, 38% of the population were women.

Also, **Schotanus M et al. (10)** that seek to assess transverse process fractures of the subaxial cervical spine in isolation, they reported that median age of cases under investigation has been 18.4 years, with range 17-85 years. Otherwise, they reported that the male-to-female ratio was 2.5:1.

Regarding classification of diagnostic error, our current study showed that false negative cases were found in 90.47% and false positive cases were found in 9.523%. Regarding location of missed finding, Spinal was found in 80.95% and extraspinal was found in 19.04%.

Along with our results, **Alessandrino F et al, (11)** reported that 86% of the diagnostic errors that came to our attention were missed findings (false negatives) (48/56). Their goal has been to assess the clinical significance of diagnostic errors in cervical spine interpretation performed for trauma and to categorize and describe them. Additional positive results have been observed in 9% of cases (5/56). In conclusion, 12 (21.4%) of the cases were extraspinal, while 44 (78.6%) were spinal.

Also, **Simon JB et al, (12)** demonstrated that 77% of the 91 CsCTs conducted for trauma initially demonstrated as negative in cases that received further assessment with magnetic resonance imaging. Clinically significant missed results were identified.

Furthermore, **Khalilzadeh O et al, (9)** report indicated that of the twenty-three diagnostic errors identified during a 2nd opinion radiology consultation, sixty-one percent were missed and thirty-nine percent have been misinterpreted.

Our findings revealed Concerning distribution of sites of missed finding in Spinal in the studied patients, fractures were found in 56.86% of cases, intervertebral disc protrusion was found in 33.33%, Atlantooccipital subluxation was found in 5.88%, and lytic bone lesions were found in 3.92%. Spinal fractures were most frequently observed in the vertebral body. (37.93%) and transverse process (31.03%).

This came in accordance with **Alessandrino F et al. (11)** who reported that, regarding distribution of sites of missed findings in Spinal in the studied patients, The vertebral body & transverse process were the most frequently fractured areas of the spinal fractures.

On the other hand, **Simon JB et al. (12)** reported that five facet fractures, one disc protrusion, and an occipital condyle fracture were the most frequently ignored outcomes.

Khalilzadeh O et al, (9) reported that transverse and spinous process fractures were the most frequently ignored radiologic results in the initial reports.

Regarding distribution of sites of missed finding in extraspinal in the studied patients, we found that Rib fractures were found in 25% of cases, Lung nodules were found in 25%, hyoid bone fractures were found in 16.67%, Clavicular fractures, dental caries, Intraluminal tracheal debris, and Thyroid lobe nodules were found in single cases.

In the same line, **Alessandrino F et al. (11)** reported regarding distribution of sites of missed findings in extraspinal in the studied patients, among 12 extraspinal missed findings, dental caries, intraluminal tracheal debris, and thyroid lobe nodules were found in single cases; there were 4 cases of rib fracture; lung nodules were found in 2 cases; hyoid bone fractures were found in one case; and cavicular fractures were found in 2 cases,

The distribution of surgeons' consensus responses to questions and clinically significant diagnostic errors revealed that the necessity for surgery or surgical approach changes based on the diagnostic error. Was it true that nonsurgical immobilization has been altered as a result of the diagnostic error in five patients? Yes, in twenty-three patients, the need for a magnetic resonance imaging change has been a result of a diagnostic error. Yes, in nineteen patients, the diagnostic error necessitated a neck CTA. In thirty patients, the answer was yes.

Similarly, **Alessandrino F et al. (11)** reported that, regarding responses to the three questions that the surgeons agreed upon, Question one (Would the necessity for surgical approach or surgery be altered as a result of the diagnostic error?) has been answered in positive in three patients. Twenty-two patients answered positively to question 2 (would the necessity of nonsurgical immobilization be altered as a result of the diagnostic error?). Question 3 (Would the necessity of magnetic resonance imaging be altered as a result of the diagnostic error?) has been answered positively in sixteen patients. The response to question 4 (would the necessity of a cervical total arthroplasty be altered as a result of the diagnostic error?) was positive in twenty-eight patients.

Conclusion

We concluded that 90.47% of diagnostic errors were false negatives, while 9.523% were false positives. Spinal fractures were most common in vertebral bodies and transverse processes.

Extraspinal missed findings were found in rib fractures, lung nodules, hyoid bone fractures, clavicular fractures, thyroid lobe nodules, intraluminal tracheal debris, and dental caries in single cases.

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