

Review Article

Cervical spine clearance in the adult obtunded blunt trauma patient: A systematic review

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ARTICLE INFO

Article history:

Accepted 5 November 2018

Keywords:

Blunt injury
Cervical clearance
Cervical collar
Cervical vertebrae
Nervous system
Obtunded
Trauma

ABSTRACT

Background: A missed cervical spinal injury could have devastating consequences. Patients with a suspected cervical spinal injury are kept in rigid collars for cervical immobilisation. Prolonged collar use has important clinical implications. A well-defined guideline related to the removal of cervical collars from adult obtunded blunt trauma patients has not been developed.

Aim: We sought to determine if Magnetic Resonance Imaging offered a definitive benefit over Computer Tomography with respect to patient management.

Method: We searched Ovid Online, EBSCO, NICE Evidence Journals, Medline, PubMed, BNI, CINAHL and Google Scholar as well as the grey literature. Data extraction and synthesis were performed on studies that compared the radiologic findings and clinical outcomes of Computer Tomography scan and Magnetic Resonance Imaging in this patient group.

Results: There is evidence that supports the safe discontinuation of cervical collar use after a negative multidetector Computer Tomography scan result alone. Magnetic Resonance Imaging may detect a significant number of ligamentous injuries, but such injuries are rarely of clinical significance because they rarely alter clinical management. Its use should be limited to specific circumstances.

Conclusion: It is important for institutions to re-examine the latest evidence regarding cervical spinal clearance in order to update their guidelines.

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Implications for clinical practice

- Prolonged use of a cervical collar has important clinical implications.
- Although it remains controversial, it is emphasised by the literature that purely ligamentous cervical spine injuries are exceptionally rare, especially in the absence of bony fracture.
- MRI may detect a significant number of ligamentous injuries, but such injuries are rarely of clinical significance because they rarely alter clinical management.
- It is important to re-examine the latest evidence regarding cervical spinal clearance in order to update institutions' guidelines.

Introduction

Blunt trauma is associated with a 2% to 6.6% risk of cervical spine, bone and/or ligamentous injury (Plackett et al., 2016). An

injury to the c-spine is considered 'significant' when if overlooked it could result in irreversible neurological deterioration, including paralysis and death (Raza et al., 2013). The Committee on Trauma of the American College of Surgeons recommends that all patients with multiple blunt injuries have their c-spines immobilised until assessed (Stelfox et al., 2007). Once initial CT scan examinations have been performed and normal results have been obtained, ligament injuries must be excluded. In awake and alert patients with blunt c-spine trauma, the absence of distracting injuries, no c-

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spine tenderness or pain on full range of movements, plus a normal neurological examination implies the c-spine can be safely cleared on clinical grounds. In patients with pain or c-spine tenderness, neurological deficit, patients with significant distracting injuries, or patients with altered sensorium additional radiological screening is indicated, (Raza et al., 2013). However, c-spine clearance of the Obtunded Blunt Trauma Patient (OBTP) is less straightforward.

The term 'obtunded' implies a state of cognitive dysfunction in which the clinical examination of a patient becomes unreliable due to decreased Glasgow Coma Scale (GCS) (Raza et al., 2013). It is important to understand the balance between the risks of missing injuries, delaying diagnosis, and secondary spinal cord damage, and the risks of taking unnecessary, potentially harmful spinal precautions at unjustified cost (Richards, 2005). A cervical collar is applied to patients with suspected c-spine injury. Prolonged use is associated with:

- more attempts at intubation with more risks
- delayed tracheostomy
- increased incidence of deep vein thromboses, chest infections and aspiration
- impaired intravenous access (Richards, 2005)
- increased incidence of skin breakdown and pressure ulcers
- raised intracranial pressure
- difficulties with performing mouth care, airway management and daily nursing care (Crim et al., 2001; Plackett et al. (2016); Tan et al., 2014).

A study by Stelfox et al. (2007) found 186 complications in 117 patients, secondary to c-spine immobilisation. When both cervical and ligamentous injuries can be ruled out the collar can be removed, (Richards, 2005), but this does not necessarily mean that spinal turns can be discontinued if required for other reasons.

Different approaches have been advocated to manage obtunded patients with unstable c-spines but a well-defined algorithm has not been agreed (Raza et al., 2013). In a telephone survey performed by Gupta and Clancy (1997), they contacted all twenty-five general intensive care units (ICUs) dealing with major adult trauma in a single National Health Service (NHS) region (South and West). Six of the units' surveys stated they would wait until the patients had regained consciousness before removing immobilisation precautions. It was not unusual for trauma patients to have their c-spines immobilised for prolonged periods of time despite the imaging tests showing no abnormalities. However, this survey was carried out more than twenty years ago.

In 2005, Richards stated that after a normal Computer Tomography (CT) scan, gentle in-line handling was permitted on the ICU while the patient remained unconscious or was deeply sedated allowing the hard collar to be taken off. The collar was replaced when the sedation was reduced and the patient was re-evaluated clinically when awake. This option was preferred if the patient was unlikely to remain unconscious for more than 24 h (Richards, 2005).

C-spine clearance guidelines must be evidence-based to allow for timely and safe removal of collars in patients without injury and to avoid the use of unnecessary advanced imaging modalities (Duane et al., 2016). The ideal imaging modality should not only be able to detect a ligamentous c-spine injury but should also enable the reporting clinician to comment on the stability or not of the c-spine as this might in turn require a significant change in patient management (Raza et al., 2013).

Multiple studies have focused on various modalities but the main options include: plain radiographs; dynamic studies, such as dynamic fluoroscopy or flexion/extension radiography; CT scan

and Magnetic Resonance Imaging (MRI) (Hennessy et al., 2010; Plumb and Morris, 2012).

In polytrauma, radiographs at the cranio-cervical and cervicodorsal junction are often technically inadequate or incomplete, commonly failing to demonstrate the peg or upper border of T1, which reduces the specificity of plain films (Blackmore and Deyo, 1997). Therefore, most authors agree that there is little place for routine plain radiographs in the management of the OBTP (Plumb and Morris, 2012).

A number of studies reported the inadequacy, cost inefficiency and safety concerns of passive flexion-extension radiographs (Anglen et al., 2002; Bolinger et al., 2004; Davis et al., 2001; Griffiths et al., 2002; Spiteri et al., 2006). Thus, The Eastern Association for the Surgery of Trauma (EAST) updated their guidelines in 2009 to reflect these concerns and recommends against this technique in OBTP (Como et al., 2009); a position supported by several authors (Chew et al., 2013; Hennessy et al., 2010; James et al., 2014) and by the American College of Radiology (Richards, 2005).

The technology behind CT scan has progressed considerably since 2004. CT is especially good for highlighting c-spine bony injuries (Berne et al., 1999; Brohi et al., 2005; Brown et al., 2005; Como et al., 2007; Diaz et al., 2005; Hashem et al., 2009; Holmes and Akkinepalli, 2005; Holmes et al., 2002; Mathen et al., 2007; Platzer et al., 2006), with specificities approaching 100%. Harris et al. (2008) quote a negative predictive value of 99.7% for the ability of CT to highlight clinically significant injury. As the majority of neurologic deficits are associated with fractures, our first-line screening modality has evolved to maximise identification of fractures, hence the universal acceptance of CT scan as the initial radiologic examination when an injury of the c-spine is suspected based on clinical criteria (Plackett et al., 2016).

In clinical practice, MRI has been found to be superior at identifying soft tissue injuries not readily detectable on CT scanning (Chew et al., 2013; Stassen et al., 2006). However, it has yet to be determined if these injuries represent a source of occult instability that requires continued spinal immobilisation or a subclinical finding of minimal significance (Chew et al., 2013). MRI is also less sensitive to fractures of the posterior elements of the spine (Holmes et al., 2002; Plumb and Morris, 2012) and to injuries of the cranio-cervical junction (Crim et al., 2001). Routinely performing MRI also carries significant resource implications, requires transfer and introduces the patient to the ferromagnetic environment (Plumb and Morris, 2012), which could not be feasible in all patients (Chew et al., 2013). Although MRI offers additional information about the soft tissue that cannot be visualised with a CT scan, for it to be useful and effective it must impact treatment (Plackett et al., 2016; Raza et al., 2013).

This systematic review sought to answer the following question formulated using the PICO tool: In the adult obtunded blunt trauma patient can use of the cervical collar be discontinued on the basis of a c-spine CT scan alone?

Methods

A search of the literature was performed in October 2016 using the online databases: Ovid Online, EBSCO, NICE Evidence Journals and Databases (Medline, PubMed, BNI and CINAHL) and Google Scholar. The review protocol was not registered in advance. The following keywords were used: blunt trauma, cervical collar, cervical spine, clearance, obtunded. These words were used singly and in combination. The search terms used were mapped to a thesaurus to achieve comprehensive search results. Citation tracking, as well as manual searching online within the library, and review of organisations' papers and guidelines also supplemented this

research. Inclusion criteria were: adult population (≥ 18 years of age); obtunded, who had suffered blunt trauma and underwent both CT and MRI of the cervical spine; publication available in English and downloadable in full text format. Primary and secondary literature was included, and qualitative and quantitative studies that addressed the research question. Excluded were: publications not addressing the research question; articles discussing awake, alert patients; publications related to accident and emergency and pre-hospital settings. Years searched were not limited. Articles were selected and extracted by the main author by reviewing the title and abstract first to determine if the criteria for inclusion were met, followed by review of the full version text (Fig. 1).

Results

From the research, and after duplicates had been removed, 57 potentially relevant articles were retrieved in full text form, from which eight were selected for detailed appraisal. Individual study characteristics and results are shown in Fig. 2. Due to varied study designs and outcome measures we focused on describing the studies and their results and outcomes using a qualitative synthesis. Of the eight papers, five were meta-analyses (Panczykowski et al., 2011; Plackett et al., 2016; Russin et al., 2013; James et al., 2014; and Patel et al., 2015), two were retrospective cohort studies (Hogan et al., 2005; Stassen et al., 2006) and one combined a meta-analysis and a retrospective cohort study (Raza et al., 2013).

Panczykowski et al. (2011) performed a meta-analysis of studies that included OBTP who had normal CT findings and who sub-

sequently underwent MRI. They determined that CT had a sensitivity, specificity and negative predictive value for acute injury that approached 100%. Patel et al. (2015) suggested the negative predictive value for c-spine CT was 100% for an unstable c-spine injury and 91% for any stable injury of the c-spine. There is a best-case 0% cumulative literature incidence of unstable c-spine injuries after negative initial imaging result with a high-quality c-spine CT (Patel et al., 2015). Hogan et al. (2005) stated that CT had a negative predictive value of 98.9% for ligament injury and a negative predictive value of 100% for unstable c-spine injury.

Purely ligamentous c-spine injuries represented between 0.1 and 0.7% of OBTP (Chiu et al., 2001; Davis et al., 2001; Davis et al., 1993; Demetriades et al., 2000; Grossman et al., 1999; Harris et al., 2000; Morris and McCoy, 2004). In order for there to be bony instability without fracture there must be a radiologic abnormality of all three columns on the MRI, known as Denis' Model (Plackett et al., 2016). Plackett et al. (2016) suggested that the incidence of 3-column injury after a negative CT of the c-spine was less than 1 in 1714 patients. In fact, no MRI had identified the type of ligamentous injuries that are commonly agreed upon to necessitate intervention. In another study of more than 9000 adult blunt trauma patients (not only obtunded), when the CT scan was negative for c-spine injury, the incidence of significant ligamentous injury making the c-spine unstable was nil (Duane et al., 2016).

In Russin et al's (2013) analysis of 1322 patients, 137 patients (10%) had positive findings on MRI, of which 52% had changes to their management. The vast majority required further imaging or

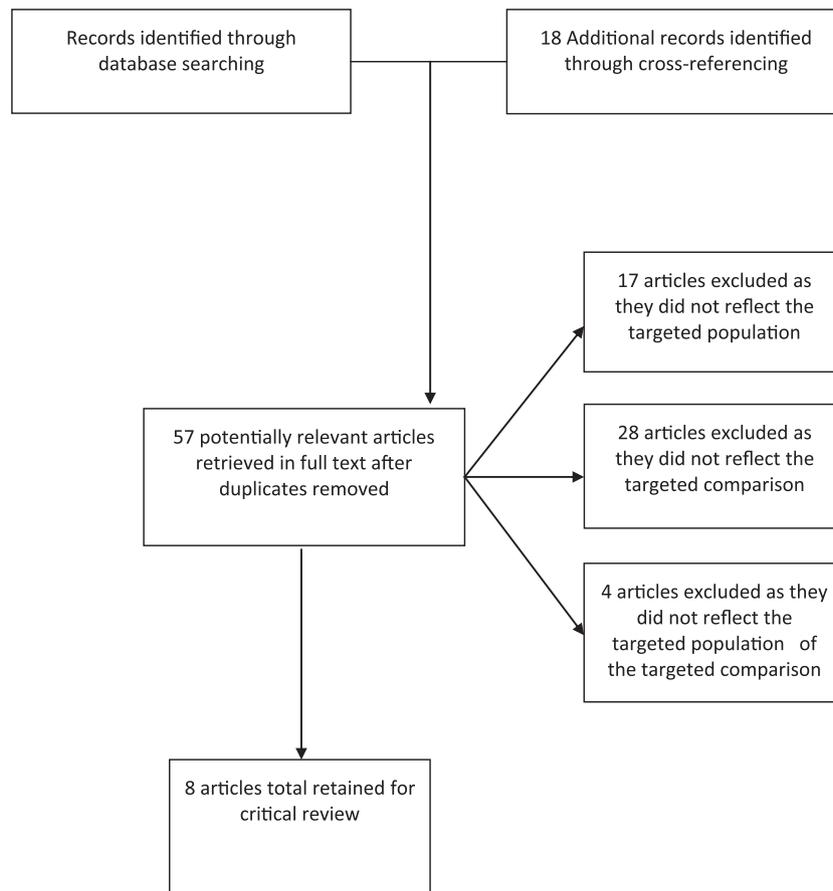


Fig. 1. Literature search trailing using PRISMA flowchart.

Study	Purpose	Design	Sample	Key findings
Hogan et al. (2005) USA	To determine what information, if any, c-spine MRI of the obtunded or “unreliable” patient with blunt trauma adds to multi-detector row CT of the entire c-spine.	Retrospective cohort study	366 obtunded blunt trauma patients who had both CT and MRI to evaluate potential cervical spine injuries.	To consider a c-spine protocol for the obtunded trauma patient that includes routine complete c-spine multi-detector row CT screening without the need for MRI if findings at CT are negative.
James et al. (2014) USA	To analyse current literature to address the controversies surrounding clearance of c-spine injury in obtunded blunt trauma patients.	Retrospective analysis of database (2003 – 2014)	1535 adult (greater than 18 years of age) obtunded blunt trauma patients who had a negative c-spine CT and underwent MRI evaluation.	Clearance of the cervical spine for patients with a normal CT and intact gross motor function, but requires MRI for other obtunded blunt trauma patients when an MRI scanner is available.
Panczykowski et al. (2011) USA	To determine the diagnostic performance of modern CT alone for detecting unstable cervical spine injuries in the population with blunt trauma.	Systematic review and meta-analysis (1966-2009)	17 studies and 14,327 obtunded trauma patients undergoing radiological evaluation of the c-spine (CT, plain radiography, MRI or dynamic fluoroscopy).	Modern CT alone is sufficient to detect unstable c-spine injuries in trauma patients.
Patel et al. (2015) USA	To develop evidence-based recommendations to answer: In the obtunded adult blunt trauma patient, should cervical collar removal be performed after a negative c-spine CT result alone or after a negative c-spine CT result combined with adjunct imaging?	Retrospective analysis of database	1718 adult (16 years or older) obtunded blunt trauma patients who underwent c-spine CT scan	In obtunded adult blunt trauma patients, we conditionally recommend cervical collar removal after a negative high-quality C-spine CT scan result alone.
Plackett et al. (2016) USA	To compare and analyse CT and MRI radiologic findings and clinical outcomes in the assessment of the c-spine in patients who cannot be evaluated.	Retrospective analysis (Studies from 1980 to 2013)	1714 obtunded blunt trauma patients	The vast majority of the additional injuries identified by MRI are of minor clinical significance. Routine MRI after a negative CT scan of the c-spine is not supported by these authors.

Fig. 2. Appraised articles.

were treated with extended time in a cervical collar. [Stassen et al. \(2006\)](#) concluded that 25% of the patients who had a negative CT had a positive MRI for c-spine ligamentous injury. For this reason, MRI was performed if the patient remained obtunded at day three of being in hospital. If both studies were negative, the c-spine was considered 'cleared' and the trauma surgeon removed the cervical collar ([Stassen et al., 2006](#)). In the review conducted by [Plackett et al. \(2016\)](#) noted above from the 1714 OBTP with a negative CT

scan of the c-spine who subsequently underwent an MRI, 271 patients (15.8%) were found to have additional radiologic findings not previously noted on CT. The most common findings were ligamentous injury or oedema, spinal oedema or contusions, and spinal cord compression. Among eleven studies evaluated by [James et al. \(2014\)](#), CT failed to reveal acute ligamentous injury, which was the reason for prolonged cervical collar immobilisation in 4.8% of the patients after MRI and surgical intervention in 0.7% of

Raza et al. (2013) United Kingdom	To determine whether in obtunded adult patients with blunt trauma, a clinically significant injury to the cervical spine be ruled out on the basis of a cervical spine computed tomography.	Retrospective analysis of prospective and retrospective studies (Research 1998 onwards) And Retrospective cohort study (October 2007 - December 2008)	53 adult blunt trauma patients with altered sensorium/obtunded.	The results support the removal of cervical precautions in obtunded blunt trauma patient after normal c-spine CT scan. Any further imaging like MRI should be performed on case-to-case basis.
Russin et al. (2013) USA	To review CT as a stand-alone test for the clearance of cervical spine injury in the unevaluable patient population.	Retrospective analysis	1322 obtunded blunt trauma patients who underwent both CT and MRI of the c-spine.	Insufficient evidence supporting CT for the stand-alone evaluation of the c-spine. It must be supplemented by an additional examination addressing ligamentous instability in this patient population.
Stassen et al. (2006) USA	To evaluate the safety and efficacy of a c-spine clearance guideline utilizing CT and MRI.	Prospective cohort study (January 2003 - January 2004)	52 obtunded blunt trauma patients who underwent both a c-spine CT and c-spine MRI.	CT scan alone for c-spine evaluation misses a statistically significant number of c-spine injuries. When used in combination with MRI (at day 3 as per suggested protocol), no injuries are missed.

Fig. 2 (continued)

the patients. [Khanna et al. \(2012\)](#) found that MRI identified an abnormality in 49% of their patients, with the vast majority of injuries (81%) involving soft-tissue and ligamentous injuries. The false negative rate where unstable injuries were found following a normal CT scan varied from almost 0% ([Como et al., 2007](#); [Sanchez et al., 2005](#)), 2.5% ([Dunham et al., 2008](#)) to approximately 4.3%, of whom approximately 0.29% would require surgical stabilisation ([Plumb and Morris, 2012](#)).

Methodological quality

The quality of the articles included in this review varied. [Panczykowski et al. \(2011\)](#) registered their review protocol on the PROSPERO international register and used QUADAS-2, and PRISMA guidelines, like [Patel et al. \(2015\)](#), to evaluate different aspects of the evidence. Both sets of authors searched a number of databases. [Raza et al. \(2013\)](#) also searched a number of databases for their meta-analysis, but did not describe how they evaluated the evidence. The results from their retrospective review did not include the length of time to follow-up. [Russin et al. \(2013\)](#) and [Plackett et al. \(2016\)](#) used one database, PubMed and did not describe how they evaluated the evidence. [James et al. \(2014\)](#) used MEDLINE and evaluated the evidence using adapted guidance from the Center for Evidence-Based Medicine. [Stassen et al. \(2006\)](#)'s retrospective review acknowledged that the radiologists reviewing MRI results

were not blinded to the results of the associated CT scan for each patient which may have introduced bias. Data from [Hogan et al.'s \(2005\)](#) retrospective review was included in all five of the meta-analyses above.

[Panczykowski et al. \(2011\)](#) investigated outcomes related to unstable cervical spine injury necessitating orthotic or operative treatment. [Patel et al. \(2015\)](#) investigated outcomes related to new neurological change resulting in paraplegia or quadriplegia following cervical collar removal and identification of an unstable injury. Both groups had used GRADE methodology to identify the outcomes they wished to investigate. The other articles did not clearly state primary outcomes, but discussed outcomes related to ligamentous injuries and the need for surgical procedures.

Discussion

Overall, from the eight articles reviewed, only two stated that there was insufficient evidence supporting CT for the stand-alone evaluation of the c-spine ([Stassen et al., 2006](#); [Russin et al., 2013](#)). The two reviews with the most robust methodology strongly supported CT for stand-alone evaluation of the c-spine, when the CT was of high quality, using a modern CT scanner. Some authors supported the idea of using MRI in addition to CT but with some specific criteria. In the setting of a normal CT, the incidence of diagnosing any occult injury is very low. This allows the clearance

of the cervical spine for patients with a normal CT and intact gross motor function (gross movement of all extremities), but requires MRI for other OBTP when an MRI scanner is available. So, these authors suggest in resource-limited settings where MRI is not available, patients without a reliable physical examination can be managed with prolonged cervical immobilisation despite its drawbacks (James et al., 2014).

However, although an MRI scan may be better than a CT scan for identifying soft tissue abnormalities, it is important to understand if these results will change patient management. Khanna et al. (2012) found none of the injuries identified on MRI to be unstable and the authors determined that MRI did not alter clinical management. The American College of Radiologists acknowledge that MRI may detect a significant number of ligamentous injuries, but such injuries are rarely of clinical significance (Chew et al., 2013).

On the other hand, some authors have stated that the detection of such injuries appreciably altered patient management that has consisted almost exclusively of prolonged cervical collar immobilisation (Diaz et al., 2005; Ryken et al., 2013).

It is questionable, however, whether these ligamentous injuries represent instability and if removal of the collar would have resulted in neurological injury to the patient (Chew et al., 2013). In studies where the decision to continue use of a cervical collar was left to the discretion of the spine surgeon, less than a quarter were maintained in a hard collar and none of these patients were reported to have neurologic sequelae. This suggests that there is a significant population of patients with MRI findings who do not clinically benefit from immobilisation (Plackett et al., 2016).

Limitations

Only articles available free and in full text format published in the English language were searched, therefore studies may have been missed which could introduce bias. Ethical concerns may have hindered any randomised controlled blinded studies on the imaging required to assess the c-spine in an OBTP (Richards, 2005), i.e. CT scan alone, or CT plus MRI. This may account for most of the literature being based on retrospective investigations comparing clinical follow-up results of patients that had both CT scan and MRI. The issue has been contentious for many years and has resulted in burgeoning but inconclusive guidance (Richards, 2005). Retrospective, observational studies are also considered to be at greater risk from bias than prospective studies.

This search was conducted two years ago. Since this date, a survey of national trauma centres in England carried out in 2016 was published earlier this year (Chilvers et al., 2018). It aimed to assess current practice in cervical spinal clearance and review current guidelines. The survey included 16 and 17 year olds, so would not have met this review's inclusion criteria. 82% of national trauma centres responded. 72% used CT as the first-line imaging technique. If the initial CT was normal, 52% performed MRI to clear the cervical spine. They found that practice was highly variable. Many centres would prefer continuing immobilisation or MRI to clear the cervical spine, with a small minority removing spinal precautions based on high quality multidetector CT alone.

Generalisability of results

The articles all used data from the USA and UK. The majority also only used data from modern Multidetector CT Scanners (MDCT). In resource poor areas where modern MDCT scans are not available, reliance on negative CT scan results alone to clear the c-spine is unlikely to be appropriate. If MRI is also not available, then spinal precautions are likely to be required despite all the potential negative sequelae associated with them.

Conclusion

In the adult OBTP, the weight of evidence supports the discontinuation of use of the cervical collar after a negative c-spine CT scan result alone (Chew et al., 2013; Duane et al., 2016; Hogan et al., 2005; Patel et al., 2015; Plackett et al., 2016; Raza et al., 2013). This negative CT scan must have been performed using a modern MDCT scanner. Adjunctive imaging after an MDCT scan increases the number of low-value diagnoses, places patients at risk from unnecessary treatment plans, puts patients with multiple injuries at risk by moving them out of the ICU to the resource limited MRI room and, at best, results in the same clinical action of collar removal. However, the use of this approach may result in a nonzero rate of neurologic deterioration (Patel et al., 2015). The 2018 survey (Chilvers et al., 2018) suggests that practice related to the cervical clearance of the obtunded remains highly variable. It is the role of the medical specialties to determine when the evidence is sufficient to dispense with MRI in the clearance of the c-spine when MDCT is negative for acute injury. The medical community have unsuccessfully tried to eliminate missed c-spine injuries with c-spine imaging alone, but the goal should be to achieve the greatest good for the greatest number of patients at reasonable risk, without significant overtriaging or undertriaging, to efficiently use finite resources and to eliminate low-value, low-impact services (Patel et al., 2015). It needs to be acknowledged that no study can ever 'prove' that an MDCT scan alone is sufficient. Adjunctive MRI should be limited to specific circumstances based on the mechanism of injury, neurological signs and symptoms and continued or delayed-onset clinical symptoms in the setting of c-spine injury (Raza et al., 2013).

Acknowledgements

Role of the funding source: None.

Conflict of interest: None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.iccn.2018.11.001>.

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