American College of Radiology
ACR Appropriateness Criteria®
Acute Spinal Trauma

Variant: 1 **Age greater than or equal to 16 years and less than 65 years. Acute cervical spine blunt trauma; imaging not indicated by CCR or NEXUS clinical criteria. Low-risk criteria. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography cervical spine	Usually Not Appropriate	☢☢
Arteriography cervicocerebral	Usually Not Appropriate	☢☢☢
MRA neck with IV contrast	Usually Not Appropriate	O
MRA neck without and with IV contrast	Usually Not Appropriate	O
MRA neck without IV contrast	Usually Not Appropriate	O
MRI cervical spine with IV contrast	Usually Not Appropriate	O
MRI cervical spine without and with IV contrast	Usually Not Appropriate	O
MRI cervical spine without IV contrast	Usually Not Appropriate	O
CT cervical spine with IV contrast	Usually Not Appropriate	☢☢☢
CT cervical spine without and with IV contrast	Usually Not Appropriate	☢☢☢
CT cervical spine without IV contrast	Usually Not Appropriate	☢☢☢
CTA head and neck with IV contrast	Usually Not Appropriate	☢☢☢
CT myelography cervical spine	Usually Not Appropriate	☢☢☢☢

Variant: 2 **Age 16 years or older. Acute cervical spine blunt trauma. Imaging indicated by CCR or NEXUS clinical criteria. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
CT cervical spine without IV contrast	Usually Appropriate	☢☢☢
Radiography cervical spine	Usually Not Appropriate	☢☢
Arteriography cervicocerebral	Usually Not Appropriate	☢☢☢
MRA neck with IV contrast	Usually Not Appropriate	O
MRA neck without and with IV contrast	Usually Not Appropriate	O
MRA neck without IV contrast	Usually Not Appropriate	O
MRI cervical spine with IV contrast	Usually Not Appropriate	O
MRI cervical spine without and with IV contrast	Usually Not Appropriate	O
MRI cervical spine without IV contrast	Usually Not Appropriate	O
CT cervical spine with IV contrast	Usually Not Appropriate	☢☢☢
CT cervical spine without and with IV contrast	Usually Not Appropriate	☢☢☢
CTA head and neck with IV contrast	Usually Not Appropriate	☢☢☢
CT myelography cervical spine	Usually Not Appropriate	☢☢☢☢

Variant: 3 **Age 16 years or older. Acute cervical spine blunt trauma. No unstable injury demonstrated initially, but kept in collar for neck pain. No new neurologic symptoms. Follow-up imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
CT cervical spine without IV contrast	Usually Appropriate	☢☢☢

Procedure	Appropriateness Category	Relative Radiation Level
Radiography cervical spine	May Be Appropriate	☢☢
MRI cervical spine without IV contrast	May Be Appropriate	O
Arteriography cervicocerebral	Usually Not Appropriate	☢☢☢
MRA neck with IV contrast	Usually Not Appropriate	O
MRA neck without and with IV contrast	Usually Not Appropriate	O
MRA neck without IV contrast	Usually Not Appropriate	O
MRI cervical spine with IV contrast	Usually Not Appropriate	O
MRI cervical spine without and with IV contrast	Usually Not Appropriate	O
CT cervical spine with IV contrast	Usually Not Appropriate	☢☢☢
CT cervical spine without and with IV contrast	Usually Not Appropriate	☢☢☢
CTA head and neck with IV contrast	Usually Not Appropriate	☢☢☢
CT myelography cervical spine	Usually Not Appropriate	☢☢☢☢

Variant: 4   Age 16 years or older. Acute cervical spine blunt trauma. Suspected arterial injury with or without positive cervical spine CT. Next imaging study.

Procedure	Appropriateness Category	Relative Radiation Level
CTA head and neck with IV contrast	Usually Appropriate	☢☢☢
Arteriography cervicocerebral	Usually Not Appropriate	☢☢☢
MRA neck with IV contrast	Usually Not Appropriate	O
MRA neck without and with IV contrast	Usually Not Appropriate	O
MRA neck without IV contrast	Usually Not Appropriate	O

Variant: 5   Age 16 years or older. Acute cervical, thoracic or lumbar spine blunt trauma. Suspected or confirmed ligamentous, spinal cord or nerve root injury, with or without trauma identified on CT. Next imaging study.

Procedure	Appropriateness Category	Relative Radiation Level
MRI spine area of interest without IV contrast	Usually Appropriate	O
Arteriography spine area of interest	Usually Not Appropriate	Varies
MRA spine area of interest with IV contrast	Usually Not Appropriate	O
MRA spine area of interest without and with IV contrast	Usually Not Appropriate	O
MRA spine area of interest without IV contrast	Usually Not Appropriate	O
MRI spine area of interest with IV contrast	Usually Not Appropriate	O
MRI spine area of interest without and with IV contrast	Usually Not Appropriate	O
CT myelography spine area of interest	Usually Not Appropriate	Varies
CTA spine area of interest with IV contrast	Usually Not Appropriate	Varies

Variant: 6   Age 16 years or older. Acute thoracic or lumbar spine blunt trauma in a high-risk or unexaminable patient. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
CT spine area of interest without IV contrast	Usually Appropriate	Varies
Radiography spine area of interest	Usually Not Appropriate	Varies
MRI spine area of interest with IV contrast	Usually Not Appropriate	O
MRI spine area of interest without and with IV contrast	Usually Not Appropriate	O
MRI spine area of interest without IV contrast	Usually Not Appropriate	O
CT myelography spine area of interest	Usually Not Appropriate	Varies

Procedure	Appropriateness Category	Relative Radiation Level
CT spine area of interest with IV contrast	Usually Not Appropriate	Varies
CT spine area of interest without and with IV contrast	Usually Not Appropriate	Varies

Variant: 7   Age 16 years or older. Acute cervical spine blunt trauma. Obtunded. No trauma identified on cervical spine CT without IV contrast. Next imaging study.

Procedure	Appropriateness Category	Relative Radiation Level
MRI cervical spine without IV contrast	May Be Appropriate (Disagreement)	O
Arteriography cervicocerebral	Usually Not Appropriate	☢☢☢
MRA neck with IV contrast	Usually Not Appropriate	O
MRA neck without and with IV contrast	Usually Not Appropriate	O
MRA neck without IV contrast	Usually Not Appropriate	O
MRI cervical spine with IV contrast	Usually Not Appropriate	O
MRI cervical spine without and with IV contrast	Usually Not Appropriate	O
CTA head and neck with IV contrast	Usually Not Appropriate	☢☢☢
CT myelography cervical spine	Usually Not Appropriate	☢☢☢☢

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Summary of Literature Review

Introduction/Background

Injury to the spinal column has been widely reported in patients with blunt trauma. There is a variation in epidemiological data with motor vehicle-related accidents and falls accounting for most of the spinal injuries with a higher incidence in obtunded and intoxicated men [1,2]. The wide spectrum of injury patterns can make the decision for when to image and what type of imaging to perform challenging. Because of its wide availability, fast volumetric acquisition, and accuracy, multidetector CT is generally the first-line imaging modality, with consideration for MRI in specific scenarios. However, inappropriate imaging and overuse can lead to iatrogenic injuries related to prolonged cervical collar placement [3], increased economic burden, and prolonged emergency center visits while awaiting imaging. On the other hand, failure to identify an unstable cervical spine or vascular injury can have devastating consequences.

In response to this quandary, multiple criteria have been developed to determine if a patient with blunt trauma may benefit from cervical spine imaging. The 2 commonly used screening criteria in North America are the National Emergency X-Radiography Utilization Study (NEXUS) and the Canadian C-Spine Rule (CCR). The NEXUS low-risk criteria and CCR, despite their lack of specificity, are widely employed due to their high-sensitivity for cervical injuries. The application of these criteria can substantially reduce imaging overuse [4,5]and also capture clinically significant injuries.

The NEXUS low-risk criteria (Appendix 1) were prospectively validated in a large, multicenter, observational study [4] evaluating 34,069 patients with blunt trauma who underwent imaging of the cervical spine. Of these patients, 818 (2.4%) had sustained a cervical spinal column injury. Sensitivity, specificity, and negative predictive value (NPV) of the NEXUS low-risk criteria for a clinically significant injury were 99.6% (95% confidence interval [CI], 98.6%-100%), 12.9 % (95% CI, 12.8%-13.0%), and 99.9 % (95% CI, 99.8%-100%), respectively. Insignificant injuries were defined as those that would not lead to any consequences if left undiagnosed. Patients >60 years of age were excluded from the study population. Further investigations on the sensitivity of the NEXUS criteria for identifying cervical spine injuries in those >65 years of age yielded a lower sensitivity of 66% to 89% [6,7]. The addition of injury to the face or head and deviations from baseline mental status has improved the sensitivity and NPV of the NEXUS criteria to 100% in patients >65 years of age [8]. A prospective Western Trauma Association multi-institutional trial found a 98.5% sensitivity and 99.97% NPV for the NEXUS criteria using CT [9]. Additionally, a separate prospective study showed that implementing the NEXUS criteria to determine the appropriateness of CT scans would lead to a reduction in the number of CTs performed in the emergency department [10].

The CCR attempted to address the low specificity of the NEXUS criteria that might increase the use of cervical spine imaging [5]. CCR relies on complex algorithms, using a set of high- and low-risk criteria to guide cervical spine imaging (Appendix 2 and 3). If the low-risk criterion is met, the patient is asked to actively rotate the head from left to right. If the patient can move the head 45° past midline in both directions, regardless of pain, imaging is not needed. Finally, if the patient is unable to move the neck by 45°, the cervical spine is imaged. In the derivation study, the CCR demonstrated a sensitivity of 100% and a specificity of 42.5% for identifying clinically important cervical spine injuries [5]. The sensitivity, specificity, and NPVs of the CCR for clinically significant injuries were 99.4% (95% CI, 96%-100%), 45.1% (95% CI, 44%-46%), and 100%, respectively. A prospective assessment of the CCR criteria found 100% sensitivity and NPV for clinically significant cervical spine injury using CT as the reference standard [11].

Thoracolumbar spine fractures have a reported prevalence of 4% to 7% in trauma patients [1,12,13]. These are more frequently observed in high-energy mechanism trauma but can also occur with low-energy mechanisms. Clinical examination has a low sensitivity in identifying thoracolumbar spine injuries [14-16]. In a large prospective study, over 20% of patients with blunt thoracolumbar spine requiring surgical management or fixed immobilization had no significant findings on physical examination [17]. Therefore, a low threshold should be maintained for screening the thoracolumbar spine with imaging, particularly in patients who are at increased risk for low-energy spine fractures such as the elderly, patients with osseous demineralization, and patients with diseases that result in spine rigidity such as ankylosing spondylitis or diffuse idiopathic skeletal hyperostosis [18-21]. Thoracolumbar spine screening in multitrauma patients is best done using reformatted images acquired when scanning the chest, abdomen, and pelvis rather than re-scanning [21]. If CT is not indicated to evaluate visceral injuries, based on available evidence, it is advisable to perform imaging in certain situations (Appendix 4) [12,18-22]. The presence of a single vertebral fracture mandates assessment of the entire spine, due to the potential risk of a second, noncontiguous fracture, especially in high-energy blunt trauma and with cervical fractures where these occur in up to 20% of cases [1,23].

This document provides imaging recommendations in patients with acute spinal trauma. It draws upon available evidence and addresses a variety of clinical presentations. The narrative variants are

explored to elucidate the evidence supporting best practices. It is important to acknowledge overlap of symptoms and examination findings. In the setting of spinal cord or nerve root injury, evaluation of those findings should be addressed separately by the ACR Appropriateness Criteria[®] topic on "[Myelopathy]" [24] or the ACR Appropriateness Criteria[®] topic on "[Plexopathy]" [25], respectively. This criterion is for patients ≥16 years of age. For children with suspected spine trauma, see the ACR Appropriateness Criteria[®] topic on [Suspected Spine Trauma-Child]" [26].

Initial Imaging Definition

Initial imaging is defined as imaging at the beginning of the care episode for the medical condition defined by the variant. More than one procedure can be considered usually appropriate in the initial imaging evaluation when:

- There are procedures that are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care)

OR

- There are complementary procedures (ie, more than one procedure is ordered as a set or simultaneously wherein each procedure provides unique clinical information to effectively manage the patient's care).

Discussion of Procedures by Variant

Variant 1: Age greater than or equal to 16 years and less than 65 years. Acute cervical spine blunt trauma; imaging not indicated by CCR or NEXUS clinical criteria. Low-risk criteria. Initial imaging.

Both the NEXUS and CCR criteria are widely employed for clinical screening of cervical spine injuries, and it is generally accepted that patients who do not meet either the NEXUS or CCR criteria do not require imaging evaluation for cervical spine injury [4,5].

Variant 1: Age greater than or equal to 16 years and less than 65 years. Acute cervical spine blunt trauma; imaging not indicated by CCR or NEXUS clinical criteria. Low-risk criteria. Initial imaging.
A. Arteriography cervicocerebral

There is no relevant literature to support the use of cervicocerebral arteriography in the evaluation of acute cervical blunt spine trauma in cases meeting low-risk criteria.

Variant 1: Age greater than or equal to 16 years and less than 65 years. Acute cervical spine blunt trauma; imaging not indicated by CCR or NEXUS clinical criteria. Low-risk criteria. Initial imaging.
B. CT cervical spine with IV contrast

There is no relevant literature to support the use of CT cervical spine with intravenous (IV) contrast in the evaluation of acute cervical blunt spine trauma in cases meeting low-risk criteria.

Variant 1: Age greater than or equal to 16 years and less than 65 years. Acute cervical spine blunt trauma; imaging not indicated by CCR or NEXUS clinical criteria. Low-risk criteria. Initial imaging.
C. CT cervical spine without and with IV contrast

There is no relevant literature to support the use of CT cervical spine without and with IV contrast in the evaluation of acute cervical blunt spine trauma in cases meeting low-risk criteria.

Variant 1: Age greater than or equal to 16 years and less than 65 years. Acute cervical spine blunt trauma; imaging not indicated by CCR or NEXUS clinical criteria. Low-risk criteria. Initial imaging.
D. CT cervical spine without IV contrast

Patients who meet the NEXUS or CCR clinical criteria are unlikely to benefit from imaging [4,5].

Variant 1: Age greater than or equal to 16 years and less than 65 years. Acute cervical spine blunt trauma; imaging not indicated by CCR or NEXUS clinical criteria. Low-risk criteria. Initial imaging.
E. CT myelography cervical spine

There is no relevant literature to support the use of CT myelography of the cervical spine in the evaluation of acute cervical blunt spine trauma in cases meeting low-risk criteria.

Variant 1: Age greater than or equal to 16 years and less than 65 years. Acute cervical spine blunt trauma; imaging not indicated by CCR or NEXUS clinical criteria. Low-risk criteria. Initial imaging.
F. CTA head and neck with IV contrast

There is no relevant literature to support the use of CT angiography (CTA) head and neck with IV contrast in the evaluation of acute cervical blunt spine trauma in cases meeting low-risk criteria.

Variant 1: Age greater than or equal to 16 years and less than 65 years. Acute cervical spine blunt trauma; imaging not indicated by CCR or NEXUS clinical criteria. Low-risk criteria. Initial imaging.
G. MRA neck with IV contrast

There is no relevant literature to support the use of MR angiography (MRA) neck with IV contrast in the evaluation of acute cervical blunt spine trauma in cases meeting low-risk criteria.

Variant 1: Age greater than or equal to 16 years and less than 65 years. Acute cervical spine blunt trauma; imaging not indicated by CCR or NEXUS clinical criteria. Low-risk criteria. Initial imaging.
H. MRA neck without and with IV contrast

There is no relevant literature to support the use of MRA neck without and with IV contrast in the evaluation of acute cervical blunt spine trauma in cases meeting low-risk criteria.

Variant 1: Age greater than or equal to 16 years and less than 65 years. Acute cervical spine blunt trauma; imaging not indicated by CCR or NEXUS clinical criteria. Low-risk criteria. Initial imaging.
I. MRA neck without IV contrast

There is no relevant literature to support the use of MRA neck without IV contrast in the evaluation of acute cervical blunt spine trauma in cases meeting low-risk criteria.

Variant 1: Age greater than or equal to 16 years and less than 65 years. Acute cervical spine blunt trauma; imaging not indicated by CCR or NEXUS clinical criteria. Low-risk criteria. Initial imaging.
J. MRI cervical spine with IV contrast

There is no relevant literature to support the use of MRI cervical spine with IV contrast in the

evaluation of acute cervical blunt spine trauma in cases meeting low-risk criteria.

Variant 1: Age greater than or equal to 16 years and less than 65 years. Acute cervical spine blunt trauma; imaging not indicated by CCR or NEXUS clinical criteria. Low-risk criteria. Initial imaging.
K. MRI cervical spine without and with IV contrast

There is no relevant literature to support the use of MRI cervical spine without and with IV contrast in the evaluation of acute cervical blunt spine trauma in cases meeting low-risk criteria.

Variant 1: Age greater than or equal to 16 years and less than 65 years. Acute cervical spine blunt trauma; imaging not indicated by CCR or NEXUS clinical criteria. Low-risk criteria. Initial imaging.
L. MRI cervical spine without IV contrast

There is no relevant literature to support the use of MRI cervical spine without IV contrast in the evaluation of acute cervical blunt spine trauma in cases meeting low-risk criteria.

Variant 1: Age greater than or equal to 16 years and less than 65 years. Acute cervical spine blunt trauma; imaging not indicated by CCR or NEXUS clinical criteria. Low-risk criteria. Initial imaging.
M. Radiography cervical spine

Patients who meet the low-risk criteria are unlikely to benefit from imaging [4,5].

Variant 2: Age 16 years or older. Acute cervical spine blunt trauma. Imaging indicated by CCR or NEXUS clinical criteria. Initial imaging.

The literature strongly supports using the NEXUS low-risk criteria and the CCR criteria as valuable tools for identifying patients who may or may not benefit from cervical spine imaging. Both NEXUS criteria and CCR have high sensitivity but low specificity for detection of significant cervical spine injury. The reported sensitivity for NEXUS ranges from 81.2% to 99.6%, though the specificity ranges from 12.9% to 45.8% [4,11]. The original study of CCR reported a sensitivity of 100%, which was confirmed in later studies [11,27]. However, the specificity of CCR has been reported to range from 0.6% to 42.5% [5,11,27,28], overlapping with that of the NEXUS criteria.

Variant 2: Age 16 years or older. Acute cervical spine blunt trauma. Imaging indicated by CCR or NEXUS clinical criteria. Initial imaging.
A. Arteriography cervicocerebral

There is no relevant literature to support the use of cervicocerebral arteriography in the initial evaluation of acute cervical blunt spine trauma.

Variant 2: Age 16 years or older. Acute cervical spine blunt trauma. Imaging indicated by CCR or NEXUS clinical criteria. Initial imaging.
B. CT cervical spine with IV contrast

There is no relevant literature to support the addition of IV contrast to CT imaging to aid in the detection of cervical spine injuries in the initial evaluation of acute cervical blunt spine trauma.

Variant 2: Age 16 years or older. Acute cervical spine blunt trauma. Imaging indicated by CCR or NEXUS clinical criteria. Initial imaging.
C. CT cervical spine without and with IV contrast

There is no relevant literature to support the use of CT cervical spine without and with IV contrast in the initial evaluation of acute cervical blunt spine trauma.

Variant 2: Age 16 years or older. Acute cervical spine blunt trauma. Imaging indicated by CCR or NEXUS clinical criteria. Initial imaging.
D. CT cervical spine without IV contrast

CT is considered the reference standard in identifying cervical spine fractures because of its superior diagnostic ability to detect fractures as well as its safety [29]. Volumetric acquisition with multidetector CT allows seamless high-quality multiplanar (sagittal and coronal) reformations. In addition, modern CT is now sufficiently fast to avoid most motion degradation. Numerous studies have reported that the sensitivity and specificity of multidetector CT (with multiplanar reformations) to be close to 100% in detecting clinically significant injuries [9,30,31]. In a comprehensive meta-analysis including 3,832 patients who were examined for suspected cervical spine trauma, the sensitivity of CT in identifying patients with injuries was 98% [32]. In patients who meet NEXUS or CCR criteria for imaging, CT outperforms radiography in identifying fractures across various risk stratifications and is sufficient to rule out clinically significant cervical spine injuries [29].

Variant 2: Age 16 years or older. Acute cervical spine blunt trauma. Imaging indicated by CCR or NEXUS clinical criteria. Initial imaging.
E. CT myelography cervical spine

There is no relevant literature to support the use of CT myelography of the cervical spine in the initial evaluation of acute cervical blunt spine trauma.

Variant 2: Age 16 years or older. Acute cervical spine blunt trauma. Imaging indicated by CCR or NEXUS clinical criteria. Initial imaging.
F. CTA head and neck with IV contrast

Multiple guidelines (the expanded Denver criteria among one of the most used) provide criteria for the use of CTA head and neck in trauma. A few studies report that the expanded Denver criteria have a false-negative rate of 16% to 17.5% for blunt cerebrovascular injury [33,34]. A retrospective study of other guidelines, including those of the Eastern Association for the Surgery of Trauma, the Western Trauma Association, and the Scandinavian Neurotrauma Committee, found similar false-negative rates [34,35]. However, based on these studies, if universal screening were implemented, only a very small number of scanned patients would have an actionable vascular injury missed by the expanded Denver criteria.

Variant 2: Age 16 years or older. Acute cervical spine blunt trauma. Imaging indicated by CCR or NEXUS clinical criteria. Initial imaging.
G. MRA neck with IV contrast

There is no relevant literature to support the use of MRA neck with IV contrast in the initial evaluation of acute cervical blunt spine trauma.

Variant 2: Age 16 years or older. Acute cervical spine blunt trauma. Imaging indicated by CCR or NEXUS clinical criteria. Initial imaging.
H. MRA neck without and with IV contrast

There is no relevant literature to support the use of MRA neck without and with IV contrast in the initial evaluation of acute cervical blunt spine trauma.

Variant 2: Age 16 years or older. Acute cervical spine blunt trauma. Imaging indicated by CCR or NEXUS clinical criteria. Initial imaging.
I. MRA neck without IV contrast

There is no relevant literature to support the use of MRA neck without IV contrast in the initial

evaluation of acute cervical blunt spine trauma.

Variant 2: Age 16 years or older. Acute cervical spine blunt trauma. Imaging indicated by CCR or NEXUS clinical criteria. Initial imaging.
J. MRI cervical spine with IV contrast

There is no relevant literature to support the use of MRI cervical spine with IV contrast in the initial evaluation of acute cervical blunt spine trauma.

Variant 2: Age 16 years or older. Acute cervical spine blunt trauma. Imaging indicated by CCR or NEXUS clinical criteria. Initial imaging.
K. MRI cervical spine without and with IV contrast

There is no relevant literature to support the use of MRI cervical spine without and with IV contrast in the initial evaluation of acute cervical blunt spine trauma.

Variant 2: Age 16 years or older. Acute cervical spine blunt trauma. Imaging indicated by CCR or NEXUS clinical criteria. Initial imaging.
L. MRI cervical spine without IV contrast

There is no relevant literature to support the use of MRI cervical spine without IV contrast in the initial evaluation of acute cervical blunt spine trauma.

Variant 2: Age 16 years or older. Acute cervical spine blunt trauma. Imaging indicated by CCR or NEXUS clinical criteria. Initial imaging.
M. Radiography cervical spine

Radiography has a low sensitivity of 36% for identifying cervical injuries [29]. CT has supplanted radiography for assessment of traumatic cervical spine injury and is significantly more sensitive than radiographs for identifying cervical spine fractures. A minimum of 3 views (anteroposterior, lateral, and open-mouth odontoid) of the cervical spine may also be obtained. Visualization of the cervicothoracic junction is essential on the lateral projection. An additional "swimmer's lateral view" can be obtained if the cervicothoracic junction is not visible on the conventional lateral view. Flexion-extension views do not add useful clinical information and rarely demonstrate cervical instability not identified on conventional cervical radiographs or CT [36-41].

Variant 3: Age 16 years or older. Acute cervical spine blunt trauma. No unstable injury demonstrated initially, but kept in collar for neck pain. No new neurologic symptoms. Follow-up imaging.

Some patients may experience persistent neck symptoms following blunt cervical trauma, even when initial cervical spine imaging is negative. These signs and symptoms include neck pain, point tenderness, stiffness, reduced range of motion, or even mild neurological findings. Collectively, these manifestations are known as whiplash-associated disorders (WAD), attributed to rapid acceleration-deceleration mechanism of neck injury. Various structures, such as the paraspinal muscles, facets, disks, and craniocervical ligaments, have been implicated as potential causes for symptoms alongside inflammatory and psychological factors [42-46].

Imaging has limited value in the evaluation of WAD as the diagnosis primarily relies on clinical factors [44,46-50]. Nonetheless, imaging may play a role in the assessment of delayed presentation of cervical spine instability not present or overlooked on baseline evaluation.

Variant 3: Age 16 years or older. Acute cervical spine blunt trauma. No unstable injury demonstrated initially, but kept in collar for neck pain. No new neurologic symptoms. Follow-up imaging.

A. Arteriography cervicocerebral

There is no relevant literature to support the use of cervicocerebral arteriography in the assessment of stable patients with neck pain and a cervical collar in place.

Variant 3: Age 16 years or older. Acute cervical spine blunt trauma. No unstable injury demonstrated initially, but kept in collar for neck pain. No new neurologic symptoms. Follow-up imaging.
B. CT cervical spine with IV contrast

There is no relevant literature to support the use of CT cervical spine with IV contrast in the assessment of stable patients with neck pain and a cervical collar in place.

Variant 3: Age 16 years or older. Acute cervical spine blunt trauma. No unstable injury demonstrated initially, but kept in collar for neck pain. No new neurologic symptoms. Follow-up imaging.
C. CT cervical spine without and with IV contrast

There is no relevant literature to support the use of CT cervical spine without and with IV contrast in the assessment of stable patients with neck pain and a cervical collar in place.

Variant 3: Age 16 years or older. Acute cervical spine blunt trauma. No unstable injury demonstrated initially, but kept in collar for neck pain. No new neurologic symptoms. Follow-up imaging.
D. CT cervical spine without IV contrast

CT is considered the reference standard for the identification of cervical spine fractures across various risk stratifications [29]. CT is superior to other imaging modalities in identifying vertebral fractures including stable and unstable osseous injuries and is more than 98% sensitive in detecting clinically significant injuries [9,30,31].

Variant 3: Age 16 years or older. Acute cervical spine blunt trauma. No unstable injury demonstrated initially, but kept in collar for neck pain. No new neurologic symptoms. Follow-up imaging.
E. CT myelography cervical spine

There is no relevant literature to support the use of CT myelography of the cervical spine with IV contrast in the assessment of stable patients with neck pain and a cervical collar in place.

Variant 3: Age 16 years or older. Acute cervical spine blunt trauma. No unstable injury demonstrated initially, but kept in collar for neck pain. No new neurologic symptoms. Follow-up imaging.
F. CTA head and neck with IV contrast

There is no relevant literature to support the use of CTA head and neck with IV contrast in the assessment of stable patients with neck pain and a cervical collar in place.

Variant 3: Age 16 years or older. Acute cervical spine blunt trauma. No unstable injury demonstrated initially, but kept in collar for neck pain. No new neurologic symptoms. Follow-up imaging.
G. MRA neck with IV contrast

There is no relevant literature to support the use of MRA neck with IV contrast in the assessment of stable patients with neck pain and a cervical collar in place.

Variant 3: Age 16 years or older. Acute cervical spine blunt trauma. No unstable injury demonstrated initially, but kept in collar for neck pain. No new neurologic symptoms.

Follow-up imaging.
H. MRA neck without and with IV contrast

There is no relevant literature to support the use of MRA neck without and with IV contrast in the assessment of stable patients with neck pain and a cervical collar in place.

Variant 3: Age 16 years or older. Acute cervical spine blunt trauma. No unstable injury demonstrated initially, but kept in collar for neck pain. No new neurologic symptoms. Follow-up imaging.
I. MRA neck without IV contrast

There is no relevant literature to support the use of MRA neck without and with IV contrast in the assessment of stable patients with neck pain and a cervical collar in place.

Variant 3: Age 16 years or older. Acute cervical spine blunt trauma. No unstable injury demonstrated initially, but kept in collar for neck pain. No new neurologic symptoms. Follow-up imaging.
J. MRI cervical spine with IV contrast

There is no relevant literature to support the use of MRI cervical spine with IV contrast in the assessment of stable patients with neck pain and a cervical collar in place.

Variant 3: Age 16 years or older. Acute cervical spine blunt trauma. No unstable injury demonstrated initially, but kept in collar for neck pain. No new neurologic symptoms. Follow-up imaging.
K. MRI cervical spine without and with IV contrast

There is no relevant literature to support the use of MRI cervical spine without and with IV contrast in the assessment of stable patients with neck pain and a cervical collar in place.

Variant 3: Age 16 years or older. Acute cervical spine blunt trauma. No unstable injury demonstrated initially, but kept in collar for neck pain. No new neurologic symptoms. Follow-up imaging.
L. MRI cervical spine without IV contrast

MRI is considered the reference standard for diagnosing traumatic soft tissue injuries in the neck, which could be culprits for ongoing neck discomfort. Trauma patients who undergo a negative cervical spine CT may have traumatic soft tissue findings on MRI in approximately 5% to 24% of cases [51-58]. Despite being the modality of choice in the assessment of ligaments, disk herniation, and bone bruising, MRI tends to overestimate the severity of ligament and other soft tissue injuries with specificity of 64% to 77% and reported false-positive rates ranging from 25% to 40% [59,60]. Moreover, soft tissue edema and signal alteration may linger after the patient has recovered, although subacute to chronic soft tissue injuries can become challenging to discern once edema subsides.

In the absence of clinical indications of neurological problems or unstable ligament injuries, MRI has a low probability in identifying soft tissue injuries that require surgical intervention not evident on CT [52,54,55,57,58,61-63]. The Western Trauma Association Multi-Institutional Trial demonstrated that CT scans are highly effective for ruling out clinically significant injuries, with a sensitivity rate of 98.5% [9]. In the absence of neurological symptoms, the combined use of CT scans and clinical examination often provides sufficient information to rule out clinically significant injuries and may obviate the need for MRI [9,64,65].

When MRI alters a change in the management, it frequently pertains to cervical cord injuries that would present with neurologic complaints or in the setting of cervical spine injury seen on CT [66].

Several investigators have attempted to identify MRI criteria that can aid in the diagnosis or prediction outcomes for WAD [47,48,67,68]. Only weak associations were found between WAD and MRI findings such as signal changes within the craniocervical ligaments, paraspinal muscle atrophy, muscle fat infiltration, and the progression of cervical degeneration [47,67]. Most studies have found no discernible differences in MRI findings between patients with WAD and patients without WAD [48,69], and there's generally no correlation between MRI findings and WAD symptoms or progression [68,69].

Variant 3: Age 16 years or older. Acute cervical spine blunt trauma. No unstable injury demonstrated initially, but kept in collar for neck pain. No new neurologic symptoms. Follow-up imaging.

M. Radiography cervical spine

Flexion-extension radiographs are often insufficient for ruling out ligament injuries in acute cases due to limited motion and inadequate visualization of the lower cervical spine [38,41]. It is common for patients to have limited cervical mobility due to muscle spasms following trauma, though cervical spine instability may only become evident near the endpoints of flexion or extension. WAD has been associated with factors such as the progression of degenerative changes, increased mobility of the upper and mid cervical spine, and decreased cervical mobility [70]. However, no radiographic findings that definitively distinguish WAD from nontraumatic neck pain have been reported [68].

Although flexion-extension radiographs have been shown to detect fewer cervical ligamentous injuries compared to MRI [38], they can supplement MRI and may be useful in further assessing patients with ongoing neck pain despite negative MRI results.

Variant 4: Age 16 years or older. Acute cervical spine blunt trauma. Suspected arterial injury with or without positive cervical spine CT. Next imaging study.

Blunt cerebrovascular injuries (BCVIs) are infrequent, accounting for <5% of trauma patients [33,71,72]. BCVIs encompass a wide range of vascular injury patterns, some of which can have devastating consequences if undiagnosed and not treated promptly [73-78]. BCVIs carry a significant risk, with approximately 56% leading to severe neurological morbidity and a mortality rate of around 30% among initial survivors [75,79,80].

Diagnosis can be challenging, because up to two-thirds of patients with BCVIs may be asymptomatic at the time of presentation [73]. Moreover, many patients remain asymptomatic with a latency period of several hours to a few days after the initial traumatic injury [75,77,81,82]. Therefore, accurate screening for BCVIs is crucial for timely management and improved outcomes [81-83].

Spine fractures are the most significant predictive factor for BCVI, with the highest risk typically associated with injuries to the vertebral artery. The top-risk cervical spine injury is subluxation, followed by fractures that involve the transverse foramen and the upper cervical spine [84-86]. Although there is no universally accepted set of criteria for guiding the imaging evaluation of BCVIs, the revised Denver criteria remain a practical option, with cerebrovascular imaging recommended for any patient displaying signs or symptoms of BCVI or having one of the

recognized risk factors ([Appendix 5](#)) [77]. The revised Denver criteria have demonstrated high sensitivity and excellent NPV, leading to the identification of BCVIs in many asymptomatic blunt trauma patients, and reliably ruling out injury without requiring imaging in other patients, surpassing previous screening criteria [77].

Variant 4: Age 16 years or older. Acute cervical spine blunt trauma. Suspected arterial injury with or without positive cervical spine CT. Next imaging study.
A. Arteriography cervicocerebral

Digital subtraction angiography (DSA), known for its high spatial and temporal resolution, has traditionally been considered the reference standard for diagnosing and treating BCVIs. However, it has been replaced by CTA in recent years for screening purposes [87]. The role of DSA in BCVI evaluation has now shifted towards the assessment of injuries in select patients with hemodynamic instability requiring emergent intervention. DSA also plays a role in identifying and characterizing cervical arterial injuries that may be missed on the screening examination, assessment of collaterals, low-flow velocity lesions, and in treatment planning [88,89].

It is important to note that the effectiveness of DSA can be hindered by variable rates of contrast injection into the vessels of interest, and potential limitation of 2-D projections in capturing vessel wall injuries [74,76,78,89,90].

Additionally, DSA carries a 1% to 2% risk of complications, including iatrogenic arterial dissection and stroke [90].

Variant 4: Age 16 years or older. Acute cervical spine blunt trauma. Suspected arterial injury with or without positive cervical spine CT. Next imaging study.
B. CTA head and neck with IV contrast

Multidetector CTA has gained widespread acceptance as the preferred imaging modality for evaluating BCVIs because of its rapid acquisition, high resolution, wide availability, and low complication rate. With its high sensitivity, a normal CTA can accurately exclude significant arterial injuries [83,91-93].

Paulus et al [87] advocated that 64-channel CTA should replace DSA as the primary BCVI screening method, citing CTAs per-vessel sensitivity of 68% and specificity of 92%. In a recent meta-analysis, CTA demonstrated a pooled sensitivity of 64% (95% CI, 53%-74%) and specificity of 95% (95% CI, 87%-99%), with a risk for underdiagnoses of BCVIs [94]. It is important to note that most of the missed injuries on CTA are low-grade [87,95], with little to no clinical significance at a 10-year follow-up [96].

Some studies have suggested universal CTA screening [33,34], but it is crucial to use the established screening criteria for CTA in conjunction with multidisciplinary institutional protocols to avoid overutilization. A notable concern is the relatively high false-positive rate [87,88,97-99], which can lead to unnecessary anticoagulation, antiplatelet medications, or additional imaging studies, carrying potential risks [83].

Variant 4: Age 16 years or older. Acute cervical spine blunt trauma. Suspected arterial injury with or without positive cervical spine CT. Next imaging study.
C. MRA neck with IV contrast

There is no relevant literature to support the use of MRA neck with IV contrast in the assessment of

suspected arterial injury.

Variant 4: Age 16 years or older. Acute cervical spine blunt trauma. Suspected arterial injury with or without positive cervical spine CT. Next imaging study.
D. MRA neck without and with IV contrast

MRA is valuable in assessing arterial injuries in patients who have a high risk of iodinated-contrast allergies with no benefit shown to its sensitivity or specificity with the addition of postcontrast sequences. If MRA is to be performed, the evidence supports a noncontrast examination only [100].

Variant 4: Age 16 years or older. Acute cervical spine blunt trauma. Suspected arterial injury with or without positive cervical spine CT. Next imaging study.
E. MRA neck without IV contrast

MRA can detect most clinically significant cervical arterial injuries [93] and is especially valuable in assessing arterial injuries in patients who have a high risk of iodinated-contrast allergies.

A systematic review and meta-analysis yielded a pooled sensitivity of 55% (95% CI, 32.1%-76.7%) and a specificity of 91% (95% CI, 66.3%-98.2%) for MRA when assessing patients with blunt vertebral artery injuries. Studies comparing 2-D and 3-D time-of-flight MRA with DSA for BCVI screening have reported sensitivities ranging from 50% to 75% and specificities from 67% to 100% for carotid, and 47% to 97% for vertebral artery injuries respectively [101,102].

In a direct comparison between MRA and CTA, CTA was favored for identifying blunt cervical arterial injuries [103]. However, because of its superior soft tissue contrast, MRA optimized with additional sequences (specifically T1-weighted fat saturation) may outperform CTA or conventional arteriography in identifying intramural hematoma [103].

Variant 5: Age 16 years or older. Acute cervical, thoracic or lumbar spine blunt trauma. Suspected or confirmed ligamentous, spinal cord or nerve root injury, with or without trauma identified on CT. Next imaging study.

High-quality multidetector CT is the preferred modality in the initial assessment of spinal injuries. CT has limitations in detecting important soft tissue pathologies, such as disk ligamentous injuries, traumatic cord contusions, epidural hematomas, and nerve root avulsions. These conditions can lead to devastating neurological deficits and may require surgical intervention [52,55,61,104]. Therefore, CT alone may not be sufficient for ruling out significant soft tissue abnormalities in patients who present with signs or symptoms of spinal cord or nerve root injuries. In patients without neurologic deficits, the evidence for performing imaging beyond CT is weak because most studies conducted on this topic are retrospective without randomization or controls.

The body regions covered in this clinical scenario are the cervical, thoracic, lumbar, or the complete spine. These body regions might be evaluated separately or in combination as guided by physical examination findings, patient history, and other available information.

Variant 5: Age 16 years or older. Acute cervical, thoracic or lumbar spine blunt trauma. Suspected or confirmed ligamentous, spinal cord or nerve root injury, with or without trauma identified on CT. Next imaging study.
A. Arteriography spine area of interest

There is no relevant literature to support the use of spine arteriography in the evaluation of

suspected or confirmed ligamentous, spinal cord, or nerve root injury, with or without trauma identified on CT.

Variant 5: Age 16 years or older. Acute cervical, thoracic or lumbar spine blunt trauma. Suspected or confirmed ligamentous, spinal cord or nerve root injury, with or without trauma identified on CT. Next imaging study.
B. CT myelography spine area of interest

CT myelography can be performed to assess for traumatic spinal canal narrowing due to disc herniation, extradural hematoma, or to assess for preganglionic nerve root avulsions. However, CT myelography is inferior to MRI and is limited in assessing spinal cord contusion, cord hemorrhage, and postganglionic nerve root injuries [52,61,104]. Performance of a CT myelogram can be technically challenging and is not recommended in suspected unstable spine injury.

Variant 5: Age 16 years or older. Acute cervical, thoracic or lumbar spine blunt trauma. Suspected or confirmed ligamentous, spinal cord or nerve root injury, with or without trauma identified on CT. Next imaging study.
C. CTA spine area of interest with IV contrast

There is no relevant literature to support the use of CTA spine with IV contrast in the evaluation of suspected or confirmed ligamentous, spinal cord, or nerve root injury, with or without trauma identified on CT.

Variant 5: Age 16 years or older. Acute cervical, thoracic or lumbar spine blunt trauma. Suspected or confirmed ligamentous, spinal cord or nerve root injury, with or without trauma identified on CT. Next imaging study.
D. MRA spine area of interest with IV contrast

There is no relevant literature to support the use of MRA spine area of interest with IV contrast in the evaluation of suspected or confirmed ligamentous, spinal cord, or nerve root injury, with or without trauma identified on CT.

Variant 5: Age 16 years or older. Acute cervical, thoracic or lumbar spine blunt trauma. Suspected or confirmed ligamentous, spinal cord or nerve root injury, with or without trauma identified on CT. Next imaging study.
E. MRA spine area of interest without and with IV contrast

There is no relevant literature to support the use of MRA spine area of interest without and with IV contrast in the evaluation of suspected or confirmed ligamentous, spinal cord, or nerve root injury, with or without trauma identified on CT.

Variant 5: Age 16 years or older. Acute cervical, thoracic or lumbar spine blunt trauma. Suspected or confirmed ligamentous, spinal cord or nerve root injury, with or without trauma identified on CT. Next imaging study.
F. MRA spine area of interest without IV contrast

There is no relevant literature to support the use of MRA spine area of interest without IV contrast in the evaluation of suspected or confirmed ligamentous, spinal cord, or nerve root injury, with or without trauma identified on CT.

Variant 5: Age 16 years or older. Acute cervical, thoracic or lumbar spine blunt trauma. Suspected or confirmed ligamentous, spinal cord or nerve root injury, with or without trauma identified on CT. Next imaging study.
G. MRI spine area of interest with IV contrast

There is no relevant literature to support the use of MRA spine area of interest with IV contrast in the evaluation of suspected or confirmed ligamentous, spinal cord, or nerve root injury, with or without trauma identified on CT.

Variant 5: Age 16 years or older. Acute cervical, thoracic or lumbar spine blunt trauma. Suspected or confirmed ligamentous, spinal cord or nerve root injury, with or without trauma identified on CT. Next imaging study.
H. MRI spine area of interest without and with IV contrast

There is no relevant literature to support the use of MRI spine area of interest without and with IV contrast in the evaluation of suspected or confirmed ligamentous, spinal cord, or nerve root injury, with or without trauma identified on CT.

Variant 5: Age 16 years or older. Acute cervical, thoracic or lumbar spine blunt trauma. Suspected or confirmed ligamentous, spinal cord or nerve root injury, with or without trauma identified on CT. Next imaging study.
I. MRI spine area of interest without IV contrast

MRI can be beneficial in uncovering the cause of unexplained neurologic deficits in patients with normal CT; but the value of MRI for detecting soft tissue pathology in neurologically intact patients is low [9,12,21,36,56,61,105-120].

MRI is the crucial diagnostic tool in the assessment of patients with suspected spinal cord injury, characterizing the cause and extent of spinal cord injuries from traumatic disk herniations, hematoma, or retropulsion fracture fragments [36,61,66,107,121-127]. Important findings such as intramedullary hemorrhage, edema length, cord compression severity, and cord transection, assessed through MRI, can aid in predicting neurological outcomes [128]. MRI excels in displaying cord compression caused by disk herniation, bone fragments, and hematomas, making it a valuable resource for guiding surgical interventions [55,61]. If patients have symptoms or signs suggestive of spinal cord, conus medullaris, or nerve root injury, further assessment with MRI may be indicated. In the subacute and chronic stages, MRI remains indispensable in delineating the extent of cord injury. This is particularly valuable for patients experiencing late deterioration, because it may reveal treatable causes such as the development or enlargement of intramedullary cavities [129].

However, it's essential to recognize that the false-positive rate of cervical spine MRI in various studies has been estimated to range from 25% to 40% [59,108,114,130]. This consideration raises caution on labeling MRI as a reference standard because it tends to overestimate its benefits. Overtreating neurologically intact patients based on otherwise clinically insignificant MRI findings can have negative consequences. Prolonged use of cervical collars or spine immobilization, whether awaiting MRI testing or because of MRI results, can lead to poor outcomes and increased health care expenditures, with limited overall benefit. This emphasizes the importance of judicious and appropriate usefulness of MRI in these cases.

Variant 6: Age 16 years or older. Acute thoracic or lumbar spine blunt trauma in a high-risk or unexaminable patient. Initial imaging.

Imaging plays a crucial role in the assessment of thoracolumbar spine injuries. However, unlike cervical injuries, specific clinical criteria for determining when thoracolumbar imaging is warranted have not been established.

High-risk patients include those with midline thoracolumbar tenderness, high-energy injury mechanisms, or >60 years of age with complaints or a mechanism consistent with thoracolumbar spine injury. Patients may not be adequately examined if intoxicated, altered (Glasgow coma scale [GCS] <15), or with distracting injuries. Consideration to screening the entire spine should be made because about 20% of spine injuries may involve a second injury at a noncontiguous level [23,131].

Because of the poor sensitivity of clinical examinations in identifying thoracolumbar injuries, it is advisable to perform imaging in unexaminable trauma patients who are at higher risk for thoracolumbar injury and may need imaging depending on their level of alertness, examination findings, and clinical suspicion.

The body regions covered in this clinical scenario are the thoracic or lumbar. These body regions might be evaluated separately or in combination as guided by physical examination findings, patient history, and other available information.

Variant 6: Age 16 years or older. Acute thoracic or lumbar spine blunt trauma in a high-risk or unexaminable patient. Initial imaging.
A. CT myelography spine area of interest

There is no relevant literature to support the use of CT myelography in the initial assessment of thoracolumbar spine injury.

Variant 6: Age 16 years or older. Acute thoracic or lumbar spine blunt trauma in a high-risk or unexaminable patient. Initial imaging.
B. CT spine area of interest with IV contrast

There is no relevant literature to support the use of CT spine area of interest with IV contrast in the initial assessment of thoracolumbar spine injury.

Variant 6: Age 16 years or older. Acute thoracic or lumbar spine blunt trauma in a high-risk or unexaminable patient. Initial imaging.
C. CT spine area of interest without and with IV contrast

There is no relevant literature to support the use of CT spine area of interest without and with IV contrast in the initial assessment of thoracolumbar spine injury.

Variant 6: Age 16 years or older. Acute thoracic or lumbar spine blunt trauma in a high-risk or unexaminable patient. Initial imaging.
D. CT spine area of interest without IV contrast

CT of the thoracolumbar spine without IV contrast is generally considered the reference standard for detecting thoracolumbar fractures with a sensitivity of 94% to 100% [21,132-134]. Reconstructed images obtained from body imaging are usually adequate in the detection of thoracolumbar fractures [134,135].

Variant 6: Age 16 years or older. Acute thoracic or lumbar spine blunt trauma in a high-risk or unexaminable patient. Initial imaging.
E. MRI spine area of interest with IV contrast

There is no relevant literature to support the use of MRI spine area of interest with IV contrast in the initial assessment of thoracolumbar spine injury.

Variant 6: Age 16 years or older. Acute thoracic or lumbar spine blunt trauma in a high-risk or unexaminable patient. Initial imaging.
F. MRI spine area of interest without and with IV contrast

There is no relevant literature to support the use of MRI spine area of interest without and with IV contrast in the initial assessment of thoracolumbar spine injury.

Variant 6: Age 16 years or older. Acute thoracic or lumbar spine blunt trauma in a high-risk or unexaminable patient. Initial imaging.
G. MRI spine area of interest without IV contrast

Isolated unstable ligamentous injury in the absence of fractures is exceedingly rare in the thoracolumbar spine. Several studies have noted that clinically significant soft tissue findings detected solely on MRI in the absence of CT abnormalities or neurologic deficits are infrequent [18,56]. MRI can be considered in addition to CT to clear spine injury in an unevaluable or obtunded patient [108].

Variant 6: Age 16 years or older. Acute thoracic or lumbar spine blunt trauma in a high-risk or unexaminable patient. Initial imaging.
H. Radiography spine area of interest

Radiographs have a reported sensitivity of 49% to 62% for thoracic spine fractures and 67% to 82% sensitivity for lumbar spine fractures [133,135,136], compared with CT having a sensitivity of 94% to 100% for identifying thoracolumbar spine fractures [133,135,136]. However, the clinical significance of fractures missed on radiographs is uncertain. The screening radiographs of the thoracolumbar spine should include anteroposterior and lateral projections. If the upper thoracic region is obscured by overlying shoulders, an additional "swimmer's lateral" view is recommended.

Variant 7: Age 16 years or older. Acute cervical spine blunt trauma. Obtunded. No trauma identified on cervical spine CT without IV contrast. Next imaging study.

Imaging plays an important role in evaluating an obtunded patient who may not be able to provide a reliable medical history or undergo a proper physical examination. A multicenter prospective study assessing over 10,000 intoxicated trauma patients found that a high-quality negative CT scan is highly accurate with a 100% NPV, effectively ruling out unstable injuries that might pose a risk if spinal precautions are discontinued. It is safe to conclude that CT-based clearance of the cervical spine is reliable and avoids the associated risks of prolonged immobilization [137].

Variant 7: Age 16 years or older. Acute cervical spine blunt trauma. Obtunded. No trauma identified on cervical spine CT without IV contrast. Next imaging study.
A. Arteriography cervicocerebral

There is no role for cervicocerebral arteriography in assessment of an obtunded patient without traumatic injury identified on CT.

Variant 7: Age 16 years or older. Acute cervical spine blunt trauma. Obtunded. No trauma identified on cervical spine CT without IV contrast. Next imaging study.
B. CT myelography cervical spine

There is no role for CT myelography of the cervical spine in assessment of an obtunded patient without traumatic injury identified on CT.

Variant 7: Age 16 years or older. Acute cervical spine blunt trauma. Obtunded. No trauma identified on cervical spine CT without IV contrast. Next imaging study.
C. CTA head and neck with IV contrast

There is no role for CTA head and neck with contrast in assessment of an obtunded patient without traumatic injury identified on CT, however, if the patient displays the signs or symptoms of BCVI or

meets the risk factors by revised Denver criteria, screening with CTA can be obtained [77,78].

Variant 7: Age 16 years or older. Acute cervical spine blunt trauma. Obtunded. No trauma identified on cervical spine CT without IV contrast. Next imaging study.
D. MRA neck with IV contrast

There is no role for MRA neck with IV contrast in assessment of an obtunded patient without traumatic injury identified on CT.

Variant 7: Age 16 years or older. Acute cervical spine blunt trauma. Obtunded. No trauma identified on cervical spine CT without IV contrast. Next imaging study.
E. MRA neck without and with IV contrast

There is no role for MRA neck without and with IV contrast in assessment of obtunded patients without traumatic injury identified on CT.

Variant 7: Age 16 years or older. Acute cervical spine blunt trauma. Obtunded. No trauma identified on cervical spine CT without IV contrast. Next imaging study.
F. MRA neck without IV contrast

There is no role for MRA neck without IV contrast in assessment of obtunded patients without traumatic injury identified on CT.

Variant 7: Age 16 years or older. Acute cervical spine blunt trauma. Obtunded. No trauma identified on cervical spine CT without IV contrast. Next imaging study.
G. MRI cervical spine with IV contrast

There is no role for MRI cervical spine with IV contrast in assessment of obtunded patients without traumatic injury identified on CT.

Variant 7: Age 16 years or older. Acute cervical spine blunt trauma. Obtunded. No trauma identified on cervical spine CT without IV contrast. Next imaging study.
H. MRI cervical spine without and with IV contrast

There is no role for MRI cervical spine without and with IV contrast in assessment of obtunded patients without traumatic injury identified on CT.

Variant 7: Age 16 years or older. Acute cervical spine blunt trauma. Obtunded. No trauma identified on cervical spine CT without IV contrast. Next imaging study.
I. MRI cervical spine without IV contrast

Although it is important to acknowledge the superior capability of MRI in detecting and characterizing ligament and soft tissue injuries of the cervical spine [138-140], there is no additional benefit in obtaining a MRI following a normal CT scan [111,141-143].

A multispecialty systematic review and practice management guideline by the Eastern Association of Surgery of Trauma does not endorse follow-up MRI of the cervical spine in obtunded patients with a normal screening cervical spine CT scan.

It is important to underscore the low specificity of MRI with a false-positive rate of 20% to 40% in the detection of clinically significant disk ligamentous injury [108,113]. In an obtunded posttrauma patient, particularly in the intensive care unit, adding MRI to CT for cervical spine clearance prolongs the duration of rigid collar immobilization and mechanical ventilation while increasing the risks for associated morbidities [108].

Studies have shown that compared to CT followed by MRI, using CT alone can lead to shorter stays in the intensive care unit and reduced morbidity associated with rigid cervical collars and ventilation. Importantly, omitting an MRI from the workup in these patients did not result in missed unstable cervical spine injuries or differences in patient mortality [144].

In patients with persistent or localized signs and symptoms alongside a normal cervical spine CT, a follow-up MRI is recommended for further evaluation, given CT limitations in the assessment of certain soft tissues such as ligaments, intervertebral disks, epidural hematoma, and the spinal cord [51,55,123].

Summary of Highlights

This is a summary of the key recommendations from the variant tables. Refer to the complete narrative document for more information.

- **Variant 1**: Imaging is not recommended for patients ≥16 and <65 years of age with suspected acute blunt cervical spine trauma who meet low-risk criteria and do not meet NEXUS or CCR clinical criteria.
- **Variant 2**: CT cervical spine without IV contrast is the recommended initial imaging of patients ≥16 years of age with suspected acute blunt trauma of the cervical spine when NEXUS or CCR clinical criteria are met.
- **Variant 3**: CT cervical spine without IV contrast is usually appropriate in patients ≥16 years of age with acute blunt trauma of the cervical spine with no unstable injury initially but kept in a collar for neck pain and no new neurologic symptoms. In some situations, for example, if there are persistent neurologic symptoms, MRI of the cervical spine without IV contrast may be considered appropriate. In some situations, cervical spine radiography may also be indicated.
- **Variant 4**: CTA head and neck with IV contrast is usually considered appropriate as the next imaging study for patients ≥16 years of age with acute cervical blunt trauma with suspected arterial injury, regardless of cervical spine CT findings.
- **Variant 5**: In patients ≥16 years of age with acute cervical, thoracic, or lumbar blunt trauma, where there is suspected or confirmed ligamentous, cord, or nerve root injury, spine MRI (area of interest) without IV is the next appropriate imaging modality.
- **Variant 6**: CT (area of interest) spine without IV contrast is the recommended initial imaging in high-risk or unexaminable patients ≥16 years of age with suspected acute thoracic or lumbar blunt trauma.
- **Variant 7**: In an obtunded patient ≥16 years of age with acute cervical blunt trauma, in which no trauma is identified on initial CT, follow-up imaging may not be indicated. However, in certain situations, MRI cervical spine without contrast may be considered appropriate.

Supporting Documents

The evidence table, literature search, and appendix for this topic are available at https://acsearch.acr.org/list. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

For additional information on the Appropriateness Criteria methodology and other supporting documents, please go to the ACR website at https://www.acr.org/Clinical-Resources/Clinical-Tools-

Gender Equality and Inclusivity Clause

The ACR acknowledges the limitations in applying inclusive language when citing research studies that predates the use of the current understanding of language inclusive of diversity in sex, intersex, gender, and gender-diverse people. The data variables regarding sex and gender used in the cited literature will not be changed. However, this guideline will use the terminology and definitions as proposed by the National Institutes of Health.

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, because of both organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared with those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria[®] Radiation Dose Assessment Introduction document.

Relative Radiation Level Designations

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv

☢	<0.1 mSv	<0.03 mSv
☢ ☢	0.1-1 mSv	0.03-0.3 mSv
☢ ☢ ☢	1-10 mSv	0.3-3 mSv
☢ ☢ ☢ ☢	10-30 mSv	3-10 mSv
☢ ☢ ☢ ☢ ☢	30-100 mSv	10-30 mSv

*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."

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