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Controversies in Imaging Acute Cervical Spine Trauma

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Controversy surrounding the imaging of patients with acute trauma to the cervical spine is twofold. The first issue concerns the most clinically appropriate way to image these spine-injured patients and the second involves the value added by obtaining such studies as computed tomography (CT) and magnetic resonance (MR) imaging after initial plain radiography. In this report, we briefly highlight some of the background relating to this subject and then outline our current approach to imaging patients with acute cervical spine trauma.

While it is generally accepted that plain radiographs of the spine are obtained first, questions arise as to what should constitute an initial study and what is the clinical value of additional examinations, such as CT, once either a fracture and/or a dislocation has been demonstrated. Furthermore, no consensus exists as to what should be done whenever the radiologist is asked to "clear the spine."

Plain radiography in the setting of cervical spine trauma is used to identify unstable injuries that require prompt treatment and/or precautions. It is generally agreed that a single lateral radiograph of the cervical spine is inadequate to exclude all injuries, whether in a severely traumatized patient or in an alert, asymptomatic patient, because, for a screening study, the false-negative value of this single film is too high (1). This is in part explained by the fact that in an unconscious or uncooperative multitrauma victim the cervicothoracic junction is often difficult or impossible to image with plain radiography and, as a result, fractures at the T-1 and T-2 levels can go undiagnosed with this single lateral view. In essence, therefore, the cross-table lateral

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radiograph should serve only to assess obvious signs of instability and to detect gross fractures and dislocations.

The questions that remain then are: How many radiographs should be obtained? What constitutes the ideal trauma series? What is the anticipated rate of missed diagnoses with plain radiography? These issues have been addressed by a number of authors. In a retrospective study of 740 patients reported by Davis et al (2), the diagnosis of a cervical spine injury on plain radiographs was delayed or missed in 34 cases. In 10 of those 34 patients, permanent neurologic sequelae developed that might have been avoided had the diagnosis been established at the outset. In another series, Woodring and Lee (3) reported that fractures went undetected in 23% of patients, and in half of those, there was an unstable cervical spine injury. The importance of proper initial diagnosis is emphasized further by the fact that approximately 10% of patients with spine trauma who have normal clinical findings at an initial neurologic examination will subsequently incur neurologic deficits (4). It is therefore critical to maximize the chances of detecting fractures on the initial radiographic study. The *Advanced Trauma Life Support Manual* published by the Committee on Trauma of the American College of Surgeons (5) recommends that in severe injuries, an initial cross-table lateral radiograph be obtained and that after resuscitation (if it is necessary), additional views be acquired to exclude injuries not detectable on the initial film.

In trying to assess what should constitute a proper spine series based on the type and severity of an injury, it is worthwhile to mention other published observations. Freemyer et al (6) did not detect any additional injuries when prospectively comparing a basic three-view (anteroposterior, odontoid, lateral) trauma series with a five-view trauma series that also included lateral flexion and extension views. A five-view evaluation that adds oblique supine views has been suggested by other authors (7, 8), who have claimed that this increased their reliability in evaluating the cervicothoracic junction.

With these considerations in mind, and on the basis of our own experience in which we found that a significant number of cervical fractures may be missed on plain films (A. A. Ahmad, C. G. Coin, J. L. Becerra, D. B. Nunez Jr, R. F. Soto, S. D. LeBlang, "Plain Films versus Spiral CT in the Evaluation of Cervical Spine Injuries" (abstract), *Radiology* 1993;189:325), CT has been proposed as an important additional procedure in imaging patients with cervical spine injuries (9). Ross et al (1) recommended the use of limited CT to depict those portions of the spine that are inadequately shown by plain films. Blacksin and Lee (10) reported an 8% frequency of fractures of the craniocervical junction detected by CT that were not recognized by plain radiography. Link et al (11) performed routine limited CT of the craniocervical region in patients with severe head trauma and also found a significant number of occipital condyle and C1–2 fractures that were not seen on plain radiography. Borock et al (12) evaluated the role of CT for groups of spine-injured patients (eg, patients with evidence of cervical spine injury on plain radiography, patients with plain film findings suggestive of injury, patients in whom plain films failed to reveal all the cervical vertebra, and patients with persistent symptoms or neurologic deficits) and found that CT alone showed 98% of the injuries, and when it was combined with plain radiography, 100% of the injuries were detected. We consider combined CT and plain radiography to be the proper approach to spine injury in such groups of patients. For cases in which the plain film and CT findings are normal, lateral radiographs in flexion and extension can then be obtained to assess for possible ligamentous injury.

From the standpoint of efficient patient care in a busy trauma center, we found a significant delay in "clearance" of the cervical spine when we relied exclusively on plain radiography and limited CT. We were frequently confronted with the problem of having to obtain multiple radiographs to clear the proximal or distal cervical spine, and even after obtaining those films, visibility of those areas was often unsatisfactory. This recurring problem prompted our recommendation for routine CT examination, not only for documented spine trauma as discussed above but also for those patients who were undergoing CT of the brain and/or abdomen to evaluate other possible injuries. Using CT in this manner avoided double use of the scanner. In our trauma center, patients are considered to be at high risk for spine injury if they meet certain clinical criteria based on mechanism of injury (eg, high velocity accident), associated injuries (eg, multiple fractures or visceral lesions), and/or diminished mental status. In such patients, we have incorporated helical CT of the entire cervical spine into the initial imaging examination immediately after the initial cross-table lateral radiograph.

The technique we use on our helical CT unit is determined by the clinical circumstances. If the spine is being examined as part of a multisystem trauma survey in which the cervical spine is to be cleared, then the image data set is obtained by using 5-mm collimation with a 1:1 pitch, and extends from C-1 to C-7. This adds negligible time to the total CT examination and enables an accurate evaluation that eliminates the delays that often occur when a series of routine spine radiographs are obtained. As mentioned above, a significant number of fractures that were not shown on plain films were detected on CT scans, a fact that relates to suboptimal plain radiographs frequently obtained in uncooperative and obtunded trauma victims. More recently, we retrospectively evaluated the type, distribution, and significance of missed lesions by plain radiography and found that, as one would expect, the fractures missed most often occurred at the C1–2 and C-7 levels (13). More important, however, was the fact that one third of the patients in this category had either clinically significant or unstable injuries, as determined by imaging criteria. In patients whose initial cross-table radiographs show a specific level of injury, CT can be used to characterize the injury more clearly and rule out other levels of cervical injury not apparent on the initial film. Thinner collimation and reformatted images (sagittal and/or coronal) may be helpful in this circumstance. While some may question this approach, *it is our opinion that the initial evaluation of the cervical spine after significant trauma should be based on*

an approach in which a combination of plain films and helical CT scans are obtained.

MR imaging in patients with cervical spine injury, a technique preferred over CT myelography, is also controversial, because the influence such imaging has on eventual patient outcome has not been conclusively established. In addition, while the time from injury to treatment and the initial neurologic status of the patient are both variables that, in theory, could be used to determine the timing of surgical management, randomized studies to prove the long-term efficacy of early surgical intervention are not available. Nonetheless, even in the absence of such information, we advocate emergency MR imaging, because surgical decisions may in part be based on the MR findings.

The presence of hemorrhagic versus nonhemorrhagic cord contusion and how that relates to neurologic recovery (14, 15) have been reported, but the use of MR imaging as an indicator of prognosis is not the most crucial issue. Rather, it is the presence or absence of cord compression by bone, disk, or hematoma that is at the heart of surgical decision making, because it allows one to answer the basic question of whether immediate decompressive surgery should be performed. In general, at our institution, surgery is considered warranted in any patient with an acute spine injury in whom cord compression is shown by MR imaging, regardless of whether the patient has a complete or incomplete neurologic deficit. This situation becomes less well defined in a patient for whom emergency surgery is being considered more than 24 hours after injury.

The specific MR techniques used to examine the injured spine are far less important than the timing of the examination relative to the occurrence of the injury. To answer the most pressing question (ie, the presence or absence of cord compression), spin-echo and/or gradient-echo imaging is used in patients who are medically stable and adequately immobilized. We favor the use of T1-weighted spin-echo and T2*-weighted gradient-echo imaging in both the axial and sagittal planes. These examinations are sensitive to the presence of blood either within the cord or extrinsic to the cord and allow evaluation of the degree of cord and canal compression. In evaluating these images, the radiologist must keep in mind that, prior to the MR examination, decompression of the spine may have occurred as a result of cervical traction in the trauma center. Consequently, the degree of initial spinal cord compression may have been far greater than it appears on the MR study, which is frequently obtained with the patient in cervical traction.

Aside from these radiologic issues and the issues surrounding medical treatment of acute spinal cord injury, a focus of controversy is whether acute spine decompression performed within 8 to 12 hours after injury in a patient with a neurologic deficit results in improved outcome as compared with nonemergency delayed decompression. In other words, can a strong case be made, based on scientific evidence, that there is a need to provide immediate spine decompression by surgery when traction alone will not reduce cord compression? Despite the lack of a well-controlled clinical outcome study that addresses this issue, it is the practice at our institution to perform emergency spine decompression on the basis of MR findings and the clinical condition of the patient.

In summary, although controversy surrounds the routine use of helical CT and MR imaging in cases of acute injury to the cervical spine, we adhere to a policy whereby all significant or suspected cervical spine injuries are imaged with CT. Emergency MR imaging then follows in medically stable patients. Although the long-term efficacy of this strategy has yet to be proved, until compelling evidence to the contrary is provided, we believe that imaging in this manner can best guide the treating physician and thereby improve patient outcome.

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