

ARE “NORMAL” CT SCANS SUFFICIENT TO ALLOW COLLAR REMOVAL IN THE TRAUMA PATIENT?

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INTRODUCTION:

Universally accepted guidelines for clearance of the cervical spine (C-spine) in the trauma patient do not exist. Numerous algorithms have been proposed and evaluated utilizing combinations of clinical examination, plain radiography, fluoroscopy, computer aided tomography (CT) and magnetic resonance imaging (MRI).^{1 2 3} The goal is to definitively identify any injury that would put the spinal cord at risk during mobilization with or without a collar. When a patient is unable to participate in the clinical examination due to injury, intoxication or intubation, cervical spine evaluation is even more difficult.^{4 5} In this particular setting, the practitioner must depend solely on the available imaging modalities to detect bony and soft-tissue injuries prior to discontinuing cervical spine immobilization.^{6 7} When abnormalities are found, it must be determined if the findings are suggestive of *instability* and therefore represent a risk to the spinal cord or nerve roots when the patient is mobilized. This determination is further complicated by the degenerative changes that become more common with increasing age, thus changing the definition of “normal”.

In the traumatized patient, multi-detector CT scan (MDCT) is a rapid means of C-spine evaluation. Unlike MRI, it allows for closer monitoring of the traumatized patient during study acquisition.⁸ Many emergency departments have direct access to these machines. Furthermore, CT image resolution has improved to the point where it may be sensitive enough to indirectly identify inferred soft tissue injuries by subtle vertebral malalignment or loss of congruity of the facet joints.⁹ Previous literature has reported sensitivities as high as 98-100% for the detection of unstable C-spine injuries with MDCT.^{10 11} This

would suggest that MDCT alone may be sufficient, in and of itself to clear the C-spine.¹²

In our study, 2 attending spine surgeons evaluated the cervical spine MDCT scans of traumatized patients who previously had their studies interpreted as negative by fellowship trained Emergency Medicine Radiology attendings. Our objective was to determine whether and how often an initial MDCT scan interpreted as having no bony injury or evidence of instability by an attending Emergency Room radiologist would be confirmed as sufficient to rule out a C-spine injury by an attending spine surgeon, and therefore allow for patient mobilization without the use of a collar.

METHODS:

The study protocol was approved by the Institutional Review Board at Brigham and Women's Hospital, an ACS verified Level 1 Trauma Center. Seven hundred and forty patients consecutively admitted to the Emergency Department between June 2001 and July 2006 with a presenting diagnosis of trauma who underwent both a CT scan and MRI of their C-spine as part of an institutional protocol were included. From the onset of data acquisition until June 2006, all scans were performed on a 16-detector CT. All subsequent scans were performed using a 64-detector scanner. Each scan was read by a fellowship trained Emergency Room attending radiologist and the reports were made part of the official medical record.

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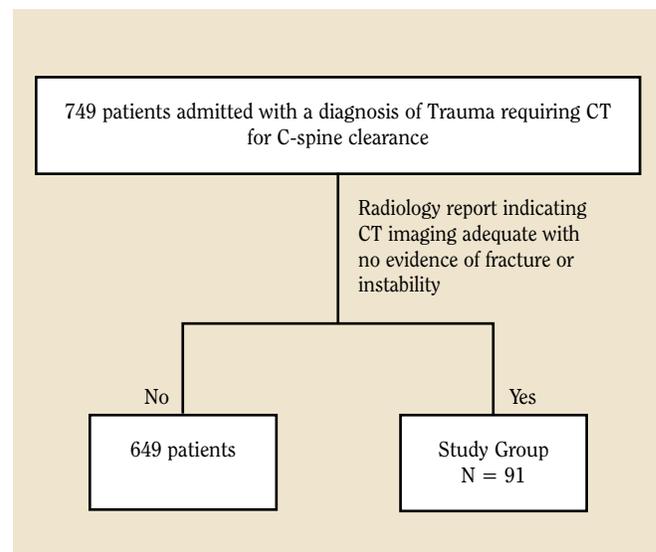


Fig. 1. Study outline

The official CT scan reports were reviewed by members of the study group who were not involved in evaluating the study images. 649 studies were officially read as either inadequate for analysis or demonstrating evidence of fracture or ligamentous injury and were omitted from the database. Following this review, 91 patients were identified who were reported by the attending radiologist as having an adequate CT scan of the C-spine that contained no evidence of fracture or ligamentous injury (Figure 1).

A database of these patients was created for directed CT review by our 2 fellowship trained spine surgeons. The spine surgeons were blinded to the radiologists' specific findings but were aware that all of the studies had been read as not containing evidence of fracture or signs of instability. They were also blinded to each patient's presentation including the mechanism of injury and clinical evaluation as well as to any other radiographic imaging. All CT images were made available electronically.

After evaluating the CT scans, the surgeons were instructed to address the following questions:

- Is the study adequate?
- Is the MDCT scan positive (or negative) for findings suggestive or suspicious of an acute injury?
- Is the c-spine *stable*?
- Is there sufficient information to safely remove the collar?

Reasons for the studies to be judged inadequate included: motion artifact, insufficient visualization of the cervical-thoracic or occipital-cervical junctions, incomplete reconstructive views, or poor quality. Studies were deemed positive if they were thought to contain evidence of fracture or occult signs or suggestions of instability.

Analysis was performed by examining the extent that each attending spine surgeon agreed or disagreed with the attending radiologist with respect to the following four variables:

- whether the study was adequate;
- whether it had abnormal findings;
- whether there was evidence or suspicion of C-spine instability; and
- whether it would require continued use of the c-collar.

Inter-observer agreement was then calculated between the readers. Ninety-five percent confidence intervals were calculated using the binomial distribution.

RESULTS:

Both spine surgeons agreed that 77 of the 91 (85%) studies were *adequate* to evaluate for possible C-spine injuries (Table 1). Seven of 91 (8%) MDCT's were deemed *inadequate* by both

surgeons (2.3-13.1%, 95th CI). The total observer agreement between the spine surgeons was 91% (Kappa 0.59)

Three of the *adequate* MDCT scans had fractures that were identified by both spine surgeons. Another 2 studies were thought to show a fracture by at least one of the readers. The fractures identified were of the occipital condyles, and facets of C6 and C7.

Of the 77 studies read as adequate, the readers agreed that 60 (78% agreement, Kappa 0.15) contained no evidence of fracture or instability.

Fifteen of 91 (16%) scans had findings that were suspicious for instability by at least one of the spine attendings. These findings included loss of cervical lordosis, hyperextension thru the disc space of C3-4, mid-cervical kyphosis, and a C6-7 facet subluxation. Of the 77 *adequate* MDCTs, 3% (0-7.0%, 95th CI) were felt to contain findings consistent with c-spine instability by both readers (82% observed agreement, Kappa 0.12). Five studies were thought to contain abnormal findings that would not lead to instability. These findings were predominantly degenerative changes and the continued use of a C-spine collar was thought to be unnecessary.

Fifteen MDCT's (16%) were felt to require continued use of the collar by the spine attendings due to fracture or abnormality. The readers agreed on 64 (83%) of these studies (Kappa 0.22).

DISCUSSION:

Our institution's current algorithm for clearance of the C-spine in the traumatized patient who cannot participate in the clinical examination includes MDCT and MRI or continued collar use until a clinical examination or definitive radiographic evaluation is obtainable. Cervical collar immobilization is continued until both MDCT and MRI demonstrate no evidence of injury that could lead to instability or a fracture that requires immobilization for healing. Given the difficulty of obtaining an MRI on many of these patients due to mechanical ventilation, removing the patient from the controlled environment of the ICU,¹² and the need for nursing staff to chaperone the patient during the study, we sought to evaluate if a MDCT scan read as normal was sufficient to rule out C-spine injury.

Several recent publications extol the sensitivity and reliability of the MDCT to identify any cervical spine injury that may cause instability.^{11,13} This imaging modality is indeed very sensitive and accurate, however, readings have subjectivity. Thus, as our study highlights, it is important to have more than one reviewer evaluate the imaging studies. This is quite similar to the protocol adopted and reported by Stelfox and Velmahos et al.¹³

Our analysis suggests that a "normal" MDCT (as read by a fellowship-trained emergency radiology attending) of the cervical spine may not fully eliminate the possibility of subtle injuries such as a facet fracture, facet subluxation or a pure ligamentous injury. Three percent (3.3%) of patients with MDCTs read as normal in our cohort were thought to have findings that could represent instability by both readers.

The large percentage (8%) of CT scans in this study judged to be inadequate to accurately evaluate the C-spine for

“clearance” was a surprising finding. In this subset of trauma patients, additional studies such as a repeat MDCT or MRI would thus be necessary prior to c-collar removal.

While our spine surgeons identified fractures, evidence or suspicion of instability and inadequate studies, there was a significant degree of inter-observer disagreement. For example, three fractures were identified by both of the attending spine surgeons, but these same surgeons did not agree on an additional 20 abnormalities. Examples of abnormalities identified by one but not both of the readers were a C7 superior facet fracture and an occipital condyle fracture. There was a greater degree of agreement on study adequacy and whether the collar could be safely removed than whether a study was positive or negative or whether or not instability was evident. The associated kappa values are low because the majority of studies did not have abnormal findings. Thus, considerable agreement would be anticipated by chance alone. Furthermore, the differences in the readers’ observations highlight the subjective nature of CT interpretation as well as the ambiguity of the term *instability*.

Perhaps the most significant limitation to our study is the question of whether the injuries identified by the spine surgeons were in fact true injuries. The validity of these findings could have been further evaluated by additional readers or through correlation with MRI or repeat MDCT. This comparative study is currently underway.

Our study was not thought to be affected by the change of the CT scanners from 16 detector to 64 detector machines. The amount of data obtained per centimeter of patient movement through the scanner is the same, but the 64-detector scanner is able to acquire the data in a more rapid fashion.¹⁴

While it is recognized that continued C-collar immobilization has been associated with complications including difficulties in airway management¹⁵ and skin breakdown,¹⁶ reliance purely on the initial MDCT scan alone to clear the C-spine may not always be feasible.

The consistency between the 2 spine surgeons in identifying occult injuries and the significant number of suboptimal studies suggests that MDCT scans obtained on trauma patients need to be thoroughly evaluated both by the primary team and often a spine consultation if there is any suggestion of abnormality. Direct communication between the primary team and the attending radiologist might also lead to more consistent interpretations between services and ultimately a safer and more efficient approach to cervical spine evaluation and collar management.

CONCLUSION:

The safest and most expeditious mode of C-spine clearance has not yet been defined. Reliance on a single imaging modality may lead to missed injuries. If the decision to remove the C-collar is going to be heavily weighted on the interpretation of the MDCT alone, it is recommended that both the primary service and the radiologist independently read the study. In the event of lack of agreement or concerns about the quality of the study, it would be prudent to involve spine surgeons early in the course of evaluation. Ultimately, improved communication and cooperation among the many care-givers of the polytrauma patient will lead to a safe, efficient and cost-effective way of clearing the C-spine.

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