



Cervical spine clearance after blunt trauma: current state of the art

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- No definite consensus exists for the clearance of the cervical spine (C-spine) after blunt trauma, despite many validated algorithms, recommendations and guidelines. We intend to answer the most relevant questions with which physicians are confronted when clearing C-spines after blunt trauma in emergency departments (EDs). To exclude significant C-spine injuries we designed an algorithm to be compatible with clinical practice, to simplify patient management and avoid unrewarding evaluation.
- We conducted an exploratory PubMed search including articles published from January 2000 to October 2018. Keywords used were “cervical spine”, “injury”, “clearance”, “Canadian C-spine Rule”, “CCR” and “national emergency x-radiography utilization study”. Clinical and experimental studies were included in a detailed review.
- We based our literature review on 33 articles. While answering fundamental triage questions from daily clinical practice, the current literature is discussed in detail. We designed an algorithm for the C-spine clearance suitable for any trauma centre with a high-quality multiplanar reconstruction computerized tomography (CT) scan continuously available.
- The high sensitivity of the Canadian C-spine Rule (CCR) prevents missing C-spine injuries while limiting the amount of unnecessary radiologic examinations. Plain radiographs were fully abandoned for C-spine clearance. A negative CT scan is sufficient to clear the majority of C-spine injuries and allows for collar removal. In case of motor symptoms or radio-clinical discrepancy, the advice of a specialized spine surgeon must be requested. Magnetic resonance imaging must not be routinely used. Neck pain despite negative imaging is not a reason to delay removal of stiff cervical collars.

Keywords: algorithm; cervical spine; collar; c-spine clearance; diagnostics; trauma

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Background

During a blunt trauma, the cervical spine (C-spine) is injured with a 3.7% prevalence.¹ A C-spine injury can result in serious neurological impairment leading to disability and poor health-related quality of life (HRQL). Consequently, in case of trauma, the exclusion of a potential C-spine injury is crucial. Primary cervical immobilization with a stiff collar is only appropriate during the rescue period and needs to be evaluated as soon as the primary survey has been completed. Subsequently, it is mandatory to identify patients who need long-term immobilization and those who can be freed. In order to avoid secondary spine injuries or immobilization side effects such as pressure ulcers, it is important to limit unnecessary time wearing a stiff cervical collar (C-collar).

For optimal patient management, protocols should predetermine all actions taken in the emergency department (ED). This will help to minimize the time of cervical restriction, without, however, jeopardizing patients with a significant C-spine injury. Also, by excluding a major impairment among polytraumatized patients, C-spine clearance improves the distribution of resources during the patient's medical management. Despite these facts, only 57% of American level-1 trauma centres had established a C-spine clearance protocol in 2014, of which less than half seemed to be evidence-based.²

Despite its importance, C-spine clearance remains controversial in many points and further investigation needs to be carried out. At the same time, it is important to simplify the screening for treating physicians. This review aims to outline the most relevant literature on C-spine clearance in blunt trauma and suggests an easy-to-use algorithm in order to minimize the risk of missed C-spine injuries.

Methods

For this narrative non-systematic review, an exploratory literature search was performed in the US National Library of

Medicine and the National Institutes of Health involving English-language articles covering the period January 2000 to October 2018. Keywords used were “cervical spine”, “injury”, “clearance”, “Canadian C-spine Rule” and “national emergency X-radiography utilization study”. Clinical and experimental studies were included in a detailed review. Off-topic articles, case reports, letters to the editors, editorials, general commentaries as well as paediatric articles were excluded. Additionally, the references of reviewed articles were checked for relevant studies not yielded by the initial search and added if appropriate.

We selected articles containing relevant information to answer the three most common questions when encountering a suspected C-spine injury in blunt trauma patients in the ED: Who needs radiological assessment before C-collar removal? What imaging needs to be requested? How to clear obtunded patients? An additional question arose during the research: How to manage patients with neck pain after a negative cervical CT scan? We have endeavoured to answer this tricky question as well.

Results

The literature search returned 417 articles. After the exclusion of non-relevant and non-eligible articles by screening, 65 met the eligibility criteria for this narrative review. We avoided redundant information by excluding articles already analysed in systematic reviews or meta-analyses incorporated in this review. We finally based our literature review on 33 articles.

Who needs radiological assessment before C-collar removal?

The use of the C-collar is an important procedure for trauma patients in modern prehospital care in order to minimize the risk of secondary injury to the spinal cord by immobilizing a potentially unstable spine (prehospital trauma life support). Despite the clear worldwide consensus about the use of C-collars for spine trauma patients and polytraumatized patients, some adverse effects have been found. Hauswald et al found evidence of clinical deterioration being more frequent in patients with suspected spinal injuries fitted with a C-collar than in patients who never received a prophylactic C-collar.³ Among other adverse effects, early tissue ulceration, increased intracranial pressure through jugular venous compression, mechanical respiratory restriction and harmful unfitted immobilization in ankylosing spondylitis have been demonstrated.⁴⁻⁷ Based on the findings of a study of 299 trauma patients by Ackland et al, the Eastern Association for the Surgery of Trauma (EAST) recommends that C-collars should be removed as soon as feasible after the trauma to avoid pressure ulcers; the risk increasing by 66% for every immobilized day.^{8,9} Nonetheless, the importance of C-collars in prehospital care still stands.

Two clinical decision rules (CDRs) are available in the literature to facilitate decision-making on who needs a radiographic assessment of the cervical spine. These methods have been developed for awake and haemodynamically stable patients after a blunt trauma. Hoffman et al published the National Emergency X-Radiography Utilization Study (NEXUS), a decision instrument of five clinical criteria: no midline cervical tenderness, no focal neurologic deficit, normal alertness, no intoxication and no painful distracting injury.¹⁰ This assessment features a sensitivity of 99.6% and a specificity of 12.9%. Therefore, a negative result reliably excludes a clinically important C-spine injury and avoids an unnecessary radiographic examination.

The Canadian C-spine Rule (CCR) published in 2001 showed an alternative way to select patients who require radiography.¹¹ Again, this clearance protocol has been developed for trauma patients who are awake, stable and alert with a Glasgow Coma Scale (GCS) score of 15. Patients will then undergo radiological assessment if one of the following three high-risk criteria applies: age \geq 65 years, dangerous trauma mechanism (fall from \geq 1 metre/5 stairs, axial load to head, motor vehicle collision $>$ 100 km/h, rollover/ejection, motorized recreational vehicles, bicycle collision) or paraesthesia in extremities. Afterwards, if one of the five low-risk criteria (simple rear-end motor vehicle collision, sitting position in the emergency department, ambulatory at any time, delayed onset of neck pain, absence of midline C-spine tenderness) is present, the physician can safely assess range of motion of the C-spine and the patient’s ability to actively rotate their neck 45° to either side. The CCR allows identification of patients with a significant spine injury with a sensitivity of 100% and a specificity of 42.5%.

Stiell et al published a prospective cohort study to compare the NEXUS and the CCR in 2003.¹² Among the 8283 patients included, 169 had clinically important C-spine injuries. The NEXUS criteria would have missed nearly 10% of the injuries while the CCR would only have missed one patient injury. Moreover, the CCR demonstrated a better specificity (45.1% vs. 36.8%) thereby decreasing the necessity of a radiological evaluation. More recently, a systematic review compared the accuracy of the two clearance rules and found a better sensitivity and specificity for the CCR (sensitivity and specificity ranged from 0.90 to 1.0 and from 0.01 to 0.77, respectively, for the CCR versus from 0.83 to 1.0 and from 0.13 to 0.46, respectively, for the NEXUS criteria).¹³ Despite less common use on a global scale, the CCR has been successfully applied in the UK.¹⁴

With only five criteria to check before C-collar removal and no need for clinical testing, the NEXUS criteria are more easily applied in an emergency setting. Their analysis on validity has shown very good results. The CCR includes three high-risk and five low-risk criteria as well

as a clinical exam. However, with reference to the current articles and results, we recommend the application of the CCR for screening of trauma patients due to its superior statistical performance and the importance of the clinical assessment.

What imaging needs to be requested?

The Spine Section of the German Society for Orthopaedics and Trauma has declared two major goals of diagnostics for the cervical spine: ‘precise morphologic detection and quantification of instability as a possible source of secondary pain syndromes, deformity or neurologic damage’, and ‘detection of neurologic deficits and a correlation with structural injuries detected on imaging modalities’. These considerations form a basis for further interventions, either conservative or operative, aiming to achieve a permanently stable, pain-free cervical spine and to avoid secondary neurologic damage.¹⁵ Originally, recommendations for radiographic screening included three plain radiographs (lateral, anteroposterior and odontoid).¹⁶ Diagnostic accuracy of plain radiographs has since been proven insufficient, missing 55.5% of clinically significant fractures.^{17,18} In 2005, a meta-analysis compared plain films to cervical CT scan. Sensitivity of plain radiographs was found to be as low as 52% compared to 98% for CT scans.¹⁹

Multidetector or multiplanar reconstruction (MPR) CT scans have been strongly supported as the safest way to rule out a C-spine injury with high sensitivity and specificity by Como et al.⁹ They recommend an axial CT from the occiput to T1 with sagittal and coronal reconstruction instead of conventional imaging by means of plain radiographs.

The utility of magnetic resonance imaging (MRI) within the context of C-spine clearance after screening by CT is still uncertain. Mainly due to a high false-positive rate, its utility mandates further studies and no consensus has yet been found in the literature. We considered seven recent articles published between 2014 and 2018. Three articles highlight a non-negligible risk of unstable injuries after negative CT screening. Two of them showed a 1.3–1.4% rate of unstable injuries missed by CT scan in 316 and 767 patients, respectively.^{20,21} However, a meta-analysis by Malhotra et al in 2017 considering 23 studies and 5286 patients only found 16 unstable injuries that were missed by CT screening and quantified the failure rate of CT at 0.30%.²² A more recent study published by the same study group ascertains a potentially remaining utility of MR imaging in patients with persistent abnormal neurological findings.²³ These results concur with a prospective study of more than 10,000 patients published in 2016.²⁴ Finally, two prospective studies of 5676 and 9227 patients conclude a 100% sensitivity of the MPR CT for detection of unstable injuries, and justify safe C-collar removal in view of negative CT results.^{25,26}

From an economic point of view, the literature indicates good cost and time effectiveness for moderate and high-risk patients.^{27–31} Not surprisingly, MRI featured a lower health benefit measured in quality-adjusted life years (QALY) and higher costs after normal cervical CT findings.³⁰ Based on our review, we conclude that a routine use of MRI is not beneficial for clearing a cervical spine after blunt trauma. For normal mental state patients without neurological symptoms, we consider the removal of the C-collar to be safe after 64-slice (or higher) computed tomography interpreted by a qualified musculoskeletal radiologist.³² In very rare cases with discrepancy between imaging and clinical findings with a pathologic neurological status, an MRI could be requested upon advice of a spine specialist.

How to clear obtunded patients?

By definition, it is impossible to clinically clear an obtunded trauma patient using the CCR. Obtunded trauma patients should directly undergo a CT scan. Formerly, a negative CT alone did not assure the absence of injury according to the guidelines of the Eastern Association for the Surgery of Trauma of 2009.^{9,33} However, due to the latest research, the EAST modified its guidelines about the cervical clearance by CT in 2015.³⁴

We found six recent articles, including the new EAST guidelines, which try to clarify the necessity of complementary imaging after a negative computed tomography on an obtunded patient. In a systematic review published in 2014 including a total of 3443 patients, the authors suggest that using a 64-slice MPR CT or higher quality scan is sufficient to clear a C-spine injury if the images are interpreted by an experienced radiologist and the patient has no obvious neurological symptoms.³² They also suggest that a safety clearance of C-spine injury is not guaranteed by earlier generation of CT without multiplanar reconstruction, explaining the amount of non-identified injury could be up to 5% in earlier studies.

Two meta-analyses of 1535 and 3627 obtunded patients conclude a safe clearance of the C-spine after a negative high-quality CT scan.^{35,36} The MRI may detect spinal soft tissue injuries missed by CT that, however, have no impact on further patient care. James et al nevertheless recommend a clinical exam to ensure intact gross motor function. In case of impairment, a complementary MRI is to be considered.³⁶ Patel et al recommended a conditional C-collar removal (securing head–shoulder alignment) after a negative high-quality MPR CT uniquely.³⁴ The MRI use restriction is principally based on the fact that it leads to potentially false-positive and inconsistent treatment plans, whereas the injury rate after a CT screening is near 0%.

Recent prospective studies focusing on intoxicated patients had similar conclusions on the reliability of a high-quality CT for the clearance of the C-collar.^{37,38} Even

with a low rate of disco-ligamentous injuries (< 5%), physicians cannot neglect this potentially dangerous eventuality.³⁶ However, based on the current literature, a routine MRI or extended immobilization of the patient with a negative CT can lead to excessive expenses and complications. Medical care of the patient is obviously made more difficult by the C-collar, placing the patient at risk during transfer, which may in turn lead to additional injuries. Complementary evaluation might be more harmful than C-collar removal after a negative high-quality MPR CT scan in a patient with intact motor function, considering the statistical performance of this investigation.

Despite the near complete safety of C-collar removal after MPR CT scan alone, the high responsibility level of this procedure causes most of the previous studies to remain cautious. Clinically confirmed absence of gross motor deficiency and an experienced radiologist must be assured.^{32,36,38} Therefore we suggest that in case of gross motor function deficiency or the impossibility of obtaining a reliable clinical exam to exclude it, specialized advice should be required. A multidisciplinary consensus between the qualified musculoskeletal radiologist, the spine surgeon and the emergency doctor is recommended. It enables rereading of the images in order to search for indirect signs of instability to establish whether or not a complementary imaging by MRI is necessary before C-collar removal.

How to manage patients with neck pain after a negative cervical CT scan?

This fourth clinical question, yet unanswered, arose after reviewing the actual literature. Situations in which important pain remains although unstable injury was excluded after CT, challenge our clinical practice. This scenario is rather common but poorly studied and poorly covered by actual guidelines.^{9,33} The recommendations are similar to the clearance protocol in obtunded patients (retaining the C-collar and obtaining specialized advice for complementary imaging by MRI), but add the possibility of flexion/extension (F/E) radiographs.

In 2016, Oh and Asha reviewed the utility of flexion/extension radiographs in cervical spine clearance.³⁹ They did not find additional information provided by F/E films after a MPR CT scan, and suggested abandoning functional radiographs in C-spine clearance protocols due to an disproportionate cost increase for a very low testing sensitivity.^{40,41} The necessity of the patient's cooperation, as well as the lack of image quality criteria, lead to a high number of non-interpretable films. In addition, F/E films are limited in terms of how interpretable they are in the acute trauma phase due to pain and muscle spasms as described by Ulbrich et al.⁴² Regarding this evidence, we do not include F/E radiographs in our clearance algorithm in the acute period.

We do not think that any complementary evaluation is necessary for awake, alert and stable patients with neck pain. The sensitivity of a clinical examination in combination with negative high-quality CT scan is nearly 100% and therefore sufficient to detect any significant injury.^{13,25,26,43} After a blunt injury, CT scan allows us to exclude the need for major treatment. Patients may have pain related to minor soft tissue injuries, which should not lead to unnecessary wear of the C-collar or complementary examination. However, a soft collar can be applied for pain management for a few days.

Algorithm

We developed an algorithm (Fig. 1) to clear C-spine injuries in case of blunt trauma. This algorithm aims to exclude significant C-spine injuries and to avoid secondary injuries while minimizing the use of radiographic evaluation. Avoiding unnecessary complementary examinations reduces costs and improves care management in the ED. The time wearing the C-collar is also diminished, likely decreasing its potential side effects.

The CCR is more reliable for the clinical clearance of blunt trauma patients than the NEXUS criteria. Its use in awake, stable and alert (GCS = 15) patients improves accuracy in decision-making, leading to either selected imaging or C-collar removal. Asleep, intoxicated, or obtunded patients must directly pass through a radiological evaluation if they are unlikely to recover a normal level of consciousness during the following hours.

Negative MPR CT clears the C-spine and allows the ED team to remove the C-collar in case of a reliable examination. The examination must exclude any motor compromise or any neurological symptoms in discrepancy with the imaging in alert patients. Otherwise the patient must remain immobilized and the advice of a spinal surgeon must be obtained as soon as possible. The same attitude must be followed in case of an unstable injury detected by CT. Neck pain despite negative imaging is not a reason to delay C-collar removal and must not lead to complementary evaluation in awake patients.

Although MRI does not seem to provide significant clinical information for C-spine clearance, we retain its utility in case of discrepancy of clinical and radiological findings. In unalert patients where clinical evaluation is not shortly feasible, C-spine MRI could be requested according to specialized advice. Functional radiographs should be abandoned during C-spine clearance.

Conclusion

Based on the current literature, we developed an algorithm (Fig. 1) designed for use in the ED. We aimed to derive an algorithm to exclude significant C-spine injuries

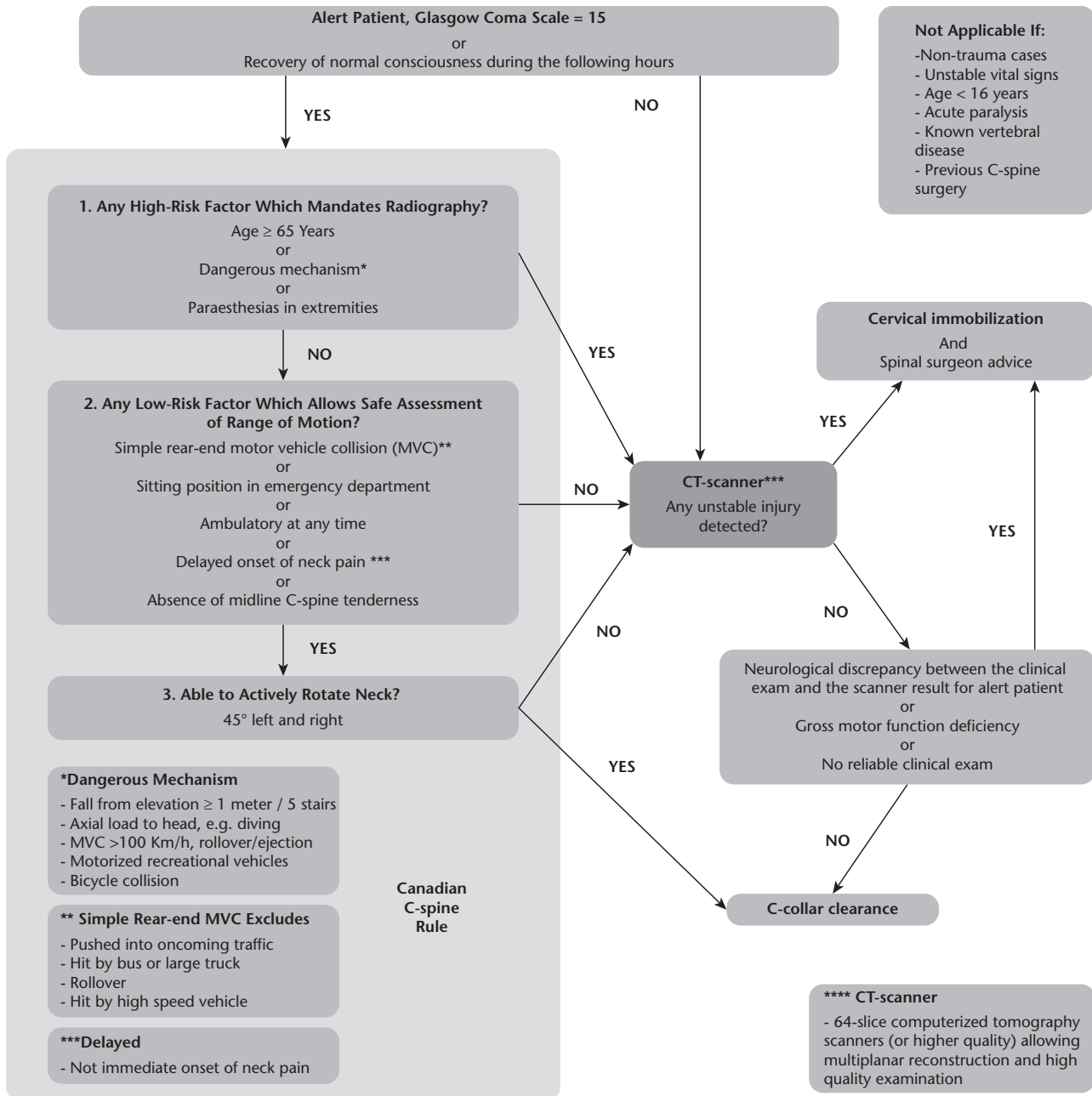


Fig. 1 Alert patients with Glasgow Coma Scale of 15 or patients showing a potential recovery during the following hours are cleared through the Canadian C-spine Rule (CCR). Clearing by CCR allows removal of the cervical stiff collar. Patients without inclusion criteria, obtunded patients as well as patients who were not cleared by the CCR must undergo multiplanar reconstruction CT scan. If the imaging excludes an unstable injury and a reliable examination excludes any gross motor function deficiency or radio-clinical discrepancy, the cervical stiff collar is removed. Otherwise, collar immobilization is maintained until advice from a spinal surgeon is obtained.

while simplifying patient management and avoiding unrewarding evaluation. The CCR shows better statistical performance than the NEXUS criteria despite its slightly superior complexity and, thus, should be favoured. A negative MPR CT scan is sufficient to clear the C-spine except when gross motor symptoms are highlighted,

radio-clinical discrepancies persist or when a clinically reliable examination is not feasible. In our opinion, clinical assessment remains a pivotal point of the evaluation. In these cases, as well as for positive CT scans, the advice of a spinal surgeon must be obtained to determine the following care before C-collar removal. Neck pain despite

negative imaging is not a reason to delay C-collar removal and must not lead to complementary evaluation. MRI does not seem to be clinically relevant, and leads to potentially false-positive findings. It should not be routinely used to clear the C-spine but could be requested upon advice of a spine specialist, especially in case of radio-clinical discrepancy. Functional radiographs should be abandoned during C-spine clearance.

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LICENCE

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