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The Royal Australian  
and New Zealand  
College of Radiologists®

# Education Modules for Appropriate Imaging Referrals

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## **PAEDIATRIC CERVICAL SPINE TRAUMA**

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This document is part of a set of ten education modules which are aimed at improving the appropriateness of referrals for medical imaging by educating health professionals about the place of imaging in patient care.

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## 1. INTRODUCTION

### **WHAT IS PAEDIATRIC CERVICAL SPINE INJURY?**

#### HOW COMMON IS IT?

Paediatric cervical spine injury is uncommon. Only about 1% of trauma in children is associated with cervical spine injury.

Older children and adolescents have spinal injuries similar to adults and mainly involve injuries below C4.

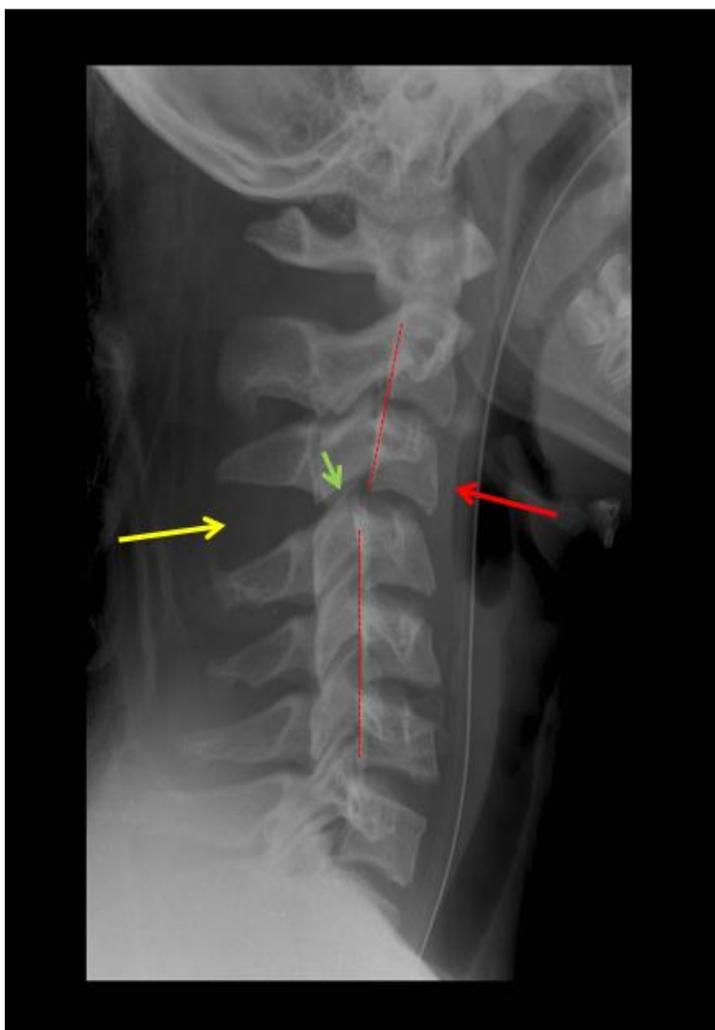
Younger children are more likely to have higher cervical spine injuries. This is due to the different fulcrum due to the relatively bigger head of smaller children and infants. The spine of younger children also differs from older children due to their ligamentous laxity, flatter vertebral bodies and more horizontal facet joints<sup>1</sup>.

SCIWORA (spinal cord injury without radiological abnormalities) is regarded as a typical paediatric type spinal injury. It consists of neurological abnormalities due to spinal cord injury with normal plain radiographs thought to be due to the ligamentous laxity of the paediatric cervical spine that allows for greater stretching of the vertebral column than is tolerable for the spinal cord, resulting in cord injury. More recently, however, SCIWORA has been found to be rare in children, and this is likely to be due to the advent of MRI and CT scanning which have the ability to demonstrate bony, disc, and especially ligamentous injuries that may not be depicted by plain radiographs (x-rays) of the cervical spine. SCIWORA is occasionally found in adults<sup>2</sup>.

#### WHAT CAUSES CERVICAL SPINE INJURY IN THE PAEDIATRIC AGE GROUP AND WHO GETS IT?

In children less than 8 years of age motor vehicle or pedestrian injuries are the most frequent cause of cervical spine injuries. In older children and adolescents they are often also caused by sports-related activities.

Non accidental injuries (NAI) need to be considered in infants and toddlers. They can be due to shaking and lead to whip-lash type injuries.



**FIGURE 1: PLAIN X-RAY OF CERVICAL SPINE, ADOLESCENT PATIENT**

Lateral cervical spine radiograph of a 15 year old that fell off a first floor balcony sustaining a moderate head injury. He has a nasogastric tube in place to reduce the risk of aspiration during neck immobilisation because of his altered conscious state.

There is 3mm of abnormal anterior subluxation of C3 on C4 (red arrow): the anterior margin of the C3 vertebral body has moved anteriorly relative to the C4 vertebral body indicating partial or complete disruption of the anterior and posterior longitudinal ligaments at this level and thus the potential for instability. There is abnormal widening of the interspinous space (yellow arrow) and C3-4 facet joint articulations (short green arrow), widening of the C3-4 disc space especially posteriorly compared with C2-3 and C4-5 discs. A line joining the posterior aspects of the C2 and C3 vertebrae is not continuous with and not parallel to a line joining the posterior aspects of C4 and C5. These findings indicate probable anterior and posterior longitudinal ligament and C3-4 intervertebral disc disruption and subluxation of the facet joints at C3-4 without evidence of a fracture on this view. This is an unstable injury due to radiological evidence of multiple column ligamentous disruption. Cervical spine immobilisation precautions are required and urgent neurosurgical involvement in further patient management is needed.

#### WHAT ARE THE POTENTIAL ADVERSE CONSEQUENCES OF THIS CONDITION?

A missed spinal injury may have catastrophic and irreversible consequences ranging from disability to death. Cervical spine injury should be assumed in all trauma patients; the cervical spine should be protected from further injury by immobilisation (one piece semi rigid collar, manual in-line immobilisation) from the pre-hospital setting onwards until formal assessment occurs.

Immobilisation is, however, not without problems. It is uncomfortable, can cause pain and lead to pressure areas. Children who vomit can be at increased risk of aspiration and airway management is more difficult while immobilised.

## HOW CAN IT BE DIAGNOSED?

Paediatric cervical spine injury is suspected when an abnormal neurological examination indicates spinal cord or nerve root injury or in patients with neck pain or spinal tenderness and trauma that could have led to cervical spine injury.

If imaging is performed the key initial test is a plain radiograph of the cervical spine. The goal of imaging in the paediatric age group is to demonstrate all cervical spine injuries, but of particular importance is the detection of unstable injuries.

“Instability” in this context is defined as:

“Loss of the ability of the bony and ligamentous structures to maintain vertebral segment alignment under normal physiologic load” and this represents a considerable risk to the integrity of the spinal cord.

Plain radiographs will demonstrate the majority of clinically important fractures in acute trauma in the paediatric age group:

- In older children the standard 3 view plain radiograph series includes a lateral cervical spine, an anteroposterior and an odontoid view.
- “Trauma oblique” or a “swimmer’s view” (performed with one arm up and one arm by the side) should be added to this whenever the C7 – T1 level is not demonstrated. This occurs more frequently in the preadolescent/adolescent age group due to obscuration of this area by larger shoulders. The lateral, AP, odontoid and two trauma oblique views represent the standard 5 view radiograph series performed in adults.
- In children <5 years of age the odontoid view is generally omitted as it requires a cooperative child to obtain a view of appropriate quality (opening the mouth). Patients in whom the transition from cervical to thoracic spine (C7 to T1) is obscured may require a swimmers view where one arm is elevated above the head which then allows better visualisation of C7 to T1.

CT imaging of the cervical spine may be required:

- If abnormalities are detected/suspected as a result of plain radiographs.
- In patients at high risk of spinal injury (e.g. intubated trauma patients who are undergoing head CT).

CT is sensitive in detecting fractures or dislocations but associated with a much higher exposure to ionising radiation (especially to the thyroid, upper lungs, bone marrow and brain) than are plain radiographs.

MRI is indicated when:

- There is imaging or clinical evidence suggesting spinal cord injury or compression and in some cases when ligamentous or nerve root injury is suspected.
- Planning of the treatment of spinal injuries demonstrated with plain radiographs or CT requires evaluation of the soft tissue structures of the cervical spine (ligaments, discs, epidural space, spinal cord, spinal nerve roots).

## CLINICAL DECISION RULES FOR PATIENTS WITH CERVICAL SPINE TRAUMA

In adults, two clinical decision rules (CDRs) based on large prospectively collected multicentre data sets have been developed to help decide which patients with acute trauma do not need a plain radiograph of the cervical spine in trauma:

- **The Canadian C-Spine Rule (CCR) (Stiell et al 2001<sup>3</sup>); and**
- **The National Emergency X-radiography Utilization Study (NEXUS) - rule (Hoffman et al 2000<sup>4</sup>).**

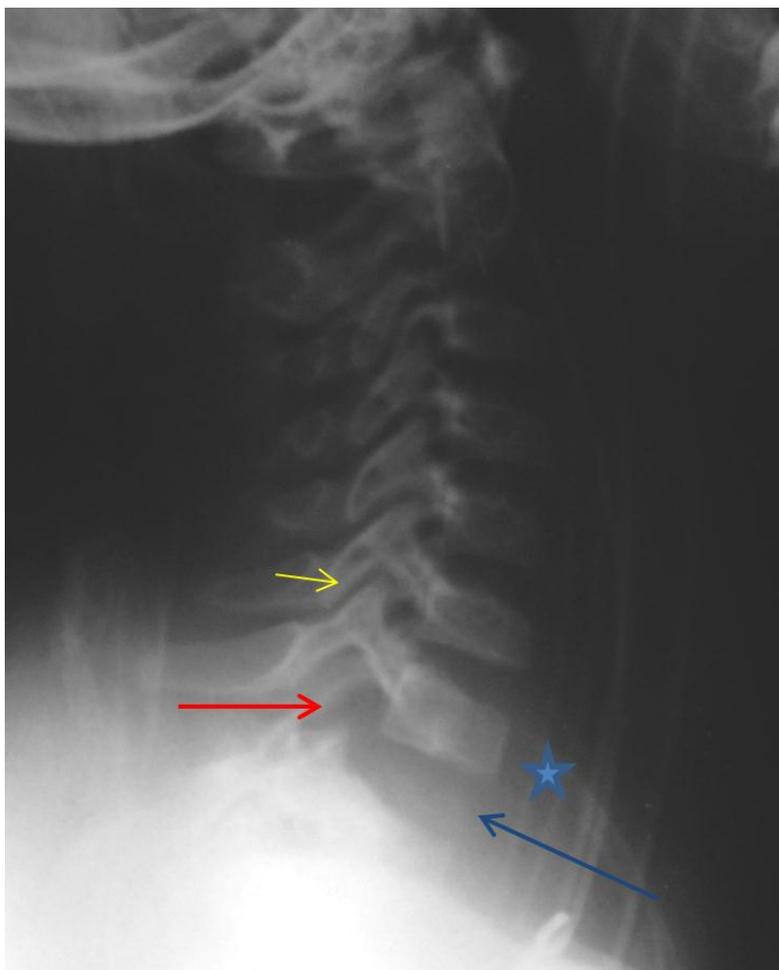
**The NEXUS data set included children but the sample size was small and there were few young children with cervical spine injury.** A validation study using NEXUS exclusively in children performed by Viccellio et al<sup>2</sup> showed NEXUS to be sufficiently sensitive in children, in that no clinically important injuries were missed when the NEXUS CDR was used, but this validation study was limited by a low incidence of *actual* cervical spine injury and small numbers of children in the youngest age group (under 9 years). This raises some questions about its actual performance in younger children. Use of the NEXUS decision rule in children, however, may prevent up to 20% of injured children receiving unnecessary imaging by helping to identify those with no significant injury.

**A dedicated CDR for paediatric cervical spine trauma does not exist for children.** Factors associated with cervical spine injury in children have recently been identified in a large case control study conducted by Leonard et al 2011<sup>5</sup> for the PECARN (Paediatric Emergency Care Applied Research Network) which provides a basis for risk stratification of children with cervical spine trauma.

**The presence of one or more of the following risk factors was 98% sensitive (95%CI: 96-99%) and 26% specific (95%CI: 23-29%) for cervical spine injury (and thus the requirement for plain radiography):**

- Altered mental status.
- Focal neurologic deficit(s).
- Complaint of neck pain.
- Torticollis.
- Substantial torso injury.
- Diving.
- High risk motor vehicle crash.
- Predisposing condition that makes the cervical spine more vulnerable to fracture and/or dislocation, such as:
  - Down syndrome.
  - Rheumatoid arthritis.
  - Rickets.
  - Osteogenesis imperfect.
  - Klippel-Feil disease.
  - Ehlers-Danlos syndrome.
  - Achondroplasia.
  - Marfan syndrome.
  - Renal osteodystrophy.

These risk factors have not yet been combined into a CDR, nor has their sensitivity and specificity been prospectively validated in a paediatric population other than the one from which they were derived. (Leonard et al 2011<sup>5</sup>)



**FIGURE 2. CHILD WITH CLOSED HEAD INJURY AND ENDOTRACHEAL INTUBATION FOLLOWING ACCIDENT WITH A MOTOR VEHICLE AS A PEDESTRIAN.**

Abnormal widening of the C7 T1 disc space (blue arrow) and facet joints (red arrow) consistent with anterior and posterior longitudinal ligament, disc and facet joint disruption. The yellow arrow indicates normal width facet joints at the level above the injury (C6-7). The blue star indicates widening of the prevertebral soft tissues due to haematoma. This is an unstable injury requiring immobilisation and urgent neurosurgical referral.

#### WHAT IS THE USUAL TREATMENT?

**Radiologically confirmed cervical spine injuries or neurological abnormalities on examination will require the involvement of surgical specialists.** Depending on local practice orthopaedic surgeons and neurosurgeons will manage bony injuries such as fractures and dislocation, spinal cord, and nerve injuries.

- In conscious, cooperative patients without distracting injury (such as a painful limb fracture) who are not affected by drugs or alcohol, a careful examination which shows a normal neurological examination and no neck pain or tenderness may allow “clearance of the cervical spine of injury” (removing the spinal immobilisation device) without radiological imaging.
- In similarly cooperative patients, such clearance will not be possible **even after normal neurological examination and normal radiological imaging, if the patient continues to complain about neck pain or midline bony tenderness.** In this case patient should be placed into a two piece collar such as an Aspen or Philadelphia collar which can be worn until re-assessment in an outpatient review.

Paediatric patients who need imaging (beginning with plain radiography) are those with:

- Altered mental status (due to head injury, intoxication or drugs); OR
- Inability to co-operate with history taking or physical exam; OR
- Distracting injuries (e.g. limb fractures, burns, chest or abdominal trauma etc.).

Ongoing immobilisation of the cervical spine and possibly further imaging with CT or MRI scans depending upon the result of the plain radiographs will be required in these patients.

## HOW CAN CLINICAL DECISION RULES HELP TO STANDARDISE PRE-TEST RISK EVALUATION OF CHILDREN WITH CERVICAL SPINE TRAUMA?

When evaluating children with suspected cervical spine injury, one of the key issues to be addressed is whether or not the patient should be investigated using imaging to confirm or exclude the presence of an injury(ies) that would change the subsequent medical treatment or investigation of the patient.

When attempting to make the decision about whether or not to use diagnostic imaging, it is important to focus on **features of the history and physical exam** that have been found to be associated with the presence of **clinically important cervical spine injury**.

At first, it might seem simpler, quicker, and safer to perform an imaging test on everyone with possible cervical spine injury. When the pre-test probability of clinically significant injury is not very low, the costs and risks of diagnostic imaging are more than outweighed by the considerable benefits of earlier diagnosis of a potentially serious injury. These benefits can include simpler, less invasive treatment or guidance for surgical or medical therapy that prevent severe disability or death.

**However, there are a number of disadvantages** to the practice of referral of patients for imaging without first considering what the pre-test probability of a condition is likely to be. They include:

- **Unnecessary exposure to ionising radiation.** This is particularly important in babies, children, and adolescents who are more sensitive to the carcinogenic effects of exposure to ionising radiation. CT scanning is associated with around 100 times the dose of radiation delivered by a plain radiograph (or x-ray).
- **Financial cost to the patient and health system of unnecessary testing.** These costs are both direct and indirect (the latter due to waiting time in emergency departments, prolonged length of stay in a hospital, time away from work and other responsibilities waiting for imaging to be performed, having it performed, and then waiting for the result).
- **Incidental findings on imaging frequently have no clinical significance for the patient but trigger further imaging follow up to exclude the very small possibility of something significant.** The flow on costs to the patient and health system and the anxiety produced in some patients by follow up testing may not be considered when imaging is requested in a situation where pre-test probability of a condition is very low and imaging likely, therefore, to be unnecessary.

Continued increases in healthcare costs are a global problem. More than ever before, medical practitioners are being asked to be accountable for utilization of finite health care resources and to add value and reduce waste in the care they deliver to patients. Reducing inappropriate use of diagnostic imaging in situations where it is highly unlikely to result in a net benefit to the patient is an important way to reduce waste and improve quality of care.

**Clinical decision rules (CDRs)** can help you to focus on the aspects of the history and examination that best discriminate between:

- **Patients with low-to-no risk of significant pathology** who are, therefore, unlikely to benefit from diagnostic imaging; and
- **Patients who do not have negligible risk** who need imaging to guide further specific treatment including in some cases in-hospital monitoring, medical therapy, or even surgery.

Please see the Clinical Decision Rules Module for more information about:

- what CDRs are;
- how they are developed; and
- what the characteristics of a high quality CDR are.

**Resources:** Something that will become apparent as you work through these modules is the difficulty involved in trying to commit the elements of CDR to memory. **It is a good idea to refer to an electronic or hard copy of the CDR each time you use it to ensure that you are applying it correctly.** To support this, the following resources are provided:

- Printable PDFs of all of the CDRs including inclusion and exclusion criteria.
- “Pocket-sized” PDFs suitable for printing, lamination, and attachment to a lanyard.
- Links to the website MDCalc where you will find a calculator that allows you to enter clinical data for your patient into a clinical decision rule. This website does not feature all published CDRs for a particular condition and does not discuss the reasons for featuring some and not others. This module will help you develop an understanding of the advantages and disadvantages as well as relative performance of the various CDRs. Go to the website now to try out the calculators for NEXUS and Canadian C-Spine Rule:
  - <http://www.mdcalc.com/nexus-criteria-for-c-spine-imaging/>
  - <http://www.mdcalc.com/canadian-c-spine-rule/>
- For more information about specific imaging tests and procedures please see – [www.insideradiology.com.au](http://www.insideradiology.com.au)

**WHAT ELSE DO YOU NEED TO THINK ABOUT WHEN YOU CONSIDER IMAGING A PAEDIATRIC PATIENT WITH CERVICAL SPINE TRAUMA APART FROM PRE-TEST RISK?**

1. **Test performance** (sensitivity, specificity, LR+ and LR-) in relation to the pathological process(es) you are trying to diagnose or exclude. For example, CT scanning is more sensitive than plain radiography (“x-ray”) for demonstrating fractures in older children. However, it is associated with a substantially higher exposure to ionising radiation. Therefore, although it may demonstrate more fractures than do plain radiographs it tends to be used as a first line investigation only in older adolescents with high risk injury mechanisms and/or significant intracranial injury, both of which increase the likelihood of significant cervical spine injury.
2. **What is available locally?** This is especially important in an emergency.
3. **Radiation dose.** This is of particular importance in young and pregnant patients.
4. **Financial and other costs** to the patient, their family, and the health system and costs may vary from one diagnostic strategy compared with another.
5. **Patient preferences** - If two diagnostic tests perform equally well at confirming or excluding the presence of a particular condition, patients may have a preference for one over another for reasons of cost, convenience, risk, or real/perceived discomfort associated with a particular diagnostic test or diagnostic strategy.

## 2. CLINICAL DECISION RULES

### HOW CAN CLINICAL DECISION RULES HELP TO DETERMINE PRE-TEST RISK OF CLINICALLY IMPORTANT BLUNT CERVICAL SPINE INJURY IN PAEDIATRIC PATIENTS WITH CERVICAL SPINE TRAUMA?

Only one clinical decision rule, the National X-Ray Utilisation Study (NEXUS), has been validated for use in people aged under 16 and this is a validation study of NEXUS conducted by Viccellio et al<sup>2</sup>.

The best CDRs are not only high performing but have been extensively validated in multiple clinical settings and have been shown repeatedly to perform just as well as at the site(s) where they were originally derived. The best CDRs often have been studied with regard to whether clinicians actually use them in practice, when they have the choice not to, and whether use of the CDR reduces healthcare costs, or volume of imaging tests performed, or changes clinician behaviour or management decisions in some way.

#### Things to consider when you use a CDR:

- **Not all CDRs with high quality development methods meet these rigorous criteria of high performance, extensive validation and impact analyses.** This is especially true of clinical decision rules designed for or validated in paediatric populations where rule performance tends to be lower and validation studies less frequent. This is in part due to the relative infrequency of the condition of interest (such as actual cervical spine injury) in a group of children who are at risk (or in this case, who have had cervical spine trauma). This makes it more expensive to conduct a validation study because the infrequent occurrence of the outcome of interest, such as actual cervical spine injury, means that large numbers of subjects need to be recruited.
- **CDRs that have not been validated in multiple clinical settings may not perform as well in practice as they did at the site(s) at which they were derived due to special training, expertise, and other factors peculiar to the people who participated in the original research that led to the development of the CDR.**

Even when these limitations are present, CDRs can be useful in guiding the clinical evaluation of the patient to ensure you look for specific examination or historical features that are known to increase the likelihood of actual pathology. Greater judgement needs to be exercised when using lower performance rules if they yield a negative result, however, because the likelihood of serious pathology may be higher than when using a higher performing CDR.

**The validation of NEXUS by Viccellio et al<sup>2</sup> has been identified through a systematic search of the literature to be the best performing tool currently available for the paediatric (under 16 years of age) patient group.** The Canadian C Spine rule<sup>3</sup> is preferable in adolescents 16 and over as it has been shown to have higher specificity than NEXUS (meaning that correct use should result in less imaging without any clinically important injuries being missed). However, the Canadian C-Spine Rule is not validated for use in children under age 16.

Information about NEXUS and the Canadian C-Spine Rule is provided below under the following headings:

1. A short summary of the nature of the CDR which includes:
  - a. an overview of the performance of the rule;
  - b. general inclusion and exclusion criteria;
  - c. precautions about routine clinical use of the CDR;
  - d. more detailed information about these aspects of the the CDRs can be found in the evidence table (Appendix One) at the end of the module. It allows rapid comparison of the performance, inclusion and exclusion criteria for each CDR.
2. An evidence summary table that provides a summary of:
  - a. **The performance of the individual rules** based on the derivation study and/or the first validation if this was performed in conjunction with the derivation study
  - b. **Inclusion and exclusion criteria for each CDR.** Note that the CDR or algorithm alone does not tell you the characteristics of patients to whom you can apply the CDR. Knowing the situations in which you CANNOT use a CDR is just as important as knowing the elements of the CDR itself. Common exclusion criteria are things like patient age, whether the person is an inpatient (rather than an ambulatory outpatient), and use of anticoagulation
  - c. **Validation studies that have been identified for the CDR** including their performance and inclusion and exclusion criteria if these differ from the derivation study
3. The elements of the rule (generally a flowchart, series of questions, or list of examination or historical findings that need to be elicited).
4. Links to the full text derivation studies for the individual CDRs

Throughout this module, you will be presented with questions that will evaluate module content and also your ability to apply this to real clinical situations.

## THE NATIONAL X-RAY UTILISATION STUDY (NEXUS) DECISION RULE

### Summary Statement:

In the past, there has been little research about the appropriateness of cervical spine imaging in the trauma setting with regard to the paediatric population. In this large, prospective multicentre study, Viccellio et al 2001<sup>2</sup> have demonstrated promising results applying the five NEXUS criteria to patients under the age of 18 years who have sustained blunt force trauma. In their study, the decision instrument did not miss any cases of cervical spine injury (CSI) and would have resulted in 20% fewer radiologic examinations. However, it must be remembered that investigation of CDR use in children is complicated by several factors:

1. Small numbers of paediatric patients with actual cervical spine injury.
2. Anatomical differences compared to adults with regard to the nature and location of clinically important CSI in children.
3. The relatively small incidence of cervical spine injuries in the paediatric population.
4. Developmental differences influencing assessment of the NEXUS criteria that were primarily developed for use in adults (e.g. posterior neck tenderness, painful distracting injuries or intoxication). Viccellio et al<sup>2</sup> point out that the youngest paediatric patients (aged 9 years or less) create most uncertainty about the performance of the NEXUS CDR, given that the number of study participants in this age group is small for both the original NEXUS study<sup>6</sup> and the Viccellio et al validation, and so too are the number of actual cervical spine injuries in this age group.

Ehrlich et al 2009<sup>7</sup> applied the NEXUS criteria retrospectively in a group of 108 paediatric patients who had undergone cervical spine imaging and reported the sensitivity for predicting cervical spine injury as 43%. This is markedly different to the results of the Viccellio study.

Booth 2012<sup>1</sup> cautions that, "overall, there is conflicting information and limited agreement in the literature concerning the use of clinical screening tools in CSI involving the young child". The use of CDRs in relation to potential cervical spine injury should be applied with caution in paediatric patients, and radiation dose should be minimised to reduce the risk of harmful long-term effects".

Instructions to participating physicians
<p><b>1. Altered neurologic function is present if any of the following is present:</b></p> <p>(a) Glasgow Coma Scale score of 14 or less;            (b) disorientation to person, place, time, or events;            (c) inability to remember 3 objects at 5 minutes;            (d) delayed or inappropriate response to external stimuli; or            (e) any focal deficit on motor or sensory examination.</p> <p>Patients with none of these individual findings should be classified as having normal neurologic function.</p> <p><b>2. Patients should be considered intoxicated if they have either of the following:</b></p> <p>(a) a recent history of intoxication or intoxicating ingestion; or            (b) evidence of intoxication on physical examination. Patients may also be considered to be intoxicated if tests of bodily secretions are positive for drugs that affect level of alertness, including a blood alcohol level greater than .08 mg/dL.</p> <p><b>3. Midline posterior bony cervical spine tenderness is present if the patient complains of pain on palpation of the posterior midline neck from the nuchal ridge to the prominence of the first thoracic vertebra, or if the patient evinces pain with direct palpation of any cervical spinous process.</b></p> <p><b>4. Patients should be considered to have a distracting painful injury if they have any of the following:</b></p> <p>(a) a long bone fracture;            (b) a visceral injury requiring surgical consultation;            (c) a large laceration, de-gloving injury, or crush injury;            (d) large burns; or            (e) any other injury producing acute functional impairment. Physicians may also classify any injury as distracting if it is thought to have the potential to impair the patient's ability to appreciate other injuries.</p>

TABLE 1: PHYSICIAN INSTRUCTIONS FROM ORIGINAL NEXUS DERIVATION STUDY (HOFFMAN ET AL., 1998) <sup>6</sup>

Algorithm:

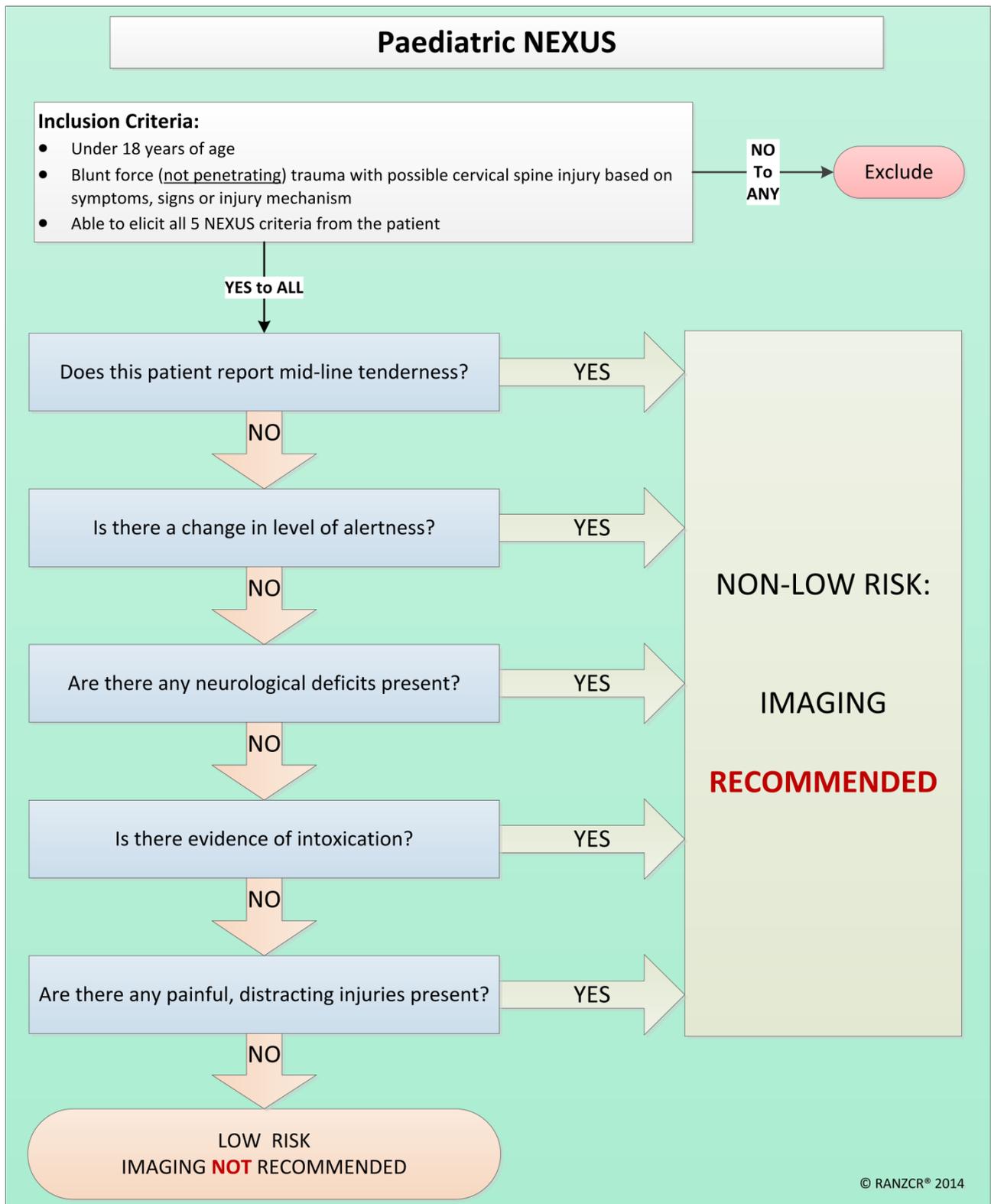


FIGURE 3: DECISION TREE DERIVED FROM NEXUS CRITERIA<sup>2,4</sup>

**QUESTION 1.**

**Which of the following risk factors have been identified BOTH by Leonard et al and NEXUS as increasing the risk of clinically important cervical spine injury in children who have experienced cervical spine trauma? Select all possible answers.**

- 1A. Focal neurological deficit.
- 1B. High risk motor vehicle crash.
- 1C. Alteration in conscious state.
- 1D. Neck pain.
- 1E. Midline bony tenderness.
- 1F. Pre-existing spinal disorder predisposing to injury.

**CORRECT ANSWERS**

The following increase the risk of clinically important cervical spine injury:

- 1A. Focal neurological deficit.
- 1C. Alteration in conscious state.

## THE CANADIAN C-SPINE RULE

### Summary Statement:

Stiell et al<sup>3</sup> have developed a highly sensitive CDR with significantly higher specificity than NEXUS for use in patients aged 16 years and over with acute cervical spine trauma. Prior to the development of the Canadian C-Spine Rule (CCSR), the NEXUS criteria constituted the best CDR available to aid decisions about whether or not to perform radiologic imaging in the setting of blunt force trauma and possible cervical spine injury. The CCSR has been shown to have higher specificity than NEXUS and because either CDR can be used in the 16 and over age group, use of the CCSR may be expected to result in less imaging being performed on these older adolescents with cervical spine trauma.

The Canadian C-Spine Rule is a high-performance rule. It can be used safely in the defined population to minimise the volume of cervical spine radiology ordered for blunt head and neck trauma, without missing clinically significant cervical spine injuries. Its use has been validated in a number of other studies, across a variety of patient populations and clinical settings.

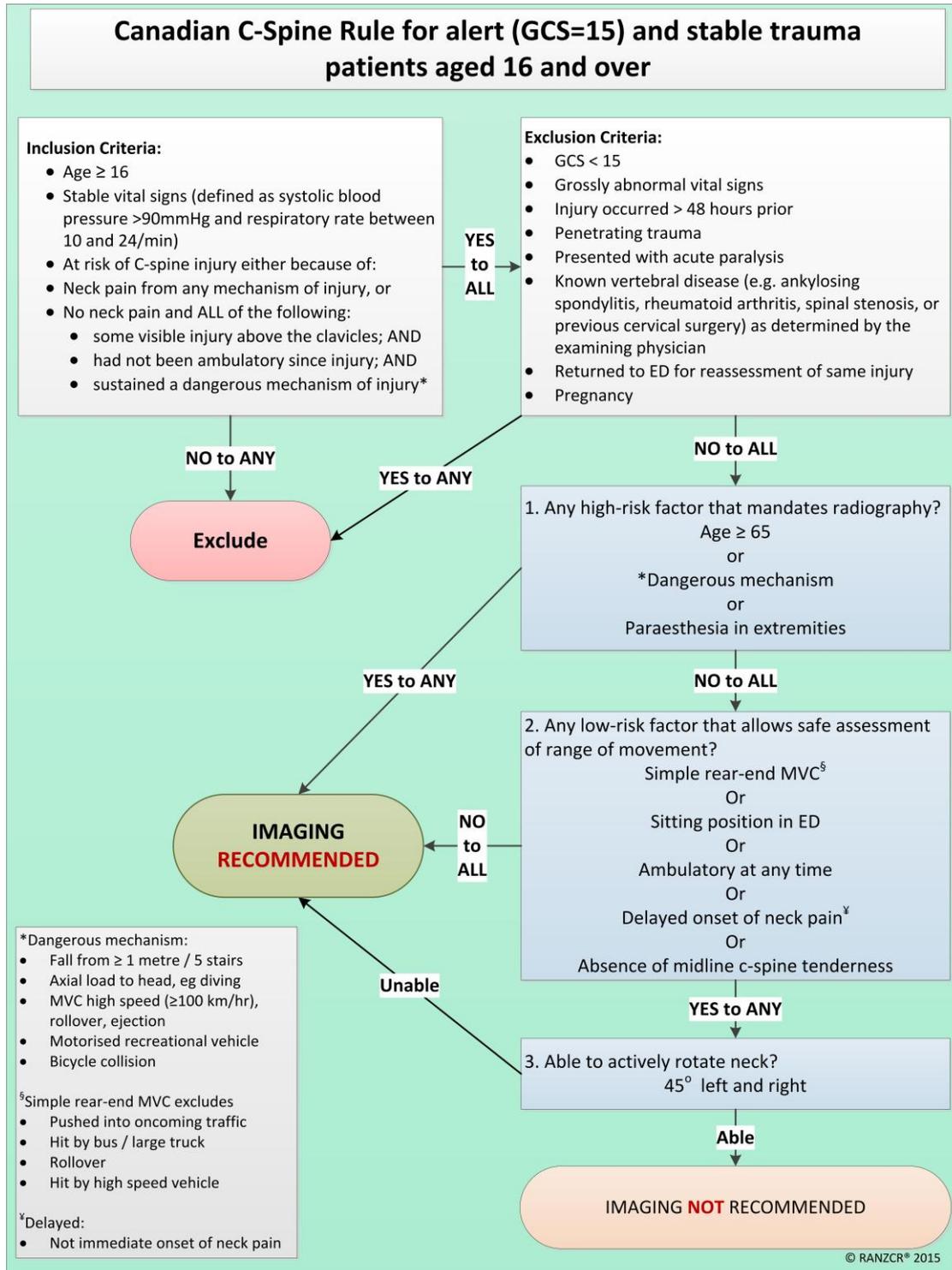


FIGURE 4: THE CANADIAN C-SPINE RULE FLOWCHART<sup>3</sup>

**QUESTION 2.**

**A 6 year old girl on a pushbike rode from the driveway onto the road. She was hit by a car travelling about 50 km/h. On arrival in the ED she is distressed with pelvic and lower limb injuries and grazes to the head.**

**What should the management should include:**

- 2A. CT of the cervical spine as there is also a head injury.
- 2B. Immobilisation of the cervical spine in a hard collar while assessing and managing ABC (airway, breathing, circulation).
- 2C. Immediate assessment of the cervical spine clinically to clear it if possible allowing easier management of other injuries.
- 2D. Immediate assessment of the airway, breathing and circulation.

**CORRECT ANSWERS:**

Management should include:

- 2B. Immobilisation of the cervical spine in a hard collar while assessing and managing ABC.
- 2D. Immediate assessment of the airway, breathing and circulation.

**FEEDBACK:** This patient has multi trauma with possible distracting injury (lower leg and pelvic injuries). The initial management must therefore be assessment and management of ABC (airway, breathing, circulation). This should be accompanied by immobilisation of the cervical spine in a hard collar and analgesia. There is only indication for CT of the spine initially if the child is intubated and having an urgent CT brain (in which case the entire cervical spine should also be included). Clearance of the cervical spine in this type of situation is difficult initially and immobilisation, management of other injuries and later assessment and investigation is prudent.

### 3. WHAT ELSE DO YOU NEED TO THINK ABOUT, OTHER THAN PRE-TEST PROBABILITY OF A CONDITION, WHEN YOU ARE CONSIDERING PERFORMING DIAGNOSTIC IMAGING IN A PATIENT WITH BLUNT CERVICAL SPINE TRAUMA?

#### **URGENCY**

When you suspect the possibility of cervical spine injury in a child, immediate spinal immobilisation is critical and imaging, beginning with plain radiographs, is urgent to facilitate either specific treatment for injuries or clearance of the cervical spine so that the immobilisation may be removed. Prolonged cervical immobilisation increases the risk of aspiration and can be very distressing for children, making it potentially harder to manage other injuries if these are present.

#### **PLAIN RADIOGRAPHS**

Should be performed before other imaging in a child with suspected cervical spine injury unless CT scanning is being performed in an intubated child due to contemporaneous significant head injury, in which case it is often most efficient to include CT of the entire cervical spine due to the increased risk of a clinically important cervical spine injury in a child in this situation.

#### **RADIATION DOSE**

This is 50 to 100 times higher for cervical spine CT compared with plain radiography of the cervical spine. Radiation dose is of particular importance in young and pregnant patients.

See InsideRadiology: [http://www.insideradiology.com.au/pages/view.php?T\\_id=57](http://www.insideradiology.com.au/pages/view.php?T_id=57)

#### **TEST PERFORMANCE**

How good is a particular diagnosis test at diagnosing or excluding this condition?

#### **OTHER**

MRI is indicated in a patient with neurological signs or symptoms that may be referable to the cervical spine regardless of the normality or otherwise of plain radiographs or CT.

See the table below for the strengths and weakness of the various imaging tests you can use to image the paediatric cervical spine in the setting of trauma.

## MODALITY TABLE

MODALITY	STRENGTHS	WEAKNESSES	COMMENTS
Plain radiograph (X-ray) Link: <a href="http://www.insideradiology.com.au/pages/view.php?T_id=24">www.insideradiology.com.au/pages/view.php?T_id=24</a>	<ul style="list-style-type: none"> <li>Widely available.</li> <li>Easy to perform even if patient has limited mobility, other injuries, or is uncooperative.</li> <li>Good for identifying the majority of clinically important fractures in the setting of acute trauma.</li> <li>Other bone lesions (e.g. tumours) that have come to attention because of an episode of blunt trauma may be shown with plain radiographs.</li> </ul>	<ul style="list-style-type: none"> <li>Ligamentous injuries may be undetectable with plain radiography but are suspected when alignment of the spine is not anatomical.</li> <li>Low to moderate ionising radiation dose.</li> </ul>	First line investigation in the patient who needs imaging.
Computed Tomography (CT) Link: <a href="http://www.insideradiology.com.au/pages/view.php?T_id=61">www.insideradiology.com.au/pages/view.php?T_id=61</a>	<ul style="list-style-type: none"> <li>Very sensitive for fracture/dislocation.</li> </ul>	<ul style="list-style-type: none"> <li>Insensitive for ligamentous and disc injuries that are not associated with abnormal alignment of the spine.</li> <li>Does not demonstrate spinal cord injury.</li> <li>Insensitive for epidural haematoma when this is not large.</li> <li>High radiation dose procedure.</li> </ul>	The best first examination for older children/adolescents with high energy injury mechanisms e.g. diving, motor vehicle accidents at high speed, focal neurology, where the likelihood of significant injury may be higher.  CT can also be used to confirm or exclude abnormal findings on plain radiography, such as a suspected fracture or subluxation/dislocation.
Magnetic Resonance Imaging (MRI) Link: <a href="http://www.insideradiology.com.au/pages/view.php?T_id=53">www.insideradiology.com.au/pages/view.php?T_id=53</a>	<ul style="list-style-type: none"> <li>Very sensitive to spinal cord, ligamentous, and disc injuries.</li> <li>No ionising radiation.</li> </ul>	<ul style="list-style-type: none"> <li>Duration of the exam (20 minutes) may be difficult for patients with confusion, other injuries, or difficulties with communication.</li> <li>Metal in or around the neck may impair interpretability of images.</li> <li>MR incompatible pacemakers are a contraindication to any type of MRI.</li> <li>Not sensitive to linear fractures of vertebral bodies or posterior elements due to inferior spatial resolution compared with CT or plain radiography. Any patient who has indications for cervical spine MRI should have this preceded by plain radiography or CT.</li> </ul>	Recommended for patients with neurological signs or symptoms that may be referable to the spinal cord or spinal nerve roots, regardless of the result of plain radiographs or CT scanning.  Can be considered for patients with suspected ligamentous injuries (because of subluxation on plain radiographs or CT or if persistent midline bony tenderness or neck pain without radiographic abnormality suggesting ligamentous injury) if the diagnosis of ligamentous injury would change further management.

TABLE 2. IMAGING OPTIONS

The following diagram illustrates a pragmatic approach to the use of imaging in a child with blunt trauma to the cervical spine.

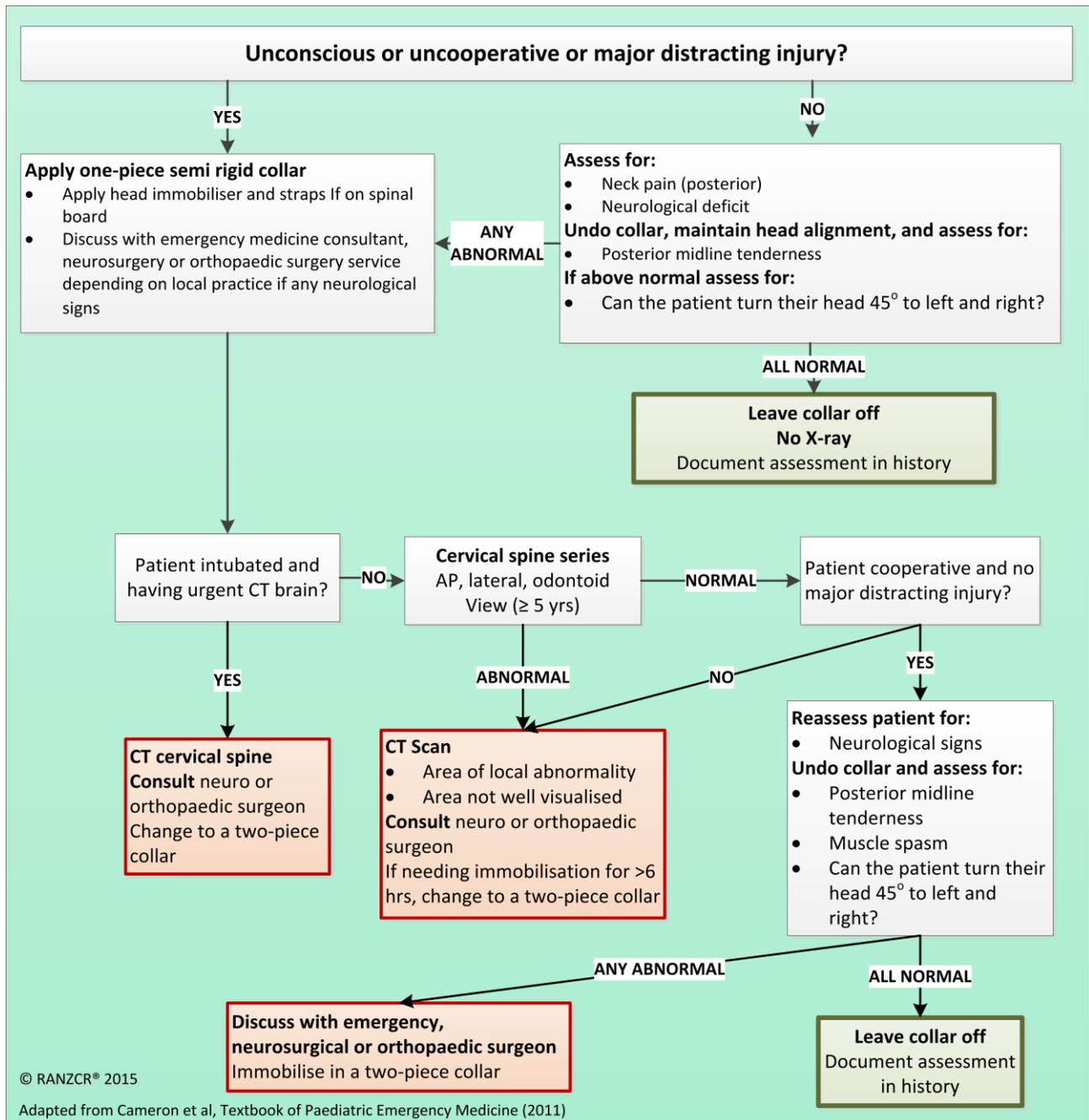


FIGURE 5: GUIDE TO MANAGEMENT OF THE POTENTIALLY INJURED CERVICAL SPINE<sup>8</sup>

**QUESTION 3.**

An 18 month old girl was being changed on a change table in the family room. She rolled off the table 1 metre onto the wooden floor. She has a bruise on the left side of the forehead and has been crying. When you see her in the ED she is in mum's arms without a cervical spine collar in place to immobilise the neck.

**What should assessment of the cervical spine include?**

- 3A. Immediate immobilisation in a hard collar lying flat on a trolley.
- 3B. Immobilisation as tolerated followed by plain x-ray of the cervical spine.
- 3C. Ignoring the c spine as injury is not going to happen from this mechanism.
- 3D. Careful assessment watching the child while interacting with mum and possibly feeding. Seeing if the head moves spontaneously, along with gentle palpation of the spine.

**CORRECT ANSWERS**

Assessment of the cervical spine should include:

- 3D. Careful assessment watching the child while interacting with mum and possibly feeding. Seeing if the head moves spontaneously, along with gentle palpation of the spine.

**FEEDBACK:** This is a common scenario. We must remember that cervical spine injury in this age group is infrequent (unless the spine or bones are abnormal), however it must still be assessed to ensure there is no injury. This assessment must include a close and careful examination using observation, playing and gentle palpation, which may need to be repeated more than once.

Immobilisation in a hard collar will distress the child causing movement of the cervical spine and should be avoided. Imaging is not indicated if observation and examination reveal a normal child with normal neck function and no tenderness.

**QUESTION 4.**

**A 10 year old boy fell 2 metres from a tree. He has abrasions to his right arm and leg and is complaining of a headache and has a lump in the right occipital region. He is in a cervical collar lying flat on the trolley in the ED when you see him. He has a GCS of 15 and responds appropriately to questions.**

**When are plain radiographs (x-rays) of the C-spine indicated?**

- 4A. Immediately as the mechanism of injury is significant and there are distracting injuries.
- 4B. After careful examination of the neck if there is midline tenderness OR limitation of movement due to posterior neck pain.
- 4C. Cervical spine examination reveals normal movements and no tenderness or pain, and other examination is normal.
- 4D. All patients in a cervical spine collar should have plain x-ray before deciding if the collar can be removed.

**CORRECT ANSWERS**

Plain radiographs (x-rays) of the C-spine are indicated:

- 4B. After careful examination of the neck if there is midline tenderness OR limitation of movement due to posterior neck pain.

**FEEDBACK:** This boy has a mechanism of injury that might cause cervical spine injury. On the available information grazes to the limbs and a bump on the head are unlikely to constitute a distracting injury if the conscious state is normal. A thorough examination of the cervical spine is indicated after airway, breathing, and circulation have been assessed and are normal. If his examination is normal with no pain, tenderness or limitation of movement of the spine and there is no abnormal neurology removing the collar is appropriate. The aim is to avoid unnecessary imaging even if patients arrive immobilised in a hard collar.

**QUESTION 5.**

**An 8 year old girl is in the ED after a motor vehicle crash. She has a head injury and is intubated and ventilated. She requires an urgent CT of the brain.**

**What should cervical spine management include?**

- 5A. Full plain radiographs of the cervical spine immediately.
- 5B. Removal of cervical spine immobilisation as the patient is intubated.
- 5C. Urgent MRI of the cervical spine as assessment of any injury is impossible.
- 5D. As this patient is likely to need an urgent CT scan of the head, and is intubated, a CT of the cervical spine at the same time is indicated.

**CORRECT ANSWERS**

C-Spine management includes:

- 5D. As this patient is likely to need an urgent CT scan of the head, and is intubated; a CT of the cervical spine at the same time is indicated.

**FEEDBACK:** This child is critically unwell with a head injury. Initial assessment is of ABC, with stabilisation and then with a full secondary survey. Cervical spine immobilisation is mandatory throughout this time. Cervical spine imaging in this child should be optimised by performing a CT of the cervical spine at the same time that the child is having a CT of the brain. MRI should be reserved for investigating possible spinal cord injury or as a later procedure to assess ligamentous injury if this seems likely based on the radiologist's interpretation of the CT.

**QUESTION 6.**

**Imaging of the cervical spine after trauma in children:**

- 6A. Is best performed with plain radiographs (x-rays) unless the patient is intubated and undergoing an urgent CT of the brain.
- 6B. Should include CT scanning in most patients.
- 6C. Is necessary in the majority of patients with a fall and a scalp haematoma to avoid missing a cervical spine injury.
- 6D. Is risk free and can be employed on all patients.

**CORRECT ANSWERS**

Imaging of the cervical spine after trauma in children:

6A. Is best performed with plain radiographs (x-rays) unless the patient is intubated and undergoing an urgent CT of the brain.

**FEEDBACK:** Cervical spine imaging carries risk to the patient of radiation, and cost risks to the health care sector. Imaging should be undertaken only when indicated – using existing rules helps to narrow the group requiring imaging. Plain radiographs are the initial modality of choice and CT should be reserved for special circumstances: to further elucidate abnormalities seen on plain radiographs, to image areas not visualized on plain radiographs, or if the patient is intubated and having an urgent CT of the brain.

**QUESTION 7.**

**A CT of the cervical spine is indicated in children if:**

- 7A. They are in a cervical collar in the ED.
- 7B. They have any chest, abdominal or multiple long bone fractures.
- 7C. There is an abnormality of plain radiographs that needs to be further investigated.
- 7D. CT is readily available it should replace the plain radiographs as the preferred imaging option.

**CORRECT ANSWERS**

A CT of the cervical spine is indicated in children if:

7C. There is an abnormality of plain radiographs that needs to be further investigated.

**FEEDBACK:** Cervical spine imaging carries risk to the patient of radiation, and costs to the health care sector. Imaging should be undertaken only when indicated – using existing rules helps to narrow the group requiring imaging. Plain radiographs are the initial modality of choice and CT should be reserved for special circumstances: to further elucidate abnormalities seen on plain radiographs, to image areas not visualised on plain radiographs, or if the patient is intubated and having an urgent CT of the brain.

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## APPENDIX ONE: EVIDENCE SUMMARY TABLE

Author and date	Name of CDR	Derivation or validation	Inclusion	Exclusion	Sensitivity (95%ci)	Specificity (95% ci)	LR- (95%CI)	High performance* (y/n)	Hierarchy
<b>Paediatric specific study:</b>									
Viccellio, 2001 <sup>2</sup>	NEXUS	Validation	<p>Under 18 years of age</p> <p>Blunt force trauma</p> <p>Considered low risk as per the five NEXUS criteria (ie. satisfies all of the following):</p> <ul style="list-style-type: none"> <li>• No midline cervical tenderness</li> <li>• No focal neurological deficit</li> <li>• Normal alertness</li> <li>• No intoxication</li> <li>• No painful, distracting injury</li> </ul> <p>Patients who underwent radiographic evaluation</p> <p>Total: n = 603 patients considered low-risk out of a sample of 3065</p>	<p>Patients not considered low-risk using NEXUS criteria</p> <p>Patients who did not undergo radiologic investigation</p> <p>Patients in whom one or more criteria were unable to be determined by the assessing physician</p>	100 (87.8-100.0)	19.9 (18.5-21.3)	< 0.1 (0.00-0.659)	N	Level III
<b>Primarily adult clinical decision rules with some paediatric participants:</b>									
Hoffman et al., 1998 and Hoffman et al, 2000 <sup>4, 6</sup>	National Emergency X-Radiography Utilisation Study (NEXUS)	Derivation	<p>All patients with blunt trauma who underwent radiography of the cervical spine in a participating emergency department were included.</p> <p><i>Total: n = 34,069 (including 818 with a radiographically documented cervical spine injury)</i></p>	<p>Patients with penetrating trauma and those who underwent cervical spine imaging for any other reason, unrelated to trauma, were not eligible for inclusion.</p>	99% (98.0 – 99.6)	12.9% (12.8 – 13.0)	(1 – 0.99)/0.129 = 0.08 <i>unable to determine CI</i>	Using the lowest values of sensitivity and specificity, the likely highest possible value of the LR- is 0.16. As this is greater >0.1. This is due to low specificity rather than poor sensitivity.	Level II

Stiell et al, 2001	The Canadian C-Spine Rule	Derivation	<p>Adult patients (≥ 16 years old)</p> <p>Blunt trauma to head/neck</p> <p>GCS 15 (ie. patient must be alert)</p> <p>Stable vital signs (defined as systolic blood pressure &gt;90mmHg and respiratory rate between 10 and 24/min)</p> <p>At risk of C-spine injury either because of:</p> <p>Neck pain from any mechanism of injury, or</p> <p>No neck pain but all of the following (some visible injury above the clavicles, had not been ambulatory since injury, had sustained a dangerous mechanism of injury)</p> <p>Patients transferred from other hospitals with C-spine injury were eligible for enrolment into the study provided that physicians completed the data form prior to reviewing radiographic films</p> <p>Total: n = 8924 patients eligible and enrolled (3281 eligible but not enrolled; 577 excluded as radiography not undertaken and unable to follow up)</p>	<p>&lt; 16 years old</p> <p>Trivial injuries (eg. Simple facial lacerations) and did not fulfil the “at risk” inclusion criteria</p> <p>GCS &lt; 15</p> <p>Grossly abnormal vital signs</p> <p>Injury occurred &gt; 48 hours prior</p> <p>Penetrating trauma</p> <p>Presented with acute paralysis</p> <p>Known vertebral disease (e.g. ankylosing spondylitis, rheumatoid arthritis, spinal stenosis, -or previous cervical surgery) as determined by the examining physician</p> <p>Returned to ED for reassessment of same injury</p> <p>Pregnancy</p>	100% (98-100)	42.5% (40-44)	<0.1 (0.00-0.05)	Y	Level I
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\*High performance (Y/N) for the derivation study defined as:

- Sens > 0.95; AND
- Lower limit of 95%CI for sensitivity >0.95; AND
- LR-<0.1; AND
- Upper limit of LR-95% CI < 0.1.
- Likelihood ratio for negative test result =  $\frac{\text{proportion of patients WITH disease who have a negative test result (1 - SENSITIVITY)}}{\text{proportion of patients WITHOUT disease who have a negative test result (SPECIFICITY)}} = \frac{(1 - \text{SENSITIVITY})}{(\text{SPECIFICITY})}$

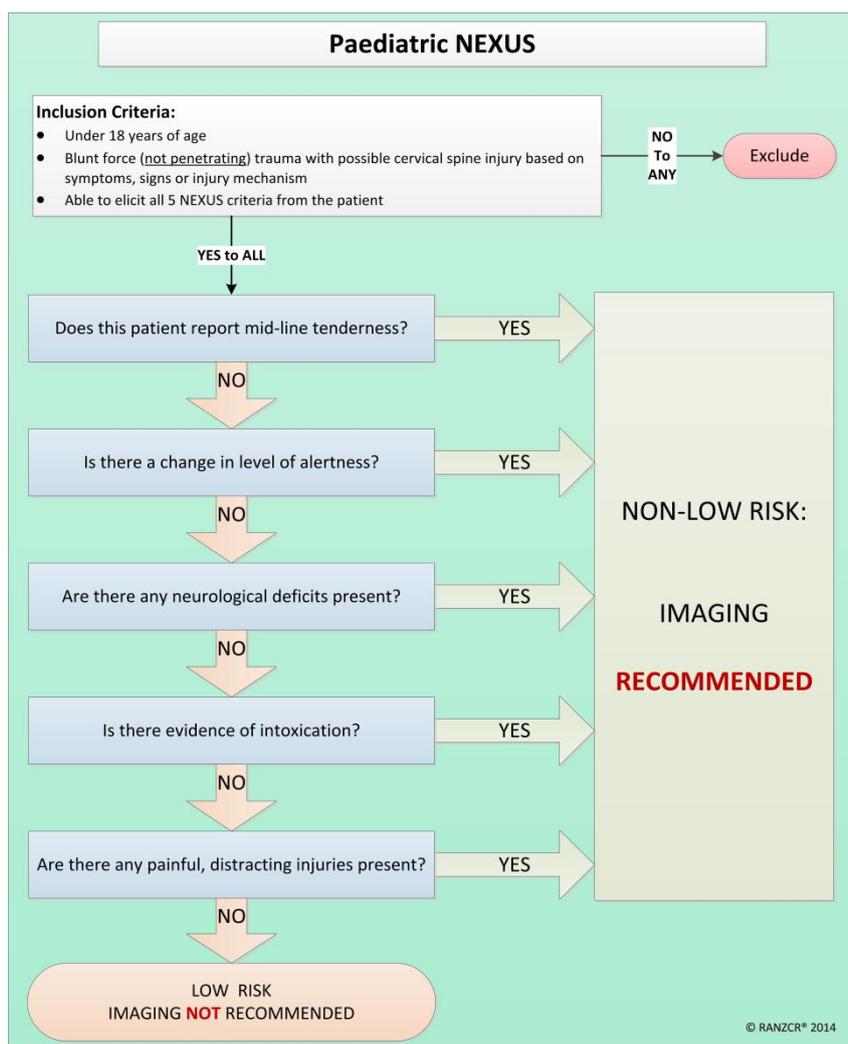
\*\*Hierarchy (see reference I. below)

- Level I:** can be used in a variety of clinical settings and includes at least one validation study (external) and at least one impact analysis showing favourable change in clinician behaviour when the CDR is used/implemented.
- Level II:** can be used in various setting with confidence about accuracy (1 prospective validation in heterogeneous population or several smaller ones).
- Level III:** use with caution in narrowly defined group of patients (validated in one narrow prospective sample).
- Level IV:** CDRs requiring more evaluation before they are implemented (no validation or only validated with statistical techniques or retrospective databases, or split samples).

**APPRAISAL TABLE REFERENCES:**

- I. McGinn T, Guyatt G, Wyer P, Naylor C, Stiell I, Richardson W. Users' guides to the medical literature: XXII: how to use articles about clinical decision rules. Evidence-Based Medicine Working Group. *JAMA*. 2000; 284(1): 79-84.
- II. Pickering A, Harnan S, Fitzgerald P, Pandor A, Goodacre S. Clinical decision rules for children with minor head injury: A systematic review. *Arch Dis Child*. 2011; 96(5): 414-21.

## APPENDIX TWO: THE NEXUS RULE

**Instructions to participating physicians****1. Altered neurologic function is present if any of the following is present:**

- Glasgow Coma Scale score of 14 or less;
- disorientation to person, place, time, or events;
- inability to remember 3 objects at 5 minutes;
- delayed or inappropriate response to external stimuli; or
- any focal deficit on motor or sensory examination.

Patients with none of these individual findings should be classified as having normal neurologic function.

**2. Patients should be considered intoxicated if they have either of the following:**

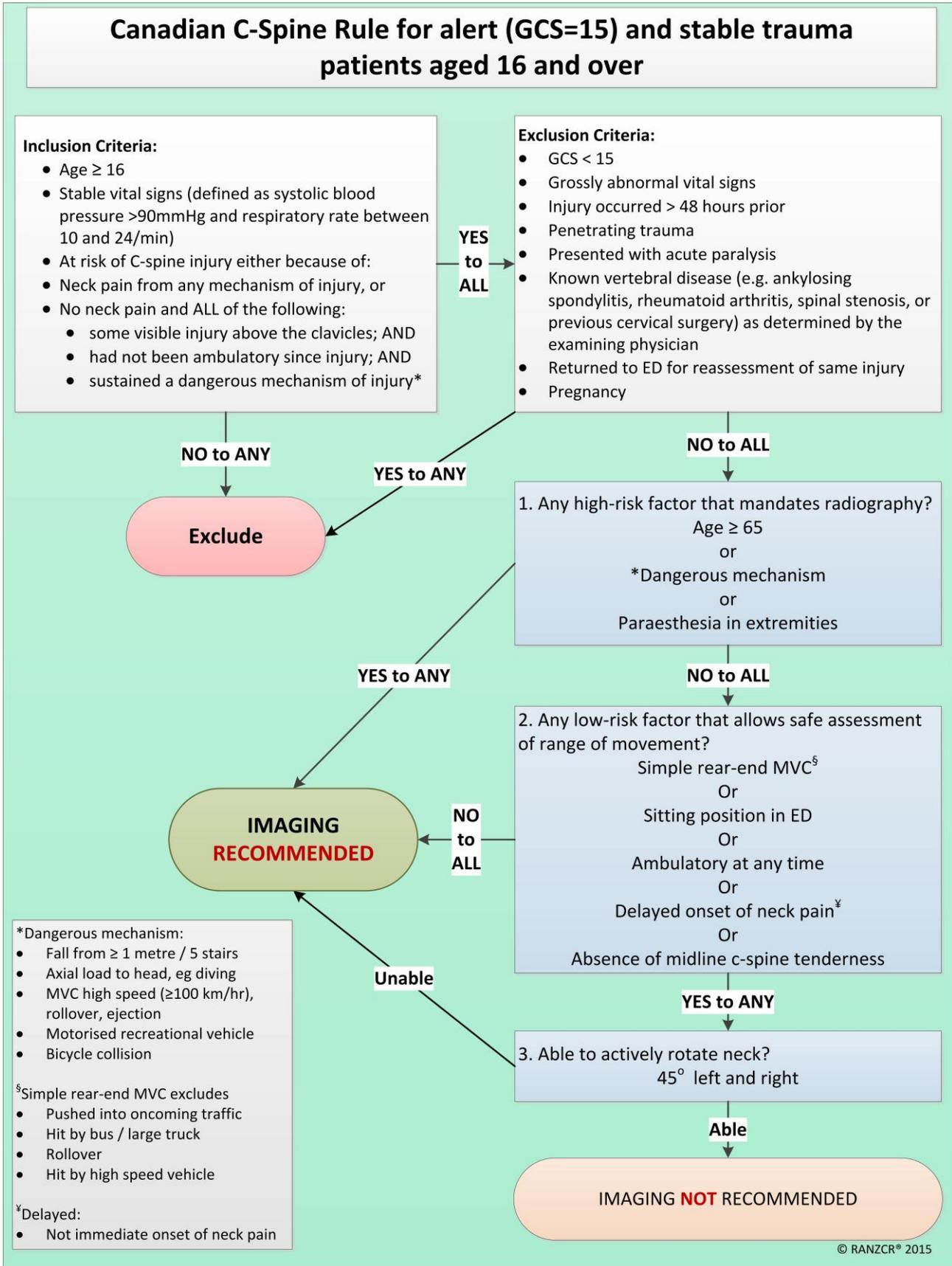
- a recent history of intoxication or intoxicating ingestion; or
- evidence of intoxication on physical examination. Patients may also be considered to be intoxicated if tests of bodily secretions are positive for drugs that affect level of alertness, including a blood alcohol level greater than .08 mg/dL.

**3. Midline posterior bony cervical spine tenderness is present if the patient complains of pain on palpation of the posterior midline neck from the nuchal ridge to the prominence of the first thoracic vertebra, or if the patient evinces pain with direct palpation of any cervical spinous process.****4. Patients should be considered to have a distracting painful injury if they have any of the following:**

- a long bone fracture;
- a visceral injury requiring surgical consultation;
- a large laceration, de-gloving injury, or crush injury;
- large burns; or
- any other injury producing acute functional impairment.

Physicians may also classify any injury as distracting if it is thought to have the potential to impair the patient's ability to appreciate other injuries.

# APPENDIX THREE: THE CANADIAN C-SPINE RULE FOR CHILDREN AGED 16 AND OVER



## APPENDIX FOUR: GUIDE TO MANAGEMENT OF THE POTENTIALLY INJURED CERVICAL SPINE

The following diagram illustrates a pragmatic approach to the use of imaging in a child with blunt trauma to the cervical spine.

