Emergency Department Evaluation and Treatment of Cervical Spine Injuries

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KEYWORDS

• Emergency department • Cervical spine • Spinal cord • Neurologic injury • Cooling • Corticosteroid use

KEY POINTS

- Most spinal cord injuries involve the cervical spine, highlighting the importance of recognition and proper management by emergency physicians.
- Initial cervical spine injury management should follow the ABCDE (airway, breathing, circulation, disability, exposure) procedure detailed by Advanced Trauma Life Support.
- NEXUS (National Emergency X-Radiography Utilization Study) criteria and Canadian C-spine Rule are clinical decision-making tools providing guidelines of when to obtain imaging.
- Computed tomography scans are now the preferred initial imaging modality.
- Consider administering intravenous methylprednisolone after discussion with the neurosurgical consultant in patients who present with spinal cord injuries within 8 hours.

Patients who arrive at the emergency department (ED) with potential cervical spine injuries pose a common challenge for emergency physicians (EPs). EPs should be prepared to manage these patients efficiently and effectively while protecting the cervical spine to prevent additional neurologic injury during evaluation and transfers. EPs must understand the complex anatomy of the cervical spine, and the mechanism and types of injuries, as well as being comfortable recognizing and managing associated injuries. EPs must also have an understanding of the utility and limitations of available imaging

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modalities. In addition, EPs should be aware of issues surrounding the management of specific patient populations at risk for neck and cervical spine injuries.

EPIDEMIOLOGY

The incidence of spinal cord injury remains unknown; however, in the United States and Canada, the incidence is estimated to be between 30 and 46 cases per million population.[1,2]

- Most patients with spinal cord injury (82%) are male, and aged 16 to 30 years.[3]
- The risk of cervical spine injury increases with age among children and adolescents (13.2 per 100,000 per year for those aged >11 years, compared with 1.2 per 100,000 in those younger than 11 years).[4]
- Most spinal cord injuries result from motor vehicle accidents (47%), falls (23%), gunshot wounds/violence (14%), and sports-related activities (9%).[5,6]
- Spinal cord injuries occur in 10% to 20% of patients with spinal fractures and are found in nearly 50% of patients with bony cervical vertebral injuries.[7]
- Cervical injuries occurred in 65% of the spinal cord injuries from motor vehicle collisions, 53% of the cord injuries from falls from heights, 37% of the cord injuries from gunshot wounds, and 97% of the cord injuries from diving.[8]
- It is estimated that cervical fractures occur in 1% to 3% of patients with blunt trauma.[8,9]

Significant cervical spine injuries can occur following minor trauma in the elderly[10] as well as in patients with predisposing arthritic conditions, such as:

- Ankylosing spondylitis[11,12]
- Psoriatic cervical spondyloarthropathy[13]
- Rheumatoid arthritis[14]

ANATOMY

Understanding the anatomy of the cervical spine is critical to recognizing injury patterns.

- The spinal column consists of 33 vertebrae:
  - 7 cervical, 12 thoracic, 5 lumbar, 5 sacral (fused), and 4 coccygeal (fused) (**Fig. 1**)
- The anterior and posterior longitudinal ligaments hold the vertebral bodies together.
- Intervertebral discs separate the vertebral bodies and provide cushioning and flexibility.
- The spinal cord is housed in a bony ring made up of 2 pedicles (or pillars) on which the roof of the vertebral canal (the lamina) rests.
- Afferent and efferent nerve roots pass through the intervertebral foramina.

The occipitoatlantoaxial complex is made up of the articulations between the base of the skull, atlas (C1), and axis (C2) (**Fig. 2**); and several strong ligaments (**Fig. 3**) with unique articular and ligamentous relationships[15] that protect the upper cervical spine while allowing a wide range of motion.[16]

- Occipital condyles articulate with the corresponding concavities in the lateral masses of the atlas to allow for flexion and extension.
- The tectorial membrane functions to stabilize extension of the occiput on the atlas.

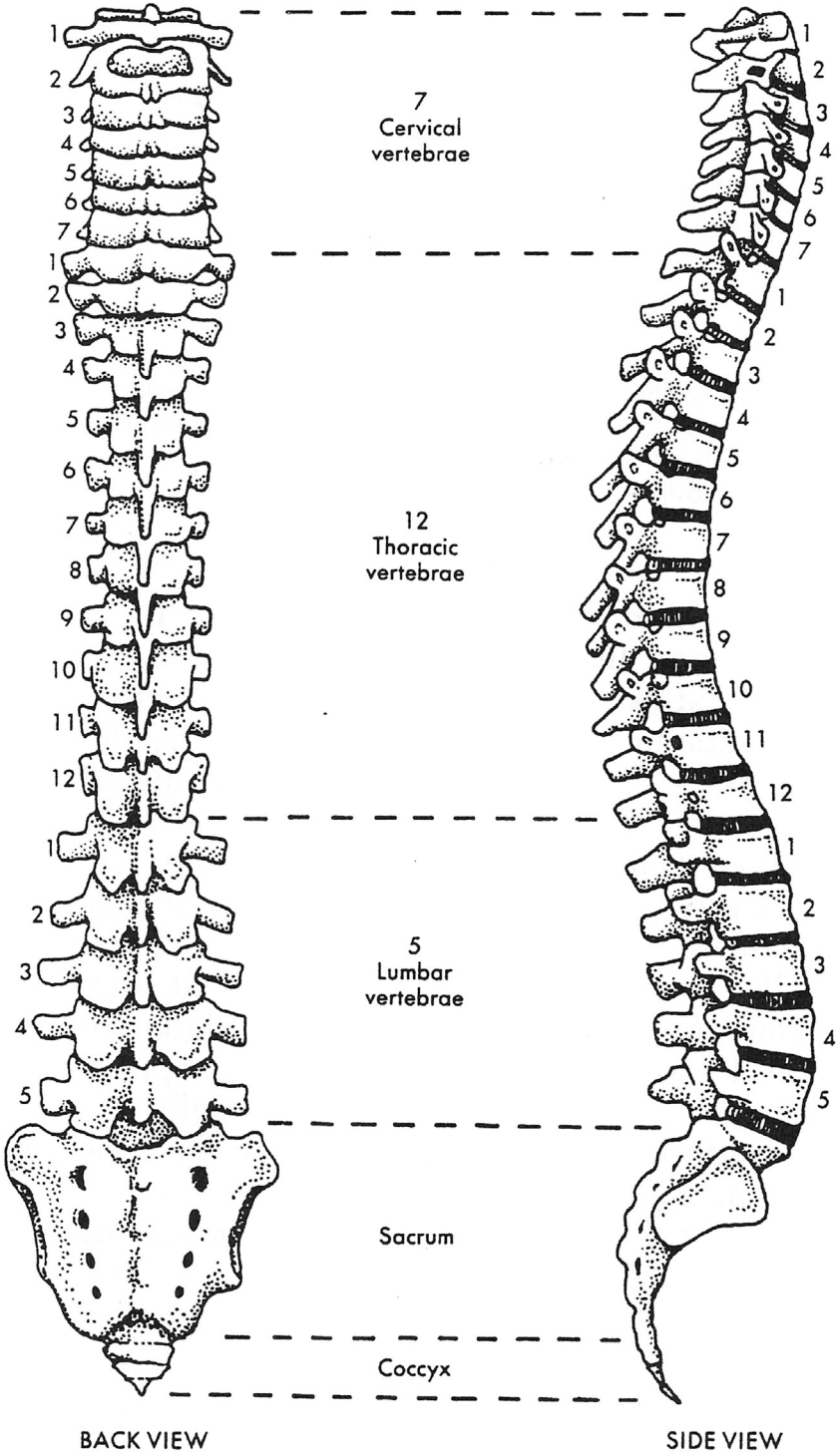


Fig. 1. Vertebral column. (*From* Hockberger RS, Kirshenbaum KJ, Doris PE. Spinal injuries. In: Rosen P, Barkin R, Danzl D, et al, editors. Emergency medicine: concepts and clinical practice. 4th edition. vol. 1. St Louis (MO): Mosby; l998. p. 463; with permission.)

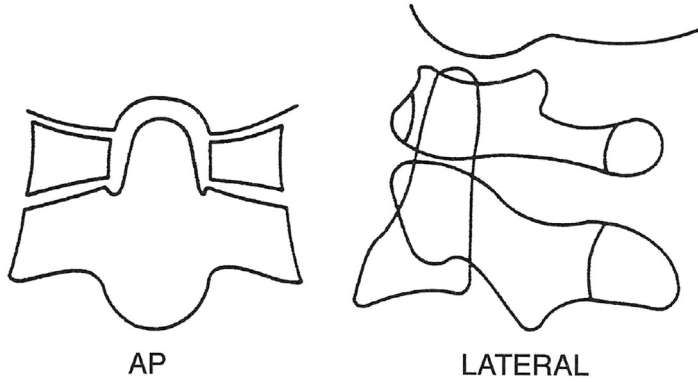


Fig. 2. The articular relationships of the occiput, atlas, and axis. The articular surfaces of the atlas and axis are convex to each other, allowing for a great deal of rotation, flexion, and extension. AP, anteroposterior. (*From* Ellis GL. Imaging of the atlas (C1) and axis (C2). Emerg Med Clin North Am 1991;9:720.)

- Between C1 and C2, the articular surfaces of the atlas and axis are convex to each other, permitting further flexion and extension.
- Articulation between the dens process and the atlas allows for rotatory motion.
- The accessory ligaments and the alar ligaments function to limit axial rotation.
- The transverse ligament is the primary stabilizer for anterior atlantoaxial translation.
- Disruption of the transverse ligament leads to significant instability
  - 1 cm of potential space within the ring of the atlas allows for some displacement of the dens without cord damage.

The anatomy of the lower cervical spine is best understood in the context of mechanical stability, which can be thought of using the 2-column concept:

- Anterior column: vertebral bodies and intervertebral disks that are held in alignment by the anterior and posterior longitudinal ligaments.
- Posterior column: pedicles, laminae, articulating facets, and spinous processes, held in alignment by the nuchal ligament complex (supraspinatus, interspinous, and infraspinous ligaments), the capsular ligaments, and the ligamentum flavum (**Fig. 4**).

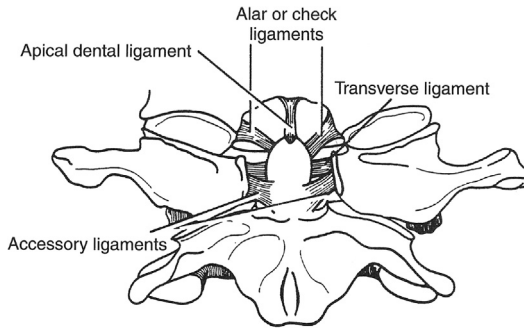


Fig. 3. The ligamentous relationships unique to the occipitoatlantoaxial region. (*From* Ellis GL. Imaging of the atlas (C1) and axis (C2). Emerg Med Clin North Am 1991;9:720.)

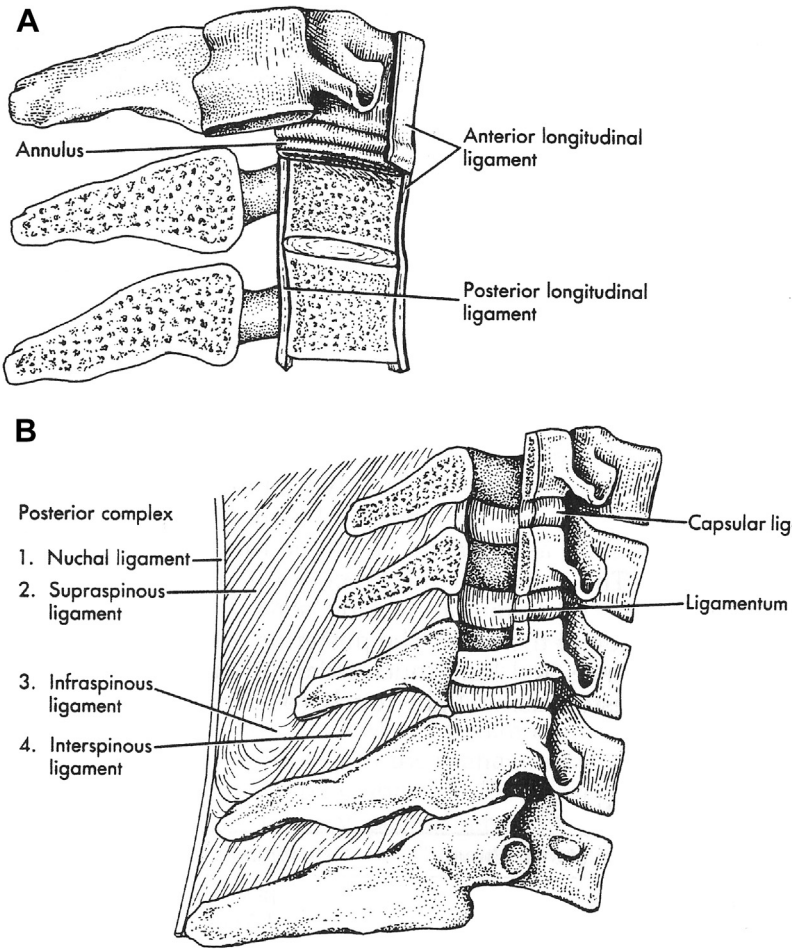


Fig. 4. Ligaments at anterior (*A*) and posterior (*B*) column. (*From* Hockberger RS, Kirshenbaum KJ, Doris PE. Spinal injuries. In: Rosen P, Barkin R, Danzl D, et al, editors. Emergency medicine: concepts and clinical practice. 4th edition. vol. 1. St Louis (MO): Mosby; l998. p. 455; with permission.)

The injured cervical spine is considered to be mechanically unstable when both columns are disrupted at the same level.

There are 3 main spinal cord tracts, which are paired tracts that can be injured on 1 or both sides. Testing strength, sensation, and reflexes provides a rapid assessment of function of these tracts (**Table 1**).

- Corticospinal tract
  - Posterolateral segment of the cord
  - Ipsilateral motor function
- Spinothalamic tract
  - Anterolateral portion of the spinal cord
  - Pain and temperature (and some light touch) sensation from the contralateral side of the body
- Posterior columns

Table 1
Motor, sensory, and reflex examinations

Level of Lesion	Resulting Loss of Motor Function	Resulting Level of Loss of Sensation	Resulting Loss of Reflex
C2	—	Occiput	—
C3	—	Thyroid cartilage	—
C4	Spontaneous breathing	Suprasternal notch	—
C5	Shrugging of shoulders	Below clavicle	—
C6	Flexion at elbow	Thumb	Biceps
C7	Extension at elbow	Index finger	Triceps
C8	Flexion of fingers	Small finger	—

From Hockberger RS, Kirshenbaum KJ, Doris PE. Spinal injuries. In: Rosen P, Barkin R, Danzl DF, et al, editors. Emergency medicine: concepts and clinical practice. 4th edition. vol. 1. St Louis (MO): Mosby–Year Book, 1998. p. 481; with permission.

- Proprioception, vibration sense, and light touch from the ipsilateral side
- Sensation can be tested using light touch (posterior columns) with a cotton wisp followed by pinprick testing (spinothalamic tract) to determine the sensory dermatome involved (**Fig. 5**, see **Table 1**)

INITIAL MANAGEMENT

The important management principle for the cervical spine is protection of the spine and spinal cord with immobilization devices or by manual in-line immobilization until all injuries are fully evaluated and cervical spine injury can be ruled out. **Fig. 6** provides an approach to the management of patients with trauma with suspected cervical spine injury.

AIRWAY MANAGEMENT

Choosing the optimal technique for definitive, emergency airway management is often perceived as a clinical dilemma and many clinicians think that orotracheal intubation is hazardous in the presence of a known or potential cervical spine injury.[17]

- Several investigators have concluded that orotracheal intubation with in-line immobilization is a safe, effective method for definitive airway management.[18–20]
- Using a cadaver model, Gerling and colleagues[21] showed no significant vertebral body movement during orotracheal intubation with manual in-line stabilization.
- There is no consensus that video-assisted laryngoscopy (VAL) is safer than direct laryngoscopy. Studies on this subject have mixed results:
  - Robitaille and colleagues[22] concluded that there was no significant difference between direct laryngoscopy and VAL at any level
  - Turkstra and colleagues[23] found that C-spine motion reduced 50% at the C2-5 segment when VAL was used
- The current Advanced Trauma Life Support (ATLS) guidelines[24] (**Figs. 7** and **8**) list orotracheal intubation with in-line manual cervical spine immobilization as the definitive airway procedure in the apneic patients with trauma.
- A surgical airway should be considered if a definitive airway is required and cannot be established using the techniques discussed earlier and while maintaining in-line stabilization.

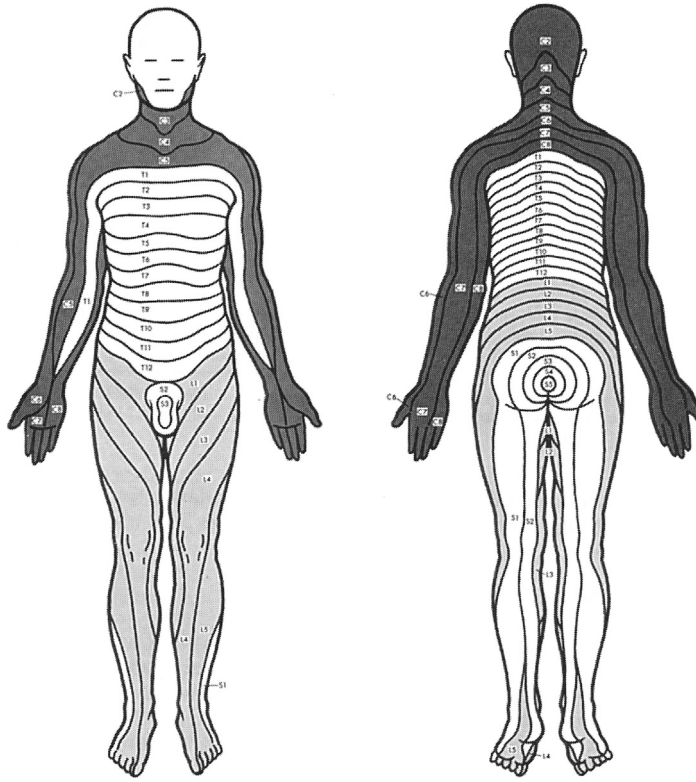


Fig. 5. Sensory dermatomes. (*From* Hockberger RS, Kirshenbaum KJ, Doris PE. Spinal injuries. In: Rosen P, Barkin R, Danzl D, et al, editors. Emergency medicine: concepts and clinical practice. 4th edition. vol. 1. St Louis (MO): Mosby; l998. p. 482; with permission.)

Immobilization

Prehospital personnel should suspect potential cervical spine injury in all patients who have sustained significant trauma, and in any patient with altered mental status of uncertain cause.

- It is estimated that nearly 5 million patients receive spinal immobilization annually at a cost of $15 per person or $75 million a year in the United States
- The 2013 National Association of EMS Physicians and the American College of Surgeons Committee on Trauma has recommended backboard immobilization only for patients with:
  - Spinal pain or tenderness
  - Blunt trauma with altered level of consciousness
  - Neurologic complaints
  - Obvious deformity of the spine
  - High-energy impact with a distracting injury, intoxication, or inability to communicate

Patients with trauma who arrive immobilized must be evaluated quickly by EPs to determine the extent of injury, probability of cervical spine injury, and adequacy and need for ongoing immobilization.

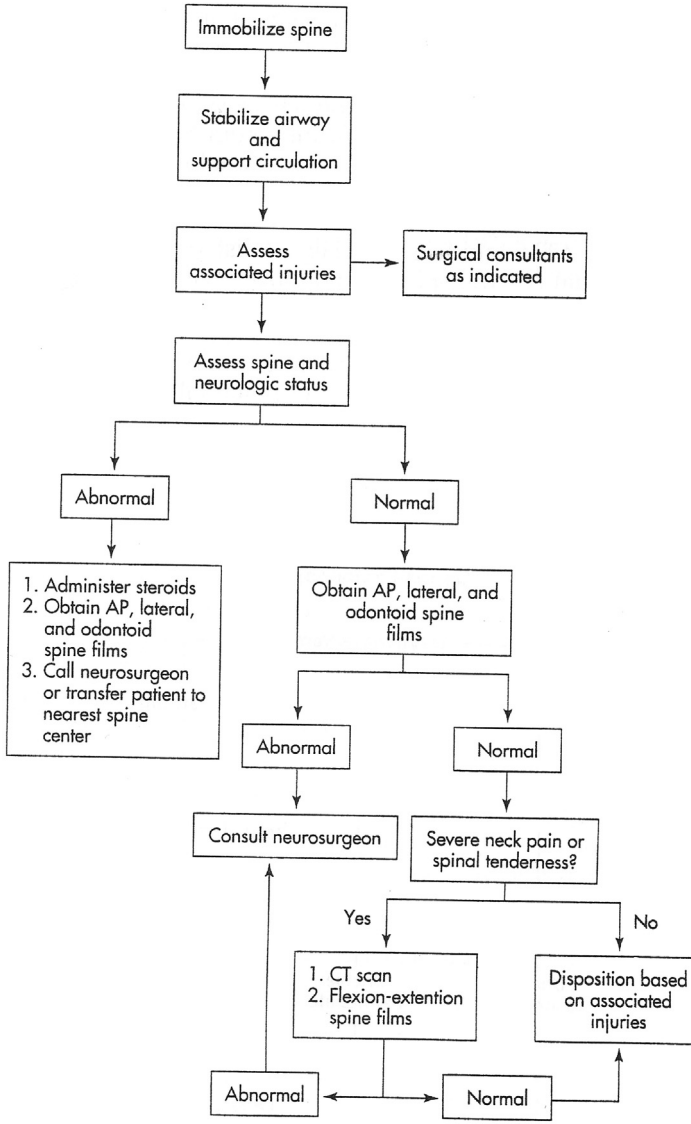


Fig. 6. Approach to patients with suspected cervical spine injury. CT, computed tomography. (*From* Kaji AH, Newton EJ, Hockberger RS. Spinal injuries. In: Marx J, Hockenberger R, Walls R, editors. Rosen's emergency medicine: concepts and clinical practice. 9th edition. St Louis (MO): Mosby; 2013; with permission.)

SHOCK

Shock (or hypotension) in multiply injured patients with trauma may have many causes, including hypovolemic, spinal/neurogenic, or (less likely) cardiogenic or distributive causes.

- Hemorrhagic shock: hypotension with tachycardia and peripheral vasoconstriction
  - Intravenous fluids while following vitals, urine output, and mental status

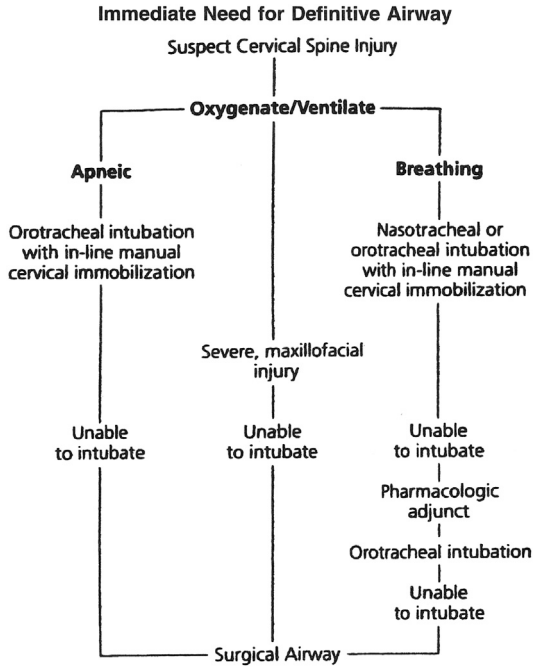


Fig. 7. Airway algorithm. Proceed according to clinical judgment and skill or experience level. (*From* Committee on Trauma. Airway and ventilatory management. In: Advanced trauma life support program for physicians. Chicago: American College of Surgeons; 1998. p. 72; with permission.)

- Neurogenic shock: hypotension, bradycardia, flaccidity, and areflexia
  - Warm, pink skin with good peripheral pulses
  - Crystalloid fluid bolus and Trendelenburg positioning

Vasopressors may be required in patients who are persistently hypotensive despite appropriate evaluation and resuscitation measures.[25]

IMAGING OF THE CERVICAL SPINE

Multiple imaging modalities are available to EPs. Plain radiographs have long been the standard initial imaging study of choice, and, in low-risk patients or those without significant mechanism of injury, they remain the first study of choice for many physicians. In patients with multiple traumatic injuries or a high suspicion for injury, many centers have moved to standard computed tomography (CT) scan of the cervical spine as part of an initial radiographic evaluation. Furthermore, MRI is becoming more widely available and many be used in cases in which there is a high level of suspicion for injury, for patients with abnormalities seen on radiograph or CT scan, or in patients for whom soft tissue or spinal cord injury are considered a part of the differential diagnosis. In addition, clinical decision rules have been developed (discussed later) to help clinicians decide which low-risk patients do not require any imaging.

Clinical Decision-making Tools

- Clinical decision-making tools have allowed EPs to make evidence-based, objective decisions about imaging, resulting in cost savings and reduced radiation exposure to patients.

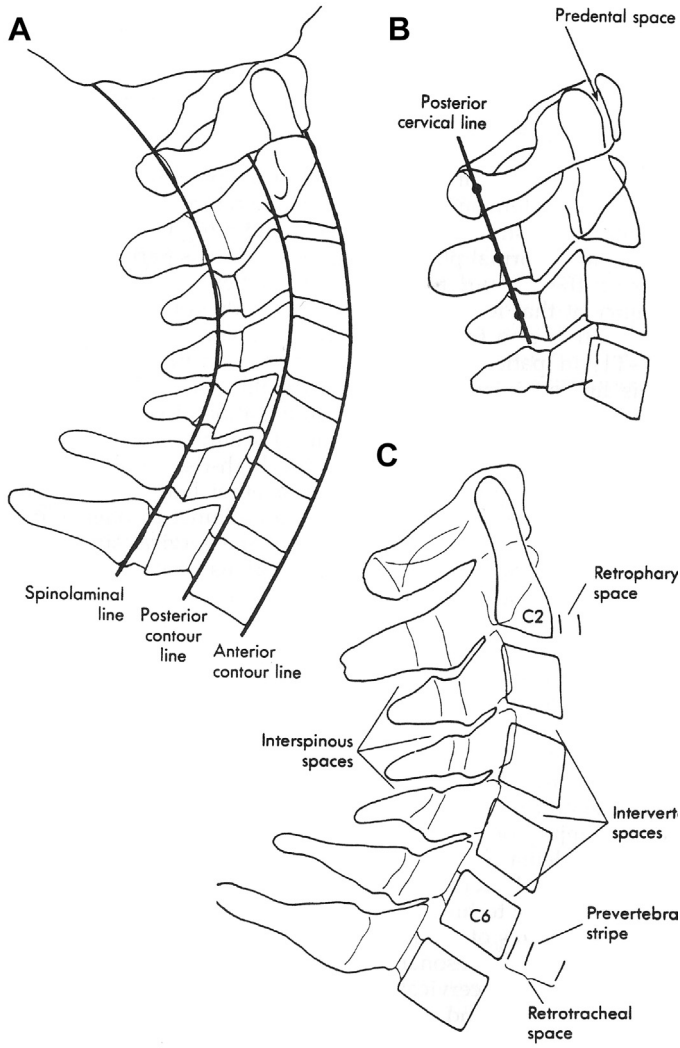


Fig. 8. (*A*, *B*) Normal structural relationships of lateral cervical spine. (*C*) In the lateral view, intervertebral spaces and interspinous spaces should be compared with spaces above and below for asymmetry, as important clues in flexion and extension injuries. Retropharyngeal and retrotracheal soft tissues are measured at C2 or C3 and C6 levels for swelling. (*From* Hockberger RS, Kirshenbaum KJ, Doris PE. Spinal injuries. In: Rosen P, Barkin R, Danzl D, et al, editors. Emergency medicine: concepts and clinical practice. 4th edition. vol. 1. St Louis (MO): Mosby; l998. p. 489–90; with permission.)

- Even with low-mechanism injury (derived from dangerous mechanism in Canadian C-spine rules; **Box 2**), patients with severe osteoporosis, advanced arthritis, cancer, or degenerative bone disease have significant risk of injury and may warrant imaging even without the application of a clinical decision tool.[25]

National Emergency X-Radiography Utilization Study

- Prospectively validated in 21 EDs across the United States.[26]

- Patients who were excluded were those with penetrating trauma to the neck, or direct blows.
- In order to determine that radiographs are not necessary, a set of 5 clinical criteria must all be met (**Box 1**)[27]
  - 99.8% negative predictive value for cervical spine injury with a sensitivity of 99% and specificity of 12.9%.
    - With the low specificity, researchers were concerned that the criteria still resulted in overimaging, resulting in the development of the Canadian C-spine Rule (CCR).

Canadian C-spine Rule

- The objective of the researchers in developing the CCR was to derive a clinical rule that was highly sensitive with improved specificity to allow physicians to be more selective in the use of radiography.[28]
- Inclusion criteria: stable and alert patients with trauma who were more than 16 years of age.
- The CCR comprises 3 main questions (**Box 2**).
- By cross-validation in 10 EDs in large Canadian community and university hospitals, the CCR has 100% sensitivity and 42.5% specificity.

Comparing the Clinical Decision-making Tools

Both rules have been validated and provide useful, objective, and highly sensitive criteria that ultimately lower rates of radiographic imaging. However, much debate exists between which is superior. Inclusion criteria from the two studies differ, with the CCR not including children less than 16 years of age and patients with Glasgow Coma Scale less than 15, both of which were included in the NEXUS study. A 2003 *New England Journal of Medicine* article concluded that the CCR is superior to the NEXUS with respect to sensitivity and specificity for cervical spine injury, and its use would reduce rates of radiography.[29]

Box 1
NEXUS criteria

- No midline cervical tenderness
- No focal neurologic deficit
- Normal alertness
  - Glasgow Coma Scale of 15
  - No disorientation to person, place, time, or events
  - Ability to remember 3 objects in 5 minutes
  - Appropriate response to external stimuli
- No intoxication
- No painful, distracting injury
  - Examples: long bone fractures, visceral injury requiring surgical consultation, large lacerations, crush injuries, or large burns

Data from Hoffman JR, Wolfson AB, Todd K, et al. Selective cervical spine radiography in blunt trauma: methodology of the National Emergency X-radiography Utilization Study (NEXUS). Ann Emerg Med 1998;32(4):461.

Box 2
CCR

- Is there any high-risk factor that mandates radiography?
  - Age 65 years or older
  - Dangerous mechanism
    - Fall from 1 m (or 5 stairs)
    - Axial load to the head (eg, diving accidents)
    - Motor vehicle collisions at high speed (>100 km/h)
    - Motorized recreational vehicle accident
    - Ejection from a vehicle
    - Bicycle collision with an immovable object
  - Paresthesias in extremities
- Is there any low-risk factor that allows safe assessment of range of motion? Patients who do not have any of the following low-risk factors should be radiographed and are not suitable for range of motion testing:
  - Simple rear-end motor vehicle collision
  - Sitting position in ED
  - Ambulatory at any time since injury
  - Delayed onset of neck pain
  - Absence of midline C-spine tenderness
- Range of motion testing
  - Is the patient able to actively rotate neck 45° to the left and right (regardless of pain)? If so, imaging is not indicated

Data from Stiell IG, Wells GA, Vandemheen KL, et al. The Canadian C-spine Rule for radiography in alert and stable trauma patients. JAMA 2001;286(15):1841.

Imaging Modalities

Plain radiography

In recent years, plain radiographs have been replaced in many trauma centers by CT scan for the assessment of acute injury; however, plain films can still provide rapid assessment of alignment, fractures, and soft tissue swelling. Although there is greater detail and multiaxis reconstructions make CT examinations better suited for patients with high-risk injuries (described earlier) or high-risk patients (eg, aged 65 years or older, severe arthritis, osteoporosis), in low-risk patients with low-risk mechanisms of injury, plain radiographs may be appropriate. However, there is a paucity of large, prospective studies that focus on the utility of plain radiographs in low-risk patients.[30]

Computed tomography

The Eastern Association for the Surgery of Trauma (EAST) states that CT has supplanted plain radiography as the primary screening modality in patients who require imaging, recommending the examination scan from the occiput to T1 with sagittal and coronal reconstructions.[31]

- Holmes and Akkinepalli[32] found that the pooled sensitivity, for identifying patients with cervical spine injury, was 52% for plain radiography versus 98% for CT.

- Daffner[33] concluded that CT scan of the cervical spine takes approximately half the time taken by a 6-view cervical plain film series.
- Disadvantages of CT examination
  - Cost
    - CT may cost more than 5 times the cost of plain radiographs.
    - One study shows that CT is more cost-effective, especially in moderate-risk to high-risk patients.[34]
  - Exposure to increased ionizing radiation
    - Rybicki and colleagues[35] measured the radiation dose to the skin over the thyroid in patients undergoing cervical spine CT and plain radiography. They found that CT delivered 26.0 mGy to the thyroid versus 1.80 mGy by radiographs.
    - It is unclear what future cancer risk this single exposure to an increased radiation dose may hold.

MRI

Although the CT scan is an excellent modality for evaluating bony spine injuries, MRI may be indicated in patients who, despite a negative CT scan, have persistent midline tenderness and/or neurologic abnormalities.

- MRI provides more detailed imaging of the spinal cord, spinal canal, spinal ligaments, intervertebral discs, and paraspinal soft tissues.
- MRI may be particularly useful in the following situations:
  - Neurologic deficits caused by hemorrhage, edema, or injury to the cord
  - Determining acuity of bony injuries
  - Assessment of vascular injury (MRI and magnetic resonance arteriography)[25]
- Disadvantages of MRI
  - High false-positive rate (as high as 40% of findings are either incidental or would not change management)[36]
  - Contraindication with some cardiac pacemakers and other implanted devices or metallic objects
  - Enclosed space and duration, which makes it difficult for unstable patients

Spinal Cord Injury Without Radiographic Abnormality

Before the advent of MRI, spinal cord injury without radiographic abnormality (SCIWORA) was a term assigned to patients who had ongoing neurologic deficits despite normal imaging (radiograph and/or CT scan). With the increased use of MRI and better imaging of the spinal cord, ligaments, and vasculature, the incidence of SCIWORA has decreased dramatically.[37] Permanent neurologic injury is rare and most patients who have SCIWORA ultimately see resolution of their symptoms and return to baseline function.[38]

TYPES OF CERVICAL SPINE INJURIES

Cervical spine injuries have been variably classified according to mechanism of injury, stability, and morphology of injury. **Table 2** combines mechanism of injury with stability. **Table 3** shows the classification system developed by the Orthopedic Trauma Association. Spinal instability can be difficult to assess; therefore, **Table 4** provides a checklist to assist in the determination of subaxial stability.

Upper Cervical Spine Injuries

Common upper cervical spine injuries are described here. Note that a stable injury refers to either the anterior or posterior column being injured, but not both columns (although unstable refers to both columns being injured).

Table 2
Classification of spinal injuries

Mechanisms of Spinal Injury	Stability
Flexion	
Wedge fraction	Stable
Flexion teardrop fracture	Extremely
Clay shoveler's fracture	Stable
Subluxation	Potentially unstable
Bilateral facet dislocation	Always unstable
Atlanto-occipital dislocation	Unstable
Anterior atlantoaxial dislocation with or without fracture	Unstable
Odontoid fracture with lateral displacement fracture	Unstable
Fracture of transverse process	Stable
Flexion-Rotation	
Unilateral facet dislocation	Stable
Rotary atlantoaxial dislocation	Unstable
Extension	
Posterior neural arch fracture (C1)	Unstable
Hangman's fracture (C2)	Unstable
Extension teardrop fracture	Usually stable in extension
Posterior atlantoaxial dislocation with or without fracture	Unstable
Vertical Compression	
Bursting fracture of vertebral body	Stable
Jefferson fracture (C1)	Extremely
Isolated fractures of articular pillar and vertebral body	Stable

From Hockberger RS, Kirshenbaum KJ, Doris PE. Spinal injuries. In: Rosen P, Barkin R, Danzl DF, et al, editors. Emergency medicine: concepts and clinical practice. 4th edition. vol. 1. St Louis (MO): Mosby–Year Book, 1998. p. 481; with permission.

Atlanto-occipital dislocation

Atlanto-occipital dislocation (AOD) is typically a fatal injury secondary to severe injury to the brainstem. AOD is a general term for functional instability at the occipitocervical junction and manifests as subluxation or dislocation at the atlanto-occipital joint, the atlantoaxial joint, or both.[39]

- This injury usually results from severe hyperextension with distraction[40] but can also occur with lateral flexion and hyperflexion.[41]
- There are 3 types.[42]
  - Type I: most common type of AOD; the cranium moves anterior with respect to the atlas
  - Type II: the most common type in children; a longitudinal distraction of the occiput from the atlas
  - Type III: the cranium is displaced posteriorly with respect to the atlas
- Radiograph findings in AOD are shown in **Figs. 9** and **10**.[16,43]
- If a hanging mechanism is reported, obtain a CT scan because plain radiographs may not show all injuries.
- Acute management
  - ATLS and immobilization with a halo vest followed by occipitocervical surgical fixation is the usual treatment

Table 3
Cervical spine trauma classification of the Orthopedic Trauma Association

51	**Upper cervical spine**
51	Al: occipital cervical dislocation A1.1: anterior A1.2: vertical A1.3: posterior
51	A2: cervical spine, occipital condyle A2.1: type 1 A2.2: type 2 A2.3: type 3
51	A3: atlas A3.1: Jefferson A3.2: lateral mass A3.3: posterior arch A3.4: anterior arch
51	B1: cervical spine, transverse ligament B1.1: rupture midsubstance B1.2: rupture avulsion
51	B2: cervical spine, dens fracture B2.1: type 1 B2.2: type 2 B2.2.2: type 2a B2.3: type 3
51	C: cervical spine traumatic spondylolisthesis of the axis C1: type 1 C2: type 2 C2.2: type 2a C3: type 3
52	**Lower cervical spine**
52	A1.1: spinous process fracture A1.2: extension avulsion or teardrop A1.3: lateral mass fracture without subluxation A1.4: isolated lamina fracture A1.5: ligamentous strain
52	B1.1: facet injury B1.1.1: perched unilateral Bl.1.2: perched bilateral
52	B2.2.1: facet dislocation B2.2.1: without fracture unilateral B2.2.2: without fracture bilateral B3.3.1: with displacement unilateral B3.3.2: with displacement bilateral
52	C: severe injuries C1.1: flexion teardrop C2.1: severe ligamentous injury C3.1: compression fracture C3.2: burst fracture

From Finkelstein JA, Anderson PA. Surgical management of cervical instability. In: Capen DA, Haye W, editors. Comprehensive management of spine trauma. St Louis (MO): Mosby–Year Book, 1998. p. 146; with permission.

Table 4
Checklist for the diagnosis of clinical instability in the lower cervical spine

Element	Point Value
Anterior element destroyed or unable to function	2
Posterior element destroyed or unable to function	2
Relative sagittal plane translation >3.5 mm	2
Relative sagittal plane rotation >11°	2
Positive stretch test	2
Spinal cord damage	2
Root damage	1
Abnormal disk narrowing	1
Dangerous loading anticipated	1
Developmentally narrow spinal canal	1

Total of 5 or more indicates clinical instability.

From Finkelstein JA, Anderson PA. Surgical management of cervical instability. In: Capen DA, Haye W, editors. Comprehensive management of spine trauma. St Louis (MO): Mosby–Year Book, 1998. p. 146; with permission.

Fracture of the atlas

Fractures of the atlas are usually the result of compressive forces resulting from motor vehicle collisions, falls, or diving into shallow water.

- From 3% to 13% of all cervical spine fractures[44]
- Nearly 40% are associated with a fracture of the axis (C2)
- Accompanying neurologic injury is uncommon
- Three common patterns of atlas fractures:
  - Posterior arch fractures: most common fracture pattern
    - Stable fractures of the posterior arch and lateral masses
    - Treatment: Philadelphia-style collar

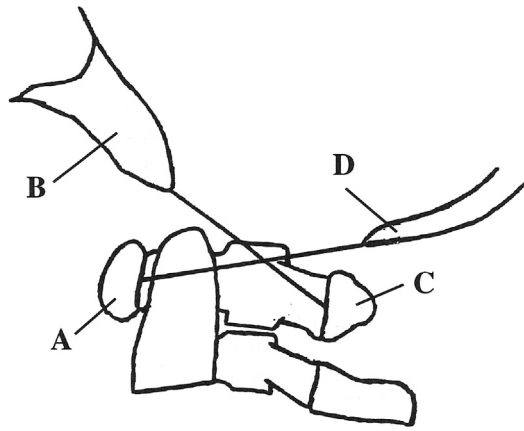


Fig. 9. The Power method. The ratio of the distance between the basion (B) and the anterior aspect of the posterior arch of C1 (C) to the distance between the opisthion (D) and the posterior aspect of the anterior arch of C1 (A), BC/DA, is normally less than 1.0. (*From* Ferrera PC, Bartfield JM. Traumatic atlanto-occipital dislocation: a potentially survivable injury. Am J Emerg Med 1996;14:294; with permission.)

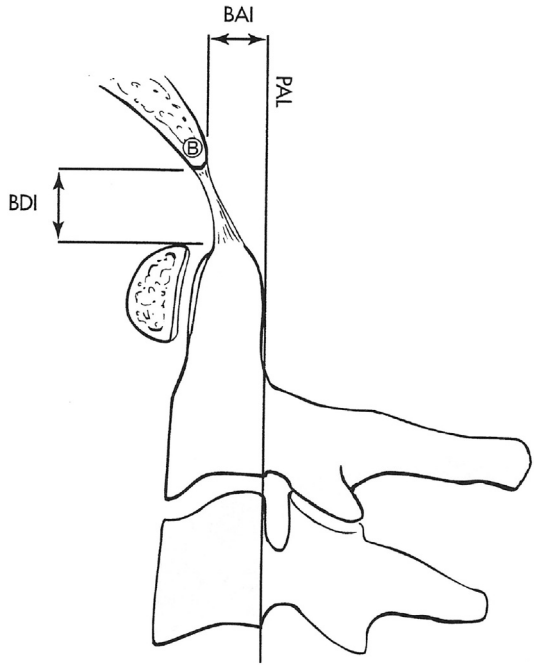


Fig. 10. The rule of 12 for occipitocervical dissociation. The posterior axial line (PAL) is the rostral extension of the posterior cortex of the axis body. The basion-axial interval (BAI) is the horizontal distance between the basion (B) and the PAL. The basion-dens interval (BDI) is the vertical distance between the basion and the tip of the dens. Values in excess of 12 mm for the BAI or BDI suggest occipitocervical dissociation. (*From* Finkelstein JA, Anderson PA. Surgical management of cervical instability. In: Capen DA, Haye W, editors. Comprehensive management of spine trauma. St Louis (MO): Mosby; 1998. p. 154; with permission.)

  - Jefferson or burst fracture (Fig. 11)
    - Disruption of both the anterior and posterior rings of C1 with displacement of the lateral masses
      - Lateral mass displacement greater than or equal to 7 to 8 mm of instability at C1-C2
    - Treatment
      - Stable: external immobilization
      - Unstable: potential operative fixation
  - Fractures of the lateral masses are uncommon
- Treat as potentially unstable until evaluated by neurosurgery or orthopedics

Atlantoaxial ligamentous injuries

These injuries occur secondary to flexion or extension forces that could be combined with rotation. Recall that the transverse ligament prevents anterior movement of the atlas on the axis, and the alar ligaments prevent excessive rotation.

- Atlantoaxial subluxation: tears of the transverse ligament widened predental space
- Rotary subluxation: atlantoaxial subluxation plus C2 being abnormally rotated with respect to C1 (Fig. 12)[45]

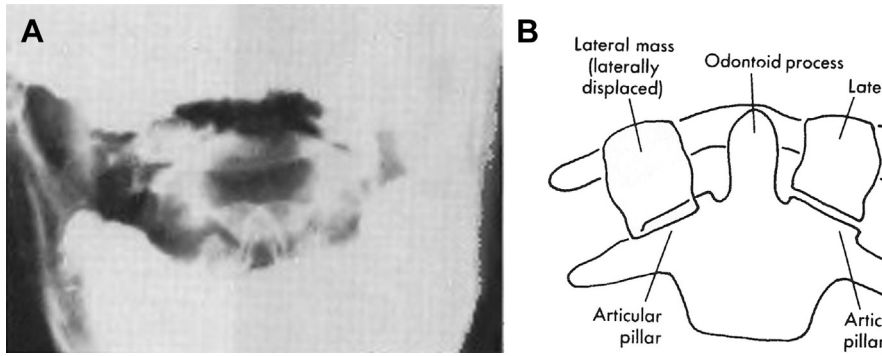


Fig. 11. Jefferson fracture. (*A*, *B*) Unilateral or bilateral lateral displacement of lateral masses of C1 with respect to articular pillars of C2 confirms Jefferson fracture. (*From* Hockberger RS, Kirshenbaum KJ, Doris PE. Spinal injuries. In: Rosen P, Barkin R, Danzl D, et al, editors. Emergency medicine: concepts and clinical practice. 4th edition. vol. 1. St Louis (MO): Mosby; l998. p. 478; with permission.)

- Atlantoaxial rotatory dislocation or rotary (rotatory) fixation
  - Rotational dislocation of the articular sources of C1 on C2 owing to alar ligament injury
  - Occurs more commonly in children
  - Seen following trauma, surgery, an upper respiratory infection, or with rheumatoid arthritis
  - The open-mouth odontoid view shows an abnormal relationship between the atlas and axis that does not change on rotation of the head (Fig. 13)
    - Whenever ligamentous injury is suspected, MRI should be obtained
- Treatment includes cervical collar immobilization and emergency neurosurgical or orthopedic consultation

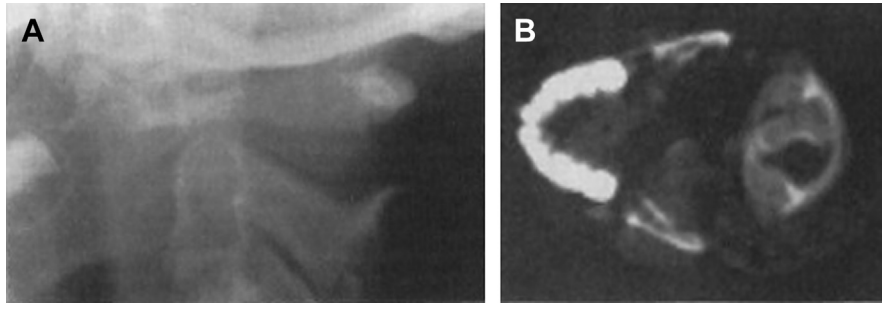


Fig. 12. Rotary subluxation. (*A*) Lateral radiograph of craniocervical junction reveals the ring of C1 to be properly oriented with respect to the base of the skull, but there is abnormal rotation between C1 and C2. (*B*) Axial CT scan of another patient who crashed into a tree on a snow sled shows that the head is oriented 90° to the cervical spine because of facet subluxation. (*From* Rothman SL. Imaging of spinal trauma pearls and pitfalls. In: Capen DA, Haye W, editors. Comprehensive management of spine trauma. St Louis (MO): Mosby; 1998. p. 52; with permission.)

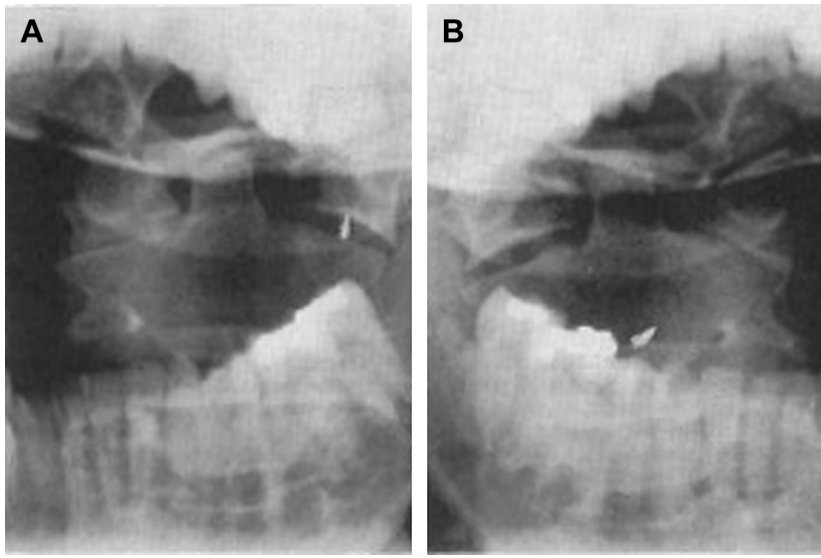


Fig. 13. Rotary fixation. Frontal radiographs of the craniovertebral junction through the open mouth with the patient's head turned to the right (*A*) and to the left (*B*) reveal consistent malposition of the dens with respect to the lateral masses of C1. The distance between the dens and the lateral mass is narrow on the same side regardless of the direction of rotation of the head. (*From* Rothman SL. Imaging of spinal trauma pearls and pitfalls. In: Capen DA, Haye W, editors. Comprehensive management of spine trauma. St Louis (MO): Mosby; 1998. p. 53; with permission.)

Fractures of the dens

Acute fractures of the axis (C2) represent 18% of all cervical fractures, and nearly 60% of these involve the dens or odontoid process. Fractures of the dens are high-energy injuries sustained in falls or motor vehicle collisions.

- Neurologic injury occurs in approximately 25% of these fractures
- There are 3 types of odontoid fractures (Fig. 14)[46]
  - Type I: uncommon (2%–3% of odontoid fractures) and appear as a fracture to the tip of the dens that occurs after an avulsion of the alar ligaments. This is a stable injury and is managed with external mobilization.[47]
  - Type II: most common (60%), and occurs through the waist of the dens near the attachment of ligaments
    - Most are displaced and unstable
    - Controversial management
      - High rates (30%–60%) of nonunion using external immobilization have led some clinicians to advocate surgical fixation as the primary treatment
  - Type III: occur at the very base of the dens into the body of the axis
    - Stable and managed with reduction using skeletal traction with light weight followed by immobilization with the halo vest
    - Nonunion fractures need surgical fixation

Traumatic spondylolisthesis of the axis

These injuries involve fractures through the posterior elements of C2 (Fig. 15).

- From 5% to 10% of all cervical spine fractures

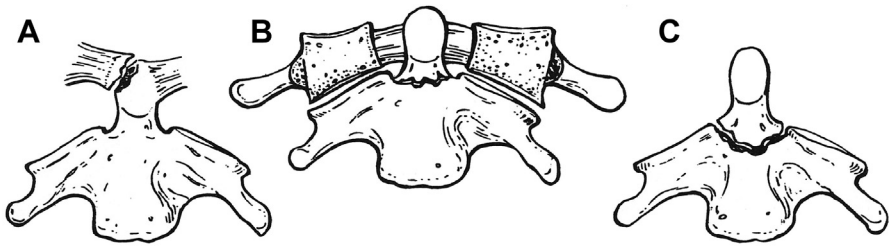


Fig. 14. Anderson-DeAlarzo classification of odontoid fractures. (*A*) Type I, avulsion fractures of the alar ligament. (*B*) Type II, fractures through the waist of the odontoid caudad to the transverse ligament. (*C*) Type III, fractures into the cancellous body of the axis. (*From* Nelson AW. Nonsurgical management of cervical spine instability. In: Capen OA, Hays W, editors. Comprehensive management of spine trauma. St Louis (MO): Mosby; 1998. p. 137; with permission.)

- Neurologic deficits are rare because the anteroposterior diameter of the spinal canal is greatest at C2 and the bilateral pedicle fractures allow decompression

The Hangman's fracture

- Occurs with extreme hyperextension (**Fig. 16**).
  - Motor vehicle collisions and diving accidents
- Consider these fractures unstable injuries and continue external immobilization

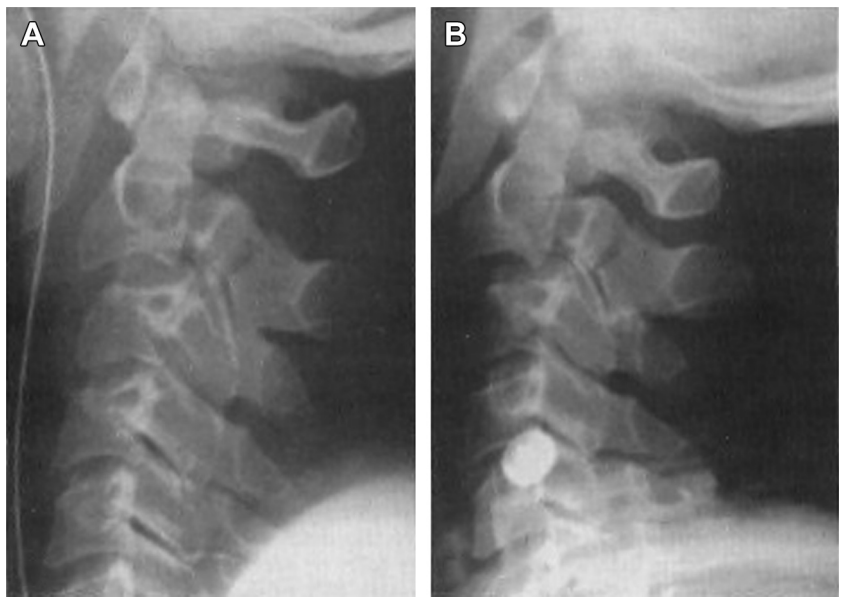


Fig. 15. (*A*) The lateral supine radiograph shows an unstable type II traumatic spondylolisthesis of the axis in a 41-year-old man. Closed reduction with traction and halo-vest immobilization was performed. (*B*) An upright radiograph showed loss of reduction with an increase in anterior translation. (*From* Finkelstein JA, Anderson PA. Surgical management of cervical instability. In: Capen DA, Haye W, editors. Comprehensive management of spine trauma. St Louis (MO): Mosby; 1998. p. 166; with permission.)



Fig. 16. Hangman's fracture. Axial CT scan shows traumatic spondylolysis of the 2 sides of the neural arch just posterior to the body of the axis. (*From* Rothman SL. Imaging of spinal trauma pearls and pitfalls. In: Capen DA, Haye W, editors. Comprehensive management of spine trauma. St Louis (MO): Mosby; 1998. p. 61; with permission.)

- Nonsurgical management is successful in more than 95% of cases

Other injuries of the atlas and axis

- Avulsion fracture of the anterior arch of the atlas
  - Rare injury caused by hyperextension forces[48]
  - The lateral radiograph reveals a horizontal fracture line through the anterior arch of the atlas with associated prevertebral soft tissue swelling
- Extension teardrop fracture
  - Avulsion of the anterior inferior corner of the body of the atlas
  - Result of hyperextension forces applied to an intact anterior longitudinal ligament
  - Risk factors: older patients with osteopenia or cervical spondylosis

Subaxial Cervical Spine Injuries

Fractures and dislocations of the subaxial cervical spine (C3–C7) are best categorized according to mechanism of injury.

- C5 is the most commonly fractured
- C5 on C6 is the most common site of subluxation
- Smaller diameter of the spinal canal leads to an increased incidence of neurologic injury at these levels

Cervical hyperflexion injuries

- Posterior ligamentous injuries:
  - Range from mild to severe
  - Focal tenderness but no focal neurologic deficits

- Severe injuries with complete ligamentous disruption lead to cervical spine instability and anterior subluxation of the vertebral body
- Radiographs
  - Normal or may show subtle findings (**Fig. 17**)
  - Initial radiographs and/or CT appear normal, and/or if the patient shows persistent tenderness MRI should be ordered
- Treatment
  - Rigid cervical collar immobilization for mild, stable ligamentous injuries
  - Posterior cervical fusion for severe, unstable ligamentous injuries

- Wedge or compression fracture
  - Hyperflexion forces lead to impaction of one vertebra against another
  - Diminished height and increased concavity of the anterior border of the vertebral body, increased density of the vertebral body from bony impaction, and prevertebral soft tissue swelling (**Fig. 18**)
  - Stable without accompanying neurologic deficit
- Flexion teardrop fracture
  - Characterized by the presence of a triangular body fragment at the anteroinferior aspect of the involved vertebral body
  - Often accompanied by severe ligament and intervertebral disk injury (**Fig. 19**)[49]
  - Fragments can also be produced by downward displacement of the anterior edge of the superior endplate
  - Unstable and often associated with severe neurologic injury

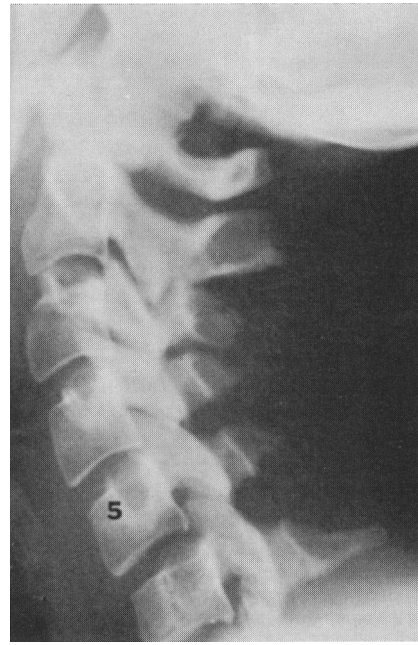


Fig. 17. Anterior subluxation of C5 is indicated by the hyperkyphotic angulation at the C5-C6 level secondary to anterior rotation and translation of C5, resulting in widening of the interspinous and interlaminar space, subluxation of the C5-C6 interfacetal joints, and posterior widening and anterior narrowing of the fifth intervertebral disk space. (*From* Harris JH, Edeiken-Monroe B, Kopaniky DR. A practical clarification of acute cervical spine injuries. Orthop Clin North Am 1986;17:17.)

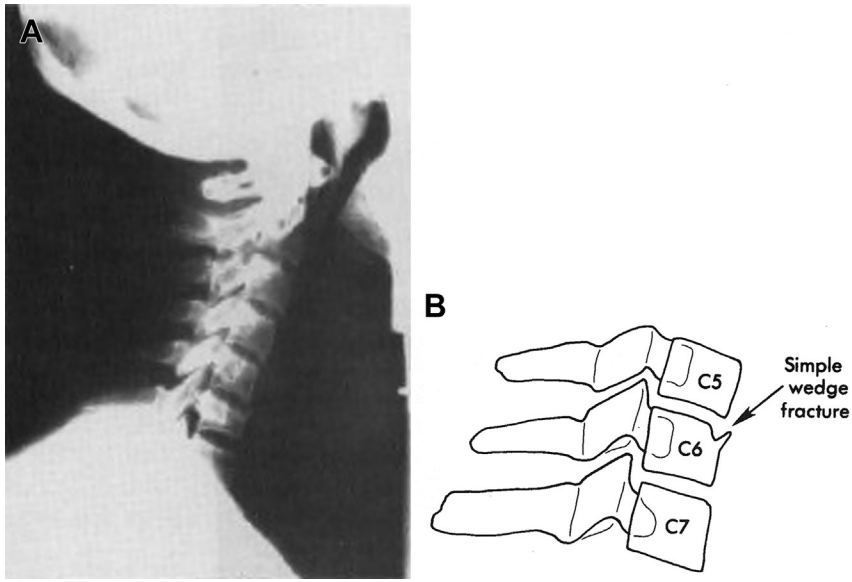


Fig. 18. (*A*, *B*) Lateral view of a simple wedge fracture. Note decrease in height of anterior aspect of C6 vertebral body. (*From* Hockberger RS, Kirshenbaum KJ, Doris PE. Spinal injuries. In: Rosen P, Barkin R, Danzl D, et al, editors. Emergency medicine: concepts and clinical practice. 4th edition. vol. 1. St Louis (MO): Mosby; 1998. p. 467; with permission.)

- Treatment: reduction followed by surgical fixation
- Bilateral facet dislocation (Fig. 20)
  - Severe injury characterized by 50% or greater anterior translation of the vertebral body
  - Extremely unstable and often accompanied by severe spinal cord injury
  - May be associated with vertebral artery injury or occlusion
  - Treatment: reduction followed by surgical stabilization
- Clay shoveler's fracture (Fig. 21)
  - Most commonly results from direct trauma to the spinous process (eg, weight lifters who drop a loaded bar onto their neck from overhead), sudden deceleration in motor vehicle collisions, or forced flexion of the neck
  - Stable and not typically associated with neurologic deficits

Rotational injuries

- Unilateral facet dislocation (Fig. 22)
  - Combined cervical flexion with simultaneous rotation
  - The dislocated facet becomes wedged into the intervertebral foramen; this is a stable injury
  - Radiographic findings
    - Lateral view
      - From 25% to 50% anterior translation of the vertebral body
      - The bowtie sign (ie, visualization of both of the facets at the level of the injury instead of their normal superimposed position)
      - Widening of the spinous processes[50]
    - Frontal view

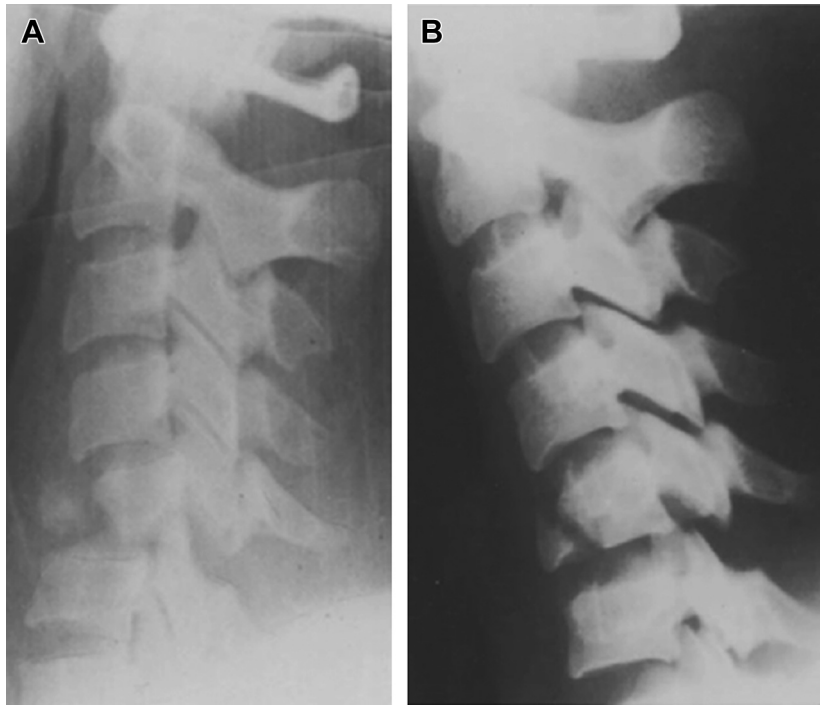


Fig. 19. Flexion teardrop fracture. (*A*) In the lateral radiograph of the cervical spine obtained immediately after the injury, the cervical spine is in the flexed attitude. A single large fragment consisting of the anteroinferior corner of the body of C5 is present. The fifth vertebral body is posteriorly displaced and, in addition, widening of the interfacetal and interspinous spaces between C5 and C6 indicates complete disruption of the posterior ligament complex and bilateral interfacetal dislocation. (*B*) In the lateral examination performed 2 weeks after the injury, the characteristic teardrop-shaped fragment is seen. In addition, the subjacent intervertebral disc space is abnormally widened, as are the interfacetal and interspinous spaces, indicating complete soft tissue disruption at the involved level. (*From* Adam A, Dixon AK, Grainger RG, et al. Grainger and Allison's diagnostic radiology. 5th edition. Philadelphia: Churchill Livingstone; 2008; with permission.)

        - Spinous processes above the level of dislocation displaced to the same side as the dislocated facet
    - Oblique views
        - May show the dislocated facet sitting in the neural foramen
- Unilateral facet dislocations can occur with or without associated fractures
- The patient may be neurologically intact or may show signs and symptoms consistent with nerve root injury, or incomplete or complete cord injuries
- Treatment
    - Closed reduction and halo-vest immobilization can be used for pure unilateral facet dislocations
    - Reduction with surgical management is used for fracture-dislocations and failures of closed reduction attempts

Cervical hyperextension injuries

Extension teardrop fractures, as described earlier (Fig. 23), may involve the axis or lower cervical (C5–C7) vertebrae. Extension teardrop and other hyperextension

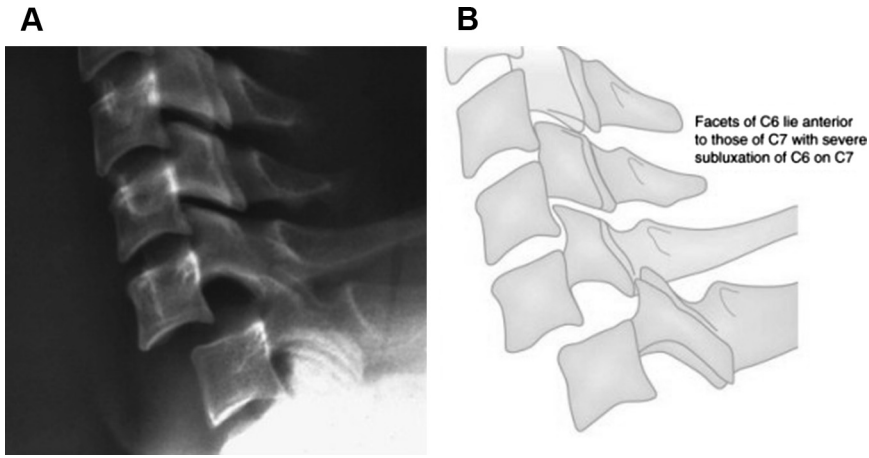


Fig. 20. (*A*, *B*) Bilateral facet dislocation. Facets of C6 lie anterior to those of C7 with severe subluxation of C6 on C7. (*From* Kaji AH, Newton EJ, Hockberger RS. Spinal injuries. In: Marx J, Hockenberger R, Walls R, editors. Rosen's emergency medicine: concepts and clinical practice. 9th edition. St Louis (MO): Mosby; 2013; with permission.)

injuries are associated with variable degrees of cord injuries, including transient neurologic deficits, central cord syndrome (described later), or complete quadriplegia. Definitive management depends on imaging studies and can include reduction, decompression, and fusion.

Compression injuries

A burst fracture of the lower cervical spine (Fig. 24) is a comminuted fracture of the vertebral body. The nucleus pulposus is forced into the vertebral body from severe compression forces, causing the vertebral body to shatter outward from within.

- Radiographs
  - Lateral view: comminuted vertebral body fracture
  - Anteroposterior view: vertical fracture
- CT imaging
  - Obtain to show the position of the fracture fragments in relationship to the spinal canal
- Stable (all ligaments remain intact)
- Neurologic injury depends on degree of fragment retropulsion into the spinal canal
- Treatment
  - Nonsurgical treatment includes reduction with alignment and immobilization
  - Surgery is indicated for unstable injuries and inadequate closed reduction and decompression

ASSOCIATED INJURIES

Spinal Cord Injuries

A complete spinal cord injury is defined as total loss of sensory and/or motor function below a certain level. If any motor or sensory function remains (eg, sacral sparing), it is an incomplete injury and the prognosis for recovery is significantly better.

- Sacral sparing: persistent perianal sensation, rectal sphincter tone, or great toe flexor movement

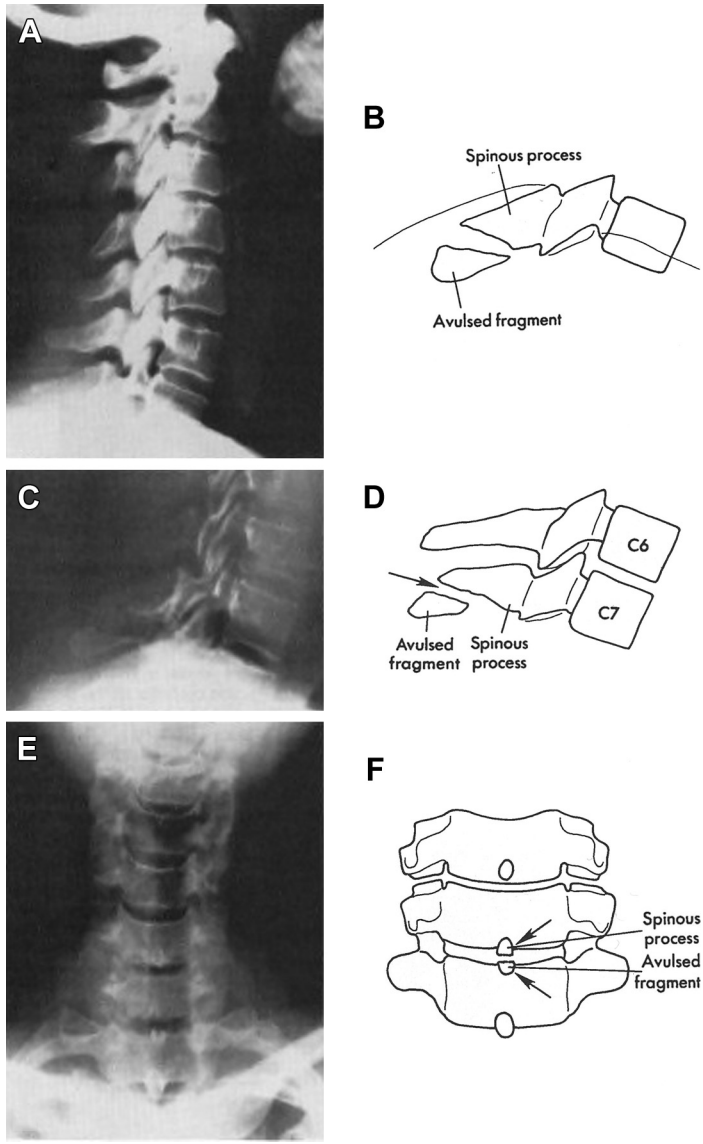


Fig. 21. Clay shoveler's fracture. (*A*, *B*) Avulsed fragment off the tip of the C7 spinous process in underpenetrated lateral view. (*C*, *D*) Avulsed fragment off the tip of the C7 spinous process in coned lateral view. (*E*, *F*) Vertically split appearance of the C7 spinous process confirms fracture in anteroposterior view. (*From* Hockberger RS, Kirshenbaum KJ, Doris PE. Spinal injuries. In: Rosen P, Barkin R, Danzl D, et al, editors. Emergency medicine: concepts and clinical practice. 4th edition. vol. 1. St Louis (MO): Mosby; 1998. p. 468; with permission.)

- Sensory level: most caudal segment with normal sensory function on both sides
- Motor level: lowest level providing key muscle innervation that maintains antigravity strength postinjury (see **Fig. 5**, **Table 1**)

Spinal shock is the flaccidity and loss of reflexes seen after a spinal cord injury.

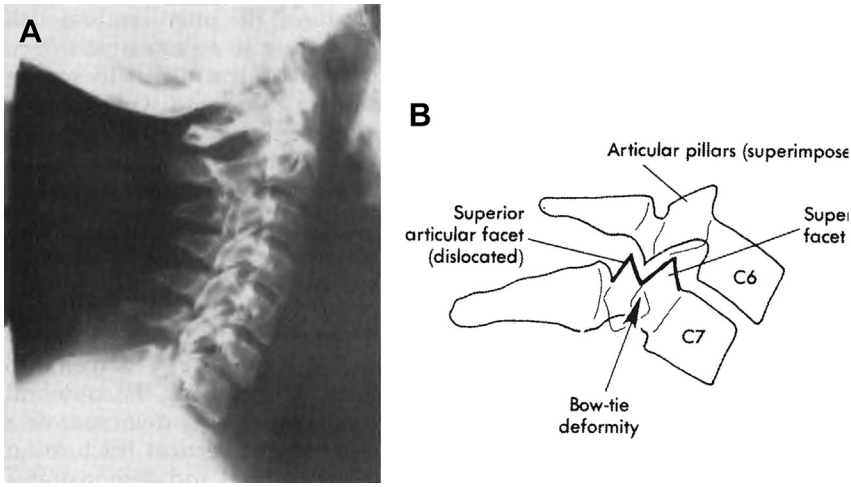


Fig. 22. Unilateral facet dislocation. (*A*, *B*) Dislocated superior articulating facet of C7 forms bow tie deformity with nondislocated superior articulating facet on the lateral view. C6 vertebral body is anteriorly subluxed on the C7 vertebral body. (*From* Hockberger RS, Kirshenbaum KJ, Doris PE. Spinal injuries. In: Rosen P, Barkin R, Danzl D, et al, editors. Emergency medicine: concepts and clinical practice. 4th edition. vol. 1. St Louis (MO): Mosby; 1998. p. 472; with permission.)

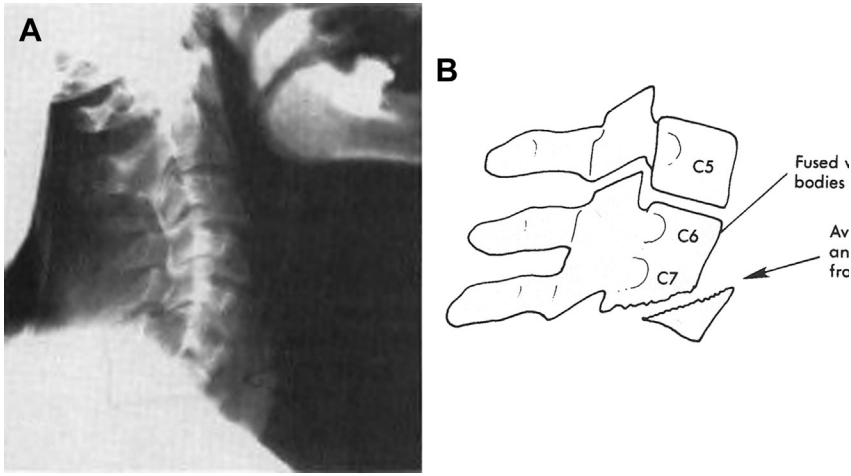


Fig. 23. (*A*, *B*) Extension teardrop fracture. Large, teardrop-shaped fragment has been fractured off the anteroinferior aspect of the C7 vertebral body. This avulsed fragment may be large or small and is caused by a pull on the anterior longitudinal ligament. (*From* Hockberger RS, Kirshenbaum KJ, Doris PE. Spinal injuries. In: Rosen P, Barkin R, Danzl D, et al, editors. Emergency medicine: concepts and clinical practice. 4th edition. vol. 1. St Louis (MO): Mosby; 1998. p. 476; with permission.)

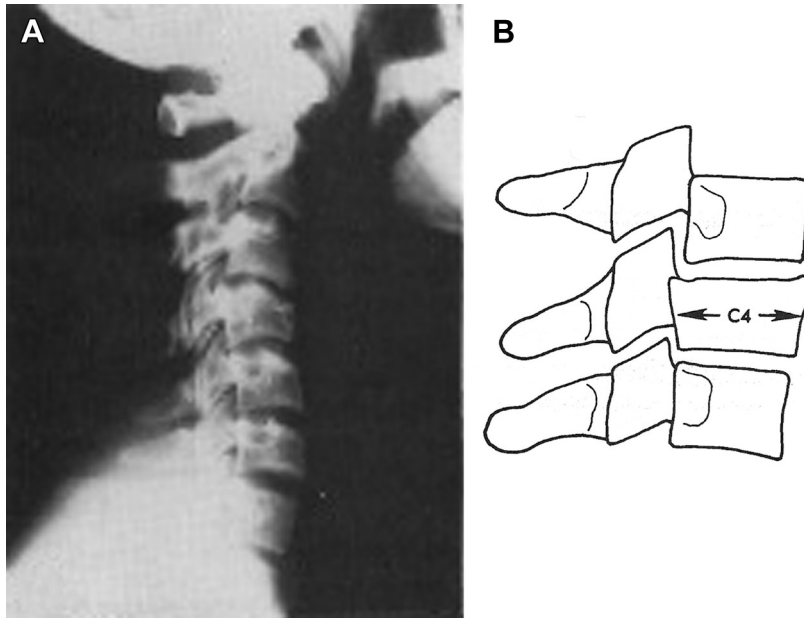


Fig. 24. (*A*, *B*) Bursting fracture of vertebral body. There is a compression fracture of the C4 vertebral body. During the bursting process the anterior aspect of the vertebral body protrudes anteriorly, and its posterior aspect protrudes into the spinal canal. This fracture is often associated with the anterior cord syndrome. (*From* Hockberger RS, Kirshenbaum KJ, Doris PE. Spinal injuries. In: Rosen P, Barkin R, Danzl D, et al, editors. Emergency medicine: concepts and clinical practice. 4th edition. vol. 1. St Louis (MO): Mosby; 1998. p. 477; with permission.)

- May cause an incomplete spinal cord injury to mimic a complete cord injury in the acute setting
- Concussive injury that usually lasts less than 24 hours

Neurogenic shock refers to the state produced by loss of vasomotor tone and sympathetic innervation of the heart.

- Vasodilation leads to hypotension
- No tachycardia or delayed capillary refill

Incomplete spinal cord injuries are often recognized by certain patterns of neurologic involvement, with approximately 90% of incomplete spinal injuries being classified as one of the 3 distinct clinical syndromes (Fig. 25).

- Central cord syndrome
  - Hyperextension injury in a patient with cervical canal narrowing secondary to degenerative arthritis
  - Ligamentum flavum is thought to buckle into the cord causing injury to central gray matter and central portions of pyramidal and spinothalamic tracts
  - Weakness in upper extremities more than in the lower extremities
  - Variable sensory loss
  - The injury can occur with or without cervical spine fracture or dislocation
- Anterior cord syndrome
  - Flexion injuries that result in cord contusion, protrusion of bony fragments, or herniated disks into the spinal canal

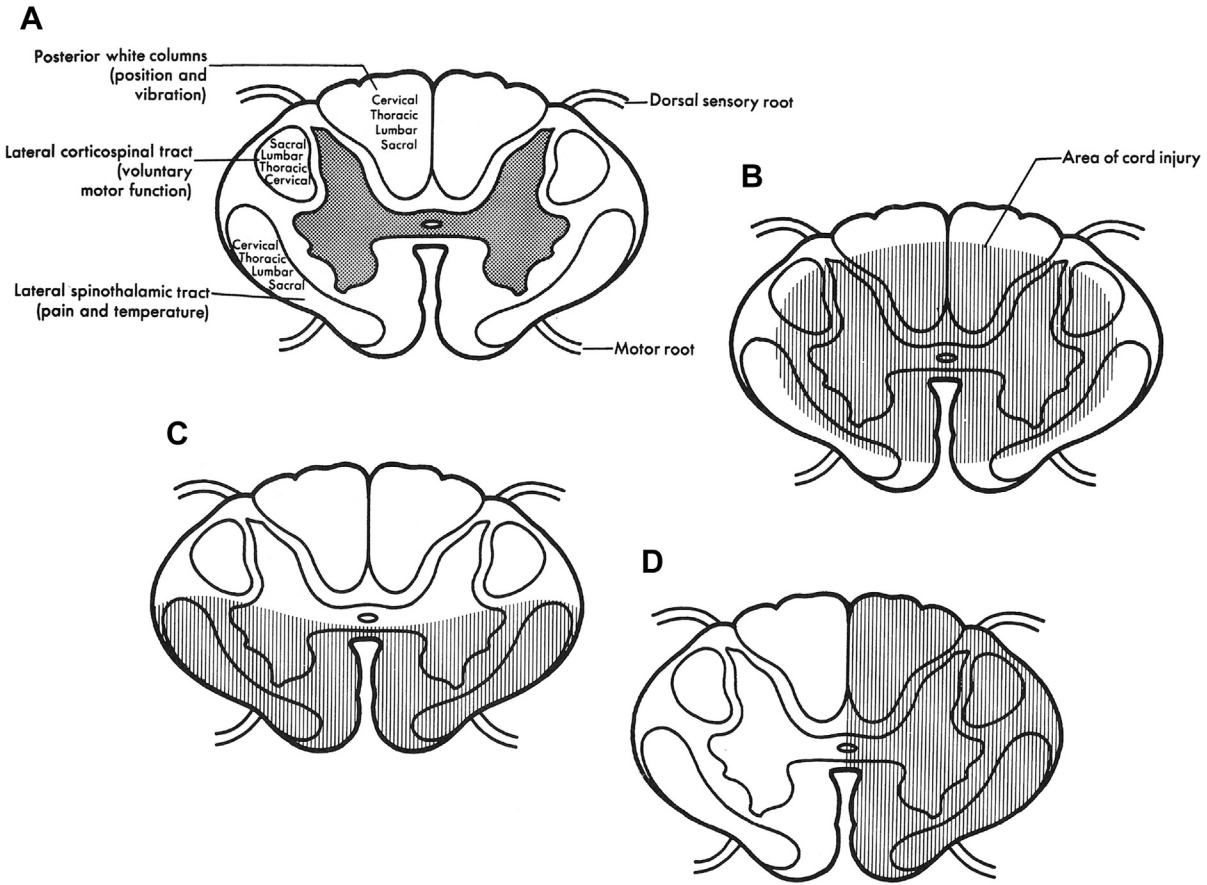


Fig. 25. Incomplete spinal cord syndromes. (*A*) Cervical spinal cord. (*B*) Anterior cord syndrome. (*C*) Central cord syndrome. (*D*) Brown-Séquard syndrome. (*From* Hockberger RS, Kirshenbaum KJ, Doris PE. Spinal injuries. In: Rosen P, Barkin R, Danzl D, et al, editors. Emergency medicine: concepts and clinical practice. 4th edition. vol. 1. St Louis (MO): Mosby; 1998. p. 483; with permission.)

- Anterior spinal artery injury, thrombosis, or laceration causes anterior cord syndrome
- Bilateral paralysis and decreased sensation to painful stimuli below the level of injury, with preservation of posterior column functions
- Poorest prognosis of the incomplete spinal injuries

- Brown-Séquard syndrome
  - Hemisection of the spinal cord
  - Rare; usually resulting from penetrating injuries but can be seen following lateral mass fractures
  - Loss of ipsilateral motor and posterior columns function associated with contralateral sensory loss beginning 1 or 2 levels below the injury
  - MRI is the imaging modality of choice
  - Treatment
    - Directed at the cause (eg, fracture, penetrating or blunt trauma) and recovery of function and depends on the severity and cause of injury

Glucocorticoid and Cooling: Use for Traumatic Spinal Cord Injury

Once considered standard of care, the benefit of methylprednisolone in traumatic spinal cord injury (TSCI) has limited evidence and is the subject of much debate. In animal studies, early use of glucocorticoids reduced spinal cord edema and thus improved neurologic recovery.[51] However, randomized controlled trials have shown limited efficacy and perhaps adverse outcomes in certain patient groups.

- NASCIS II (National Acute Spinal Cord Injury Studies II)[52]
  - Reviewed the 1-year follow-up data of a multicenter randomized controlled trial of methylprednisolone for TSCI
    - Glucocorticoids within 8 hours of injury
      - Modest increased recovery of neurologic function
    - Glucocorticoids more than 8 hours from injury
      - Recovered less motor function than placebo
- NASCIS III[53]
  - Included both complete and incomplete TSCI
  - Compared the 3 treatment groups of methylprednisolone for 24 hours, methylprednisolone for 48 hours, and tirilazad mesylate (lipid peroxidation inhibitor) for 48 hours
  - Treatment within 3 hours of injury
    - Methylprednisolone for 24 hours was most effective
  - Treatment between 3 and 8 hours of injury
    - Methylprednisolone for 48 hours is more appropriate
- Complications of high-dose glucocorticoid therapy
  - Higher risk of infection[54]
  - In 2013, the American Association of Neurological Surgeons and Congress of Neurological Surgeons stated that use of glucocorticoids in TSCI is not indicated[55]
- Cooling for spinal cord injuries
  - In 2011, investigators found improved spinal cord injury outcomes with mild hypothermia in a rat model[56]
  - A recent prospective study was done in 20 patients with neurologically complete spinal cord injury treated with a combination of surgical decompression, glucocorticoid administration, and regional hypothermia
    - Outcomes

- Improved outcomes compared with expected outcomes for these injuries
- Unclear whether the improvements were related solely to cooling

■ Debate
- The appropriate cooling temperature and method are unknown[57]
- Further research is needed to determine the risks and benefits of cooling, as well as the proper timing and temperature

Vascular Injuries

Although vascular injuries (**Figs. 26** and **27**) accompanying blunt trauma to the neck are considered rare, injuries to the vertebral artery,[58] vertebrobasilar circulation,[59] cervical part of the internal carotid,[60] and distal innominate artery[61] have been reported.

- Vertebral artery injuries: 0.9% to 46% of patients with cervical spine fractures
  - Bone fragments found within the foramen transversarium are predictive for vertebral artery injury (**Fig. 28**)[62]
- Consider when a clinically apparent level of neurologic deficit does not correlate with known level of spinal injury or in the patient with cervical spine trauma and altered mental status without an identified brain injury

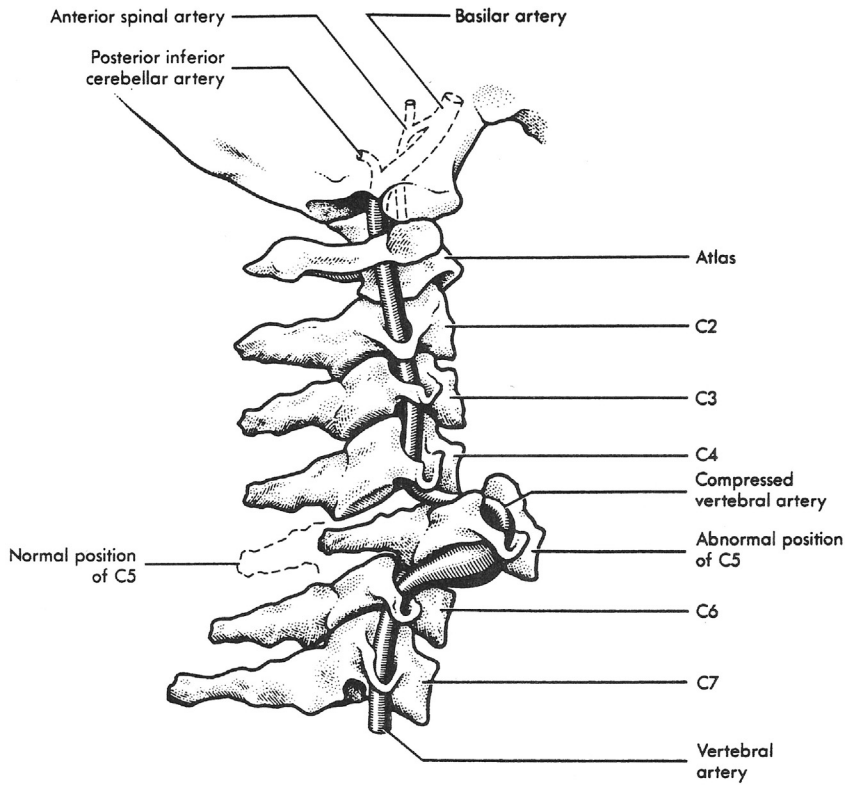


Fig. 26. Mechanism of vascular injury of spinal cord resulting from cervical vertebral injury. (*From* Hockberger RS, Kirshenbaum KJ, Doris PE. Spinal injuries. In: Rosen P, Barkin R, Danzl D, et al, editors. Emergency medicine: concepts and clinical practice. 4th edition. vol. 1. St Louis (MO): Mosby; 1998. p. 480; with permission.)

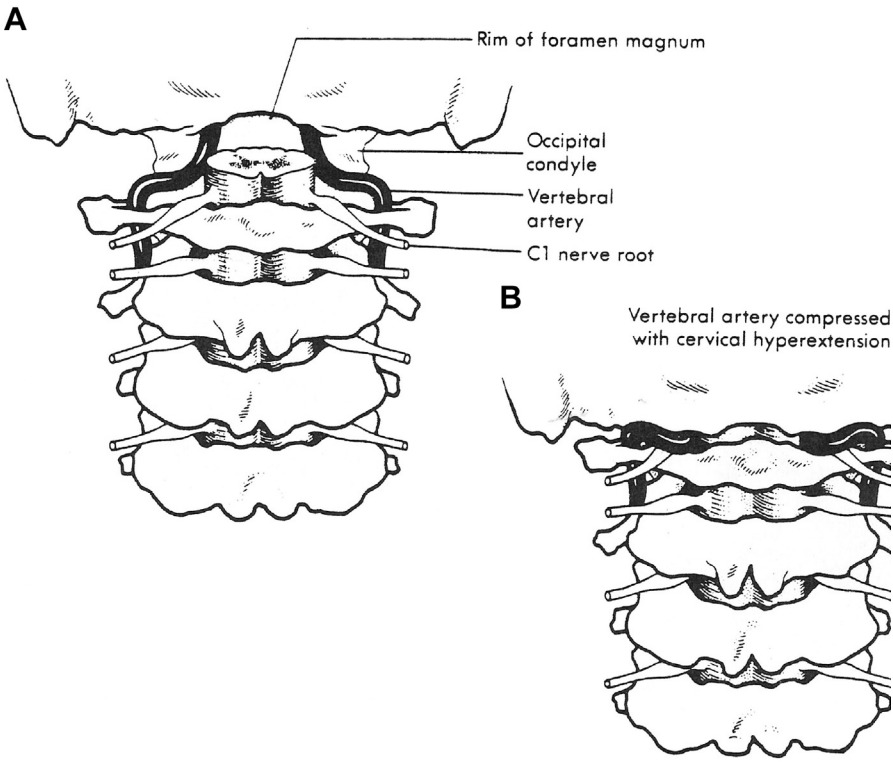


Fig. 27. (*A*, *B*) Mechanism of vertebral artery injury in extension injuries of the cervical spine. (*From* Hockberger RS, Kirshenbaum KJ, Doris PE. Spinal injuries. In: Rosen P, Barkin R, Danzl D, et al, editors. Emergency medicine: concepts and clinical practice. 4th edition. vol. 1. St Louis (MO): Mosby; 1998. p. 484; with permission.)

- Diagnostic imaging
  - MRI, magnetic resonance angiography, or conventional angiography

Soft Tissue Injuries

Soft tissue injuries to the neck following motor vehicle collisions are common. Motor vehicle trauma with a whiplash mechanism occurs approximately 1 million times per year in the United States.[63] The soft tissue neck injury is termed hyperextension strain, acceleration-deceleration injury, hyperextension/hyperflexion injury, cervical strain, cervical sprain, and whiplash. The symptom complex of protracted pain originates from the rich sensory innervation of cervical structures and trauma to muscle groups of this region (**Table 5**).

- Sudden acceleration-deceleration trauma
- Seat belt restraints are effective in reducing the frequency of serious injuries and death; however, cervical strain occurs more frequently in occupants using shoulder belts than in unrestrained occupants[64]
- Pathologic findings have been inconsistent,[65] but several investigators have attempted to better define the mechanism of whiplash injuries[66]
- Treatment

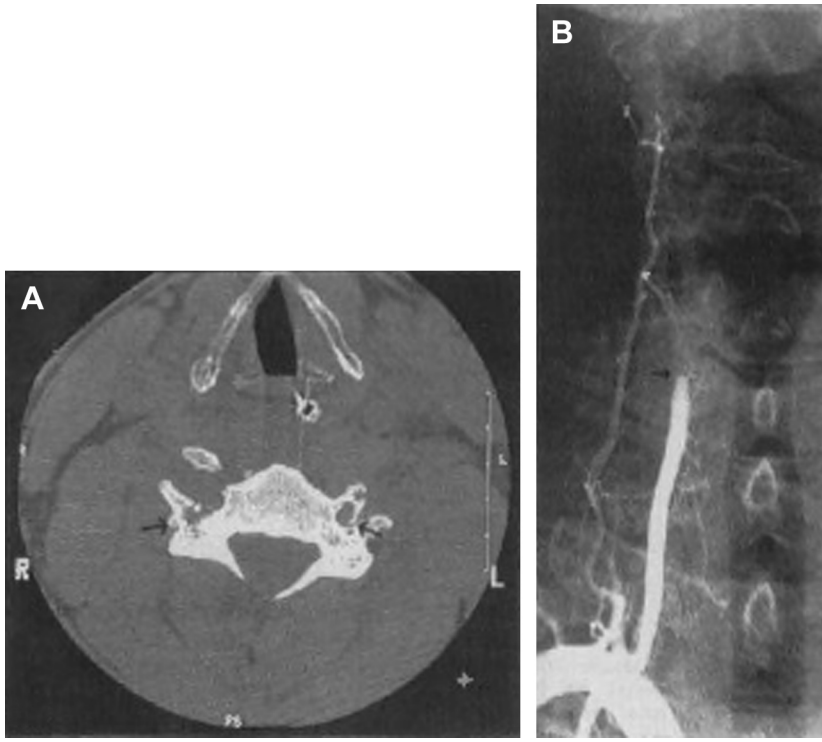


Fig. 28. (*A*) Axial CT image through C5 from a 56-year-old man who sustained a bilateral facet dislocation. He initially presented with a complete quadriplegia and a normal mental status but rapidly had deterioration in mental status. There were bilateral fractures of the foramen transversarium (*arrows*). Bone fragments are present in the right foramen. CT scan of the head was normal. (*B*) Following closed reduction using cranial tongs traction, vertebral angiography showed injury to both vertebral arteries. Complete cutoff of dye is visible in the right vertebral artery (*arrow*). (*From* Finkelstein JA, Anderson PA. Surgical management of cervical instability. In: Capon DA, Hays W, editors. Comprehensive management of spine trauma. St Louis (MO): Mosby; 1998. p. 149; with permission.)

- Rest, analgesics, nonsteroidal antiinflammatory drugs, sedatives, muscle relaxants, and physiotherapy
- Borchgrevnik and colleagues[67] found that patients who were instructed to return to normal preinjury activities had better outcomes than those who received soft neck-collar immobilization and sick leave for 14 days

INJURED ATHLETE

Injuries to the cervical spine can occur in any contact or collision sport or recreational activity.[68] The most common sports associated with vertebral column injury in the United States are football and wrestling, with C5 being the most commonly injured level.[69] Neurologic deficit from cervical spine trauma most commonly occurs in football, wrestling, and gymnastics (**Table 6**). Whether functioning as a team physician, providing sideline coverage for a competition, or evaluating athletes with cervical spine injuries in the ED, EPs should be familiar with particular issues related to on-field evaluation, special immobilization techniques, protective equipment, and return-to-play criteria.

Table 5
Cervical spine musculature

Movement	Muscle
Flexion	Sternomastoid Longus colli Longus capitis Rectus capitis anterior
Extension	Splenius capitis and cervicis Semispinalis capitis and cervicis Longissimus capitis and cervicis Trapezius and interspinales Rectus capitis posterior major and minor Obliquus capitis superior
Rotation and bend	Sternomastoid Scalenes Levator scapulae and multifidi Intercostalis and longus colli Rectus capitis lateralis

From Capen DA. Soft tissue injuries to the spine from acceleration-deceleration trauma. In: Capen DA, Haye W, editors. Comprehensive management of spine trauma. St Louis (MO): Mosby–Year Book; 1998. p. 97; with permission.

Table 6
Frequency and selected characteristics of spinal cord injuries by sport

	Cases		Age (y)		Percentage				
Sport Activity	No.	%	Mean	Range	Male	White	Quadriplegia	Recreation[a]	Skilled[b]
Aquatics	97	66	21	13–47	90	91	99	100	52
Snow sports	9	6	27	17–54	89	89	33	89	50
Football	9	6	20	14–37	100	100	100	67	22
Gymnastics	8	5	18	13–21	88	100	100	88	25
Cycling	7	4	24	14–57	100	100	43	86	43
Equestrian	5	3	28	19–42	100	80	60	60	80
Hang gliding	4	3	38	21–64	75	100	25	100	75
Wrestling	3	2	20	17–22	100	100	100	100	0
Rugby	2	1	21	20–22	100	100	100	0	100
Track and field	1	1	18	—	100	100	100	0	100
Lacrosse	1	1	17	—	100	100	100	100	100
Ice skating	1	1	22	—	100	100	100	100	100
Frisbee	1	1	Unknown	—	100	100	100	100	Unknown
Total	148	100	—	—	—	—	—	—	—
Average	—	—	22	13–64	92	93	91	92	50
sans Aquatics	51	34	23	14–64	94	96	78	78	46

[a] Not a participant in an organized class or team when injured.
[b] Adept in the skills of the sport in which injured.
From Clarke KS. Epidemiology of athletic neck injury. Clin Sports Med 1998;17:87; and *Adapted from* Clarke K. Sport-related permanent spinal cord injuries, 1980–1982. Phoenix (AZ): A report to the National Spinal Cord Injury Data Research Center; 1983.

- On-field assessment
  - Marks and colleagues[68] developed an algorithm for the initial evaluation of the injured athlete (**Fig. 29**)
  - Preparedness should include ensuring availability of proper equipment (eg, spine board, immobilization devices, airway equipment, tools to remove helmets/uniform, and stretcher), and rehearsal and review of team member roles, including assigning a captain to direct the efforts of the medical team.[70]
- Unconscious athletes
  - Should be log rolled into a supine position with someone maintaining in-line C-spine stabilization (**Fig. 30**)
  - Protective equipment (eg, helmet and shoulder pads) should be left in place until adequate immobilization of the head and neck has occurred
- Removal of protective equipment
  - Palumbo and colleagues[71] and Gastel and colleagues[72] used radiographs of cadavers to show that immobilizing neck-injured football players with only the helmet or only the shoulder pads in place causes significant cervical spine malalignment
  - Donaldson and colleagues[73] showed significant cervical spine movements during helmet and shoulder pad removal in a cadaveric model
  - Several expert recommendations describe techniques for helmet removal (See 'Techniques of Helmet Removal,' Available at: https://www.facs.org/~/media/files/quality%20programs/trauma/publications/helmet.ashx),[74] and the overall initial management of athletes with spine injuries (**Fig. 31**)

Management of specific cervical spine injuries and return-to-competition decisions following treatment of these injuries is beyond the scope of this article. However,

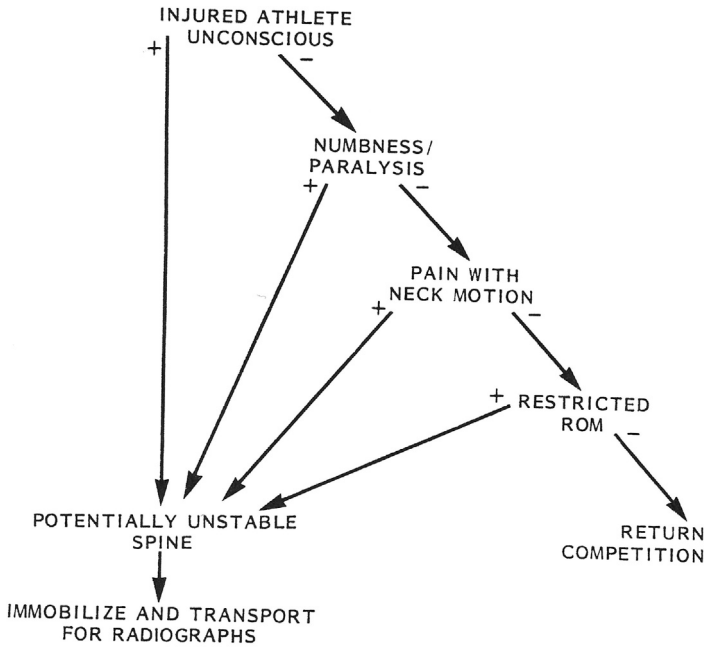


Fig. 29. Evaluation of injured athletes. (*From* Marks MR, Bell BR, Boumphrey FR. Cervical spine fractures in athletes. Clin Sports Med 1990;9:14.)

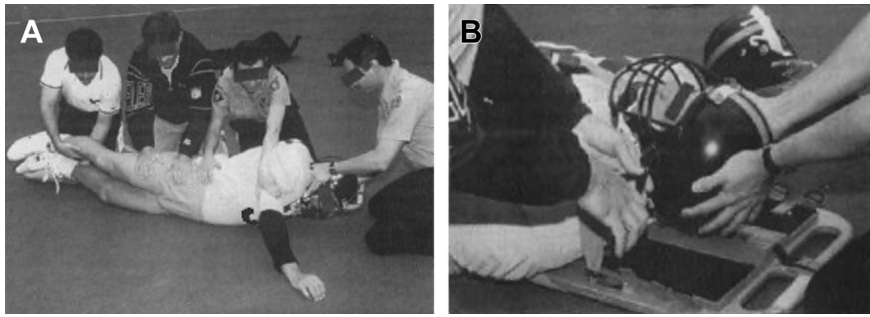


Fig. 30. Proper technique for moving an athlete thought to have a cervical spine injury. (*A*) The player is turned. One member of the medical term is responsible only for ensuring that the neck is maintained in a neutral position. The player is next placed on the long splint board, while every precaution is used to prevent secondary injury. (*B*) Proper technique for immobilizing the athlete's head and neck while another medical team member removes the face mask to gain access to the airway if necessary. (*From* Warren WL, Bailes JE. On the field evaluation of athletic neck injury. Clin Sports Med 1998;17:106.)

Fig. 32 is included for reference; Warren and Bailes[70] describe 3 types of athletic spinal injuries.

- Type I: permanent spinal cord injury
- Type II: transient neurologic deficit after trauma in persons with normal radiographic studies (SCIWORA)
  - Burning hands syndrome: variant of the central cord syndrome
    - Burning paresthesias and dysesthesias in both arms or hands and occasionally in the legs, accompanied by variable weakness[75]
  - Cervical cord neuropraxia
    - Transient quadriplegia has been estimated to occur in 7 out of 10,000 football players[76]
    - Transient conduction block or a concussion of the cord
    - Tingling and weakness in upper and possibly lower extremities with or without neck pain lasting from 15 minutes to 48 hours
    - Recurrence rate is as high as 50% and therefore controversy exists on return to play after this injury
  - Stinger injury (Fig. 32)
    - Traction on the brachial plexus or from compression of the nerve root in the neural foramen following axial compression[77]
    - Unilateral burning dysesthesias from shoulder to hand, with occasional weakness or numbness in the C5 and C6 distribution.
    - Typically lasts minutes but can persist for days to weeks
    - The unilaterality, brevity, and pain-free range of neck motion in the athlete can assist in discriminating between a stinger and a cord injury
      - Some investigators suggest that symptoms that resolve in seconds to minutes may lead physicians to consider same-day return to competition
- Type III: those with radiographic findings (ie, fracture, fracture-dislocations, and ligamentous injuries) but without permanent neurologic deficits
- Continued symptoms, neck pain, incomplete range of motion, or suspicion of more serious neck injury should lead to removal from competition and further evaluation, including radiologic evaluation.[78]

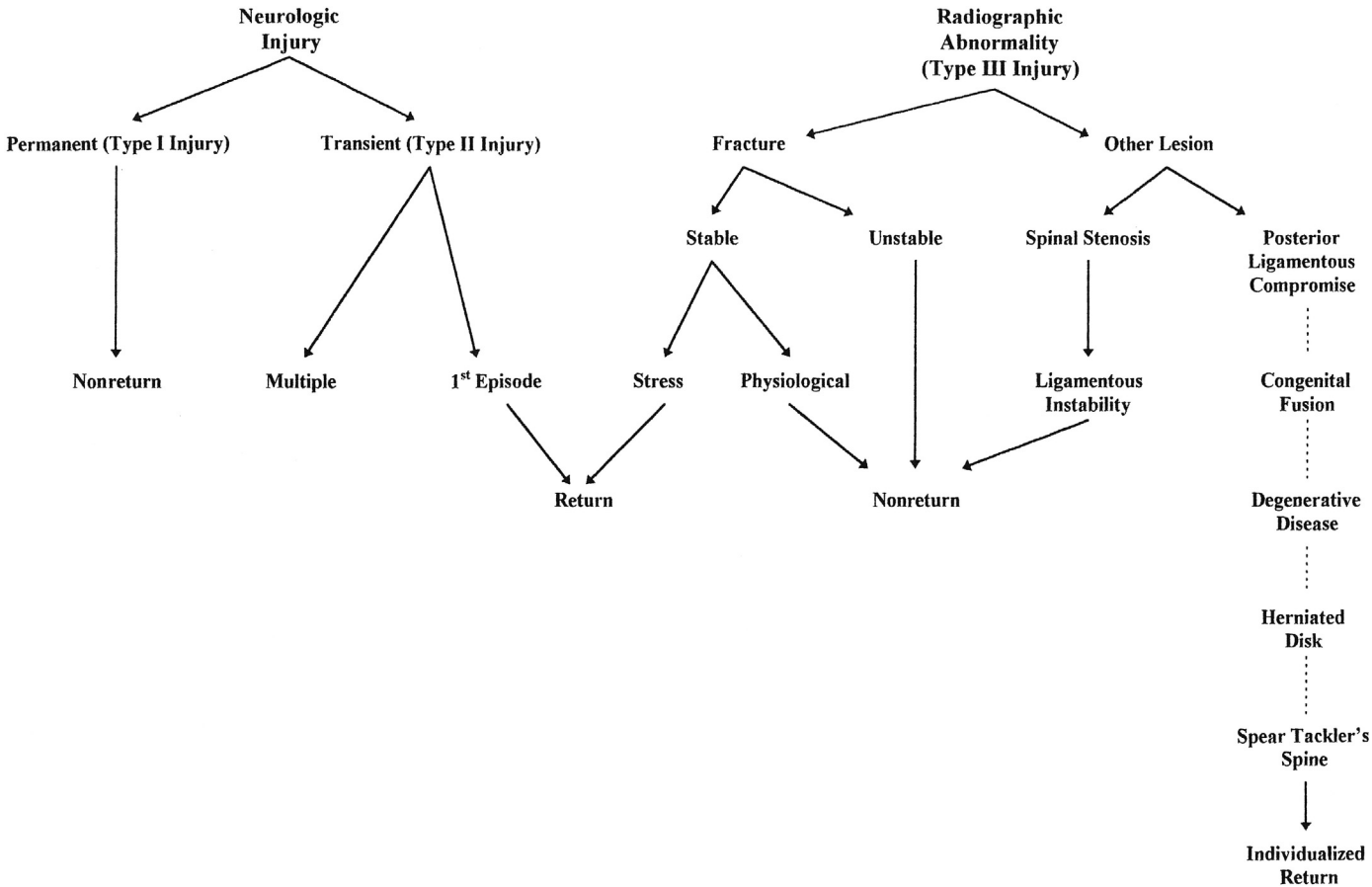


Fig. 31. Management of symptomatic athletic injuries of the cervical spine. (*From* Warren WL, Bailes JE. On the field evaluation of athletic neck injury. Clin Sports Med 1998;17:102.)

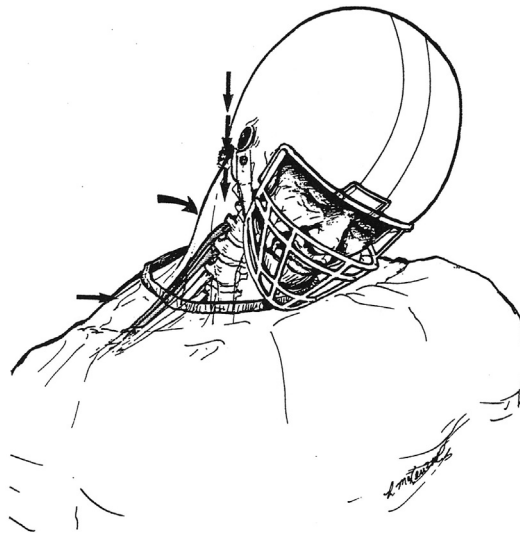


Fig. 32. Stingers or burners are thought to be caused by one of 3 mechanisms: a blow causing the neck to flex laterally away from the side of a depressed shoulder (as in tackling), stretching the upper trunk of the brachial plexus; axial loading of the head producing compression of the nerve root in the neural foramen; or, rarely, a direct blow to the trapezius or shoulder area, resulting in a contusion to the brachial plexus. (*From* Warren WL, Bailes JE. On the field evaluation of athletic neck injury. Clin Sports Med 1998;17:104.)

SUMMARY

EPs must be able to effectively and efficiently manage patients with potential cervical spine injury. The major management principle for patients with trauma with multiple injuries remains cervical spine protection during the initial evaluation and stabilization of the patient with a goal to preventing additional neurologic injury. EPs must have an understanding of the complex anatomy; types of cervical spine injury; and associated neurologic, vascular, and soft tissue injuries to manage this potentially devastating injury positively. EPs must understand the utility and limitations of different radiographic techniques for evaluating the cervical spine to manage these patients efficiently. EPs must understand the potential role of steroids and cooling, and make these decisions in conjunction with the consulting physicians. In addition, EPs who supervise prehospital providers or who function as sideline or team physicians must be aware of the specific issues related to out-of-hospital management of cervical spine injuries and return-to-competition guidelines.

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