Chapter 9
Cervical Spine Fractures/Acute Cervical Spinal Cord Injury

David O. Okonkwo and Harry M. Mushlin

Clinical Scenario

A 31-year-old male presented to the trauma bay after a motor vehicle collision. At the scene, the patient did not report any loss of consciousness. Glasgow Coma Scale (GCS) score was recorded as 15. Per EMS, the patient had no sensation or movement in his lower extremities at the scene and was hypotensive. The patient was also noted to have priapism and be incontinent of stool. On arrival to the trauma bay, the patient had a patent airway, systolic blood pressure >100 mmHg, and regular pulses. FAST (focused assessment with sonography in trauma) examination was negative. He was noted by the surgical trauma team to have antigravity movement of the proximal upper extremities and weakened handgrip, with no movement in the lower extremities. Radiographic assessment by cervical computed tomography (CT) scan demonstrated C6–7 bilateral facet fracture dislocation (jumped facets) and anterolisthesis >50% of C6 over C7 (Fig. 9.1a–c).

9.1 History and Neurologic Exam

The initial assessment of the trauma patient is based on Advanced Trauma Life Support protocols and includes primary assessment of the airway, breathing, and circulation (ABCs). It is of particular importance to address hypotension in the

D. O. Okonkwo (✉)
Department of Neurosurgery, University of Pittsburgh Medical Center, Pittsburgh, PA, USA
e-mail: okonkwodo@upmc.edu

H. M. Mushlin
Stony Brook Neurosurgery Spine Center, Stony Brook, NY, USA
e-mail: harry.mushlin@stonybrookmedicine.edu

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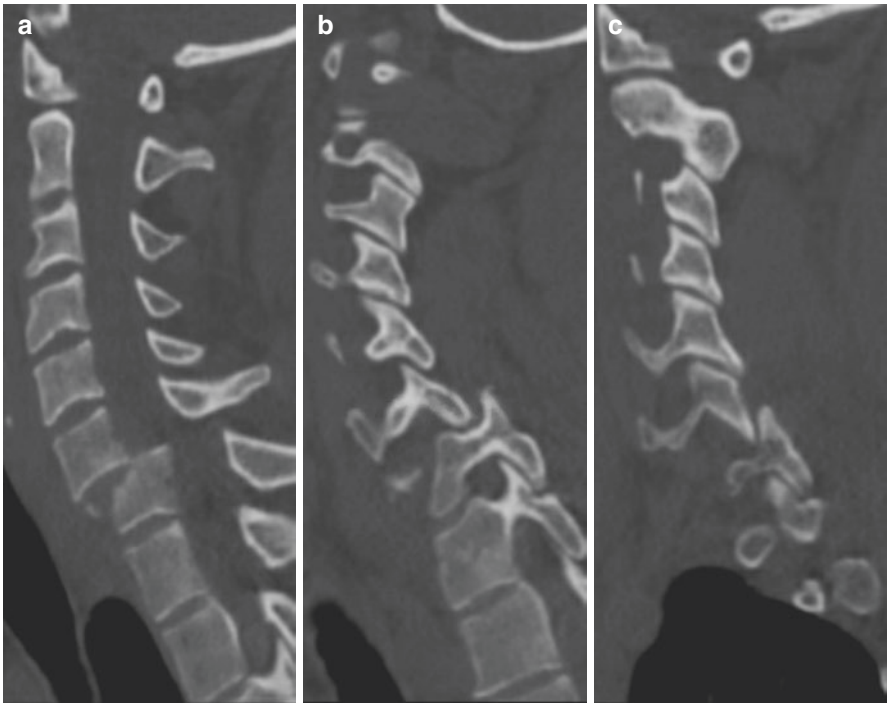

Fig. 9.1 (**a**–**c**) Cervical CT showing bilateral jumped facets. (**a**) Sagittal midline view showing anterolisthesis of C6 over C7; (**b**) sagittal view of left-sided jumped facet atC6/C7; (**c**) sagittal view of right-sided jumped facet at C6/C7

setting of spinal shock and loss of sympathetic tone [1]. Cervical injury patients can, less commonly, have autonomic dysreflexia with resultant hypertension [2]. Noxious stimuli such as an overdistended bladder can lead to a massive sympathetic response. An indwelling urinary catheter should be placed in all patients with suspected spinal cord injury to help prevent this phenomenon.

Once the patient is stabilized from a respiratory and hemodynamic perspective, a more detailed history and physical can be performed. Initial history should include an understanding of the mechanism of injury. Facet dislocations are usually found in the setting of a high-impact trauma, including motorcycle and car collisions and fall from heights [3, 4]. Medical history including medications should be obtained if possible from an awake, alert, and oriented patient. Relevant medications such as antiplatelet/coagulants should be known prior to any surgical planning and properly reversed. A detailed secondary survey including manual palpations for pain, step offs, tenderness, and spinous process gaps is important when evaluating for traumatic spinal injuries.

Patients with cervical facet dislocation can present with a wide range of symptoms from no clinical sequelae to radiculopathy and neck pain to incomplete or complete spinal cord injury [5]. A formal neurologic exam will document motor

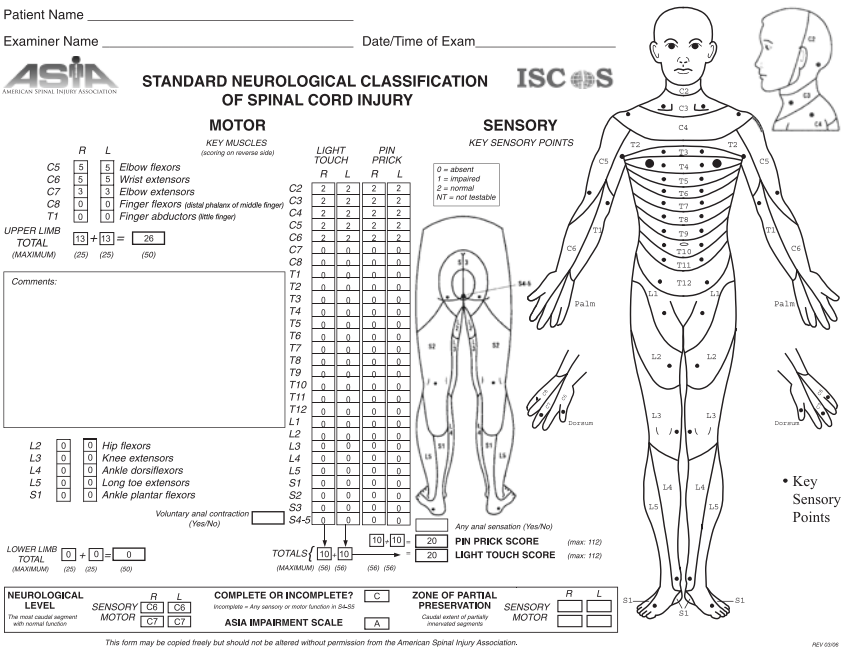

Fig. 9.2 Completed ASIA exam form. Motor level was C7, and sensory level was C6. Neurological level of injury was C6. Patient had a complete injury and was ASIA Impairment Scale Grade A

and/or sensory deficits. A rectal exam must be performed. The exam of the spinal cord injury patient is recorded in accordance with the International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI), using the guidelines set forth by the American Spinal Injury Association (ASIA). A completed ISNCSCI exam is shown in Fig. 9.2. Proper examination can help localize the level of injury prior to imaging and classify the severity of the injury. When spinal shock (temporary loss of sympathetic tone) is suspected, the bulbocavernous reflex should be tested. The absence of the bulbocavernous reflex supports the presence of a spinal shock [6]. A patient must be out of spinal shock before the final determination of whether a patient has a complete versus incomplete spinal cord injury can be made.

9.2 Differential Diagnosis

A detailed neurological exam will determine if there is a neurologic deficit referable to spinal column trauma and, if so, the level of injury. The neurological level of injury is defined as the lowest level of normal motor and sensory function. In the clinical case presented here, a cervical injury was suspected given that the patient was involved in a high-impact collision and had a neurological level of C6. In

general, if there is suspicion of a cervical injury, spinal immobilization should be maintained along with proper spinal precautions for movement and positioning of the patient.

The differential diagnosis of the cervical spinal cord injury patient includes craniovertebral junction injuries—between the occiput and C2—and subaxial cervical spine injuries—from C3 to T1. Neurologic deficits occur more commonly with certain injury morphologies, including atlanto-occipital dislocation, unstable Hangman's fracture, unilateral facet fracture dislocation, bilateral facet fracture dislocation, burst fracture, and teardrop fracture. Type II odontoid fractures are far less likely to induce neurologic deficits, given the relative width of the canal at that level, though these fractures can cause spinal cord injuries in rare cases.

9.3 Diagnostic Evaluation

A detailed neurological exam will determine the level of injury. The neurological level is defined as the lowest level of normal motor and sensory function. In the clinical case presented herein, a cervical injury was suspected given that the patient was involved in a high-impact collision and had a neurological level of C6. In general, if there is suspicion of a cervical injury, spinal immobilization should be maintained along with proper spinal precautions for movement and positioning of the patient.

Standard of care in the trauma evaluation is to obtain a high-quality CT scan for imaging assessment as recommended by the *2013 Guidelines for the Management of Acute Cervical and Spinal Cord Injuries* [7]. The injury morphology cannot be determined without proper imaging. Plain radiographs were traditionally used for the assessment of cervical spine trauma; however, CT scans have supplanted X-rays given the substantial superiority of CT for injury evaluation [8]. CT scans provide detailed understanding of injury morphology. In addition to osseous evaluation, CT can reveal distraction in the anterior and posterior column or suggest ligamentous damage. In our clinical scenario, the CT scan showed C6-7 bilateral jumped facets with a C6 laminar fracture and C7 superior end plate fracture (Fig. 9.1a–c).

The injury morphology classification can be determined from CT imaging and will guide appropriate surgical intervention. There have been multiple proposed classification systems. The AO Spine Subaxial Cervical Spine Injury Classification System is a more recent system that also guides clinical decision-making. In the case presented, the facet fracture dislocation is classified as Type C (translational) injury [9]. The Subaxial Cervical Spine Injury Classification (SLIC) system includes a point-based system assessing morphology, discoligamentous complex, and neurological status to inform surgical intervention [10].

In cases of bilateral jumped facets, the utility of MRI has been widely debated [11]. The patient with an acute neurologic deficit secondary to cervical spine trauma is best served with early decompression. MRI can delay surgical intervention and,

thus, should be obtained judiciously [12]. Postoperative MRI can document spinal cord injury and confirm successful surgical decompression.

The necessity of MRI prior to closed reduction, regardless of level of consciousness, has been proposed by some authors [13], largely based on the theoretical risk of neurological worsening after reduction in the setting of cervical disk herniation and limited case reports of neurological deterioration after reduction [14]. However, Gelb et al., in their 2013 guidelines on cervical dislocation, found only two documented cases of neurological worsening after attempted closed reduction for cervical dislocation [15, 16]. Multiple studies have reported the safety of closed reduction in awake and alert patients without a pre-reduction MRI [17–19]. In one series from Grant et al., 22% of 80 dislocated cervical patients had an associated disk herniation on post-reduction MRI, but there were no cases of neurological worsening following closed reduction [20]. An additional series from Koivikko et al. reported no neurological deterioration in 65 dislocated patients with no pre-reduction MRI [21]. In 2006, Darsaut et al. showed that soft disk herniations seen on pre-reduction MRI were reabsorbed as seen on post-reduction MRI [22]. In the case of unsuccessful closed retraction or an uncooperative/obtunded patient, a cervical MRI can be obtained prior to open reduction.

In addition, patients with cervical spine injury should undergo evaluation for blunt cerebrovascular injury (BCVI) as recommended by the Denver Criteria [23]. This patient's vascular studies were negative for BCVI. Studies have shown that up to 24% of patients with cervical spine injuries also have a vertebral artery injury [24]. Patients with jumped facets and translocation are at the highest risk for BCVI of the vertebral artery, and delayed therapy places patients at increased risk of stroke. Antiplatelet/anticoagulation medication should be started as soon as deemed safe.

9.4 Clinical Decision-Making and Next Steps

After initial stabilization based on ATLS protocols, the cervical spinal cord injury patient should have an arterial line and indwelling urinary catheter placed. The mean arterial blood pressure (MAP) goal is set at >85 mmHg [25]. More recent evidence supports the placement of a lumbar drain, measurement of intrathecal pressure, and management of SCI in accordance with spinal cord perfusion pressure goals (SCPP >15 mmHg).

In our clinical scenario, CT imaging demonstrated bilateral jumped facets (Fig. 9.1a–c), which requires immediate reduction. Traction has been recognized as a quick and safe technique for closed reduction. In addition, timely reduction has been shown to decompress the spinal cord and improve neurological outcomes and is a recommended option in the AANS/CNS *Guidelines for Management of Acute Cervical Spine and Spinal Cord Injuries* [26–31]. This technique can be applied to the awake and alert patient.

Closed reduction is accomplished using traction in the flexion-distraction vectors. Closed reduction has been shown to be successful up to 70–90% of the time

[13, 32]. Closed reduction is more successful in the setting of bilateral jumped facets than with unilateral fracture dislocations. Traction can be applied with a halo device or, more commonly, Gardner-Wells tongs. It is critical to ensure the forces applied are in the proper vector or risk of further distraction and injury can occur. Fluoroscopy should be utilized frequently as weight is added during traction. It is important to assess for over distraction on imaging. Neurological assessment should be performed frequently, and closed traction should be aborted with any exam changes. Traction should begin with low weights, with the sequential addition of 5–10 lb. Once alignment is attained, the weight can be reduced, and the patient can be placed in light extension to prevent loss of reduction.

If closed reduction is not attempted or is unsuccessful, an open reduction is performed either through a posterior or anterior approach. As mentioned above, MRI can help dictate the approach if there is concern for extruded disk fragment which could favor an anterior approach. However, there is a lack of expert consensus for the appropriate open reduction approach. This was highlighted by Spine Trauma Study Group which surveyed its members and found a poor surgical agreement (kappa <0.1) for management of cervical dislocation [33].

At our institution, closed reduction is not typically attempted for bilateral facet fracture dislocation. Patients are immediately taken to the operating room from the trauma bay for posterior reduction and fixation. We believe this allows the fastest time to cervical reduction within our hospital. Posterior reduction and fixation have been shown to be a successful procedure for realignment and fusion [30]. Furthermore, multiple biomechanical studies have shown the superiority of posterior stabilization over anterior plating [34, 35]. Posterior, open reduction can be achieved by drilling an adequate amount of the superior articulating process to allow for leveraging of the inferior articulating process over the superior articulating process. Due to high biomechanical instability of bilateral facet dislocations, we support multiple level fixation above and below the level of dislocation. In addition, laminectomies should be performed at the site of injury to ensure adequate decompression of the injured spinal cord and prevent compression from anterior pathology. In most cases, we also perform a second, anterior approach, typically in a delayed fashion a few days later, to achieve a 360° fusion and maximize biomechanical stability of the construct.

An anterior approach may also be considered as a standalone intervention for bilateral cervical facet fracture dislocations. The anterior approach has been shown as viable option for both reduction and fixation [36–38]. This approach requires distraction and posterior maneuvering of the cephalad vertebral body which can be accomplished with the use of laminar spreaders or Caspar pins.

A prospective, randomized trial of unstable cervical injuries found no significant difference in fusion rates, alignment, and neurological recovery between posterior and anterior approaches [39]. However, additional work has shown that in the setting of cervical dislocation, 13% of anterior-only cases had postoperative loss of alignment [40]. This concern for loss of alignment in highly unstable dislocations injuries has led to expert support for additional posterior fixation after anterior

approach [41, 42]. Technical difficulty of anterior reduction has also been reported with failure of reduction as high as 25% reported [43].

In this clinical scenario, the patient has bilateral C6–7 facet dislocation with >50% anterolisthesis. This is a three-column injury, with significant disruption of the anterior and posterior tension band. We recommend a circumferential fusion and decompression in patients with bilateral jumped facets. Biomechanical studies have shown the superiority of circumferential fusion in three-column injuries [42, 44]. Unilateral facet dislocations and perched facets do not represent the same severity of injury as a bilateral dislocation and may be managed with a single approach (either anterior or posterior). In addition, patients may have underlying medical conditions, such as diffuse idiopathic skeletal hyperostosis (DISH), ankylosing spondylitis, and osteoporosis, which may warrant long posterior or circumferential fixation for additional stabilization.

The patient in this vignette underwent posterior open reduction with fixation from C5 to T1 and a multiple level cervical laminectomy. The patient subsequently had an anterior discectomy and fusion from C5 to C7 (Fig. 9.3). A postoperative MRI was obtained to show the extent of decompression and spinal cord injury (Fig. 9.4).

Fig. 9.3 Lateral cervical X-ray demonstrating cervical realignment with anterior and posterior fixation for treatment of bilateral jumped facets

Fig. 9.4 Postoperative T2-weighted sagittal MRI showing circumferential decompression and myelomalacia at the level of injury

9.5 Clinical Pearls

- Cervical facet dislocation injuries should be reduced as quickly as possible (whether open or closed reduction) to achieve decompression of the spinal cord.
- There is a lack of consensus for open reduction approach (posterior vs anterior surgery).
- Circumferential fusion should be strongly considered for bilateral cervical jumped facets.

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