

# An Analysis of Eastern Association for the Surgery of Trauma Practice Guidelines for Cervical Spine Evaluation in a Series of Patients with Multiple Imaging Techniques

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We conducted a retrospective review of 124 consecutive patients who received all of the following studies between October 1998 and December 1999: three-view plain films (3VPF), full CT survey (CTS), and MRI of the cervical spine. We compared the EAST guidelines for 1) patients with persistent neck pain, 2) those with neurologic deficits (NDs), and 3) those who were obtunded in our study group to determine whether EAST recommendations would risk a significant missed injury rate. The average age was 28 years (range 5 months–78 years). There were 94 males and 30 females. The mean Injury Severity Score (ISS) was 16.8 and the mean Glasgow Coma Score (GCS) 10.87. The most common mechanism of injury was motor vehicle crash (58%) followed by falling (15%), auto *versus* pedestrian (9%), all-terrain vehicle accident (4%), assault (3%) and other (11%). For comparisons we identified a group of 33 patients with normal mental status and normal 3VPF. Twenty patients had MRI for persistent neck pain. Eleven of 20 had normal MRI. The nine abnormal MRIs showed: six ligamentous injuries, two cord compressions, and one nonligamentous soft-tissue injury. Thirteen of the 33 patients had MRI for ND. Six had normal MRI and all these NDs resolved. The remaining seven MRIs showed: two disc herniations, two cord contusions, one cord edema, one lumbar fracture, and one brachial plexus avulsion. We also examined a group of 51 obtunded patients with normal 3VPF. Thirty-six of 51 had normal CTS and MRI. Ten patients had an abnormal MRI, two an abnormal CTS, and three abnormal MRI and CTS. No obtunded patient with an adequate 3VPF had an injury identified below C2 using CTS and MRI. In the 10 patients with abnormal MRI the mean age was 28.4 years, the mean GCS 6.6 ( $P = 0.0025$ ), and the mean ISS 24.3 ( $P = 0.03$ ) (Wilcoxon two-sample test). The injuries identified by MRI were four disc herniations, two ligamentous injuries, two soft-tissue traumas, one meningeal tear, and one cord transection. Thirty per cent of patients with persistent neck pain had potentially unstable injuries not detected by 3VPF or CTS. Fifty-four per cent of patients with ND had abnormal MRI. Twenty-two per cent of obtunded patients with normal 3VPF and CTS had an abnormal MRI. These patients have a significantly lower GCS and a higher ISS. Six per cent of these injuries were potentially unstable. Our data support EAST guidelines for patients with persistent neck pain and ND. The guidelines for obtunded patients appear safe in detecting bony injury but may not be sensitive enough for unstable ligamentous injury and significant disc herniations.

FOR THE LAST DECADE efforts to standardize medical care by using evidence-based practice guidelines have gained popularity. Guidelines can improve safety, efficacy, and cost of care when based on analysis of the existing literature and updated as new evi-

dence emerges.<sup>1</sup> One area in which evidence-based medicine has been applied is diagnosis of spine injuries in trauma patients.<sup>2,3</sup>

An estimated 11,000 cases of spinal cord injury occur per year accounting for 3 per cent of all trauma admissions.<sup>4</sup> Bony injuries including fractures and dislocations are commonly diagnosed with a three-view cervical spine series supplemented with CT scan as necessary. Clinically significant ligamentous injuries are uncommon and challenging to diagnose particularly in the comatose and obtunded patient.<sup>5,6</sup> Stan-

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standardizing care in these cases has been difficult because of the rarity of the injury and lack of quality clinical research. Although infrequent the consequences of a missed cervical ligamentous injury can be disastrous.

The Eastern Association for the Surgery of Trauma (EAST) has developed 16 evidence-based guidelines for application in the injured patient. The EAST guideline for identifying cervical spine injury after trauma identifies protocols designed to diagnose cervical spine injuries after trauma with a limited number of appropriate tests. The guidelines state that pain-free, awake, and alert adults and older children with no mental status change, not under the influence of drugs or alcohol, and free of distracting injury need no radiologic studies. EAST guidelines advocate that other major blunt trauma patients undergo a three-view spinal series supplemented with CT scans with sagittal reconstruction for suspicious or poorly visualized areas. Recommendations for the patient with persistent neck pain despite normal radiographs are active flexion/extension views. For patients with neurological deficits attributable to cervical spine origin cervical MRI is recommended. Patients with altered level of consciousness for greater than 24 hours are considered to have a stable cervical spine if adequate three-view plain X-rays and thin-cut CT through C1 and C2 are normal.

There is one trauma center that has reported good success in adopting the EAST guidelines.<sup>6</sup> However, there are centers that remain concerned about the adequacy of the protocol with regard to ligamentous injury particularly in the obtunded patient. Of particular concern is the ability of limited CT scanning to identify at-risk patients. Similarly there has been a reluctance to perform passive flexion/extension in the same population. MRI has been used to identify various lesions of the cervical spine regions including bone, ligaments, cord hematomas and other abnormalities, and clinically significant disc herniation and nerve root avulsions.<sup>7</sup>

None of these radiographic studies, however, has been shown to be completely effective in identifying injury.

### Methods

Our study is a retrospective review of 131 consecutive patients at the Level I trauma center at Louisiana State University Health Sciences Center in Shreveport, Louisiana between October 1998 and December 1999. The trauma registry and the MRI log book were used to identify the group of patients with suspected cervical spine injury who underwent all three of the following cervical spine studies: three-view plain films (3VPF), full CT survey of the cervical spine, and MRI.

Seven patients were not included in the final analysis of the study because of inadequate documentation or loss of the medical record. The remaining 124 patients' charts and registry information were surveyed for demographic data, mechanism of injury, radiographic study results, length of hospitalization, and outcome. The patients were categorized for purposes of the study into the categories of the EAST guidelines for patients with 1) persistent neck pain, 2) neurological deficit, and 3) obtundation. All radiologic studies were interpreted by university-based board-certified radiologists. Wilcoxon two-sample test was used in statistical analysis.

### Results

The mean patient age was 28.5 years with a range of 5 months to 78 years. There were 94 males and 30 females. The mean Injury Severity Score (ISS) was 16.8 and the mean Glasgow Coma Score (GCS) was 10.87. The most common mechanism of injury was motor vehicle crash (58%), followed by falling (15%), auto *versus* pedestrian (9%), all-terrain vehicle accident (4%), assault (3%), gunshot wound (2%) and other mechanisms (9%) (Fig. 1).

Patients were categorized for comparison with EAST guidelines initially by mental status (MS)—normal or abnormal. We defined abnormal as persistent GCS of less than 14; significant neurocognitive dysfunction; and pre-existing dysfunctional mental illness, dementia, or mental retardation. Patients were further subdivided by results of the 3VPF—normal or abnormal. There were 33 patients with normal MS and normal 3VPF. There were 32 patients with normal MS and abnormal 3VPF, 51 patients with abnormal MS and normal 3VPF, and eight patients with abnormal MS and abnormal 3VPF. These data are schematically represented in Fig. 2.

In the group of patients with normal MS and normal 3VPF patients were studied with regard to the presence of either neck pain or neurological deficit to review the adequacy of EAST cervical spine guidelines

MVA = 72 (58%)	Tornado = 2 (2%)
Fall = 19 (15%)	Auto/Bike = 2 (2%)
Auto/Ped = 11 (9%)	Football = 1
ATV = 5 (4%)	Tree = 1
Assault = 4 (3%)	Bike/Train = 1
GSW = 2 (2%)	Hanging = 1
Animal = 2 (2%)	Ceiling = 1

FIG. 1. Mechanism of injury. MVA, motor vehicle accident; ATV, all-terrain vehicle; GSW, gunshot wound.

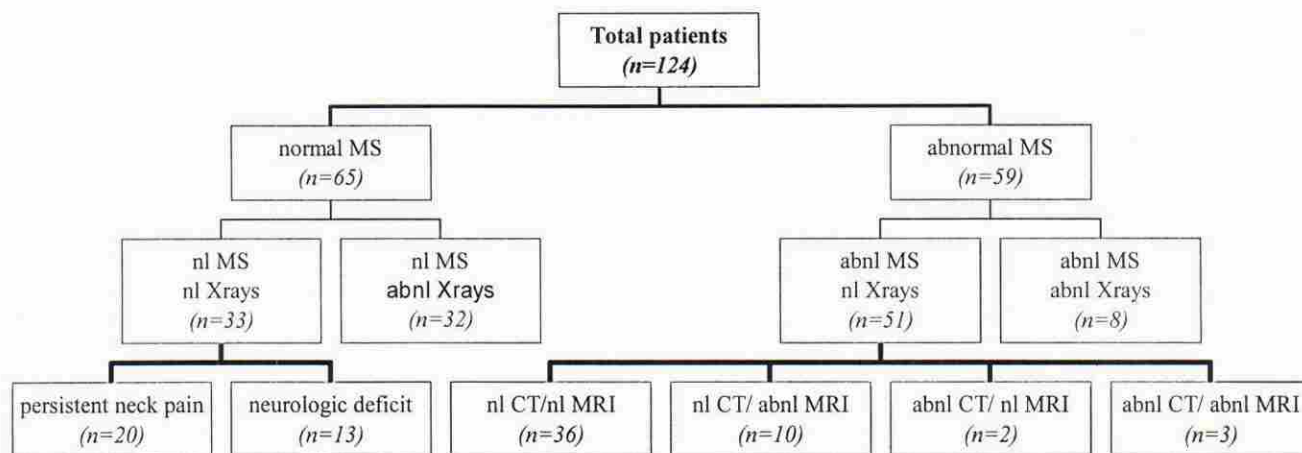


FIG. 2. Total breakdown. nl, normal; abnl, abnormal.

3 and 4. There were 20 patients with persistent neck pain. MRI in this population was normal in 11 patients. The nine remaining abnormal studies revealed six ligamentous injuries, two cord compressions, and one nonligamentous soft-tissue injury (Fig. 3).

In the group of 13 patients with neurological deficits the cervical MRI revealed six patients with no demonstrable anomaly. All six of the patients had complete resolution of symptoms. In the remaining seven patients two had disc herniation, two cord contusion, one cord edema, one brachial plexus avulsion, and one fracture identified at the lumbar level during the examination. None of these patients had a ligamentous injury identified (Fig. 4).

In the 51 obtunded patients with normal 3VPPF 36 had both a normal CT scan and a normal MRI. Two patients had a bony abnormality demonstrated on CT scan. Three patients had anomalies on both CT scan and MRI. Ten patients had an abnormality demonstrated only on MRI (Fig. 5). The mean age of the patient group with abnormal MRI alone was 28.4 years. The mean ISS was 24.3 ( $P = 0.03$ ) and the mean GCS was 6.56 ( $P = 0.0025$ ) (Fig. 6). The injuries identified by MRI in this patient subset were

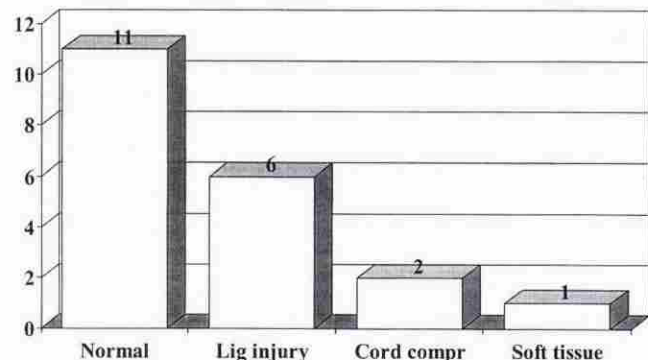


FIG. 3. Persistent neck pain (MRI results). Lig, ligament; Compr, compression.

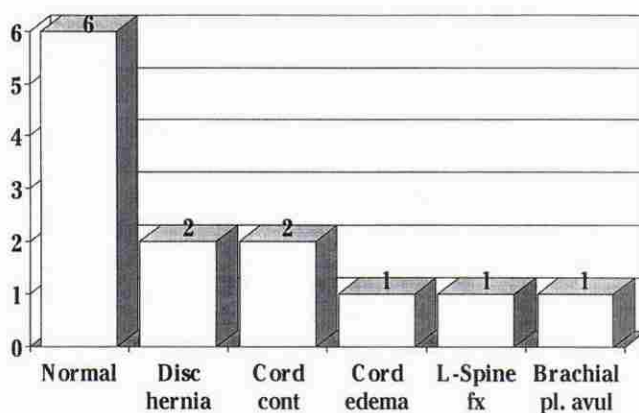


FIG. 4. Neurologic deficit (MRI results): cont, contusion; fx, fracture; pl, plexus; avul, avulsion.

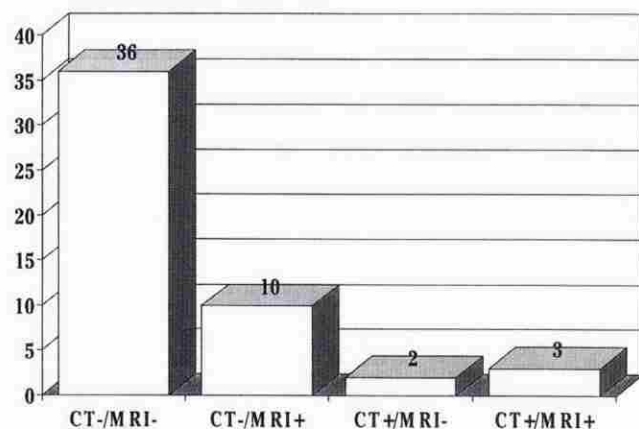


FIG. 5. Obtunded/normal X-rays.

four disc herniations, two ligamentous injuries, two nonligamentous soft-tissue injuries, one meningeal tear, and one cord transection (Fig. 7). The two patients with the ligamentous injuries were left in the cervical collar and no passive flexion/extension studies were done.

We did not identify any bony fractures below C2 in



	WHOLE GROUP	OBTUNDED /ABNL MRI
MEAN AGE	28.5 YRS	28.4 YRS
MEAN ISS ( $p = 0.03$ )	16.8 (Range 1-59)	24.3
MEAN GCS ( $p = 0.0025$ )	10.87 (Range 3-15)	6.56

FIG. 6. Demographics. Abnl, abnormal.

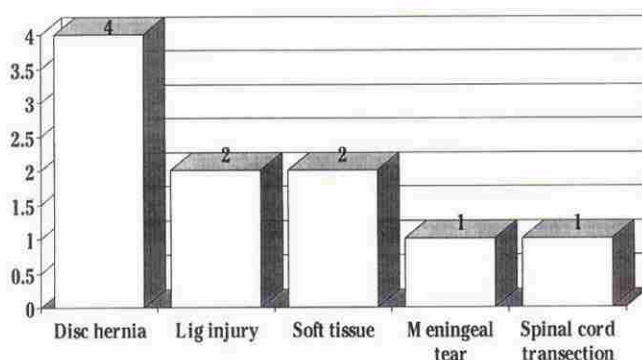


FIG. 7. Obtunded/abnormal MRI. Lig, ligament.

the obtunded patients with adequate 3VPF using full-spine CT scan or MRI.

### Discussion

Identifying cervical spine injuries in the injured patient is important for medical, economic, and legal reasons. Literature predominantly from the emergency medical field suggests that it is safe to remove the cervical collar in trauma patients who are alert, awake, cooperative, pain free, neurologically intact, without influence of drugs/alcohol, and with no distracting injuries.<sup>8,9</sup> For the practicing trauma surgeon such patients generally represent low severity of injury and are only infrequently encountered.

For the more severely injured patient the traumatologist must face a number of controversies in adequately evaluating the cervical spine. A minimum of a cervical spine physical examination and 3VPF is needed. Some centers favor a five-view cervical spine series; however, Freemeyer et al.<sup>10</sup> stated at the conclusion of their 2-year prospective study that no anomalies seen in five view studies were not at least suspected in the three-view series.

In patients with inadequate cervical plain films—a common problem at the first and second and lower cervical vertebrae—or in patients with abnormalities identified on plain films CT scanning has become a standard of care.<sup>3</sup> Newer helical scanning equipment

also has the advantage of allowing sagittal reconstruction that can predict spinal cord involvement and possibly some ligamentous injuries when read by an experienced radiologist.

Flexion/extension films in the awake and cooperative patient have been proven useful particularly for the detection of ligamentous injury. Controversy exists regarding the use and technique for such films in obtunded patients. Multiple protocols for obtaining these studies exist and range from passive mobilization with hard copy film to fluoroscopy with sensory evoked potentials to determine whether the patient is experiencing pain during the study.<sup>11</sup> Passive studies with fluoroscopy can be used to clear 65 per cent of spines for unstable ligamentous injuries but are subject to the same inadequacies as plain films particularly in clearing the lower cervical region.<sup>12</sup> An additional detractor for this study is that it is labor intensive and requires cooperation and the simultaneous presence of two or more clinical services in most institutions.

The role of MRI in identification of spinal injury in patients with neurological deficits is generally accepted. Its use for diagnosis in the remainder of the trauma population at risk for spine injury is in a state of evolution. One study of 121 brain-injured patients with normal plain films of the cervical spine revealed 25 per cent to have undetected ligamentous or bony injury.<sup>7</sup> The study has the disadvantages of requiring transport of critical patients to a less than desirable location in most hospitals, requiring an excellent history regarding presence of metal within the patient, and sometimes being subject to difficulty in interpretation of findings even with experienced radiographers.

EAST has developed practice management guidelines to assist practitioners in adequately assessing the spine in various groups of trauma patients with sensitivity to cost containment and litigious concerns. In our study we sought to critically evaluate the safety and diagnostic ability of the guidelines in a Level I trauma center.

Our study design does not permit us to comment definitively on the safety of the EAST guideline recommending flexion/extension views in the patient with persistent neck pain. However, the presence of six ligamentous injuries in this patient population supports flexion/extension for high diagnostic yield in this group. The remaining three injuries, two cord edemas with compression and a nonligamentous soft tissue injury do not represent unstable or irreversible injuries. Additionally the flexion/extension view better defines instability than MRI alone and represents a significant cost saving. The advantage of the MRI result lies chiefly in the ability to provide the physician and patient with a reasonable explanation for the pain and



some reassurance regarding its relatively benign nature. Inarguably, good patient education and the assurance of ability to obtain MRI in the late recovery period could do the same at no additional cost.

With regard to patients with neurological deficit our data support the EAST guideline for obtaining an MRI particularly if the deficit is persistent. All seven of our persistent-deficit patients had an abnormality on MRI. One patient with disc herniation had successful operative intervention in the early postinjury period. The other resolved over a 6-week period without operation. The patient with brachial plexus avulsion also had operative intervention with incomplete functional recovery. MRI helped us to separate patients who required operative intervention from those in whom expectant management was more prudent.

The area of greatest controversy generated by the EAST guidelines concerns obtunded patients. Although it is uncommon ligamentous injury is possible and potentially devastating. Other injuries such as disc herniation, cord hematomas, and edema are challenging to detect in the patient who is comatose or unable to fully cooperate with a thorough neurological examination. Our data revealed a number of clinically significant injuries in this population—ligamentous injuries, disc herniations, and a meningeal tear. The cord transection at the third cervical vertebra was suspected but not diagnosed in an intubated 2-year-old child with concomitant severe brain injury and decreased rectal tone. Our data suggest that comatose patients with high ISS are particularly at risk for spinal anomaly. In light of our retrospectively obtained data we are now conducting a prospective series in this patient population studying the spine with 3VPF, full helical CT scanning with sagittal reconstruction and MRI.

## DISCUSSION

**MICHAEL CHANG, M.D.** (Winston Salem, NC): The authors of this study have chosen a clinically important topic that all general surgeons that see injured patients in the emergency department should be aware of: cervical spine clearance. The problem is complex, integrating the images and clinical status of the patient is difficult, and the consequences of making the wrong decision are no less than disastrous. This one issue—clearing the cervical spine of injuries—consumes an enormous amount of resources in every trauma center and is one of the top clinical issues in the trauma community that remains unresolved in the country today.

Why is clearing the cervical spine so difficult? Quite simply, because there currently is no definitive test or combination of tests with a demonstrated perfect negative predictive value. Furthermore, the negative predictive value of any given test cannot be reliably improved with clinical

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examination, since confounding variables such as head injury, substance abuse, and distracting injuries make the physical examination unreliable.

Given this background we can now frame the current study in a more meaningful way. The group of patients we are most concerned with, as pointed out by the authors, are those with normal plain films and any confounding variable that makes physical examination unreliable. These patients are at risk for undetected bony injury or equally importantly unstable ligamentous injury with or without bony abnormality. Unfortunately it is in this one group of patients that the EAST guidelines fail on a theoretical basis. Limited-view static thin-cut scans simply will not reliably detect nonbony ligamentous injuries.

This study then attempts to retrospectively answer the question: How good are the EAST guidelines at finding these injuries? They further ask whether supplemental tests such as flexion/extension views and MRI are of any benefit.

Unfortunately the retrospective design of this study significantly limits its ability to answer these questions. The study population is highly selected, being only those that received all three studies (plain films, CT, and MRI). Thus the potential for a significant selection bias is very high, and in my opinion no firm conclusions can be drawn from this study as to whether the EAST guidelines are effective or not.

However, retrospective studies such as this can serve the important purpose of raising important questions to be answered prospectively, and this study fits into that category nicely. The authors point out that of the 51 patients with normal plain X-rays and abnormal mental status approximately 30 per cent had abnormalities detected with either CT or MRI, the majority being identified on MRI. Of these all but two had clinically important injuries.

Thus I think we can conclude from this study that which we already know, that is that plain films with or without flexion/extension alone are not enough. This clears the way from this point forward for prospective studies focusing on comparing MRI, thin-cut CT, and other modalities such as fluoroscopic evaluation of cervical stability in these obtunded patients. The authors are to be commended for helping us focus on these specific issues, and we all look forward to continued work from this group in this regard.

**MANMOHAN K. GHANTA, M.D.** (Closing Discussion): EAST devised these guidelines in 1998 and has since

made some changes. One was with patients with persistent neck pain and whether the patient could flex the neck for more than 30°. If they could not, they did recommend putting the patient in a collar for a couple of weeks and redoing the flexion and extension at that time. The other recommendation was with the obtunded group. They recommend doing fluoroscopic flexion and extension films in these obtunded patients. Over the past few years the EAST guidelines have been evolving, and I believe we have become comfortable with evaluating awake and alert patients, but there continue to be questions with the obtunded group with regard to what kind of test should be done. Several institutions use MRI and there are several that do use flexion extension films to rule out any cervical injuries. On the one hand you have MRI that is very sensitive for soft-tissue injuries and can detect even the clinically irrelevant minor injuries so you do not have to passively flex or extend the patient's neck preventing any further injury. At the same time it is expensive, you have to take the patient to a less desirable location to do the scan, and also you have the limitations of metal devices in these patients. On the other hand you have the flexion extension films that are cheap, that easily detect the unstable ligamentous injuries but at the same time, you have to passively flex and extend the patient's neck which probably could cause an iatrogenic cervical injury. The questions are still there. Perhaps we'll have some answers in the next few years.

