CERVICAL TRAUMA

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Mechanism of injury:

Most cervical spine fractures can be classified on the basis of the mechanism of injury. The forces and mechanism that produce the spine fracture vary according to the level of injury, A sever flexion or extension force is responsible for occipital and atlas injuries. Axial loading is accountable for the majority of fractures of the ring of C1. Rotation and hyper flexion most often account for injury at the atlantoaxial level. Hyperextension and axial loading are believed to be the most common cause of spondylolisthesis of the axis, and further injury may be associated with a second force of anterior flexion and compression. Injuries to the lower cervical spine may occur secondary to the forces of flexion, extension, lateral rotation, axial loading, or a combination of these forces.

Patient evaluation

In the multitrauma settings, patients should be considered to have cervical spine injury until completion of the secondary physical examination and thorough radiographic assessment. Noncontiguous spinal injuries occur in % 5 to % 20 of these with spine fractures.

Palpation of the spine from the skull to the coccyx for areas of localized tenderness is extremely helpful to localize a spinal injury in a cooperative patient. Root specific muscle strength testing of the upper and lower extremities and rectal examination for tone and sensation are extremely important in determining an anatomic level of injury. cranial nerve examination, determination of sensation and pin and light touch, and determination of deep tendon and plantar reflexes complete the spine injury assessment. The presence of sensory sparing should be documented. If present, it indicates a potentially hopeful prognosis. Absence of primitive reflexes, such as the bulbocavernosus reflex or anal wink, in the first 48 hours indicates that neurological deficit may be related to spinal shock or contusion rather than to a complete and permanent spinal cord injury.

Imaging

Lateral cervical spine radiographs are an essential part of the evaluation. Although % 70-85 of singificant injuries will be detected with a lateral radiograph that allows visualization of C7, an injury at the cervicothoracic junction may escape detection. Consequently, current spine trauma protocol should require complete spine radiographs with full visualization of the body of T1. If this not possible, a swimmer's view or computed tomograph scan will be required a complete cervical spine series consist of lateral, AP and open mouth views, which will diagnose 90-95% of all cervical spine injuries. The open-mouth anteroposterior view of the spine is essential for evaluation of the upper cervical spine. The standard AP view of the cervical spine allows evaluation of lateral mass and sagittal plane fractures. Oblique views provide excellent visualization of the intervertebral foramina, pedicles and facet joints. The role of flexion-extansion lateral radiographs in an emergency setting remains controversial. They may be useful in the alert, cooperative patient without neurological deficit who complains of neck pain.

Computed tomography is an excellent method of evaluating patiets with cervical spine injuries. It's advantages include axial imaging and excellent cortical detail. With new spiral CT technology, high quality sagittal reconstructions that are almost comparable to multiplanar polytomograms are possible; these reconstructions allow detection of subtle, horizontally oriented injuries of the vertebral column.

Advantages of MRI include direct multiplane imaging capabilities, ability to detect non-contiguous fractures and most importantly, its ability to determine the degree of soft-tissue injury, including the intervertebral disc, spinal cord and ligamentous structures.

Timing of surgery

When a progressive neurological deficit exists in the presence of malalignment and/or spinal canal compromise, emergency decompression is indicated. In all others with spinal cord injuries, timing of surgery is controversial. Some authors recommend treatment as soon as the patient is medically stable, while others advocate a delay of 4 or more days to allow posttraumatic swelling to resolve. Whether early decompression and reduction of neural structures enhances neurological recovery continues to be debated. Currently, a reasonable approach would be to treat non-progressive neurological deficits on a semi urgent basis, when the patient's systemic condition is medically stable.

Fractures and dislocations of the upper cervical spine

Atlas fracture

Fractures of the atlas generally are the result of an axial load injury. The C1 ring fracture, which may be isolated to the anterior arch is secondary to an axial load with flexion force. Isolated posterior arch fractures are due to an extension force combined with the axial load. Stability is determined by measuring the spreading of the lateral masses on the open mouth AP radiograph. If the total radiographic excursion of the lateral masses of C1 is greater than 8 mm's, transverse ligament is most likely torn and the fractures are unstable. Stable isolated C1 is greater than 8 mm's, transverse ligament is most likely torn and the fractures are unstable. Stable isolated C1 fractures can be treated with a hard collar. In burst and lateral mass fractures, treatment has been controversial. Immediate immobilization in a halo-vest does not maintain or achieve reduction of lateral mass displacement. In addition, short term halo traction is inadequate to maintain even an achieved reduction. Levin et al. treated their patients with isolated posterior arch fractures or burst or lateral mass fractures with 2 mm or less lateral displacement in a cervical orthosis for 10-12 weeks. Patients with lateral displacement of 2-7 mm's are treated with halo traction for up to 7 days. Then the patient is immobilized in a halo-vest for 3 months. Patients with more than 7 mm's of lateral displacement are treated with halo traction for 6 weeks. The patient is immobilized in a halo for 6-8 additional weeks. An alternative treatment for unstable fractures of the atlas is primary surgical reduction of fracture with lateral mass screws and rod, developed by Harms.

At the conclusion of treatment, dynamic flexion and extension radiographs are performed to evaluate stability. If instability persists despite of bony union, surgical stabilization of the C1-C2 can be undertaken. Occiput-C2 fusion is required only when significant damage has occurred to the occiput-C1 articulation. Patients with a fracture through the facet joint or a comminuted pattern are high risk for nonunion, chronic neck pain and spastic torticollis. They may benefit from posterior C1-2 arthrodesis. A patient who develops an unstable nonunion of C1 will require an occiput-C2 fusion.

Atlantoaxial rotatory subluxation and dislocation

Fielding and Hawkins classified atlantoaxial rotatory fixation into four groups according to severity. Type I is the most common. Here, rotation is fixed, without evidence of significant soft tissue disruption. Only mild anterior displacement (3 mm) is noted on the lateral radiograph. ın type II injuries, rotatory fixation occurs with anterior displacement of one C1 lateral mass by 3-5 mm, pivating on the non-displaced contra lateral C1-2 articular process. In type III fixation anterior displacement of >5 mm of both C1 articluar masses occurs with a marked increase in the atlantodental interval demonstrated on the lateral radiograph. Type IV fixation with posterior C1 subluxation is rare. The treatment and prognosis of rotatory injuries of the C1-2 level depend on the severity of displacement, presence of neurologic deficit, and duration of deformity. This injury often can be treated conservatively with rigid immobilization for 6-8 weeks. Occasionally however, it requires skeletal traction to reduce the subluxation. If rotatory subluxation is left untreated, it may go on to a fixed rotatory deformity and require surgical treatmant. Posterior C1-C2 fusion is classical surgical treatment. Alternatively, Harms advocates open reduction and temporary stabilization with plate through transoral approach.

Odontoid fractures

Fractures of the odontoid are most often the result of a flexion force causing anterior displacement. Fractures with posterior displacement have a much higher incidence of neurological injury and are caused by hyperextension force. The type 1 injury is an oblique fracture through the upper part of the odontoid. Type 2 fracture occurs at the junction of the odontoid process and the body of the axis. In type 3 fracture, the fracture line extends downward into the cancellous portion of the vertebral body. Type 1 fractures are extremely uncommon; they can be safely treated with a collar for 8 weeks. Type 3 fractures have 85-90% union rate and most often they can be treated successfully with a halo-vest for 12 weeks. These fractures, however are not benign lesions, and malunion may occur. Type 2 fractures have the highest rate of nonunion. Displacement greater than 10°, and age greater than 40 years contribute to a higher rate of nonunion. Despite the overall high rate of nonunion, a significant number of type 2 odontoid fractures will heal halo vest immobilization if anatomic alignment can be obtained and maintained. Primary posterior C1-2 fusion and anterior screw fixation are surgical alternatives for treating patients at high risk for nonunion or patients for whom a halo vest is contraindicated. Anterior screw fixation of the odontoid is an alternative to halo immobilization or posterior fusion. Anterior screw fixation has the advantage of decreasing the nonunion rate of type 2 dens fractures while preserving atlantoaxial rotation. Although this technique initially was used in the treatment of odontoid nonunions, its use dotay is primarily in the treatment of type 2 dens fractures. Frontal oblique fractures tend to displace laterally with compression; sagital oblique fractures often have little bone available to provide stable fixation and tend to displace sagitally. Additional contraindication is significant thoracic kyphosis.

Axis fractures

Traumatic spondylolisthesis of the axis is caused by a hyperextension force. If a flexion component is added to the injury, there may be disruption of discs and ligaments causing a forward subluxation of C2 on C3. A type 1 injury includes all nondisplaced fractures as well as all fractures that have no anglutation and less than 3 mm of displacement of C2 on C3. Type 2 is a hyperextension and axial loading injury that has angulation and translation. Type 3 fracture dislocations are secondary to a flexion as well as a posterior distraction force. They have both severe angulation and displacement along with a unilateral or bilateral C2-C3 facet dislocation. Type 1 and 2 injuries can be successfully treated with traction for reduction and then halo immobilization. Alternatively, once the fracture is reduced in traction, surgical stabilization by osteosynthesis through the pedicles can be achieved, which can be done with secrews placed through the C2 pedicle. Type 3 injuries usually require open reduction of facet dislocation with posterior fusion and stabilization. Posterior plating for C2-3 facet injury can be considered. In that instance it is necessary to use pedicle screws in the C2 pedicle. The screws at the C2 level also may be used to stabilize the accompanying pedicular fracture as well. Alternatively, an anterior C2-3 discectomy, facet reduction and fusion with anterior plate fixation can be considered. This approach may not allow for an easy reduction of the facets and the posterior approach is most probably the procedure of choice for most surgeons. Nonunions can be treated with a posterior C1-3 fusion or an anterior C2-3 discectomy and fusion.

Fractures and dislocations of the lower cervical spine

Classification

Allen's classification remains one of the most widely used today (Figure-1). In a retrospective review of 165 cases cervical spine injury, they developed a mechanistic classification of fractures and dislocations of the lower cervical spine. The authors divided the injuries into six groups, each named according to the presumed position of the cervical spine at the time of injury and initial dominant mode of load to failure. Their categories included compressive flexion, vertical compression, distractive flexion, compressive extension, distractive extension, and lateral flexion.

Spinal stability

In an intact spine, instability of the lower cervical segments was defined as a translatory displacement of two adjacent vertebre greater than 3.5 mm or an angulation of greater than 11 degrees compared with adjacent normal motion segments. Furthermore, a comprehensive checklist for the diagnosis of traumatic instability of the lower cervical spine was developed (White).

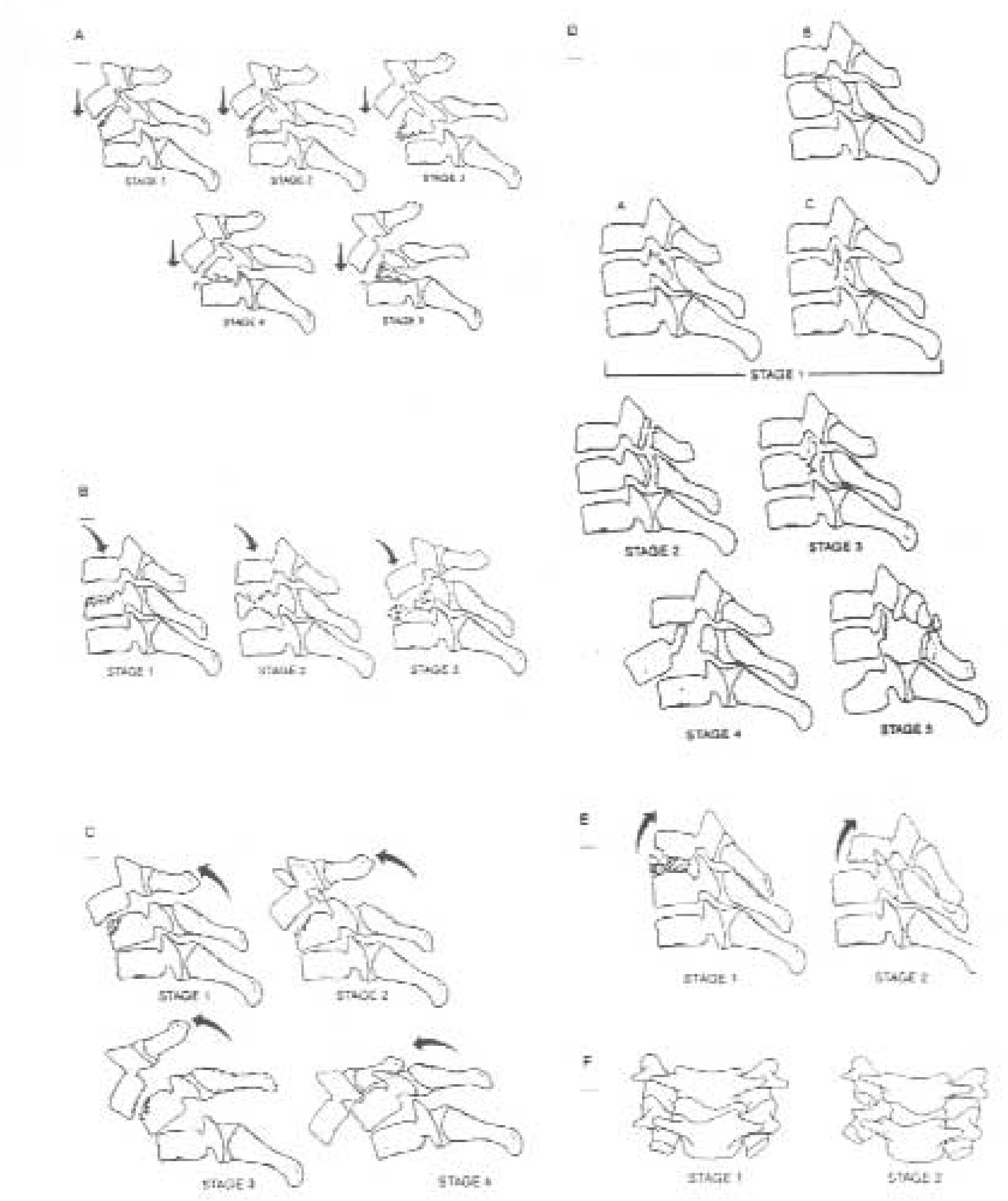

Figure 1: Allen-Ferguson Classification
A. Compressive flexion injury
B. Vertical compression injury
C. Distractive flexion injury
D. Compressive extension injury
E. Distractive extension injury
F. Lateral flexion injury

Compressive flexion injury

Compressive loads applied to the flexed spine result in compression of the anterior column and distraction of the posterior column. The resultant shortening of the anterior column and leghtening of the posterior column can be graded into five stages. In stages 1 and 2, the structural integrity of the middle and posterior elements has not occurred. Neurological injury is uncommon. Although there is risk of late kyphotic deformity, most patients can be managed successfully in a rigid cervical orthosis or halo-vest orthosis for 8-12 weeks. In stages 3 and 4 (without displacement and <3 mm displacement) complete posterior ligamentous disruption is possible. These patients require evaluation by MRI to rule out posterior ligamentous disruption. A halo-vest orthosis is sufficient for patients with an intact posterior column. However, for those patients with ligamentous disruption, the risk of late kyphotic deformity is high, and posterior cervical fusion and instrumentation recommended. A stage 5 injury involves a teardrop fragment with greater than 3 mm's of subluxation and the posteroinferior portion of the body retropulsed into the spinal canal. This injury usually involves two motion segments. A combined anterior and posterior stabilization procedure should be considered in these cases.

Vertical compression injury

These injuries are the result of compressive forces applied o a neutrally aligned spine, and lead to shortening of both the anterior and middle columns of the spine. In stage 1 and 2, posterior ligamentous structures are usually uninjured, and late kyphotic deformities are unusual. Therefore, patients who are neurologically intact can be managed for 6-8 weeks in a rigid cervical orhosis or halo-vest. Patients with neurological involvement will require anterior decompression and anterior stabilization. Stage 3 injuries usually involve fragmentation and displacement of the vertebral body. Occasionally this injury may involve bony failure in the anterior column followed by ligamentous failure of the middle and posterior columns with subsequent posterior translation and cord impingement. Patients without neurological injury may simply require posterior fusion and stabilization. However, many of these patients will present with neurological injury, and will therefore require anterior decompression and reconstruction augmented with posterior stabilization and fusion.

Distractive flexion injury

This injury represents the most common injury pattern. Distractive loads applied the spine in a flexed position cause tensile failure and lengthening of the posterior clomun in the early stages and associated failure of the anterior and middle columns during the latter stages. In general less than 25% anterior anterior subluxation is indicative of facet subluxation (S1), 25-50% subluxation indicative of unilateral facet dislocation (S2), and 50% or greater subluxation indicative of bilateral facet dislocation (S3). Full body displacement is defined as Stage 4 injury. All stages of flexion distraction injury may be associated with facet fractures as well. Closed reduction should be attempted for all stages of distractive flexion injuries as soon as the patient is medically stable. Following successful close reduction, patients with distractive flexion injuries treated by non-surgical methods in the halo-west orthosis have up to 64% incidence of late instability. Primary posterior cervical fusion is preferred for patients in all stages of distractive flexion injuries when neurologically intact. It has been recognized that 54-80% of patients with distractive flexion injuries have associated acute disc herniations at the level of injury. Several outhors have reported catasrophic neurological damage following closed reduction of this injury. Careful review of this studies however, indicates that many of these patients underwent closed reduction under general anesthesia. No case of neurological deterioration caused by herniated nucleus pulposus during a conscious closed reduction has been reported. Before an open procedure an MRI may be considered to exclude a possible disc herniation. For patients with herniated discs should have anterior discectomy before open reduction and fusion. Some authors have reported that addition of anterior plate may preclude the need for a further posterior stabilization porcedure; however in the presence of posterior element damage a combined approach is usually preferable.

Compressive extension injury

Compressive forces applied to the spine in extension result in early failure of the posterior column of the spine followed by failure of the anterior column. Stages 1 and 2 of compressive extension injuries result in single or multilevel posterior element fractures without vertebral body displacement, which are best managed with a rigid cervical orthosis or halo-west. Later stages are relatively uncommon. Later stages are more unstable and require stabilization. If neurological injury exists, decompression must be directed toward the pathology, followed by appropriate stabilization procedures.

Distractive extension injury

Distractive forces applied to the spine in extension cause tensile failure and lengthening of both anterior and posterior columns of the spine. The injuries without evidence of vertebral body displacement can be treated in a rigid orthosis. Alternatively for anterior ligamentous injury, a primary anterior arthrodesis may be considered. Vertebral body displacement mandates fusion. Anterior fusion with plate fixation is most often successful. Posterior fusion can be added in extremely unstable cases.

Lateral flexion injury

The asymmetric nature of force loading in the coronal plane results in tensile failure of one side of the spine, and compressive failure of the opposite side. Injuries without displacement can often be managed without surgery, whereas displaced injuries most frequently require surgical stabilization and fusion.