Cervical spine clearance in obtunded patients after severe polytrauma

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Objective: To provide clinicians with data supporting three different clearance techniques in the obtunded patients after severe polytrauma.

Methods: This study gave an overview of the available and pertinent literature regarding cervical spine clearance in obtunded patients after severe polytrauma.

Results: Currently, there were three accepted techniques for clearance of the cervical spine in obtunded patients after severe polytrauma. Each of these methods has advantages and disadvantages to both the patients and the clinicians.

Conclusions: There are continuous improvements in both computed tomography (CT) and magnetic resonance imaging (MRI) techniques that increase their sensitivities. The continued use of plain radiographs is called into question with respect to cost and time requirements. An algorithmic approach to the evaluation of the cervical spine in the obtunded patients will lead to fewer missed injuries.

Key words: Cervical spine; Disturbance of consciousness; Severe polytrauma

Cervical spine injury is a major concern in the obtunded patients after severe polytrauma. Clearing the cervical spine remains a particularly challenging problem for clinicians worldwide, which generally implies that after a thorough clinical examination and review of appropriate radiographs, clinicians can confidently state the unaffected cervical spine and therefore no continued immobilization or protection is required. Its pressing nature is fueled by the desire to identify all significant injuries in a timely manner, and trauma centers struggle to achieve a balance between prompt identification of these injuries and expedient confirmation of unaffected regions. A comprehensive assessment of the axial skeleton is a principal requirement for accurate assessment of the injury severity of a patient. Significant injuries are those carrying potential injuries or irreversible morbidities (neurologic deterioration, paralysis and death) to the patient if they are left unidentified. The vulnerable nature of the unprotected spinal cord highlights the importance of an early and accurate assessment of the spinal column.1,3

Historically, the unknown status of the stability of a cervical spine needs prolonged use of a cervical collar commonly. However, continued collar use in polytrauma patients, closed head-injured (CHI) patients, or any patients requiring prolonged ventilator assistance, carries risks of respiratory deterioration, pressure sores, venous thrombosis and other complications.4 In an attempt to avoid some of these issues, this article will provide the readers with literature-supported guidelines regarding the evaluation of the cervical spine in the obtunded patients after severe polytrauma. This discussion highlights the core issue nicely: How can the cervical spine of a polytrauma or CHI patient be deemed free of a significant injury when the patient cannot participate in examinations in a credible fashion?

Bases of diagnosis

Physical examinations Historically, the findings of physical examinations directed the evaluations of trauma patients. However, in order to safely and effectively evaluate the cervical spine in the obtunded patients after severe polytrauma, three-dimensional reconstructive helical computed tomography (CT) and magnetic resonance imaging (MRI) are employed. As we proceed from plain radiographs to the most sophisticated current radiographic softwares, the clinical examinations lose their essential natures. It has, to a large extent, evolved to play a more supportive or confirmatory role. The clinical examinations lose their credibilities,
which eliminate the correlation of physical examinations with radiographs.\textsuperscript{5, 6}

**Plain radiographs and CT**  Patients who are not suitable for clinical clearance of the cervical spine can undergo a three-dimensional reconstruction of plain radiographs, including anteroposterior, lateral, and open mouth odontoid ones, followed by thin-slice CT imaging of C\textsubscript{1}-C\textsubscript{2}. Plain radiographs of the cervical spine, obtained via a series of examinations for trauma popularized by the Advanced Trauma Life Support Program, claim a sensitivity greater than 90% in the detection of significant cervical spine injuries. However, fluoroscopy is potentially unsafe despite strict protocol adherence and supervision, and it has been estimated to yield inadequate results in 30% of the patients.\textsuperscript{7, 8} It is not clear from the published literature whether the benefits of fluoroscopy outweigh the risks. These plain radiographs are largely supplanted by the reconstructive views (coronal and sagittal) obtained by spiral CT. CT scans have long been accepted as both more sensitive and specific than plain radiographs in the identification of bone injuries to the cervical spine. Therefore, if the CT scan of the entire cervical spine, including the junctions, is free of bone injuries, the question arises for the necessity of plain radiographs. Although CT provides a very sensitive, specific, and practical imaging method, the studies are not 100% accurate for bone injury identification, nor do they carry a 100% negative predictive value.\textsuperscript{5, 6} The clinical significance of these missed bone injuries has not yet to be fully characterized.

Confidence in radiographs and CT for excluding injuries is limited by concerns of ligamentous instability in the absence of fracture or dislocation. Pure ligamentous cervical spine injuries are exceptionally rare, about 0.1%-0.7% of blunt trauma victims, with most published studies at the lower end of that range.\textsuperscript{3, 9} Furthermore, radiation exposure is increased to the trauma patient undergoing CT in lieu of plain radiography. Rybicki et al\textsuperscript{10} measured the radiation doses to the thyroid and found that CT of the entire cervical spine delivered a radiation dose 14 times greater than that delivered by plain radiographs. Therefore, they suggested judicious use of helical CT in routine screening.

The current consensus of opinions think that CT can be taken as the radiographic method to assess bone injury, particularly in the higher-risk category of patients, i.e., those who have experienced high-energy injuries combined with head injuries and those with focal neurologic deficits. The associated sagittal and coronal reconstructions almost have replaced plain radiographs recently. Once the cervical spine has been evaluated and found to be free of bone injuries, the principle problem comes into whether potential soft tissue injuries exist or not.

**MRI**  The remaining emergent issue is the status of the supportive soft tissues of the cervical spine. The pertinent soft tissues include the facet capsules (bilaterally), the interspinous and supraspinous ligaments, the ligamentum flavum, and the anular component of the intervertebral disc. MRI is commonly accepted to directly reveal ligamentous injuries. However, its optimal use in ruling out instabilities in obtunded patients has yet to be found. Whereas CT is highly proficient in identifying bony injuries, MRI remains to be the gold standard with respect to the evaluation of the soft tissues around the spinal column. Despite the use of this highly sensitive imaging modality, the MRI findings relating to spinal ligamentous injuries have yet to be consistently and definitively correlated to their functional integrity. Therefore, an abnormal MRI does not necessarily define an unstable cervical spine. On the other hand, MRI has a low specificity in the upper cervical spine and a low sensitivity in the posterior cervical spine. So MRI has limited abilities of a positive examination to indicate clinically relevant pathology and a negative examination to clear a cervical spine on its own. Additionally, logistical restrictions including access, cost, and metallic screening in patients remain to be significant obstacles to the inclusion of MRI in routine spine clearance protocols.\textsuperscript{10, 11}

**Flexion-extension radiographs**  In the subacute setting, active (patient-performed) flexion-extension lateral cervical radiographs remain to be the primary method for defining instabilities. However, this technique has proved ineffective and impractical in the acute setting.\textsuperscript{12} Additionally, it has little usefulness in the obtunded patients. Davis et al\textsuperscript{13} found that dynamic fluoroscopy in 301 patients showed two stable ligamentous injuries, which were not observed on focused CT of C\textsubscript{1}-C\textsubscript{2}. Further confusing the usefulness of this method is the fact that this method often cannot visualize the cervical-thoracic junction. In fact, if the cervical-
thoracic junction is not visible on the original plain radiographs, the flexion-extension view should be contraindicated. In a single patient, incomplete fluoroscopic visualization resulted in a C_2-T_1 subluxation and subsequent cord injury. It is true that fluoroscopy can be expected to recognize a small subset of the rare patients with exclusively ligamentous injury. However, Morris et al.\(^6\) reported that about 290 patients required to identify an abnormality which was not identified on CT or plain films. The number of patients doubles when considering the patients requiring surgical correction. This must be balanced against the clear risk of the procedure and the staffing costs involved as an attending spine surgeon is typically required to perform the study.

### Clearance techniques

The remaining methods for clearance of the obtunded patients’ cervical spine fall into one of three categories: early clearance, delayed clearance, and pure radiographic clearance. Early clearance is accomplished by means of fluoroscopic evaluation or gravity-assisted lateral cervical radiograph. Delayed clearance technique maintains the injured patient in a collar until the patient is capable of participating in the examination. The final category is pure radiographic clearance, which is solely dependent on the CT and MRI findings.

#### Delayed clearance technique

Delayed clearance technique is prudent and popular. It assumes the clinical scenario that the cervical spine has sustained either appreciable injury or a soft tissue injury that can be safely maintained in a cervical orthosis. The patient is maintained in a collar until he or she can effectively participate in the clinical examination. The downside of the collar is often worn for a nonspecific length of time. This extended collar use has been linked to skin breakdown in the submental and occipital areas. Nursing care protocols are frequently altered because of the presence of the collar. Additionally, the presence of a cervical collar has been demonstrated to affect the tidal volume in the anesthetized patient as well as altering the cerebrospinal fluid pressure.\(^5\)\(^6\) If the soft tissue injury turns out to be highly unstable, the collar alone may prove ineffective in controlling the instability. In most hospital settings, this is the preferred method of management for the patient who is unable to participate in the clinical examination (CHI patients and polytrauma patients needing prolonged ventilatory support).

**Radiographic clearance technique** The second most commonly-used method for cervical spine clearance in the obtunded patients after severe polytrauma is the radiographic clearance technique. This method uses the sensitivity of the CT scan to identify bone injuries and the sensitivity of the MRI for soft tissue injuries. Typically, the CT scan includes axial images as well as reformats in both the sagittal and the coronal planes. If both the CT and MRI are negative, the likelihood of an occult injury that could lead to a significant injury is remote. However, abnormalities found on the MRI can be confusing and subject to the individual physician’s interpretation. Currently, there does not exist a standardized and validated classification system for soft tissue injuries of the spine as visualized on MRI. Nonetheless, this method has gained increasing support within the trauma community because it allows for an early and accurate disposition of the status of the cervical spine.\(^16\)\(^17\) If both are negative, the collar is generally removed. If an abnormality is identified on the MRI or CT, the spine consultant’s individual expertise is called for.

Increasingly, CT has been found to identify all unstable cervical spine injuries, regardless of bone involvement. Recent literature has suggested that limb movement in an obtunded patient in combination with a normal cervical CT is sufficient for clearance, although only 12 patients in the study met such criteria.\(^11\) Additionally, Hogan et al.\(^14\) found that in 366 patients receiving both CT and MRI, CT missed only 4 injuries, each of which were stable and managed nonoperatively. Most recently, Harris et al.\(^10\) reported that CT had a negative predictive value of 99.7%, which was in line with previously published data on the sensitivity of CT for both fractures and subluxations. In light of the adequacy of CT in obtunded cervical spine clearance, the authors recommended consideration of clearance of the cervical spine after normal CT scan regardless of the state of consciousness.

**Passive cervical motion techniques** The final and most controversial method of clearance for the obtunded or polytrauma patients employs passive cervical motion. This can occur via a physician-directed fluoroscopic evaluation or an upright lateral cervical spine radiograph with the patient in a collar. The fluoroscopic technique has been consistently successful in identifying unstable injuries in the presence of negative stan-
standard plain radiographs and CT scans. Among the published fluoroscopic protocols, only one includes a stretch test to be performed before the flexion and extension views are taken. The prerequisite of a negative stretch test result before the flexion and extension views provides further safety to the unprotected spinal cord in the presence of a dangerously unstable cervical spine. There remain these issues: Who should perform the test? Is spinal cord monitoring necessary or sufficient during the fluoroscopic examination?

An alternative method to assess the cervical spine of the obtunded patients is the upright lateral cervical radiograph. The upright lateral cervical spine view is performed with a collar in place. This occurs only after a secondary review of the helical CT and plain radiographs have confirmed the absence of any subtle abnormalities. The objective of this study is to protect the spine (by maintaining the collar) while allowing it to be subject to a portion of its physiologic loading. The absence of a discernible kyphosis or vertebral body collapse suggests a stable spine. Although this technique has its ardent supporters, and in theory appears to be safe and helpful in the diagnosis of occult ligamentous injuries, the support of peer-reviewed literature is lacking. The update literature showed that in obtunded subjects with normal initial cervical spine CT imaging, nothing is gained from additional imaging with physiologic loading, and the risks of such additional imaging may outweigh any potential benefits.

Conclusion

In summary, clearance of the cervical spine injury remains a particularly challenging problem for trauma clinicians worldwide. There is a difficult management issue in the three defined patient populations: the polytrauma patients (distracting injuries), the CHI patients (no input), and the pediatric polytrauma patients (communication issues and distracting injuries). Institutional adoption of evaluation protocols is necessary to avoid random errors in the difficult process of evaluating these patients’ injuries. The clinical examination was once thought to be the principle determinant directing the formal evaluation, but it cannot be relied upon because of the patient’s associated injuries. Improvements in the associated software for both MRI and CT have led to greatly improved sensitivities. Unfortunately, to date, no imaging method is able to replace the necessity of the others in the overall assessment of the bone and soft tissue elements of the cervical spine. This monograph provides the clinicians with multiple evaluation options when faced with the necessity to clear the cervical spine in the obtunded patients.

REFERENCES


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