

Utility of MRI in Blunt Trauma Patients with a Normal Cervical Spine CT and Persistent Midline Neck Pain on Palpation

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Abstract *Introduction:* The blunt trauma patient with a normal neurologic exam, and persistent midline cervical spine tenderness remains a diagnostic challenge. The patient with a symptomatic neck can be subsequently treated with flexion-extension cervical spine X-rays, MRI of the cervical spine, or no further imaging. *Methods:* This is a single center, retrospective study that spanned five years. Our current protocol for cervical spine clearance is described, which utilizes neck MRI for the trauma patients with persistent midline neck tenderness, a normal neurologic exam, and a normal CT of the neck. These symptomatic neck patients were identified from the institution's radiology database of patients that had both a CT and an MRI. *Results:* There were 6237 patients identified during the time of the study, and 81 were found to have both a CT and an MRI of the cervical spine for a symptomatic neck without a neurological deficit. There were 4 patients identified that had a normal CT, and subsequently had a new finding on the MRI scan; all were discharged with their cervical collar on with Spine Specialist followup. *Conclusion:* In 4.94% of our patients, the MRI had significant findings that changed the management of the patient. We will continue to perform cervical MRI in our symptomatic neck patients after blunt trauma with a normal cervical spine CT.

Keywords: blunt trauma, cervical spine injury, cervical spine imaging, neck pain, spine injury

1. Introduction

Cervical spine injury after blunt trauma remains a diagnostic challenge. Compounding the complexity of this issue is that cervical spine injury is uncommon, with an incidence of 3.5% in a recent series [1]. The obligation is to fully image the cervical spine in the trauma patient, but this needs to be balanced against expeditiousness, and cost considerations. Missed injuries do still occur, even in the era of pan CT scans [2], with the potential for devastating consequences [3].

Following clinical criteria, in low risk patients, either the Canadian C-spine Rule, or the NEXUS Criteria guide clearance of the neck, without the need for further imaging [4]. Conversely, any patients with risk factors for cervical spine injury, or symptoms related to the neck mandate radiographic imaging. While traditionally this was done with plain radiographs of the cervical spine in multiple views, multidetector CT imaging of the cervical spine has supplanted plain radiography due to increased sensitivity for injury [5,6]. In a series by Sanchez *et al*, utilizing a CT based protocol to workup patients for cervical spine injury after blunt trauma had a sensitivity of 99% with a specificity of 100% [7].

As in most other trauma centers, we currently clear the C-spine after trauma with a protocol (Figure 1). Low risk patients are excluded via the NEXUS Criteria, and their collar removed without further imaging or workup.

Patients that cannot have their collar discontinued by NEXUS Criteria go on to cervical spine imaging via a CT scan with reconstruction, which is read by a board certified neuroradiologist. If the CT of the cervical spine is negative, the patient is reexamined. If the patient is obtunded, the collar is switched from a transport collar to a Philadelphia collar, and an MRI of the cervical spine is obtained, realizing that the requirement of a cervical MRI in the clearance in the obtunded patient is not without its own controversy [8,9].

Perhaps the most controversial area of cervical spine clearance is the patient with no neurological deficits, a normal CT scan of the cervical spine, and persistent midline neck pain by palpation by the examiner. As in most centers, we consider this to be a symptomatic neck. Given the current known limitations of visualizing the soft tissues of the neck with CT scans, a second study is should be obtained. The previous recommendation of ATLS in this situation was for flexion-extension views to diagnose the cervical spine with "occult instability" [10]. The latest Advanced Trauma Life Support (ATLS) guidelines indicate that there are three options for these patients: MRI, flexion-extension X-ray films or treatment with a semirigid collar for two to three weeks, with "subsequent repeat examination and imaging if necessary" [11]. Additionally, MRI of the cervical spine is recommended by the American College of Radiography as a complementary study to the Cervical CT. This is due to MRI's advantages in imaging the soft tissues, which is

useful to assess for ligamentous injury or cord injury [12]. Given the current cost of the MRI, as well the delay in obtaining it, and adding in the low yield of these confirmatory studies, we sought to study this important issue. Additionally, there are inherent disadvantages to MRI, particularly in the trauma population, including transport away from the trauma resuscitation area in most institutions, limitations of monitoring, longer image acquisition times in comparison to CT, and ferromagnetic object incompatibility [13].

<p>1- Clinical Clearance by Nexxus Criteria: Patient meets all the following:</p> <ul style="list-style-type: none"> -Patient has no neck related symptoms -Has a negative neck exam including range of motion -Is awake, alert and oriented with a GCS = 15 -No substance intoxication -No significant distracting injury <p>2- For patients that do not meet criteria for clinical clearance, Cervical Spine CT Scan cleared from cranium to T1 by the attending radiologist If the patient has midline neck pain by palpation or on passive ROM, go to #3. If the patient has altered mental status expected to persist more than 48 hours, go to #4.</p> <p>3- A second study will be obtained with MRI as the study of choice, with flexion-extension X-rays as an alternate study if there is a contraindication to MRI. If both the CT and the 2nd study are normal, the neck is cleared.</p> <p>4- Mental status is altered with a normal CT. The neck is not cleared until either an MRI is obtained and documented to be normal, or the patient's mental status is improved to allow participation in a clinical spine clearance exam.</p> <p>5- Any patient with an abnormal or questionably abnormal radiographic study, or has any neurological signs or symptoms mandates a Neurosurgical or Orthopedic Spine Surgery consultation.</p>
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Figure 1. Cervical Spine Clearance Protocol

2. Materials and Methods

This is a single institution, retrospective study of the trauma patients cared for at our institution. Winthrop University Hospital is a regional trauma center, and a tertiary care facility. It sees an annual volume of approximately 1500 trauma patients annually, predominantly blunt. There is a dedicated trauma team of Emergency Medicine attendings, five Trauma Surgery attendings and ATLS certified housestaff. All neurological imaging studies are read by board certified neuroradiologists. Any spine injuries are treated by a board certified Neurosurgeon or Orthopedic Spine Surgeon (hereafter referred to as "Spine Specialist"). This study received the approval of the hospital's Investigational Review Board.

All trauma patients are provided their care in accordance with ATLS protocols. All blunt trauma patients have their neck stabilized from the field in a transport collar, that if not clinically cleared is changed to a Philadelphia collar while still in the Emergency Department. If the patient is anticipated to require the collar for more than 72 hours, it is subsequently changed to a Miami-J collar secondary to patient comfort and skin integrity issues [14]. Full cervical spine precautions are maintained from admission until the cervical spine is clinically cleared (or radiographically cleared by both CT and MRI for a patient who is neurologically impaired and cannot participate in a clinical exam).

The radiology imaging database was used to identify those trauma patients that received both a CT of the cervical spine and an MRI within 72 hours. Data was collected from January 1st 2007, till December 31st, 2011. Inclusion criteria were blunt mechanism of trauma, and age greater than 16 years old, persistent midline tenderness on palpation, a normal official report CT of the cervical spine, and no neurological deficits on admission to the hospital. Exclusion criteria were age under 16 years old, penetrating mechanism, and any neurological deficit on admission, or before the time the cervical CT scan was completed.

Data points collected included the following: demographics, CT findings, MRI findings, mechanism of injury, treatment of any neck injury, and the interval from CT scan to MRI scan. This information was tabulated in a Microsoft Excel 2007 spreadsheet for analysis. Any abnormal MRI scan prompted a thorough chart review to confirm the normal findings of the cervical CT scan, and the treatment rendered by the Spine Specialists.

CT scan of the neck is performed using a Siemens Somatom Definition 64 slice scanner. MRI of the cervical spine is done at our institution on one of two scanners: a Philips Intera 3T, and a GE Signa MR 1.5T. All radiology reports were final reports, and part of the official medical record.

3. Results

During the 5 year duration of study, there were 6237 patients identified in the trauma database. Eighty-one patients were identified as trauma patients that received both a cervical CT and a cervical MRI, without any neurological symptom or deficit. Their mean age is forty-five years old, with male gender more common at forty-five patients (55.5%). The most common mechanisms of injury were motor vehicle accidents (includes motorcycles) 55.5%, falls 27.2%, and pedestrians struck 11.1%. Most had a normal Glasgow Coma Scale (GCS) of 15, with the lowest recorded GCS of 13 and a mean GCS of 14.8.

There was a significant interval found between the cervical CT scan and the completion of the MRI scan. This is secondary to the multiple steps involved after the CT scan including the time needed to read the scan, and the time for the clinicians to process the reading, and to order the cervical MRI scan. The mean delay was 1224.5 minutes, realizing that this is almost a full day (24 hours = 1440 minutes). This is partially explained by the unavailability of the MRI technicians, except for emergencies, during the overnight hours.

Of the 81 patients under study, that all had no neurological deficits, a normal cervical CT scan, and persistent midline tenderness by palpation, there were 4 patients (4.94%) that had an abnormal MRI cervical scan. Of these 4 patients, 3 had an acute finding on the MRI, and 1 had a chronic finding that the CT did not detect. These findings are summarized in Figure 2. In all cases, the patient did not require emergent surgery for stabilization, but were discharged in a Miami-J collar with outpatient follow-up. None of these patients needed subsequent spinal surgery for this injury at our institution, or experienced any neurological deterioration during their hospital admission.

<p><i>Acute</i></p> <ul style="list-style-type: none"> - Subtle acute fracture of C7 and T1 with no vertebral body compression - Small central disc hernia ion at C5-C6 - C4-C5 through C6-7 interspinous signal hyperintensity suggesting ligamentous injury <p><i>Chronic</i></p> <ul style="list-style-type: none"> - Severely compromised spinal cord due to ossification of the posterior longitudinal ligament
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Figure 2. Summary of Abnormal MRI Findings in Patients with a Normal Cervical CT Scan

4. Discussion

The blunt trauma patient with persistent midline neck tenderness, with no neurological deficits and a normal cervical CT continues to remain a challenge to trauma clinicians. This is in large part to the inherent limitations of the CT of the cervical spine in imaging the soft tissues of the cervical spine. Compounding this is the constant balancing act that clinicians are faced to provide a thorough workup in a timely, and cost effective manner, while simultaneously not missing any injury.

The issue of the “missed injury” is one of the central tenets of trauma care. This is why the primary and secondary surveys are repeatedly stressed, to minimize the risk of missing an injury, with a current trend towards a tertiary survey [15]. Cervical spine injury after blunt trauma exemplifies this concept to the highest degree given the quite low incidence of injury to this area, coupled with the potential devastation that spine injury represents. Injury to the cervical spinal cord that results in one patient sustaining a paralysis also represents an expensive injury with annual costs exceeding \$28,000 in one analysis [16].

It is encouraging that no patient with a normal CT of the cervical spine subsequently had an unstable spine, or one that required an operative stabilization after MRI imaging. However, it is concerning that three patients of our 81 study sample had an acute injury to their cervical spine, with an additional patient with a chronic spine issue, and all had normal cervical spine CT's. In all of these four cases, it did prompt a change in management, which involved discharging the patient with their semirigid cervical collar in place (Miami-J), with a plan for subsequent outpatient imaging and followup with the Spine Specialist.

Only 4 of the MRI's in our series provided new information, and the remaining 77 studies confirmed the normalcy of the CT of the cervical spine. The direct cost of these MRI studies is estimated to be \$27566 using current hospital cost data. However, the true cost needs to account for the delay in discharge of almost a day for these 77 patients, which adds in \$144040 of hospital stay charges, assuming they are on a regular floor, and not a higher level of care. This sums to a combined charge of both the MRI, and the increased hospital stay of \$171,606

for these 77 negative studies. However, given the previously mentioned costs of care to a paralyzed patient over time, it can be justified.

Previous studies in this area have been few. One of the early studies in this area was done by Schuster *et al*, which looked at 93 patients with a normal neurologic exam, a normal cervical spine CT, and persistent cervical spine pain who underwent an MRI [17]. While their conclusion is that MRI is unnecessary in this population, there are some issues with their study. One limitation of this study is that the neck pain was not by palpation from an experienced examiner, but rather subjective according to the patient. This will overestimate the neck pain component, and overuse MRI as it includes patients not only with midline neck tenderness, but also spasms of the paraspinal muscles lateral to the spinal column. The other limitation is that while the CT imaging was axial, it is unclear if sagittal reconstructions were done on the spine, which is the common practice currently.

A more recent study by Soult *et al* also looked at the issue of MRI of the cervical spine as an adjunct study [18]. They looked at 389 blunt trauma patients, of which 190 had “persistent pain on physical examination” subsequent to a normal cervical spine CT. Upon review of their MRI findings, they found new ligamentous edema or injury in 12%, and new disc injury in 2% of cases. Furthermore, the MRI did not change any management decision, nor did any patient require an operative intervention on the spine for instability. In addition, all hard collars were removed in their patients, and switched to a soft collar for comfort. They subsequently describe that they have incorporated this into a protocol based on CT imaging alone and forego the MRI in the patients with persistent pain. A limitation of this study is that MRI imaging was obtained on all patients with persistent neck pain, but it was not described if it was midline by palpation, or pain lateral to the neck.

Ackland *et al* performed the largest study which involved 178 subjects with persistent midline neck tenderness after blunt trauma with a normal cervical CT, and was the only prospective study of this population [19]. Their protocol was the only one that specified that the neck tenderness was in the midline on palpation by the examiner. They found that 44% of their population had an acute cervical injury on MRI, a substantially higher proportion than in previous studies. One of the possible explanations of the higher detected injury rate on MRI is that they included edema of the posterior muscle and of the ligaments as an injury. In the absence of other injuries, most other series do not count that as an injury. Even so, five of their patients (2.8%) underwent operative intervention, including one for delayed instability, and another 33 (18.5%) required semirigid cervical collars for 2 to 12 weeks. They advocate continued use of MRI scanning in these patients, with further research to target the highest at risk, including those with CT findings of advanced spondylotic degeneration, patients with minor isolated thoracolumbar fracture, and exposure to multidirectional spine forces. In a follow-up analysis, it was described that a neck disability developed in 43% of the patients [20].

Limitations of our study are several. The most important is that ours is a retrospective study, as it is challenging to obtain informed consent in the trauma population on presentation. Another limitation is that there

were two different MRI scanners used to obtain imaging, and two neuroradiologists providing official reads on the imaging studies. The patients are also examined by a variety of housestaff, including both physician assistants, and surgery residents, making the initial assessment of midline tenderness of the cervical spine not as standardized if all examined by a single practitioner.

5. Conclusion

While CT of the cervical spine is commonly used at most trauma centers as the initial study to exclude injury, it has its limitations. In the blunt trauma patient with persistent midline tenderness, a normal neurological exam, and a normal cervical spine CT, there is a low incidence of soft tissue injury not seen on a CT of this area. While the incidence of this is low, it is not negligible in our current study, and was even higher in other studies that have researched this important issue. Given the severe consequences of a missed cervical spine injury, at our center we will continue to use MRI of the cervical spine in this common subpopulation of blunt trauma patients with a symptomatic neck, but no neurological deficits and a normal CT of the cervical spine.

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