

A systematic review of the need for MRI for the clearance of cervical spine injury in obtunded blunt trauma patients after normal cervical spine CT

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ABSTRACT

Clearance of cervical spine injury (CSI) in the obtunded or comatose blunt trauma patient remains controversial. In patients with unreliable physical examination and no evidence of CSI on computed tomography (CT), magnetic resonance imaging of the cervical spine (CS-MRI) is the typical follow-up study. There is a growing body of evidence suggesting that CS-MRI is unnecessary with negative findings on a multi-detector CT (MDCT) scan. This review article systematically analyzes current literature to address the controversies surrounding clearance of CSI in obtunded blunt trauma patients. A literature search through MEDLINE database was conducted using all databases on the National Center for Biotechnology Information (NCBI) website (www.ncbi.nlm.nih.gov) for keywords: "cervical spine injury," "obtunded," and "MRI." The search was limited to studies published within the last 10 years and with populations of patients older than 18 years old. Eleven studies were included in the analysis yielding data on 1535 patients. CS-MRI detected abnormalities in 256 patients (16.6%). The abnormalities reported on CS-MRI resulted in prolonged rigid c-collar immobilization in 74 patients (4.9%). Eleven patients (0.7%) had unstable injury detected on CS-MRI alone that required surgical intervention. In the obtunded blunt trauma patient with unreliable clinical examination and a normal CT scan, there is still a role for CS-MRI in detecting clinically significant injuries when MRI resources are available. However, when a reliable clinical exam reveals intact gross motor function, CS-MRI may be unnecessary.

Key Words: Blunt trauma, cervical spine CT and MRI, obtunded

INTRODUCTION

There is no universally accepted algorithm to clear the cervical spine in an obtunded or comatose blunt trauma patient without apparent neurological deficit. Clinical practice guidelines are left

to the discretion of each institution by the Eastern Association for the Surgery of Trauma (EAST).^[1] In patients with negative computed tomographic (CT) imaging of the cervical spine (CS) and unreliable physical examinations, magnetic resonance imaging (MRI) to evaluate potential ligamentous injury is the imaging modality of choice.^[1-2] However, there is controversy on the use of MRI in the setting of normal findings on multi-detector CT (MDCT) scan in this patient population. While some authors advocate the routine use of MRI in addition to MDCT scan for the clearance of CS in obtunded patients,^[3-6] other practitioners suggest that MRI in the setting of normal findings on MDCT scan is unnecessary.^[7-16] The practice dilemma lies in the idea that the devastating effect of a missed CS injury may outweigh the costs and risks associated with subjecting an obtunded patient to MRI evaluation. In the United States, high healthcare costs and increasing fiscal constraints have prompted re-evaluation of the utilization of expensive practices such as MRI. Across the globe,

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traumatic injury continues to carry substantial public health costs and MRI is frequently not an option due to its cost or availability. On the other hand, CS immobilization is not without risks; complications related to CS immobilization occurred in 64% of obtunded patients cared for using a strict evaluation protocol utilizing MRI in one study.^[16] These risks include decubitus ulcers, dysphagia, discomfort, impaired mobility, respiratory difficulties, and elevations in intracranial pressure.

The purpose of this review article is to systematically analyze clinical studies evaluating the use of MRI in the setting of a normal CS-CT in obtunded blunt trauma patients. Our primary aim was to propose an algorithm for CS clearance in the obtunded blunt trauma patient. As CT and MRI data resolution and image quality have improved significantly over the past decade, the studies evaluated are limited to the last ten years (the period between 2003 and 2013).

MATERIALS AND METHODS

Eligibility criteria

All studies written in the English language with the following patient criteria were included: Adults greater than 18 years of age who had sustained blunt trauma, were obtunded or comatose, had unreliable physical examination, had a negative cervical spine CT and underwent MRI evaluation. Studies in the pediatric population or studies with awake, alert patients with negative CT who underwent MRI due to persistent cervical spine tenderness were excluded. Studies were classified according to levels of evidence for therapeutic studies adapted from the Center for Evidence-Based Medicine [Table 1].

Information sources

A literature search of the National Library of Medicine and the National Institutes of Health MEDLINE database was conducted using all databases on the National Center for Biotechnology Information (NCBI) website (www.ncbi.nlm.nih.gov) and by scanning through the reference lists of articles retrieved.

Table 1: Levels of evidence applied to individual studies

Level	Type of evidence
1A	Systemic review (with homogeneity) of RCTs
1B	Individual RCT (with narrow CIs)
1C	All or none study
2A	Systemic review (with homogeneity) of cohort
2B	Individual Cohort study (including low quality RCT, e.g. < 80% follow-up)
2C	"Outcomes" research; Ecological studies
3A	Systemic review (with homogeneity) of case-control studies
3B	Individual case-control study
4	Case series (and poor quality cohort and case-control study)
5	Expert opinion without explicit critical appraisal or based on physiology bench research or "first principles"

RCT: RANDOMIZED CONTROLLED TRIAL; CI: CONFIDENCE INTERVAL. ADAPTED FROM THE OXFORD CENTER FOR EVIDENCE-BASED MEDICINE.^[17]

Search

Keywords used to search all databases were: "Cervical spine injury," "obtunded," and "MRI." Limitations were applied to the English language, studies conducted within the last 10 years, and adults older than 18 years of age.

Study selection

Article selection was conducted by the authors based on our eligibility criteria discussed above.

Data collection process and items

From the selected studies, data were extracted primarily by the first author and reviewed by all authors; disagreements were resolved by discussion between the authors. The following information was extracted from all studies: Number of patients, radiology findings, method of treatment based on radiology findings, and patient outcomes.

Summary measures

The principal summary measure was any significant devastating MRI finding that was missed on CS-CT.

RESULTS

Study selection

The search yielded 44 PubMed scientific and medical abstracts, 83 PubMed Central full text journal articles, 5 book reports and 5 PubMed health clinical effectiveness, disease and drug report for a total of 137 articles [Figure 1]. Limitations of the 137 articles to publication date within the last 10 years and/or adult population and the English language resulted in 63 articles. Eleven of these articles met the inclusion criteria, yielding data on a total of 1,535 patients [Figure 2]. Descriptions of the 11 studies are listed in Tables 2 and 3.

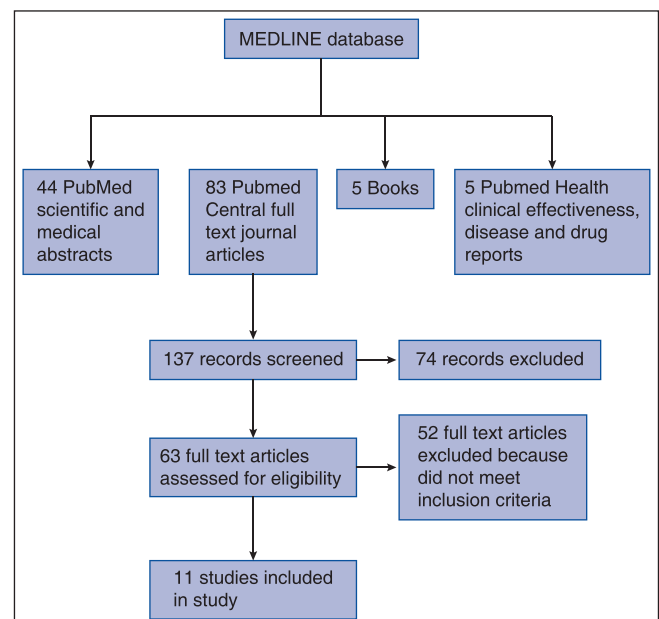


Figure 1: Methodology for identification of relevant quality studies

Table 2: The included studies, their types, levels of evidence, and summaries of conclusions

Study [ref]	Type of Study	Level of evidence	Study Conclusion(s)
Como ^[9]	Prospective Cohort	2B	CS-MRI may be unnecessary in the obtunded blunt trauma patients if the CT-CS is negative.
Hogan ^[50]	Retrospective Cohort	2B	A normal multi-detector row CT scan of the total cervical spine in obtunded and unreliable blunt trauma patients allowed the authors to exclude unstable injuries on the basis of findings at follow-up CS-MRI.
Sarani ^[6]	Retrospective Cohort	2B	The study supports the practice of obtaining CS-MRI in patients who are either un-examinable or symptomatic with a normal CT-CS finding.
Menaker ^[53]	Retrospective Cohort	2B	Continue to use MRI for CS clearance in unreliable patients because even newer generation CT-CS can miss CS injuries in unreliable patients.
Soult ^[12]	Retrospective Cohort	2B	CS-MRI does not add substantially to the decision-making of CSI clearance in an obtunded patient if the patient is able to localize on physical exam.
Steigelman ^[12]	Retrospective Cohort	2B	The use of CS-MRI in patients with normal results on the CT-CS does not appear to alter treatment.
Kaiser ^[8]	Retrospective Cohort	2B	CS-MRI continues to play a vital role in the work-up of neurologically altered patients. The use of single slice CT scanner was associated with more missed injury.
Schoenwaelder ^[33]	Retrospective Cohort	2B	A normal single-slice helical CT with sagittal reformats of the CS in intubated trauma patients excluded unstable injuries at follow-up CS-MRI.
Tomycz ^[24]	Retrospective Cohort	2B	Outside of the appropriate application to patients with neurological deficits, CS-MRI is unlikely to uncover unstable CS injuries in obtunded/comatose patients in the presence of a normal CS-CT using modern imaging protocols.
Khanna ^[55]	Retrospective Cohort	2B	The addition of a CS-MRI to the evaluation protocol of obtunded/comatose patients with an otherwise normal neurologic examination and a normal cervical CT did not provide any additional useful information to change the management of these patients.
Stassen ^[5]	Prospective Cohort	2B	CT alone missed a statistically significant number of CS injuries. The study confirms that CS-CT in combination with CS-MRI provides a safe and efficient method for CS clearance in obtunded blunt trauma patients.

CS: CERVICAL SPINE; CSI: CERVICAL SPINE INJURY; CT: COMPUTED TOMOGRAPHY; MRI: MAGNETIC RESONANCE IMAGING

Table 3: Individual and overall study results

STUDY	N	Normal MRI	Abnormal MRI	Cervical Collar removed	Prolonged Cervical Collar Immobilization	Cervical Spine injury requiring Surgical Intervention
Como	115	109	6	6	0	0
Hogan	366	354	12	NM	NM	NM
Sarani	164	122	42	11	22	9
Menaker	203	184	19*	2	15*	2
Soult	24	19	5	NM	NM	0
Steigelman	120	113	7	5 [†]	2	0
Kaiser	114	91	23 [#]	16	6	0
Schoenwaelder	55	45	10	10	0	0
Tomycz	180	142	38	NM	16	0
Khanna	150	76	74	NM	NM	0
Stassen	44	31	13	0	13	0
Total	1535	1286 (83.8%)	249 (16.2%)	50	74 (4.8%)	11 (0.7%)

MRI: MAGNETIC RESONANCE IMAGING; NM: NOT MENTIONED MENAKER³ REPORTED ONE PATIENT (*) WITH A SUBOPTIMAL MRI; WHICH WAS TREATED AS ABNORMAL WITH ONGOING NON-OPERATIVE CERVICAL SPINE IMMOBILIZATION; (†) ONE PATIENT HAD CERVICAL COLLAR REMOVED AFTER NEGATIVE FLEXION/EXTENSION FILMS; (#) ONE PATIENT WITH EPIDURAL HEMATOMA IDENTIFIED ON MRI DIED FROM MYOCARDIAL INFARCT BEFORE FULL CONSULTATION WITH SPINE SURGEON

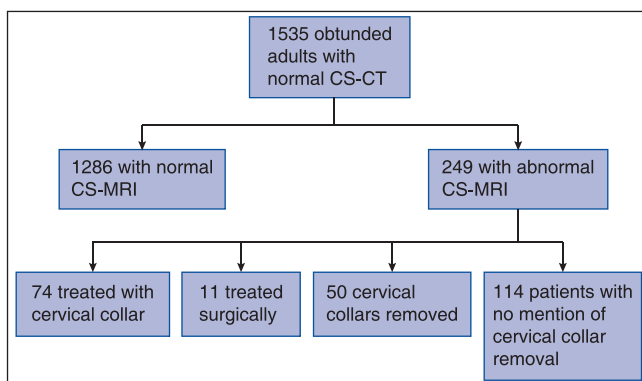


Figure 2: Evaluations, results, and interventions in included patients. CS-CT: Cervical spine computed tomography; CS-MRI: Cervical spine magnetic resonance imaging

Synthesis of results

Each of the 1,535 patients had a negative CS-CT and was subsequently evaluated with CS-MRI. One thousand two hundred and eighty-six patients out of the 1535 (83.8%) had normal MRI findings. CS-MRI detected abnormalities in the remaining 249 (16.2%), including one exam that was reported as suboptimal but treated as abnormal.^[3] The strategy of maintaining cervical collar placement as a precautionary measure with no major change in management was selected in 74 of these 249 patients (29.6%); 11 patients out of the 249 with abnormal CS-MRI (4.3%, 0.7% of the total 1543 patients) were found to have an unstable CS injury on CS-MRI, and all underwent surgical intervention. Fifty patients had their cervical collar removed after CS-MRI; no mention of cervical collar removal was mentioned in the remaining 114 patients [Table 3 and Figure 2].

DISCUSSION

As criteria for clinical assessment of potential CS injury continue to evolve, there continues to be lack of consensus regarding the evaluation of a patient with an unreliable physical examination. The obtunded patient population is more vulnerable to the risks of unindicated imaging, procedures, and orthotic immobilization due to the inability to clinically evaluate their CS for a prolonged time.^[19] There are currently no universally accepted guidelines for CS clearance in the obtunded blunt trauma patient. The Eastern Association for the Surgery of Trauma leaves practice guidelines for this difficult problem to the discretion of each institution.^[1] Computed tomography of the CS is the current gold standard for the initial evaluation of CS injury in blunt trauma patients; when this is normal, CS-MRI is often recommended as a follow-up examination for obtunded patients. There are several reports, however, suggesting that MRI is not necessary and may lead to harm in this patient population, resulting in complications related to unnecessarily prolonged immobilization and increased healthcare costs.

We performed a systematic review analyzing studies conducted from 2003 to present in an effort to develop an algorithm for CS clearance in the obtunded blunt trauma patient. All studies reviewed had level of evidence 2B with conflicting findings regarding the routine need for CS-MRI to evaluate for CS injury in the obtunded blunt trauma patient.

One of the few consistencies among the 11 studies evaluated is that in obtunded patients with gross motor function, clearing the cervical collar in the presence of a normal finding on multi-detector scanner appeared safe; none of such patients in these studies had any significant abnormalities on CS-MRI, and none subsequently developed any neurologic dysfunction. This is in alignment with a recent prospective study by Como *et al.*^[20] demonstrating that removal of cervical precautions is safe and efficacious when CS-CT is normal in obtunded blunt trauma patients who exhibit gross movement of all extremities. On the other hand, none of the included studies reported a clear definition of an “unreliable physical examination;” whether the mere obtundation of a patient classified a patient’s exam as unreliable was not consistently noted throughout the 11 articles reviewed. This limitation may be one source of the conflicting results between the studies. When the physical examination is of high quality and reliable, it may be reasonable to remove the cervical collar, but the data does not unanimously support this conclusion.

In all studies, CS-CT failed to reveal acute ligamentous injury, which was the reason for prolonged cervical collar immobilization in at least 74 (4.8%) patients after CS-MRI and surgical intervention in 11 (0.7%) patients. In the obtunded patient, the reported negative predictive value of flexion/extension films performed under fluoroscopy in ruling out ligamentous injury is over 99%; however, in the setting of normal CS-CT, the incidence of diagnosing any occult injury

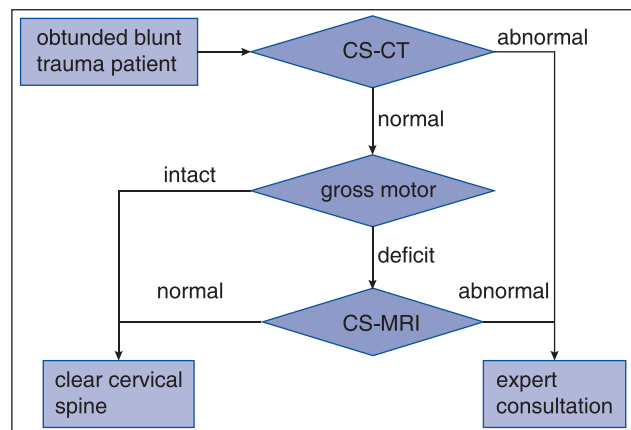


Figure 3: Simplified algorithm for the evaluation of cervical spine injury in the obtunded blunt trauma patient. CS-CT: Cervical spine computed tomography; CS-MRI: Cervical spine magnetic resonance imaging

is very low.^[21,22] Moreover, the flexion/extension views are not generally recommended in the obtunded patient due to chance for further neurologic compromise.^[23]

CONCLUSIONS

Based on these results, we recommend the simple algorithm demonstrated in Figure 3. This allows the clearance of the cervical spine for patients with a normal CS-CT and intact gross motor function, but requires CS-MRI for other obtunded blunt trauma patients when an MRI scanner is available. In resource-limited settings where MRI is not available, patients without a reliable physical examination can be managed with prolonged cervical immobilization despite its drawbacks.

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