Chapter 2
Cervical Spine Clearance

Andrew K. Simpson and Mitchel B. Harris

Keywords  Cervical spine clearance  •  Cervical spine trauma initial management  •  Clinical assessment of cervical spine injury  •  The Advanced Trauma Life Support (ATLS) protocol  •  Asymptomatic  •  Temporarily non-assessable  •  Symptomatic  •  Obtunded

GB: 25-Year-Old Male with Neck Pain

Case Presentation

GB is a 25-year-old male who presents after an all terrain vehicle (ATV) accident. At the scene the patient demonstrates a GCS score of 12 complaining of chest pain and is placed in a cervical collar. The patient presents to the local emergency room via EMS. On primary survey the patient demonstrates a flail chest and is hemodynamically unstable. In the trauma bay the patient is intubated and stabilized hemodynamically. His CXR demonstrates multiple rib fractures and a hemothorax. A left-sided chest tube is placed. Secondary survey is negative.

Past medical and surgical history are unremarkable. The patient has no allergies and negative family history.

Andrew K. Simpson, M.D., M.H.S. (✉)
Harvard Combined Orthopedic Surgery, Massachusetts General Hospital,
87 W Cedar St. Apt. 1B, Boston, MA 02114, USA
e-mail: aksimpson@partners.org

Mitchel B. Harris, M.D., F.A.C.S.
Orthopedic Trauma, Department of Orthopedic Surgery, Harvard Medical School,
Brigham and Women’s Hospital, 75 Francis St, Boston, MA 02115, USA
e-mail: mbharris@partners.org
A.K. Simpson and M.B. Harris

On physical examination the patient is moving all four extremities spontaneously. Consultation is requested regarding clearance of the Cervical Spine. X-rays and CT scan images are demonstrated (Figs. 2.1, 2.2, and 2.3).

Fig. 2.1 (a) AP radiograph C-spine, (b) Lateral radiograph C-spine

Fig. 2.2 (a) Coronal CT spine, (b) Sagittal CT spine
Interpretation of Clinical Presentation

This case presents the challenges of cervical spine clearance in the multiply injured, cognitively compromised trauma patient. Cervical spine injuries occur in approximately 1% of the more than 13 million blunt trauma patients who present annually to emergency rooms in the United States and Canada [1, 2]. The timely (early) detection of these injuries is important as undetected injuries have a higher incidence of subacute neurologic compromise [3]. Additionally, prolonged spinal immobilization can cause several complications including respiratory deterioration, dysphagia, and venous thromboembolism [4]. Therefore, the primary goal of cervical spine evaluation and clearance in trauma patients is to accurately and rapidly confirm the absence of a clinically significant spinal injury, while at the same time utilizing evaluation methods sensitive enough to accurately identify those patients that specifically require immobilization or operative stabilization.

Initial Management and ATLS

The objective in the initial management of trauma patients is to identify limb and life-threatening conditions/injuries and initiate interventions while maintaining strict spinal precautions. The Advanced Trauma Life Support (ATLS) protocol, developed by the American College of Surgeons, presents a reproducible algorithm for rapidly identifying and initiating interventions for limb and life-threatening injuries [5]. ATLS protocol dictates that all patients should be presumed to have a cervical spine injury until proven otherwise. “Spine precautions” should be initiated.
at the scene of the injury by emergency medical services personnel and include application of a hard cervical collar, maintenance of the patient in a supine position, and log roll precautions. Spine precautions should then be maintained until a secondary evaluation is performed by a qualified examiner, which can be an emergency room physician, trauma team surgeon, or spine specialist [5].

Clinical Assessment and Examination

Clinical assessment and examination of the trauma patient is perhaps the most critical aspect of cervical spine clearance. Spinal evaluation often begins concurrently with other resuscitative measures in the emergency department. The assessment generally begins with receiving the following: “scene of the accident” reports from EMS personnel regarding injury mechanism, initial condition and complaints of the patient, GCS at the scene, as well as vitals and associated injuries. The medical evaluation begins with the observation of spontaneous extremity movement; however, complete spine evaluation and neurological examination should quickly follow required resuscitation.

The first priority is assessment of a patient’s mental status and his/her ability to provide a history and examination, as further management is predicated upon not only the examination itself, but also the reliability of the examination. The ATLS algorithm provides guidelines for cervical spine clearance based on the patient’s symptomatology, ability to provide an objective and reliable examination, and hemodynamic stability. Based on these criteria, patients are categorized in one of four groups: (1) asymptomatic, (2) temporarily non-assessable, (3) symptomatic, and (4) obtunded. Patients who are awake, alert, sober, and without distracting injuries can provide evaluating clinicians with the most useful information. The ideal assessment begins with a thorough patient history addressing pre-injury function, preexisting spinal conditions, specific recollection of the trauma, and presence of pain or tenderness throughout the head, neck, or thoracolumbar spine. Specific questioning regarding motor and sensory function, even transient weakness, numbness, or paresthesias is important as it may be indicative of an unstable spine injury.

Examination of the spine begins with inspection and palpation of the neck and back. Palpation should proceed in the midline from the occiput to the sacrum. Findings which may indicate injury include focal tenderness, crepitus, and step-off or gapping of the spinous processes. Palpable manifestations of spinal injury are often subtle, and while the absence of any tenderness is a helpful finding, the presence of tenderness, however, is non-specific.

A comprehensive neurologic assessment is required for all patients with suspected spinal injury. This includes sensory and motor testing of all four limbs [6]. An accurate and reliable neurological examination is often challenging in the trauma patient with extremity injuries. It is vital that the sensory examination include rectal examination and examination of perineal sensation. Sacral sensory or
anal sphincter function, in addition to distal lower extremity motor function, is important in predicting recovery of neurologic status in the “incomplete spinal cord injury” [7, 8].

In the asymptomatic, awake, and alert patient, with a normal neurological examination, range of motion (ROM) can be assessed with the Canadian cervical spine functional test, which has been shown to have very high sensitivity for unstable cervical spine injuries [2, 9–11]. In this test, rotation and subsequently flexion and extension are tested. First, the patient is asked to rotate his or her head 45° to the left and right. If no symptoms are elicited, the patient is then asked to flex and extend their head. Patients who are asymptomatic, awake, and alert, and have a normal neurologic and functional ROM testing can be clinically cleared without radiographic evaluation [12–16].

However, in patients with midline cervical tenderness or painful motion, as well as in those patients who have distracting injuries or an altered mental status, a screening cervical spine commuted tomography (CT) scan is indicated [17].

In the initial management of patient GB, he was placed in a cervical collar by Emergency Medical Services. In the trauma bay, his flail chest and hemodynamic instability necessitated intubation. Based on his injuries and altered mental status, patient GB would be classified in the obtunded or otherwise unable to clinically evaluate category. The prevalence of clinically occult cervical spine injuries in obtunded patients is 8%, which is three times more likely than in alert trauma patients [18].

The imaging presented in this case is a cervical CT and dynamic radiographs. The cervical spine CT demonstrates overall normal alignment without listhesis and no significant boney injury. A closer look at the CT between C6 and C7 demonstrates a subtle crack in the most anterior superior aspect of C7 and a disruption in the ossified annulus at the posteroinferior aspect of C6, which may represent a ligamentous injury.

Perhaps the greatest debate in the evaluation of the cervical spine in obtunded patients is whether a normal CT scan is sufficient for cervical spine clearance, or whether magnetic resonance imaging (MRI) or another imaging study is also warranted. Many studies have documented that somewhere between 10 and 30% of patients with a “normal” cervical CT scan will have abnormalities demonstrated on MRI [19–21]. The clinical significance of these abnormalities has not been entirely borne out. Specifically, MRI of the acutely post-traumatic spine often demonstrates some abnormalities, though the majority of these abnormalities do not require intervention or immobilization. As a result, some protocols allow for “C-spine clearance” in obtunded patients with negative CT scans while others require an additional study such as an MRI, a normal and reliable physical examination, or adequate dynamic studies prior to cervical spine clearance. The latter often occurs in the subacute stages, in outpatient clinic follow-up.

Patient GB underwent dynamic radiographs. Dynamic lateral cervical spine radiographs may demonstrate cervical instability, which would manifest as listhesis or relative anteroposterior translation of adjacent vertebral bodies. The flexion-extension films presented here do not demonstrate any listhesis or other signs of instability.
Declaration of Specific Diagnosis

GB is a 25-year-old multiply injured patient who was placed in a field collar and subsequently intubated secondary to a flail chest and hemodynamic instability. GB requires cervical spine clearance and is currently pharmacologically obtunded.

Brainstorming: What Are the Treatment Goals and the Surgical Options?

Treatment goals consist of the following objectives:

1. Immobilization of the spine with a cervical collar and log roll precautions initiated at the scene.
2. Presumption of a cervical spine injury until proven otherwise.
3. Accurately and rapidly confirm the absence of a clinically significant cervical spine injury where one does not truly exist.
4. Early detection and treatment of the acute cervical spine injury, especially those associated with an incomplete neurologic deficit or those felt to be clinically unstable.

Diagnostic options include:

1. Clearance without imaging in selected group of asymptomatic patients
2. Plain radiographs
3. Dynamic radiographs
4. Upright radiographs
5. Computed tomography (CT)
6. Magnetic resonance imaging (MRI)

Evaluation of the Literature

In order to identify relevant publications on cervical spine clearance, a PubMed search was performed with the following keywords: “cervical spine,” “trauma,” and “clearance.” This search identified 159 articles which were reviewed. The search was limited to articles published from 1975 to the present.

Detailed Review of the Pertinent Articles

Cervical spine clearance is required in all trauma patients with a reasonable mechanism of injury, and as such is a common issue facing emergency medicine and trauma surgeons. The following discussion addresses the epidemiology of cervical
injuries, ATLS guidelines, classification of patients, and corresponding diagnostic and management protocols.

**Epidemiology of Cervical Spine Injuries**

The reported incidence of cervical spine injuries in blunt trauma patients who present to emergency rooms ranges from 1 to 6% in various studies, with even higher numbers reported in the multiply injured patient [2, 22, 23]. The cervical spine is the most commonly injured region of the spinal column, accounting for more than half of all spine injuries. There are several risk factors for cervical spine injury in trauma patients. Cervical spine injuries occur more commonly in patients greater than 50 years of age, after higher energy mechanisms, and in those patients with associated head injuries [24]. Cervical spinal cord injuries are relatively uncommon, occurring in less than 50 cases per million persons per year [23]. Spinal cord injury predominately occurs in younger male patients with an average age of 25 years and a 4:1 male to female gender ratio [25, 26].

**Classification of Patient Types and Corresponding Management**

Anderson et al. recently reviewed cervical spine clearance in blunt trauma patients and classified patients based on their symptoms and ability to provide a reliable evaluation [27]. Patients are acutely categorized into one of four groups: (1) asymptomatic, (2) temporarily nonassessable, (3) symptomatic, and (4) obtunded. Each of these patient groups has its own algorithm for cervical spine clearance.

**Asymptomatic**

Large prospective clinical studies and meta-analyses have demonstrated that clearance of the cervical spine in asymptomatic patients can be accomplished based on clinical evaluation alone and does not require imaging studies [13, 27]. Stiell et al. prospectively studied a cohort of almost 9,000 trauma patients, asking physicians to document 20 clinical findings prior to radiographic evaluation of the C-spine to determine clinical and exam findings predictive of cervical spine injury or lack of injury. They derived the resultant model, known as the Canadian C-spine rule, which was found to have 100% sensitivity for clinically significant cervical spine injuries. Anderson et al. performed a meta-analysis of prospective studies evaluating the clinical clearance of the cervical spine in asymptomatic patients and found an overall sensitivity of 98.1% for the detection of cervical injury based on clinical exam, including a functional ROM test.
There are two main protocols for cervical clearance in the asymptomatic patient that have been and continue to be widely utilized: (1) National Emergency X-Radiography Utilization Study (NEXUS) Low-Risk Criteria (NLC) and (2) Canadian Cervical-Spine Rule (CCR). The NEXUS method requires that all of the following criteria are met for a patient to be cleared without imaging: awake patient with normal level of alertness; no history, signs, or laboratory evidence of distracting injury; no evidence of intoxication; no focal neurologic deficit; no cervical spine pain or midline tenderness. The NEXUS criteria were established in 1992, and demonstrated 99.6% sensitivity and 12.9% specificity for cervical spine injury in a large US validation study \[12, 28–30\]. The central drawback of the NEXUS system is its low specificity, meaning that although it is a good screening test in terms of detecting injury, there are a large number of patients receiving diagnostic imaging that do not have any injury. Given that such a large number of blunt trauma patients present to emergency departments around the world, this equates to a large number of unnecessary radiographic studies and exaggerated health care costs.

The Canadian C-Spine Rule (CCR) was developed from a multicenter study following almost 9,000 blunt trauma patients \[31–33\]. As mentioned above, the CCR was established by having physicians prospectively evaluate trauma patients for 20 different criteria, looking at the correlation between these criteria and findings on cervical imaging studies to determine which clinical and exam findings were predictive of radiographically proven cervical injury. The CCR is based on three high risk criteria, five low-risk factors, and an active ROM test. The first criteria evaluate if the patient is high enough risk that imaging should be obtained. These criteria include: age greater than 65, dangerous injury mechanism, and extremity paresthesias. Patients who satisfy these criteria require imaging. The second criteria are low-risk factors that, if present, suggest that the patient is low enough risk to proceed with active ROM testing. Low-risk factors include low speed, rear-end motor vehicle collision, patient comfortably sitting up in the emergency room, history of ambulating after the injury, delayed onset of neck pain, and absence of midline cervical-spine tenderness. In patients with no high-risk factors and the presence of at least one of the low-risk criteria, active ROM testing is performed by asking the patient to turn their head 45° to the left and right. Patients who can perform adequate active ROM without pain can have their cervical spines cleared clinically without imaging. Stiell et al. reported the sensitivity and specificity of CCR testing as 100 and 42%, respectively, demonstrating a significantly higher specificity than the NEXUS protocol \[13\]. Steill et al. published another prospective cohort study in the New England Journal of Medicine in 2003 comparing the NEXUS protocol to the Canadian C-Spine Rule in over 8,000 patients. 394 physicians performed CCR and NEXUS criteria and the sensitivity and specificity of these tests were compared for detection of cervical spine injury. Results confirmed that the CCR was both more sensitive (99.4 vs. 90.7%) and more specific (45.1 vs. 36.8%) than the NEXUS protocol \[11\]. Como et al. and Hadley et al. have both performed systemic reviews of cervical spine clearance, with review of over 50 articles from MEDLINE published between
1998 and 2007, and found that there was Level I evidence supporting removal of cervical collar without imaging studies in awake, alert, asymptomatic patients who have full painless active ROM [16, 34].

**Temporarily Nonassessable**

Temporarily nonassessable patients have a transient inability to provide a reliable examination. These patients are expected to resume their baseline cognitive function and be evaluable within 24–48 hours. Harris et al. reported on this group of patients and found that most common factors in the category of temporarily nonassessable are drug/alcohol intoxication, concussion, or pain from distracting injuries [35]. Given that patients’ cognitive recovery is unpredictable, this group of patients is inherently poorly-defined and treatment recommendations therefore remain vague. Once the patient has regained adequate cognitive function and is deemed clinically asymptomatic after a comprehensive examination, he or she can be treated as such and cleared clinically without imaging. If a patient is presumed to regain his or her normal baseline cognitive function within the 24–48 h time period but cervical clearance becomes more urgent, such as when surgical intervention is required for other injuries, the individual can be evaluated as an obtunded patient with advanced imaging. The most common guideline for this patient population is to have them undergo a multi-detector CT scan and/or maintain their cervical collar.

**Symptomatic**

Symptomatic patients are those with neck pain, tenderness, or neurologic symptoms. This subgroup requires spinal imaging. The various imaging options include static and dynamic plain radiographs, CT, and MRI. Each of these various imaging methodologies has specific advantages and disadvantages, not only in regard to sensitivity and specificity but also in terms of timing and cost.

Plain radiography is one of the earliest imaging modalities and is currently readily available, fast, and low cost in comparison to other types of studies. In patients with suspected spine trauma, plain radiographic evaluation has been shown to have a wide range of reported sensitivity for cervical spine injuries ranging from 31.6 to 52% depending on the study [36–40]. Gale et al. adopted a protocol where 848 patients underwent AP and lateral plain radiographs, as well as head CT visualizing down to C2. The sensitivity for plain radiographic detection of upper cervical spine injuries demonstrated on CT was 32%. In a meta-analysis of MEDLINE articles from 1995 through 2004 [37], Holmes et al. found pooled sensitivity data from the seven included studies and determined that cervical spine radiographs detected 52%...
of injuries compared to 98% for CT [36]. The most difficult areas to assess on plain radiography are from the occiput to the axis and at the cervicothoracic junction where a significant amount of traumatic injuries occur.

In the vast majority of trauma centers, plain radiographic evaluation of the traumatic spine has been supplanted by multi-detector CT scans and their reconstructions. The sensitivity for detection of cervical spine fractures utilizing modern MDCT scanners has been reported as high as 99.3 and 99.7% [41, 42]. Brown et al. retrospectively looked at 3,500 trauma patients, 236 of which sustained a spine fracture and found that spiral CT detected 99.3% of all injuries [41]; Henessy et al. prospectively looked at 402 patients who underwent spiral CT and dynamic radiography and found that 99.7% of clinically significant cervical spine injuries were demonstrated on CT [42]. With these improved sensitivities, CT scans have been demonstrated to be cost effective in high-risk blunt trauma patients and are now considered the primary imaging study in these patients. This is even further emphasized in the polytrauma patient requiring CT evaluation of the chest, abdomen, or pelvis [43, 44]. The one noteworthy exception to this idea would be the patient in extremis that is going directly to the operating room. In order to rule out a major injury (fracture dislocation or occipito-cervical dissociation), a single lateral radiograph or lateral fluoroscopic image in the OR will provide a significant amount of information and facilitate the identification of a catastrophic cervical spine injury that may benefit from an early reduction maneuver.

There is very little utility for dynamic studies in the acute setting as recent literature has confirmed that flexion-extension radiographs provide no new information in the presence of a negative CT scan. Khan et al. demonstrated in 311 blunt trauma patients with negative CT scans that flexion-extension films performed in the acute setting did not show a single case of instability and management was therefore not affected [45]. Some authors have recently investigated the utility of flexion-extension CT scans performed at the end of a typical cervical CT series. However, to date, these dynamic CT scans have again not provided any clear benefit [46].

MRI provides an effective means of evaluating the disc-ligament complex, the posterior ligaments, and the neural elements of the cervical spine. MRI is an extremely sensitive study (near 100%) for detection of cervical spine injuries, but its specificity and positive predictive value for clinically significant and/or unstable injuries is less than perfect [20]. Vaccaro et al. studied the utility of MRI and found it very useful in patients with neurologic deficits, altering treatment in a quarter of these patients [47]. Patients admitted with isolated upper cervical spine fractures were prospectively enrolled and evaluated with MRI performed within 48 hours of their trauma. The authors found that MRI affected management for one in four of the patients with a neurologic deficit. In that same study, however, MRI did not provide any additional information to alter treatment in patients who were neurologically intact.

All symptomatic trauma patients require diagnostic imaging, more specifically with MDCT or MRI. CT scans have essentially supplanted plain radiographs in this setting and are the preferred primary imaging modality. MRI is particularly useful in symptomatic patients with neurologic deficit or suspected ligamentous injury based on other imaging.
Obtunded

Cervical spine clearance in the obtunded patient is the most controversial aspect and focuses mainly on whether an MRI is necessary in addition to a negative MDCT. Though an exceedingly rare incident, isolated neurologic injury does occur and can lead to significant morbidity [48]. The percentage of acute trauma patients who are obtunded at the time of evaluation ranges from about 20 to 30% [49, 50]. Additionally, Milby et al. found that cervical spine injury is nearly three times more common in the obtunded trauma patient than in the awake, alert patient who can provide a reliable evaluation (7.7 vs. 2.8%) [18]. Although extended cervical immobilization is possible, it is not without complications and discomfort, including occipital and submental ulcers and exacerbation of intracranial pressure. Furthermore, cervical orthoses may not provide sufficient immobilization to protect the spinal cord in cases of severe soft tissue injuries of the cervical spine [51–58]. Patients who cannot provide a reliable cervical spine evaluation require cervical spine imaging.

There have been numerous large series which have shown CT to be effective as a single and isolated modality for clearance of the cervical spine in obtunded patients. Harris et al. and Hogan et al. have both published large series, which found that CT detected all clinically significant injuries [59, 60]. In the Harris study, only one minor injury was missed and in the Hogan study 4 of the 366 patients with negative CT demonstrated isolated ligamentous injury on MRI, all of which were deemed stable. Tomycz et al. reviewed their series of 690 patients over 4 years and found that no patients with a negative CT had an acute unstable injury missed or developed delayed instability [61]. The ability to detect potential unstable ligamentous injury by CT alone, however, does vary depending upon who is interpreting the study. Simon et al. found that when spine specialists reviewed CT scans in obtunded patients read as normal by emergency room radiologists, they deemed nearly 20% of the CT scans to be concerning for ligamentous injury. A subsequent MRI performed on those cases identified a ligamentous injury in 17/22 patients [62].

There is also a body of literature supporting the utility of MRI as an adjunct for its increased detection of ligamentous injuries. Menaker et al. performed a study looking at 734 patients, 203 of which were obtunded, where MRI and CT were in obtunded blunt trauma patients and found that 8.9% of patients with a normal CT scan had an abnormal MRI. Based on the MRI findings, 7.9% had a change in their management and 1% of the patients (with a normal CT) were found to have an unstable cervical spine requiring surgical fixation [63]. Stassen et al. utilized a protocol requiring both CT and MRI in obtunded patients and described excellent results [21]. Over a 1 year period, 52 patients underwent a CT scan and MRI, and of the approximately 80% of patients who had a negative CT scan, 30% demonstrated ligamentous injury on MRI. These injuries required prolonged collar immobilization and repeat subacute evaluation. They reported no incidence of missed C-spine injuries or cervical collar related complications. Though requiring both CT and MRI for clearance is certainly a comprehensive method for spinal injury detection,
it remains unclear whether the benefits of this protocol outweigh the medical risks of prolonged immobilization awaiting MRI or the financial risks of obtaining MRI in the millions of obtunded patients seen in hospitals every year. In the case of GB, cervical spine CT was obtained and demonstrated normal alignment and no gross injury. In many institutions he would have been cleared based on that CT scan, but in this case dynamic radiographs were obtained to detect potential ligamentous instability.

The utility of dynamic radiographs performed acutely in obtunded patients has been shown to be of minimal benefit and also carries the potential risk of injury in obtunded patients, who may not have protective reflexes or the ability to verbalize pain or other potentially harmful symptoms during the examination [64]. Though dynamic radiography can visualize the mid-subaxial cervical spine rather well, the cervicothoracic junction, as with all plain radiography, is poorly visualized on the lateral projection, making lower cervical instability difficult to detect [65]. Anglen et al. reviewed 837 patients, the majority of which were obtunded, who underwent CT and subsequent dynamic radiography as part of their clearance protocol. In the three cases where dynamic films demonstrated ligamentous injury not seen on CT, no surgical intervention was required, thus concluding that dynamic films were neither clinically helpful nor cost effective [66]. Some authors advocate the use of dynamic fluoroscopy performed by the physician; potentially supplemented with SSEP neuromonitoring [67]. Although dynamic imaging can demonstrate subtle instability not seen on CT or static radiographs, it has not been shown to be superior to MRI. Upright cervical radiographs are commonly utilized to assess alignment in patients with traumatic instability undergoing non-operative management. They have not, however, demonstrated any utility for detection of subtle ligamentous instability in obtunded patients with negative CT scans, as exemplified by Harris et al. in a retrospective review of 367 patients who underwent both studies. This retrospective review found no benefit to upright radiographs in the presence of a negative CT scan [58].

Obtunded patients like patient GB present a diagnostic challenge for cervical spine clearance. Despite a significant volume of research, no single standard algorithm has proven to be superior. MDCT has proven to be the most appropriate initial screening study, as plain radiographs are unable to detect a significant number of unstable injuries. Further, many of these patients also require CT evaluation of their chest, abdomen, pelvis, or head, and therefore concomitant cervical CT is efficient and relatively cost effective. Therefore, obtunded patients, with a negative CT scan can be cleared in the majority of cases. Alternatively, a negative CT scan can be followed by cervical MRI to rule out ligamentous injury and associated potential instability. The latter is more costly and time consuming but does decrease the likelihood of an occult soft tissue injury missed with CT alone. Both options are supported in the literature, and choosing a particular algorithm may be based on availability and efficiency of MRI at a particular institution or preferences of trauma and spine specialists at that particular institution. Ultimately, there will be a very minute population of obtunded patients with negative CT scans who will have an unstable cervical injury. In determining which algorithm is appropriate for patient GB, the cost effectiveness of obtaining MRI on all obtunded patients in order to
detect these extremely rare occurrences should be considered, but has not yet been borne out in the current literature. Early involvement of spine specialists is encouraged as their ability to interpret CT scans and identify subtle findings indicative of instability may decrease the number of missed unstable injuries in institutions where CT only is the standard for cervical spine clearance [61].

**Literature Inconsistencies**

The greatest challenge in the literature is in regards to the clearance of the cervical spine in obtunded patients and whether a negative CT scan is sufficient for clearance or whether subsequent MRI or other imaging is required. Both methods of cervical clearance are supported by prospective large series. The challenges in determining an unequivocal standard algorithm seem secondary to the difficulty defining an accurate percentage of unstable injuries that go undetected on CT scan, the morbidity associated with these missed injuries, and defining the cost-effectiveness of requiring MRI in all obtunded patients in order to detect this population of patients.

**Evidentiary Table and Cervical Spine Clearance Algorithm**

**Definitive Treatment Plan**

In the case presented, GB was initially moving all extremities but is now obtunded secondary to intubation for respiratory dysfunction. The imaging presented in this case is a cervical CT and dynamic radiographs. The cervical spine CT demonstrates overall normal alignment without listhesis and no significant boney injury. A more discerning radiologist or consultant, however, may recognize that between C6 and C7 there appears to be a subtle crack in the most anterior superior aspect of C7 and a disruption in the ossified annulus at the posteroinferior aspect of C6. This potential discrepancy demonstrates why the sensitivity of cervical CT is variable based upon whom is interpreting the study. As these CT findings could indicate associated ligamentous injury, further imaging to test ligamentous stability should be obtained prior to clearance. One option would be to obtain an MRI, whereas another would be to continue a cervical collar until dynamic radiographs could be performed in the subacute setting after return of cognitive function. In the case presented, dynamic radiographs were obtained. Based on the literature discussed, dynamic cervical radiographs should not be obtained acutely in an obtunded patient and are most useful as a physiologic test for instability when obtained in the subacute setting. The dynamic radiographs in this case demonstrate no evidence of instability and the patient’s cervical spine can thus be clinically cleared (Table 2.1).
### Table 2.1  Evidentiary table

<table>
<thead>
<tr>
<th>Author (year)</th>
<th>Description</th>
<th>Summary of results</th>
<th>Level of evidence</th>
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<tr>
<td>Harris et al. (2008)</td>
<td>Retrospective cohort study</td>
<td>367 Obtunded blunt trauma patients underwent CT and were followed clinically and with upright films to detect instability. Upright radiographs did not identify any injuries missed by CT. One patient with normal CT had a central cord contusion later identified by MRI and treated non-operatively.</td>
<td>III</td>
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<tr>
<td>Hogan et al. (2005)</td>
<td>Retrospective cohort study</td>
<td>366 Obtunded blunt trauma patients underwent both CT and MRI. CT had negative predictive value of 98.9% for ligamentous injury and 100.0% for unstable cervical spine injury.</td>
<td>III</td>
</tr>
<tr>
<td>Tomycz et al. (2008)</td>
<td>Retrospective cohort study</td>
<td>690 Patients underwent concomitant cervical CT and MRI. 38 of 180 patients (26.2%) found to have a negative CT demonstrated acute findings, though none of these 38 patients with acute findings required surgical intervention.</td>
<td>III</td>
</tr>
<tr>
<td>Menaker et al. (2008)</td>
<td>Retrospective cohort study</td>
<td>203 Patients with unreliable examination underwent concomitant cervical CT and MRI. 18 patients (8.9%) with negative CT had an abnormal MRI, 14 of which required prolonged cervical immobilization and 2 of which required surgery.</td>
<td>III</td>
</tr>
<tr>
<td>Stassen et al. (2006)</td>
<td>Retrospective cohort study</td>
<td>52 Obtunded blunt trauma patients underwent both CT and MRI. 25% of patients with a negative CT had a positive MRI for ligamentous injury and were treated in hard collar for 6 weeks. None of these patients ultimately required surgical intervention.</td>
<td>III</td>
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### References

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