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NEXUS Criteria for C-Spine Imaging

The NEXUS criteria for C-spine imaging clear patients from cervical spine fracture clinically, without imaging.

Points & Pearls

- The National Emergency X-Radiography Utilization Study (NEXUS) criteria were developed to help clinicians determine whether or not cervical spine imaging can be safely avoided in appropriate patients.
 - The validation study included a prospective, observational sample of 34,069 patients, aged 1 to 101 years, presenting to 21 trauma centers in the United States. Among the patients studied, 1.7% had clinically significant cervical spine injuries (CSIs). The NEXUS criteria were found to have sensitivity of 99.6% for ruling out CSIs.
 - The study also detected 99% of all CSIs—all but 8 of 818 patients, among whom 6 had injuries that didn't require stabilization or specialized treatment.
 - In the study, adoption of the criteria could have decreased imaging in patients with cervical spine injuries by 12.6%.
 - Subsequent studies have found a sensitivity of 83% to 100% for CSI, with the majority of studies finding 90% to 100% sensitivity.

Points to keep in mind:

- Unlike the Canadian C-spine rule (CCR), the NEXUS criteria do not have age cutoffs and are theoretically applicable to all patients aged > 1 year. However, some literature suggests the use of caution in applying NEXUS criteria to

patients aged > 65 years, as the sensitivity may be as low as 66% to 84%. In a large, retrospective trauma registry study of 231,018 patients, sensitivity was still only 94.8% (95% confidence interval, 92.1%-96.7%) (Paykin 2017).

- In the only trial to undertake a prospective head-to-head comparison of the NEXUS criteria and the CCR, the CCR was found to have superior sensitivity (99.4% vs 90.7%). However, the trial was performed by the creators of the CCR at hospitals that were involved in the initial CCR validation study (Stiell 2003). There were also post hoc "clarifications" added by the authors to the original NEXUS criteria, leading to some concerns about the generalizability of the study findings.
- There is also debate about whether x-rays of the cervical spine are sufficiently sensitive to rule out cervical spine injuries in trauma patients, and whether computed tomography (CT) is a more appropriate imaging modality in this patient population.

Critical Actions

The NEXUS criteria have been prospectively validated in the largest cohort of patients ever studied for this indication. If a patient is NEXUS criteria–negative, further imaging is likely unnecessary.

Because of concerns that the NEXUS criteria do not perform as well among patients aged > 65 years, clinicians may want to consider further imaging if there is concern about the mechanism or examination in elderly patients. Although more complicated to remember, the CCR appears to perform as well or better than NEXUS in terms of sensitivity for CSI. In cases where a patient is not ruled out by the NEXUS criteria, it may be appropriate to apply

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the CCR. If the patient is negative for the CCR, then further imaging is probably unnecessary; for example, patients with midline cervical spine tenderness would need imaging according to the NEXUS criteria, but potentially could be cleared by the CCR if they did not have any high-risk features and could range their necks 45 degrees to the left and right.

There is also concern that the NEXUS criteria were derived and validated in an era when plain films were much more commonly ordered to assess for cervical spine injuries. CT imaging of the cervical spine is now more common, and there is some evidence that CT may identify CSIs that would be missed by NEXUS and/or the CCR.

Evidence Appraisal

At 34,069, the number of patients enrolled in the original validation study for the NEXUS criteria was over 3.5 times greater than in the original CCR study. As applied, the rule missed 2 of the 578 patients with a clinically significant CSI, yielding a sensitivity of 99.6% (Hoffman 1998). Subsequent evaluations of the NEXUS criteria have found the sensitivity for CSI to be more variable (83%-100%), but there have been some concerns about the methodology (retrospective review) and the way the criteria were applied in several of these analyses. One trial evaluating the NEXUS criteria, in which all patients underwent CT imaging of their cervical spine, found a sensitivity of 83%, with the rule missing 2.5% (26 of 1057) of patients with fractures. Sixteen (1.5%) of these patients required prolonged time in a cervical collar, 2 (0.2%) underwent opera-

tive repair, and 1 (0.1%) had a halo placed. A retrospective analysis attempting to apply the NEXUS criteria to the validation cohort for the CCR found a sensitivity of 92.7%.

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Calculator Creator

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[Read more about Dr. Hoffman.](#)

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Why to Use

Annually, there are more than 1 million visits to emergency departments in the United States by blunt trauma patients who present with a concern for possible cervical spine injury. Many of these patients undergo imaging of their cervical spine, with the overwhelming majority of the studies coming back negative for a fracture (98%). This imaging is both largely unnecessary and extremely costly (> \$180,000,000 annually). Application of the NEXUS criteria allows physicians to safely reduce imaging by 12% to 36% in patients presenting with concern for possible cervical spine injury, avoiding unnecessary radiographic studies and saving significant cost.

When to Use

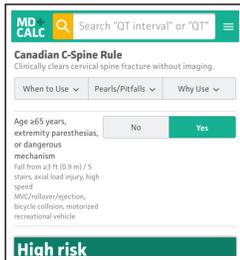
The NEXUS criteria represent a well-validated clinical decision aid that can be used to safely rule out cervical spine injury in alert, stable trauma patients, without the need to obtain radiographic images.

Next Steps

- The NEXUS criteria have been prospectively validated in the largest cohort of patients ever studied for this indication. If a patient is negative for NEXUS criteria, further imaging is likely unnecessary. If a patient has a clinically significant cervical spine injury identified on imaging:
 - » Cervical spine protection should be maintained with an appropriate collar.
 - » Neurosurgery should be consulted.
 - » The patient should be kept nonambulatory and oral intake of food and fluids should be withheld until a treatment plan is complete.
 - » Emergent operative stabilization and/or admission to the neurosurgical intensive care unit should be considered.

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Canadian C-Spine Rule

The Canadian C-spine rule clinically clears cervical spine fracture without imaging.

Points & Pearls

- The Canadian C-spine rule (CCR) was developed to help clinicians determine which trauma patients need cervical spine imaging.
- The CCR is highly sensitive for cervical spine injury, with most studies finding that it catches 99% to 100% of these types of injuries.
- Applying the CCR allows emergency clinicians to safely decrease the need for imaging among the trauma patient population by > 40%.
- Subsequent studies have found a sensitivity of 90% to 100% for cervical spine injury, with the majority finding 99% to 100% sensitivity.

Points to keep in mind:

- Some of the patients in the validation study did not undergo imaging if the treating clinician felt a patient was at very low risk of injury.
- The CCR is difficult to memorize due to its multiple criteria; using a smartphone app or digital reference is recommended.
- The CCR can be used in patients who are intoxicated if the patient is alert and cooperative, regardless of blood alcohol level.
- The quoted sensitivities are all for cervical spine injury. Some practice environments might be concerned with identifying any cervical spine injury, as the CCR is highly sensitive for clinically important cervical spine imaging.
- The lone trial with a sensitivity of 90% was a study in which nurses were trained to apply the

CCR; retrospective review by investigators in this study found the rule was misapplied in 4 cases with obvious high-risk features. The CCR has also been successfully evaluated in paramedics.

Exclusion criteria:

- Nontrauma patients
- Glasgow coma scale score < 15
- Unstable vital signs
- Age < 16 years
- Acute paralysis
- Known vertebral disease
- Previous cervical spine surgery

Critical Actions

If a patient has any high-risk factors (eg, aged > 65 years, a defined dangerous mechanism, or paresthesias in the arms or legs) then cervical spine imaging is required. Cervical spine imaging is required if a patient has no high-risk factors but meets none of the defined low-risk criteria (eg, sitting position in the emergency department, ambulatory at any time, delayed [not immediate onset] neck pain, no midline tenderness, simple rear-end motor vehicle collision [excludes pushed into traffic, hit by bus/large truck, rollover, or hit by high-speed vehicle]). If a patient has no high-risk factors and has neck pain, but meets even 1 low-risk factor, then it is safe to assess the patient's ability to rotate the neck 45 degrees to the left and right. If the patient can do this (even with some pain or discomfort), then no further imaging is required; if not, then cervical spine imaging is indicated.

Evidence Appraisal

In the derivation study, the authors looked at the primary endpoint of clinically significant cervi-

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cal spine injury. The validation study included a convenience sample of 8924 patients, aged 16 to 64 years, who presented to 10 Canadian trauma centers with stable vital signs and a Glasgow coma scale score of 15. Among the study population, 1.7% of patients had clinically significant cervical spine injury. The CCR was found to be 100% sensitive for ruling out cervical spine injury (defined as any fracture, dislocation, or ligamentous injury). Researchers also detected 96.4% (27 of 28) cervical spine injuries that were clinically insignificant (defined as injuries that do not require stabilization or specialized treatment and are unlikely to cause any long-term problems).

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Calculator Creator

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[Click here to read more about Dr. Stiell.](#)

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Why to Use

Annually, there are more than 1 million visits to emergency departments in the United States by blunt trauma patients who present with a concern for possible cervical spine injury. Many of these patients undergo imaging of their cervical spine, with the overwhelming majority of the studies coming back negative for a fracture (98%). Applying the CCR allows clinicians to safely decrease the need for imaging among this patient population by over 40%. While the CCR is more complex than other cervical spine clinical decision rules, it is a more sensitive rule and potentially can be used on patients who cannot be cleared using other rules.

When to Use

The CCR is a well-validated decision rule that can be used to safely rule out cervical spine injury in alert, stable trauma patients without the need to obtain radiographic images.

Next Steps

- The overwhelming majority of patients who are CCR negative do not warrant further imaging.
- In the case of inebriated but alert patients with a Glasgow coma scale score of 15, it is reasonable to leave patients in cervical collars until they are clinically sober; however, a 2015 systematic review calls this practice into question.
- The clinician should order appropriate imaging (x-ray vs CT) based on best clinical judgment.
- If a patient has a clinically significant cervical spine injury identified on imaging:
 - » Cervical spine protection should be maintained with an appropriate collar.
 - » Neurosurgery should be consulted.
 - » The patient should be kept nonambulatory and oral intake of food and fluids should be withheld until a treatment plan is complete.
 - » Emergent operative stabilization and/or admission to the neurosurgical intensive care unit should be considered.

Abbreviations: CCR, Canadian C-spine rule; CT, computed tomography.



Canadian CT Head Injury/Trauma Rule

The Canadian CT Head Rule was developed to help physicians determine which patients with minor head injury need head CT imaging.

Points & Pearls

- The original validation trial and multiple subsequent studies (Stiell 2001, Stiell 2005, Stiell 2010) each found the high-risk criteria of the Canadian computed tomography (CT) head rule (CCHR) to be 100% sensitive for injuries requiring neurosurgical intervention. The CCHR has an 87% to 100% sensitivity for detecting “clinically important” brain injuries that do not require neurosurgery.
- The CCHR studies excluded patients who were taking oral anticoagulants and antiplatelet agents, so no data are available for these patients.
- Patients with minimal head injury (ie, no history of loss of consciousness, amnesia, and confusion) generally do not need a CT scan. For example, patients aged > 65 years may not need a CT scan based only on age if they do not have the history mentioned above.
- When a patient fails the CCHR, clinical judgment should be used to determine if a CT scan is necessary.
- One study found the CCHR to be the most consistent, validated, and effective clinical decision rule for minor head injury patients (Harnan 2011).
- While there has been only 1 validation study from the United States for the CCHR, that study found the rule to be 100% sensitive for clinically important injuries and injuries requiring neurosurgery. A retrospective study in the United Kingdom found that applying the CCHR would have resulted in an increase in the number of patients undergoing CT scans in that particular practice setting. There is debate about whether the goal should be to find all intracranial injuries or to find patient-important ones that would require neurosurgical intervention.

Critical Actions

The CCHR has been validated in multiple settings and has been consistently demonstrated to be

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100% sensitive for detecting injuries that will require neurosurgery. Depending on practice environment, it may not be considered acceptable to miss any intracranial injuries, regardless of whether they would have required intervention.

Clinicians may want to consider applying the New Orleans criteria for head trauma, as at least 1 trial has found them to be more sensitive than the CCHR for detecting clinically significant intracranial injuries (99.4% vs 87.3%), although with markedly decreased specificity (5.6% vs 39.7%). There are other trials in which the CCHR was found to be more sensitive than the New Orleans criteria for detecting clinically important brain injuries.

Evidence Appraisal

The validation study (Stiell 2005) included a convenience sample of 2702 patients aged ≥ 16 years, who presented to 9 Canadian emergency departments with blunt head trauma resulting in witnessed loss of consciousness, disorientation, or definite amnesia and a Glasgow coma scale score of 13 to 15. Within the sample, 8.5% (231 of 2707) of the patients had a clinically important brain injury, and 1.5% (41 of 2707) of the patients had an injury that required neurosurgical intervention. In the validation trial, the CCHR was 100% sensitive for both clinically important brain injuries and injuries that required neurosurgical intervention, and was 76.3% and 50.6% specific, respectively, for these injuries.

Subsequent studies have all found the CCHR to be 100% sensitive for identifying injuries that require neurosurgical intervention. Applying the CCHR would allow clinicians to safely reduce head CT imaging by around 30% (range of 6%-40%, with most studies showing an estimated 30% reduction). In most studies, 7% to 10% of patients had positive CT scans for brain injuries that were considered “clinically important,” but typically, < 2% of patients required neurosurgical intervention. The high-risk criteria have consistently shown 100% sensitivity for ruling out the latter group.

Use the Calculator Now

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Calculator Creator

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Original/Primary Reference

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Why to Use

There are more than 8 million patients who present annually to emergency departments in the United States for evaluation of head trauma. The vast majority of these patients have minor head trauma that will not require specialized or neurosurgical treatment, but rates of CT imaging of the head more than doubled from 1995 to 2007. The CCHR is a well-validated clinical decision aid that allows clinicians to safely rule out the presence of intracranial injuries that would require neurosurgical intervention, without the need for CT imaging.

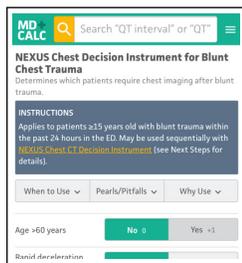
When to Use

- The CCHR should be applied only to patients with Glasgow coma scale scores of 13 to 15 with loss of consciousness, amnesia to the head injury event, and confusion.
- It should not be used in patients aged < 16 years, patients on blood thinners, or patients with seizure after injury.
- The CCHR has been found to be 70% sensitive for "clinically important" brain injury in alcohol-intoxicated patients (Easter 2013).

Next Steps

- Clinicians should always discuss postconcussive symptoms and management with patients, especially those patients who are being discharged without a head CT scan. Otherwise, a patient who feels postconcussive symptoms may worry that a CT scan was needed.
- Educating patients on the symptoms of injuries that require neurosurgical intervention versus postconcussion symptoms can help them feel empowered and reassured.

Abbreviations: CCHR, Canadian computed tomography head rule; CT, computed tomography.



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NEXUS Chest Decision Instrument for Blunt Chest Trauma

The NEXUS chest decision instrument for blunt chest trauma determines which patients require chest imaging after blunt trauma.

Points & Pearls

- The National Emergency X-Radiography Utilization Study (NEXUS) chest decision instrument can rapidly identify “very low-risk” patients with blunt thoracic trauma who would not benefit from chest imaging.
- The decision instrument was developed to address concern of radiation exposure from computed tomography (CT) of the chest, which is now common in the evaluation of trauma patients. It was developed at 3 Level 1 trauma centers in a study that included > 2600 patients.
- The NEXUS chest decision instrument uses 7 criteria to identify a low-risk cohort who have a < 2% chance of having any thoracic injury and a 1% chance of having clinically significant thoracic injuries.
- It was designed to not miss any injuries but is not very specific; just because a patient does not meet low-risk criteria does not mean the patient must be imaged.

Points to keep in mind:

- One isolated rib fracture was not included as a “thoracic injury.”
- Some clinicians may disagree with the study's definitions of clinical significance.
- Clavicular tenderness is not included as “chest wall tenderness.”
- *Distracting injury* is vaguely defined by design, with discretion given to the clinician: “any condition thought by the [clinician] to be producing sufficient pain to distract the patient from a second (intrathoracic) injury.” From the original study (Rodriguez 2011), this includes:
 - » Long bone fractures
 - » Visceral injuries requiring surgical consultation
 - » Large lacerations, degloving injuries, or crush injuries

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Why to Use

The NEXUS chest decision instrument can help reduce unnecessary imaging by identifying patients at low risk of thoracic injury. This reduces radiation exposure and provides faster evaluation for emergency clinicians and their patients. This allows emergency clinicians to focus on treatment, evaluation of other injuries or problems, or education and reassurance.

When to Use

The NEXUS chest decision instrument can be used in the following patient populations:

- Pregnant patients with minor trauma
- Patients who are of indeterminate risk
- Patients aged ≥ 15 years, because the risks associated with radiation exposure are greater for younger patients

Next Steps

- The NEXUS creators recommend using the NEXUS chest CT decision instrument for patients who have received a chest x-ray and for whom CT is being considered.
- Adequate pain control is always important in patients with trauma.
- Consider initial evaluation with chest x-ray in stable patients with isolated chest trauma.
- CT will obviously find many more injuries than x-ray, regardless of the true clinical significance of those injuries.
- CT may be more useful in patients with multiple injuries or who are sicker.

Abbreviation: CT, computed tomography.

- » Large burns
- » Any other injury producing acute functional impairment
- » Clinicians 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.
- Intoxication is also vaguely defined by design, to include:

- » A history of intoxication or recent intoxicating ingestion as reported by the patient or an observer
- » Test of bodily secretions positive for alcohol or drugs
- » Physical evidence suggesting intoxication (odor of alcohol, slurred speech, ataxia, dysmetria, or other cerebellar findings), or behavior consistent with intoxication and unexplained by medical or psychiatric illness

Evidence Appraisal

The NEXUS chest decision instrument was developed by the NEXUS study group, with the goal of reducing unnecessary chest imaging in blunt trauma patients.

Derivation

The researchers first developed the rule prospectively in a study of 2628 patients at 3 trauma centers, using 12 clinical criteria. They defined significant intrathoracic injury as: pneumothorax, hemothorax, aortic or other great vessel injury, 2 or more rib fractures, ruptured diaphragm, sternal fracture, and pulmonary contusion.

Validation

The original study was subsequently validated in a study of 9905 patients. Significant intrathoracic injury was reclassified more specifically, with an expert panel weighing diagnoses to group them as major clinical significance, minor clinical significance, or no clinical significance. (See the "Definitions" section.)

To address imaging bias, the researchers attempted to contact all patients who did not receive imaging or had negative imaging. Among the 433 patients who were contacted, none had been diagnosed with thoracic injury on follow-up. The rule was 99.7% sensitive for major thoracic injury, 99% sensitive for major and minor thoracic injury, and 98.8% sensitive for any thoracic injury.

Definitions

Major Clinical Significance

- Aortic or great vessel injury (all are considered major)
- Ruptured diaphragm (all are considered major)
- Pneumothorax, if the patient received an evacuation procedure (chest tube or other procedure)
- Hemothorax, if the patient received a drainage procedure (chest tube or other procedure)
- Sternal fracture, if the patient received surgical intervention
- Multiple rib fracture, if the patient received surgical intervention or an epidural nerve block
- Pulmonary contusion, if the patient received mechanical ventilatory assistance (including noninvasive ventilation) of any type for management

Minor Clinical Significance

- Pneumothorax with no evacuation procedure, but with inpatient observation for > 24 hours
- Hemothorax with no drainage procedure, but with inpatient observation for > 24 hours
- Sternal fracture with no surgical intervention, but with in-hospital pain management or observation for > 24 hours
- Sternal fracture with no surgical intervention and no inpatient observation, with pain managed on an outpatient basis
- Multiple rib fracture, if the patient received in-hospital pain management or inpatient observation for > 24 hours
- Multiple rib fracture, with no surgical intervention and no inpatient observation, with pain managed on an outpatient basis
- Pulmonary contusion or laceration, with no mechanical ventilatory assistance but with inpatient observation for > 24 hours

No Clinical Significance

- Hemothorax with no surgical intervention and no inpatient observation, managed on an outpatient basis
- Pneumothorax with no surgical intervention and no inpatient observation, managed on an outpatient basis
- Pneumomediastinum without pneumothorax, with no inpatient observation, managed on an outpatient basis
- Pulmonary contusion or laceration with no mechanical ventilatory assistance, no surgical intervention, and no inpatient observation, managed on an outpatient basis

Additional Instructions

The NEXUS chest decision instrument for blunt chest trauma applies to patients in the emergency department who are aged ≥ 15 years and have had blunt trauma within the past 24 hours. It may be used sequentially with the NEXUS chest CT decision instrument.

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Calculator Creator

Robert Rodriguez, MD
[Read more about Dr. Rodriguez.](#)

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Ottawa Ankle Rule

The Ottawa ankle rule shows the areas of tenderness to be evaluated in ankle trauma patients to determine the need for imaging.

Points & Pearls

- The Ottawa ankle rule was derived to aid in the efficient use of radiography in acute ankle and midfoot injuries.
- The rule has been prospectively validated on multiple occasions in different populations and in both children and adults.
- Sensitivities for the Ottawa ankle rule range from the high 90% to 100% range for “clinically significant” ankle and midfoot fractures. This is defined as a fracture or an avulsion > 3 mm.
- Specificities for the Ottawa ankle rule are approximately 41% for the ankle and 79% for the foot, although the rule is not designed or intended to make a specific diagnosis.
- The Ottawa ankle rule is useful in ruling out fracture (high sensitivity), but does poorly at ruling in fractures (many false positives).

Advice

Tips and precautions from the creators at the University of Ottawa:

- Palpate the entire distal 6 cm of the fibula and tibia.
- Do not overlook the importance of medial malleolar tenderness.
- “Bearing weight” counts even if the patient limps.
- Use with caution in patients aged < 18 years.
- Clinical judgment should prevail if the examination is unreliable due to:
 - » Intoxication
 - » Uncooperative patient
 - » Distracting painful injuries

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- » Diminished sensation in legs
- » Gross swelling that prevents palpation of malleolar tenderness
- Written instructions should always be provided.
- Patients should be encouraged to obtain follow-up care in 5 to 7 days if pain and ability to walk do not improve.

Critical Actions

Patients who fulfill none of the Ottawa ankle rule criteria do not need an ankle or foot x-ray. Patients who fulfill either the foot or ankle criteria need an x-ray of the respective body part. Many experts would consider this score “one directional.” Because the rule is sensitive and not specific, it provides a clear guide of which patients do not need x-ray if all criteria are met; however, if a patient fails the criteria, the need for x-ray can be left to clinical judgment.

Evidence Appraisal

The original derivation study in 1992 included non-pregnant patients aged > 18 years who presented to Ottawa civic and general hospitals with a new injury < 10 days old. The initial pilot study included 155 patients, while the full-scale study included 750 patients. Any fracture that was not an avulsion of ≤ 3 mm was considered a clinically significant fracture. This resulted in the initial criteria: aged ≥ 55 years, inability to bear weight immediately after the injury and for 4 steps in the emergency department, or bone tenderness at the posterior edge or tip of either malleolus for the ankle. For the foot, criteria included pain in the midfoot and bone tenderness at the navicular bone, cuboid, or the base of the fifth metatarsal (Stiell 1992).

Further validation and refinement was completed in 1993, through a prospective study of 1032 patients in the validation and refinement phase of the study with 121 clinically significant fractures. The rules were further refined by removing the age cutoff from the ankle rule and cuboid tenderness

from the foot rule, but the weight-bearing criterion was added to the foot rule. Sensitivity of the refined rules for both foot and ankle fractures was 100%, and ankle specificity increased to 41% and foot specificity to 79% (Stiell 1993).

An additional 453 patients were prospectively enrolled in the second phase of the study, where the refined rules were validated, yielding a sensitivity of 100% for both ankle and midfoot fractures.

A study of 670 children aged 2 to 16 years at 2 separate sites found that the Ottawa ankle rule again had a sensitivity of 100% for both clinically significant ankle and midfoot fractures. This study also found that ankle x-rays could have been reduced by 16% and foot x-rays by 29% if the rules were in use at the time of the study. Subsequent meta-analysis of the Ottawa ankle rule in children found 12 studies with 3130 patients and 671 fractures, with a pooled sensitivity of 98.5% and an overall reduction in x-ray utilization by 24.8%.

Use the Calculator Now

[Access the Ottawa Ankle Rule on MDCalc.](#)

Calculator Creator

Ian Stiell, MD, MSc, FRCPC

[Read more about Dr. Stiell.](#)

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Why to Use

Patients who do not have criteria for imaging according to the Ottawa ankle rule are highly unlikely to have a clinically significant fracture and do not need plain radiographs. As a result, application of the Ottawa ankle rule can reduce the number of unnecessary radiographs by as much as 25% to 30%, improving patient flow in the emergency department.

When to Use

- The Ottawa ankle rule should be applied to all patients aged ≥ 2 years who have ankle or midfoot pain and/or tenderness in the setting of trauma.
- An ankle x-ray series is only required if the patient has pain in the malleolar zone AND any of these findings:
 - » Bone tenderness at the posterior edge or tip of the lateral malleolus, OR
 - » Bone tenderness at the posterior edge or top of the medial malleolus, OR
 - » Inability to bear weight both immediately after injury and in the emergency department
- A foot x-ray series is only required if the patient has pain in the midfoot zone AND any of these findings:
 - » Bone tenderness at the base of the fifth metatarsal, OR
 - » Bone tenderness at the navicular, OR
 - » Inability to bear weight both immediately after injury and in the emergency department

Next Steps

- If ankle pain is present and there is tenderness over the posterior 6 cm of the tibia or fibula or the tip of the posterior or lateral malleolus, then an ankle-ray is indicated.
- If midfoot pain is present and there is tenderness over the navicular or the base of the fifth metatarsal, then a foot x-ray is indicated.
- If there is ankle or midfoot pain and the patient is unable to take 4 steps both immediately after the injury and in the emergency department, then x-ray of the painful area is indicated.

Management

- X-ray
- RICE plan (rest, ice, compression, elevation)
- Splinting/crutches and pain medication, pending outcome

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Click the thumbnail above to access the calculator.

Ottawa Knee Rule

The Ottawa knee rule describes criteria for knee trauma patients who are at low risk for clinically significant fracture and do not warrant knee imaging.

Points & Pearls

- The Ottawa knee rule was derived to aid in the efficient use of radiography in acute knee injuries.
- The rule has been prospectively validated on multiple occasions in different populations and in both children and adults.
- Numerous studies found sensitivities for the Ottawa knee rule of 98% to 100% for clinically significant knee fractures, although 1 study found a sensitivity of just 86%.
- Specificities for the Ottawa knee rule typically range from 19% to 50%, although the rule is not designed or intended for specific diagnosis.
- When the rule is used appropriately, the number of knee x-rays obtained can be reduced by 20% to 30%.
- The Ottawa knee rule is useful in ruling out fracture when negative (high sensitivity), but does poorly at ruling in fractures (many false positives).

Advice

Tips and precautions from the creators at the University of Ottawa:

- Tenderness of the patella is significant only if it is an isolated finding.
- Use only for injuries with a duration of < 7 days.
- "Bearing weight" counts even if the patient limps.
- Clinical judgment should prevail if the examination is unreliable due to:

- » Intoxication
- » Uncooperative patient
- » Distracting painful injuries
- » Diminished sensation in legs
- Written instructions should always be provided.
- Patients should be encouraged to obtain follow-up care in 5 to 7 days if pain and ability to walk do not improve.

Critical Actions

Patients who do not have any of the Ottawa knee rule criteria present do not need an x-ray. If 1 or more of the conditions are met, then an x-ray is recommended.

Many experts would consider this score "one directional." Because the rule is sensitive and not specific, it provides a clear guide to which patients do not need x-ray if all criteria are met; however, if a patient fails the criteria, the need for x-ray can be left to clinical judgment.

Evidence Appraisal

The original derivation study by Stiell et al was done in 1995 and included nonpregnant patients aged > 18 years who presented to Ottawa civic and general hospitals with a new injury that is < 7 days old and resulted from acute blunt trauma to the knee. The study enrolled 1054 subjects, of whom 68 had fractures, with 66 of the fractures deemed to be clinically significant (ie, not a simple avulsion fragment of < 5 mm in breadth without associated complete tendon or ligament disruption). Using recursive-partitioning techniques, the authors derived the 5 variables of the decision rule. When applied to the study population, their decision rule had sensitivity of 100% and specificity of 54% for identifying fractures and would have led to a 28% relative reduction in x-ray utilization.

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Stiell et al prospectively validated their decision rule in the same patient population. They performed telephone follow-up 14 days after the patient's emergency department visit to determine the possibility of a missed fracture. Sensitivity of the decision rule was again 100%, identifying 63 clinically important fractures out of 1096 patients. Specificity was similar to the derivation study at 49%, and there was a 28% relative reduction in x-ray utilization.

Stiell et al also prospectively implemented the decision rule in different teaching and community emergency departments. They found a relative reduction in x-ray usage of 26.4%, while maintaining a sensitivity of 100% for detecting 58 knee fractures out of 3907 patients, and a specificity of 48%. Moreover, there was a significant reduction in time to discharge and total medical charges in patients who did not get an x-ray.

The Ottawa knee rule has also been prospectively validated in populations outside of Canada. Two studies, 1 in Spain and another in the United States, found that the Ottawa knee rule had a sensitivity of 100% and 98%, specificity of 52% and 19%, and a reduction in x-ray usage by 49% and 17%.

The rule was applied to children aged 2 to 16 years in a prospective, multicenter validation study in 2003. That study found the decision rule to be 100% sensitive in finding 70 fractures out of 750 children, with a specificity of 42.8% and a potential reduction in x-ray usage by 31.2%.

The Ottawa knee rule has been compared to the Pittsburgh decision rule, another well-validated clinical decision rule. A cross-sectional comparison

of the 2 rules showed that both had sensitivities of 86%, although the Pittsburgh decision rule was significantly more specific. However, this study only included patients aged 18 to 79 years and excluded pediatric patients.

Use The Calculator Now

[Access the Ottawa Knee Rule on MDCalc.](#)

Calculator Creator

Ian Stiell, MD, MSc, FRCPC

[Read more about Dr. Stiell.](#)

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Why to Use

Patients with knee trauma who do not meet the criteria for imaging according to the Ottawa knee rule are highly unlikely to have a clinically significant fracture and do not need plain radiographs. As a result, application of the Ottawa knee rule can cut down on the number of unnecessary radiographs by 20% to 30%. This has proven to be cost-effective for patients without reducing quality of care (Nichol 1999).

When to Use

- The Ottawa knee rule should be applied to all patients aged > 2 years who have knee pain and/or tenderness in the setting of trauma.
- A knee x-ray series is only required for knee injury patients with any of these findings:
 - » Age \geq 55 years, OR
 - » Isolated tenderness of the patella (with no bone tenderness of the knee other than the patella), OR
 - » Tenderness of the head of the fibula, OR
 - » Inability to flex to 90°, OR
 - » Inability to bear weight both immediately after the injury and in the emergency department for 4 steps (unable to transfer weight twice onto each lower limb), regardless of limping

Next Steps

- Patients who do not have any of the Ottawa knee rule criteria present do not need an x-ray.
- If 1 or more of the conditions are met, then an x-ray is recommended.
- For significant nonbony injuries, often crutches and a knee immobilizer can be helpful to assist with ambulation.

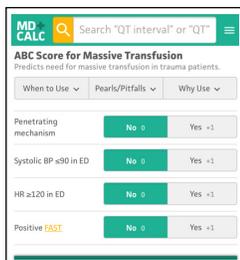
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ABC Score for Massive Transfusion

The ABC score for massive transfusion predicts the need for massive transfusion in trauma patients.

Points & Pearls

- The assessment of blood consumption (ABC) score does not require laboratory results or complex calculations.
- The focused assessment with sonography in trauma (FAST) examination that is used to determine the score relies on the skill level of the clinician performing and interpreting the examination.
- The score tends to overtriage in favor of receiving massive transfusion, ensuring a low chance of withholding massive transfusion from a patient who needs it.
- While the score can help aid the decision to initiate massive transfusion, the lead clinician(s) managing the trauma should place the order, as a massive transfusion can quickly stretch the limits of the hospital blood supply.

Critical Actions

Activation of a massive transfusion protocol (MTP) triggers the release of packed red blood cells, platelets, and fresh frozen plasma at frequent intervals until the MTP is called off.

Evidence Appraisal

The original study (Nunez 2009) was a retrospective review performed at Vanderbilt University Medi-

cal Center using the institution's trauma registry. The study population was derived from all trauma patients (n = 596) admitted to the hospital over the course of a year. Patients included were Level I trauma activations transported directly from the scene who received any blood transfusion while admitted. The ABC score was created by the trauma faculty based on clinical experience, and logistic regression modeling was used to determine the odds ratio of requiring MTP for each parameter of the score.

Of the total cohort, 76 patients (12%) required massive transfusion in the first 24 hours. Based on the number of patients who received massive transfusion and were identified using the ABC score, researchers found the best cutoff to be a score ≥ 2 , giving a sensitivity of 75% and specificity of 86%. Compared with the Trauma Associated Severe Hemorrhage scoring system and the McLaughlin score using the same dataset, the ABC score was shown to be the most accurate in predicting need for MTP.

The validation study (Cotton 2010) was a retrospective review using trauma databases from 3 institutions: Vanderbilt University Medical Center, Johns Hopkins Hospital, and Parkland Memorial Hospital. The inclusion and exclusion criteria were the same as the original study. The study population was again derived from trauma patients admitted to 1 of the 3 hospitals over the course of a year. The sample size of the study was 1604, including 586 patients from the original study. There was significant variation in demographics between the centers involved, but the massive transfusion rate in the first 24 hours of admission was similar (approximately 15%) for each hospital. There was little variability between each institution's cohort in the percentage

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of patients correctly classified as meeting the ABC score cutoff for MTP, among those who received massive transfusions. For each institution, sensitivity ranged from 76% to 90% and specificity ranged from 67% to 87%. Negative predictive value was 97% and positive predictive value was 55%.

The validation study also measured the accuracy of the ABC score at predicting need for massive transfusion in the first 6 hours of admission. Sensitivity was 87% and specificity was 82% with slightly higher negative predictive value (98%) and lower positive predictive value (55%) compared to prediction of massive transfusion need in the first 24 hours.

The major limitation to both studies was their retrospective nature. A prospective trial is ongoing. The study shows a novel means of quickly predicting the need for massive transfusion based on objective measures. While there is good data showing that early activation of MTP improves survival rates in severely injured trauma patients, a prospective study will be necessary to determine if utilization of the ABC score improves patient outcomes.

Use the Calculator Now

[Access the ABC Score for Massive Transfusion on MDCalc.](#)

Calculator Creator

Bryan Cotton, MD

[Read more about Dr. Cotton.](#)

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Original/Primary Reference

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Why to Use

Early initiation of massive transfusion has been shown to improve survival in critical trauma patients. The ABC score reduces delay in determining need for massive transfusion in a trauma patient, while also providing consistency in appropriateness of transfusion by minimizing practice variations among clinicians.

When to Use

The ABC score should be used in trauma patients for whom massive transfusion is being considered.

Next Steps

- Massive transfusion protocols are institution-specific, but common ratios are 1:1:1 or 1:1:2 for fresh frozen plasma, platelets, and packed red blood cells (Holcomb 2015).
- The ABC score does not indicate if trauma patients should receive blood, only if they should receive blood through an MTP.
- The score should be repeated as the patient's clinical examination changes. Repeating vital signs and FAST examinations can change a patient's ABC score.
- Familiarity with an institution's MTP will reduce delays in activation and administration of blood products.
- The most widely-accepted definition of massive transfusion is the administration of ≥ 10 units of packed red blood cells in the first 24 hours.
- Institutions may have different ratios of blood products as part of an MTP.
- Chances of survival increase with early initiation of massive transfusion in severely injured patients. Identification and activation should not be delayed in critical trauma patients.

Abbreviations: ABC, assessment of blood products; FAST, focused assessment with sonography in trauma; MTP, massive transfusion protocol.

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