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## Cervical Spine Evaluation in the Bluntly Injured Patient

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**Background:** Cervical spine injuries causing spinal cord trauma are rare in blunt trauma yet lead to devastating morbidity and mortality when they occur. There exists considerable debate in the literature about the best way for clinicians to proceed in ruling out cervical spine injuries in alert or obtunded blunt trauma patients.

**Methods:** We reviewed the current literature and practice management guidelines to generate clinical recommendations for the detection and clearance of cervical spine injuries in the blunt trauma patient.

**Results:** The NEXUS and Canadian C-Spine Rules are clinical tools to guide in the clearance of the cervical spine of patients who have sustained low risk trauma and who are pain free, with the Canadian C-Spine Rules having superior sensitivity and specificity. In the alert, high risk patient with pain (or without, if over the age of 65 years), follow up imaging is required. The best imaging modality to use is Computerized Tomography (CT) of the cervical spine. In the obtunded trauma patient, CT clearance of c-spine injury is adequate, unless there is soft tissue injury or any non-bony abnormalities detected. At such point, definitive clearance may be obtained with Magnetic Resonance Imaging.

**Conclusions:** It is imperative to assume cervical spine injury in the blunt trauma patient. Clinical tools for cervical clearance may be used in low risk patients, avoiding imaging. High risk patients require imaging in the form of CT scan of the cervical spine.

Injury to the cervical spine occurs frequently in trauma. Over 13 million patients are assessed each year in Emergency Departments (ED) across the United States for cervical spine injuries. Of these, 30 000 (0.2%) will have cervical spine injuries and of this group, only 10 000 (0.08% overall) will have spinal cord injuries.<sup>1</sup> The principles of the Advanced Trauma Life Support course from the American College of Surgeons<sup>2</sup> advocate assuming a cervical spine injury until proven otherwise in all trauma patients who present after blunt trauma. Emergency Medical Technicians have been trained to apply cervical collars early in the pre-hospital course of patient care, although the effectiveness of this is currently being debated in the medical literature<sup>3</sup>. The early role of the clinician caring for injured patients is thus to protect the cervical spine while concomitant treatment and assessments continue. This is to prevent further harm by manipulating an unstable cervical spine injury, which can render an incomplete injury into a complete spinal cord injury. Assessment of the cervical spine is also important in the primary survey as spinal injury may contribute to life threatening hemodynamic instability due to neurogenic shock. This is a diagnosis of exclusion and only accepted once all potential sources of bleeding have been ruled out<sup>4</sup>. Once life-threatening issues in the primary survey have been addressed, the traumatologist can proceed with a secondary survey to identify non-life threatening injuries. At that point she or he can decide if indeed a cervical spine injury is present, in the absence of overt neurological disability identified in the primary survey. The most important factor in deciding this is to assess if your patient is examinable or not, and to assess if the cervical spine may be cleared on clinical grounds alone. The typical trauma patient that is not examinable is considered "obtunded". This may be due to a variety of factors including traumatic brain injury, acute intoxication, intubation / sedation or other reasons. In this review we will discuss the approach to the evaluation of the cervical spine in the trauma patient who has sustained blunt or penetrating injury. We have divided this approach into evaluation of the cervical spine in the alert, non-obtunded and obtunded patient. This includes the use of appropriate imaging, when possible, largely but not exclusively in the context of blunt trauma.

### The Alert, Non-Obtunded Patient After Blunt Trauma

In the alert, non-obtunded patient, a variety of clinical rules have been developed to assist with deciding which patients require cervical spine imaging and which do not. Imaging constitutes a significant expenditure for hospitals and health care systems, and thus clinically and prospectively validated tools can reliably exclude patients from needing imaging are worthwhile<sup>5</sup>. Typical criteria for clinical clearance require that the patient is awake and alert without drugs, alcohol or other sensorium-altering substances in the patient's bloodstream. Additionally, neurological deficits cannot be present in order to clinically clear the spine, as assessed by neuromotor exam of both upper and lower extremities. Additionally, no 'distracting' injury can be present. This means an injury that causes significant enough pain to distract the patient from the pain of a cervical spine injury. How much of an injury constitutes as truly distracting injury still remains to be clearly defined.<sup>6</sup> The main clinical tools that traumatologists have used to clear the cervical spine clinically, without the need for imaging, include the National Emergency X Radiography Utilization Study (NEXUS)<sup>7</sup> and Canadian C-spine Rules (CCR)<sup>8</sup>. Both represent clinical decision-making tools used by clinicians in the ED to assess with the clinical clearance of the cervical spine, without the need for imaging.

The NEXUS tool was developed in 1992 and was predicated on five elements: no cervical spine tenderness, signs of intoxication or altered mental status, no significant and painful distracting injuries and no focal neurological deficits (figure 1). The sensitivity and specificity of NEXUS in detecting a c-spine injury is 99.6% and 12.9%, respectively, indicating that it is a helpful screening tool in ruling out injury<sup>9,10</sup>. A similar sensitivity was also found in elderly patients, over the age of 80 years, when using NEXUS criteria to clear the c-spine, however this is being currently disputed in updated trials<sup>11</sup>. The CCR were similarly developed in parallel with a focus on high and low risk mechanism of injury (figure 2). Age alone (> 65 years) was considered high risk, together with significant mechanism of injury (fall > 3 feet / 5 stairs; axial loading; high speed motor vehicle collision (>100 km/h); collision with a recreational vehicle or bicycle) and paresthesias in the extremities<sup>8</sup>. If any of these factors are present, imaging is required. If they are absent, low risk factors are assessed including simple rear-end collision, sitting in the ED or ambulatory at the scene with no or delayed onset neck pain. In absence of high risk criteria, and with the presence of at least one low risk criteria, the patient is then assessed for any pain with a 45° range of motion assessment. In a direct comparison of NEXUS and the CCR involving 8 283 trauma patients across Canada, the CCR were found to have better sensitivity and specificity, reducing costs related to unnecessary imaging of the c-spine<sup>12</sup>. Trauma surgeons or trauma team leaders working in specialized Level I or II trauma centers rarely employ these tools as patients have been triaged by Emergency Medical Services to be high risk and thus transported directly to a trauma center, bypassing local hospitals and EDs. Thus the CCR is a helpful tool for clinicians working with trauma patients that are low risk in absence of significant mechanisms of injury.

Trauma surgeons and respective associations have devised their own practice management guidelines for the identification of cervical spine injuries following trauma. Several recommendations incorporate the above CCR and were based on a thorough review of the trauma literature. In particular, the Eastern Association for the Surgery of Trauma (EAST) has highlighted the clinical conundrums surrounding c-spine injuries in trauma<sup>13</sup>: who needs CS imaging; what imaging should be obtained; when should computed tomography (CT), magnetic resonance imaging (MRI), or flexion/extension (F/E) radiographs be obtained; and how is significant ligamentous injury excluded in the comatose patient? In focusing on the non-

obtunded patient, the recommendations regarding the use of cervical collars include early removal as soon as feasible and non-use for isolated penetrating trauma to the head (Level 3 recommendations). Interestingly, the EAST guidelines also recommend c-spine clearance in patients who are awake, alert, no distracting injury with no neck pain to palpation or on range of motion (Level 2). They have combined elements of both NEXUS and CCR while eliminating others, such as age > 65 years as being an absolute contraindication to clearance based on clinical grounds alone. If the patient requires imaging, computerized tomography (CT) is recommended from the occiput to T1, with no additional information gained from the use of plain films (Level 2). It remains difficult to make specific recommendations on the appropriate level of resolution of CT scan (4 - 64 multidetector row CT or greater) due to heterogeneity in the literature. If there is an injury present on CT, a prompt spinal consultation is recommended. If there is a spinal cord injury in addition to bony c-spine injury, MRI should be obtained urgently. In the presence of spinal cord injury, close attention should be paid to limiting secondary central nervous system injury (in particular avoidance of hypotension and hypoxia)<sup>14</sup>. If the trauma patient with neck pain has a negative CT scan, the cervical collar should be kept in place while an MRI is obtained to rule out the presence of ligamentous injury. If an MRI is unobtainable, flexion /extension plain films may be obtained in lieu of this. If either MRI or flexion / extension films are negative, the cervical collar may be removed. This is despite the occasional false positive reads on MRI, when abnormalities may be detected but these do not warrant any change in clinical management. To date, detecting these false positive reads on MRI has proven to be difficult. There is one meta-analysis (which is methodologically flawed) that states that an accurate assessment of the number of false positive MRIs in the setting of blunt cervical spine trauma cannot be accurately determined.<sup>15</sup>

### The Obtunded Patient After Blunt Trauma

In contrast to the alert patient, cervical spine clearance in the obtunded patient is an ongoing area of controversy derived primarily from two issues. First, what is the definition of an “obtunded” patient? Second, is CT alone sufficient to evaluate for clinically significant spinal column injury? CT is considered too insensitive to detect non-bony injuries, such as ligamentous, that may still progress to permanent disability if missed.<sup>16</sup> The primary outcome of concern is conversion of a stable spinal column injury into an unstable injury with permanent paraplegia or quadriplegia.

The term “obtunded” has been broadly interpreted in the literature leading to confusion amongst practitioners as to which patients can be safely considered for cervical collar removal. It has been defined to mean any abnormal GCS, intoxication, intubation, or coma, to name a few. With no consensus as to the definition of obtunded, the result has been significant variability in interpretation and practice implementation.<sup>17</sup> The critical point to remember is that any blunt trauma patient without a reliable clinical exam is at increased risk for an occult cervical spinal column injury.

The consequences of exacerbating an occult cervical spine injury can be devastating. Since these patients cannot be cleared by clinical exam alone, there is understandable widespread reluctance to remove the cervical collar in this patient population. However, it is important to recognize that adhering to a strict practice that ignores the complications of prolonged cervical

collar use has many implications. Delayed collar removal carries significant morbidity such as pressure ulcers on the chin and occiput,<sup>18</sup> respiratory complications including aspiration pneumonia or prolonged mechanical ventilation, prolonged immobility that may contribute to venous thromboembolism, and elevated intracranial pressure complicating severe traumatic brain injury.<sup>19,20</sup> Clearly, the impact of unnecessary cervical collar use carries significant impact on the patient and hospital resources.

Recognizing the significant morbidity of prolonged cervical collar use, safe and expeditious removal is the goal in all blunt trauma patients. A high quality CT of the cervical spine is the optimum imaging modality to use for evaluating the cervical spine. Historically, clearance of the cervical spine in an obtunded patient required a CT and some adjunctive imaging such as an MRI, or flexion-extension plain films. In the absence of adjunctive imaging, the cervical collar remained in place until the patient was alert enough for a clinical exam. The concern was that an occult ligamentous injury would not be identified on a CT; a modality used to determine bony injury. However, a number of recent studies, including the latest Practice Management Guidelines from the EAST (2015), advocate removing the cervical collar in an obtunded patient if a high quality CT demonstrates no fractures.<sup>21,22</sup> The negative predictive value of a clinically significant ligamentous injury is nearly 100%; therefore, adjunctive imaging is not necessary.<sup>23,22</sup> In short, cervical spine clearance in the obtunded patient has evolved to where a high-quality CT is sufficient for safe removal of the collar. If there are any abnormalities that do not involve the bony cervical spine (such as a widened disk space), then MRI may be used as an adjunct to CT to rule out any adjacent soft tissue injury that may contribute to spinal instability<sup>24</sup>. The CT signs suggestive of ligamentous injuries are similar to those seen, in fact, on plain lateral films (with lower sensitivity) and include dislocations, subluxations, or listheses of any part of the cervical spine.<sup>25</sup> However, in one study, multi-detector row CT had a negative predictive values of 98.9% for ligament injury and 100% for unstable cervical spine injury.<sup>26</sup>

### Penetrating Trauma

While there exists a body of literature supporting the clearance of cervical spines after penetrating trauma to the cranium, this remains level 3 evidence due to its retrospective nature. Most retrospective chart reviews have failed to demonstrate the presence of cervical spine injuries after isolated blast or gunshot wounds to the head.<sup>27,28</sup> In fact, official EAST guidelines state that immobilization in a cervical collar is not necessary unless the trajectory suggests direct injury to the cervical spine.<sup>13</sup> Nonetheless, it is important to note that while the rate is low, it is not zero and the prevalence may be up to 5%.<sup>29</sup>

In conclusion, while injuries to the cervical spine after blunt trauma are rare, with true spinal cord injuries being even more rare, the disability that may ensue after a missed injury can be significant and devastating. The cervical spine is always assumed to have an injury after blunt trauma and must be protected during the primary and secondary surveys. The “disability” part of the primary survey rules out any neurogenic shock or focal neurological deficits. Clinical rules exist to assist clinicians working with alert, examinable trauma patients to safely clear the cervical spine when they are at low risk for injury after insignificant mechanisms of trauma. If pain exists, a careful neurological exam with CT scan is recommended with spine specialist

consultation if an injury is found. Conversely, if the mechanism of injury is significant, even without c-spine pain, the patient should proceed to a CT scan. If this is negative, follow up imaging with MRI or flexion-extension films are recommended. In the obtunded patient, however, current clinical guidelines recommend CT scan alone to rule out c-spine injury. If no bony injury is seen, the likelihood of a c-spine or spinal cord injury is low. Nonetheless, if non-bony injuries or abnormalities detected, there should be a low threshold for proceeding with definitive and confirmatory imaging using MRI when and where possible.

## References:

1. Reid, D. C., Henderson, R., Saboe, L. & Miller, J. D. Etiology and clinical course of missed spine fractures. *J. Trauma* **27**, 980–986 (1987).
2. <https://www.facs.org/quality%20programs/trauma/atls>.
3. Ahn, H. *et al.* Pre-hospital care management of a potential spinal cord injured patient: a systematic review of the literature and evidence-based guidelines. *J. Neurotrauma* **28**, 1341–1361 (2011).
4. Mallek, J. T. *et al.* The incidence of neurogenic shock after spinal cord injury in patients admitted to a high-volume level I trauma center. *Am. Surg.* **78**, 623–626 (2012).
5. Grogan, E. L. *et al.* Cervical spine evaluation in urban trauma centers: lowering institutional costs and complications through helical CT scan. *J. Am. Coll. Surg.* **200**, 160–165 (2005).
6. Kamenetsky, E., Esposito, T. J. & Schermer, C. R. Evaluation of distracting pain and clinical judgment in cervical spine clearance of trauma patients. *World J. Surg.* **37**, 127–135 (2013).
7. Hoffman, J. R., Wolfson, A. B., Todd, K. & Mower, W. R. Selective cervical spine radiography in blunt trauma: methodology of the National Emergency X-Radiography

- Utilization Study (NEXUS). *Ann. Emerg. Med.* **32**, 461–469 (1998).
8. Bandiera, G. *et al.* The Canadian C-spine rule performs better than unstructured physician judgment. *Ann. Emerg. Med.* **42**, 395–402 (2003).
  9. Vinson, D. R. Nexus cervical spine criteria. *Ann. Emerg. Med.* **37**, 237–238 (2001).
  10. Hoffman, J. R., Wolfson, A. B., Todd, K. & Mower, W. R. Selective cervical spine radiography in blunt trauma: methodology of the National Emergency X-Radiography Utilization Study (NEXUS). *Ann. Emerg. Med.* **32**, 461–469 (1998).
  11. Denver, D., Shetty, A. & Unwin, D. Falls and Implementation of NEXUS in the Elderly (The FINE Study). *J. Emerg. Med.* (2015). doi:10.1016/j.jemermed.2015.03.005
  12. Stiell, I. G. *et al.* The Canadian C-spine rule versus the NEXUS low-risk criteria in patients with trauma. *N. Engl. J. Med.* **349**, 2510–2518 (2003).
  13. Como, J. J. *et al.* Practice management guidelines for identification of cervical spine injuries following trauma: update from the eastern association for the surgery of trauma practice management guidelines committee. *J. Trauma* **67**, 651–659 (2009).

14. Witiw, C. D. & Fehlings, M. G. Acute Spinal Cord Injury. *J. Spinal Disord. Tech.* **28**, 202–210 (2015).
15. Muchow, R. D., Resnick, D. K., Abdel, M. P., Munoz, A. & Anderson, P. A. Magnetic resonance imaging (MRI) in the clearance of the cervical spine in blunt trauma: a meta-analysis. *J. Trauma* **64**, 179–189 (2008).
16. Joaquim, A. F. *et al.* Upper cervical injuries - a rational approach to guide surgical management. *J. Spinal Cord Med.* **37**, 139–151 (2014).
17. Patel, M. B. *et al.* Cervical spine collar clearance in the obtunded adult blunt trauma patient: a systematic review and practice management guideline from the Eastern Association for the Surgery of Trauma. *J. Trauma Acute Care Surg.* **78**, 430–441 (2015).
18. Walker, J. Pressure ulcers in cervical spine immobilisation: a retrospective analysis. *J. Wound Care* **21**, 323–326 (2012).
19. Halpern, C. H. *et al.* Clearance of the cervical spine in clinically unevaluable trauma patients. *Spine* **35**, 1721–1728 (2010).
20. Hennessy, D. *et al.* Cervical spine clearance in obtunded blunt trauma patients: a prospective study. *J. Trauma* **68**, 576–582 (2010).

21. Patel, M. B. *et al.* Cervical spine collar clearance in the obtunded adult blunt trauma patient: a systematic review and practice management guideline from the Eastern Association for the Surgery of Trauma. *J. Trauma Acute Care Surg.* **78**, 430–441 (2015).
22. Panczykowski, D. M., Tomycz, N. D. & Okonkwo, D. O. Comparative effectiveness of using computed tomography alone to exclude cervical spine injuries in obtunded or intubated patients: meta-analysis of 14,327 patients with blunt trauma. *J. Neurosurg.* **115**, 541–549 (2011).
23. Hennessy, D. *et al.* Cervical spine clearance in obtunded blunt trauma patients: a prospective study. *J. Trauma* **68**, 576–582 (2010).
24. Awad, B. I. *et al.* Adjacent Level Ligamentous Injury Associated with Traumatic Cervical Spine Fractures: Indications for Imaging and Implications for Treatment. *World Neurosurg.* **84**, 69–75 (2015).
25. Chiu, W. C., Haan, J. M., Cushing, B. M., Kramer, M. E. & Scalea, T. M. Ligamentous injuries of the cervical spine in unreliable blunt trauma patients: incidence, evaluation, and outcome. *J. Trauma* **50**, 457–463; discussion 464 (2001).
26. Hogan, G. J., Mirvis, S. E., Shanmuganathan, K. & Scalea, T. M. Exclusion of unstable cervical spine injury in obtunded patients with blunt trauma: is MR imaging needed

when multi-detector row CT findings are normal? *Radiology* **237**, 106–113 (2005).

27. Kaups, K. L. & Davis, J. W. Patients with gunshot wounds to the head do not require cervical spine immobilization and evaluation. *J. Trauma* **44**, 865–867 (1998).
28. Kennedy, F. R., Gonzalez, P., Beitler, A., Sterling-Scott, R. & Fleming, A. W. Incidence of cervical spine injury in patients with gunshot wounds to the head. *South. Med. J.* **87**, 621–623 (1994).
29. Lanoix, R., Gupta, R., Leak, L. & Pierre, J. C-spine injury associated with gunshot wounds to the head: retrospective study and literature review. *J. Trauma* **49**, 860–863 (2000).

**Figure 1: The NEXUS Low-Risk Criteria\***

C-spine imaging is recommended for patients with trauma unless they meet all of the following criteria:

- Absence of posterior midline cervical-spine tenderness,#
- No evidence of intoxication,\*
- A normal level of alertness and consciousness (baseline mental status),◆
- Absence of focal neurological deficit,\*
- Absence of any distracting injuries.○

# Midline posterior bony cervical-spine tenderness is present if the patient reports pain on palpation of the posterior midline neck from the nuchal ridge to the prominence of the first thoracic vertebra, or if the patient expresses pain with direct palpation of any cervical spinous process.

\* Patients should be considered intoxicated if they have a recent history provided by the patient or an observer of intoxicating ingestion or evidence of intoxication on physical exam such as an odor of alcohol, slurred speech, ataxia, or any behavior indicative of intoxication. Patients may also be considered to be intoxicated if laboratory tests are positive for alcohol or drugs that affect the level of alertness.

◆ An altered level of alertness can include any of the following: a GCS score of 14 or less; disorientation to person, place, time, or events; inability to recall three objects at five minutes; a delayed or inappropriate response to external stimuli; or alternative findings consistent with altered mental status.

\* A focal neurological deficit is any focal neurological finding on motor or sensory examination.

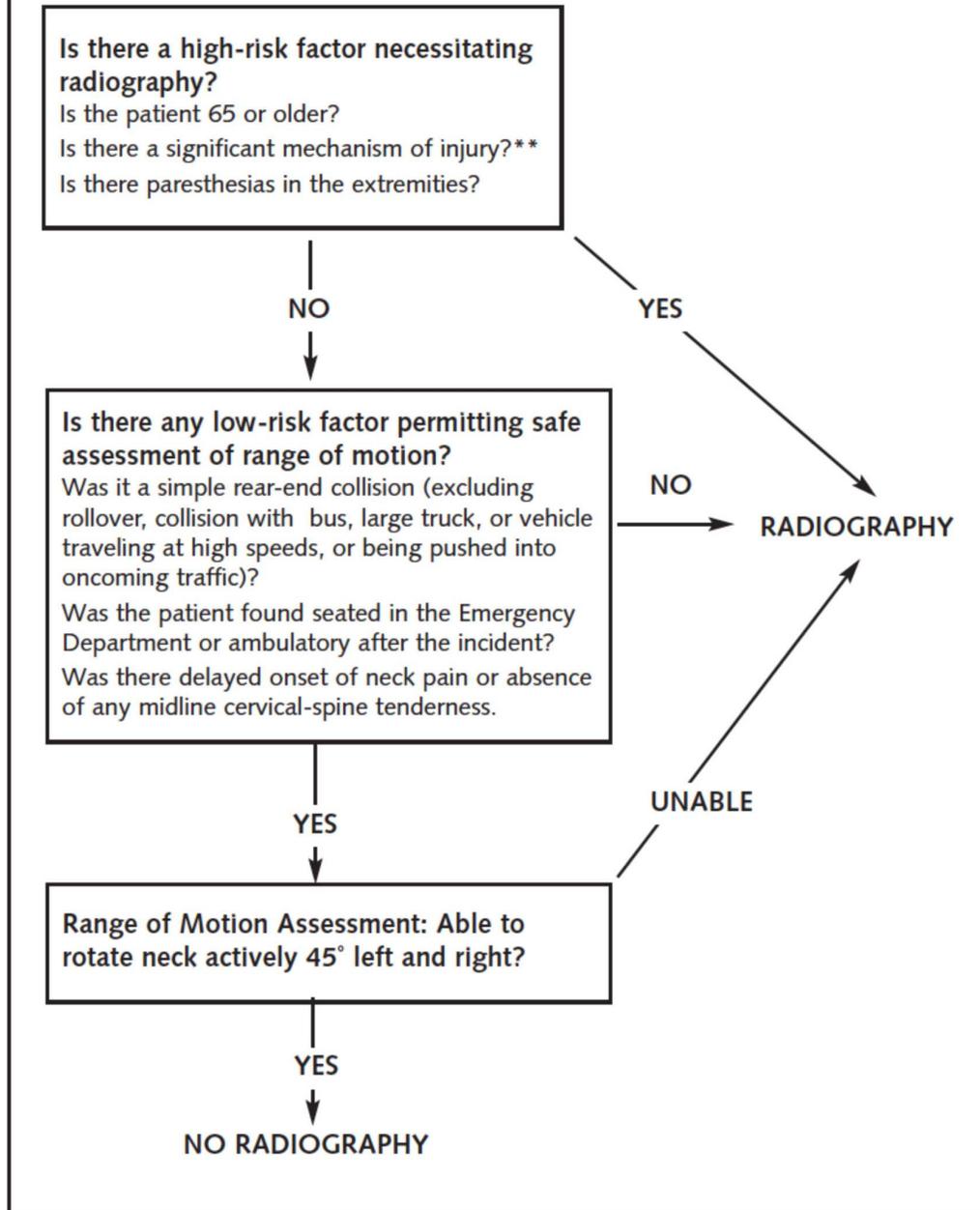
○ A distracting injury is any condition that, in the examiner's judgment could be producing enough pain so as to distract the patient from another, particularly cervical, injury. Such injuries may include a long-bone fracture; a visceral injury; a significant laceration, degloving injury, or crush injury; large burns; or any other injury causing acute functional impairment.

Adapted from Hoffman and colleagues, as presented by Stiell et al.,<sup>4,9</sup>

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**Figure 2: The Canadian Cervical-Spine Rule\***

To be used on alert (GCS of 15) and stable trauma patients with potential C-spine injury.



\*Adapted from Stiell et al. 3,4

\*\* A Dangerous Mechanism includes: a fall from an elevation  $\geq 3$  feet

or 5 stairs; an axial load to the head (e.g. diving); a motor vehicle collision at high speed ( $>100$  km/hr) or with rollover or ejection; a collision involving a motorized recreational vehicle; or a bike collision.

**Highlights:**

- not all cervical spine injuries require imaging
- clinical guidelines exist for clearance
- in patients who are obtunded, CT scan is adequate to clear the cervical spine in blunt trauma