Screening for thoracolumbar spinal injuries in blunt trauma: An Eastern Association for the Surgery of Trauma practice management guideline

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BACKGROUND: Thoracolumbar spine (TLS) injuries have an incidence rate of 5% in blunt trauma patients. The Eastern Association for the Surgery of Trauma published Practice Management Guidelines for the Screening of Thoracolumbar Spine Fracture in 2007. The Practice Management Guidelines Committee was assembled to reevaluate the literature.

METHODS: A search of the United States National Library of Medicine and the National Institutes of Health database was performed using MEDLINE through PubMed (www.pubmed.gov). The search retrieved English-language articles from March 2005 to December 2011 that referenced traumatic TLS injuries and fractures. The questions posed were the following: (1) What is the appropriate imaging modality to screen patients for TLS injuries? (2) Which trauma patients require radiographic screening for TLS injuries? (3) Does a patient who is awake and alert without distracting injuries require radiologic workup to rule out TLS injuries?

RESULTS: Thirty-seven articles that referenced traumatic TLS injuries in association with screening published between March 2005 and December 2011 were collected and disseminated to the committee. Twelve were found to be relevant. Nine publications from the previous 2006 guidelines were reviewed and referenced to create and validate the updated guidelines.

CONCLUSION: Practice patterns have changed regarding screening blunt trauma patients for TLS injuries. Software reformatted multidetector computed tomographic scans are more sensitive and accurate than plain films. Multidetector computed tomographic scans have become the screening modality of choice and the criterion standard in screening for TLS injuries. The literature supports a Level 1 recommendation to validate this based on a preponderance of Class II data. Patients without altered mentation or significant mechanism may be excluded by clinical examination without imaging. Patients with gross neurologic deficits or concerning clinical examination findings with negative imaging should receive a magnetic resonance imaging expediently, and the spine service should be consulted. (J Trauma Acute Care Surg. 2012;73: S326–S332. Copyright © 2012 by Lippincott Williams & Wilkins)

KEY WORDS: Thoracic spine fractures; lumbar spine fractures; blunt trauma; practice management guidelines; screening for traumatic thoracolumbar injuries.

STATEMENT OF THE PROBLEM

Thoracic and lumbar spinal fractures are commonly encountered in blunt trauma patients. Approximately 50% of all vertebral fractures occur in the thoracolumbar spine (TLS), and the incidence of TLS fractures in trauma patients presenting to Level 1 trauma centers is 4% to 5%.

Neurologic injury to the spinal cord occurs in 19% to 50% of these patients, and a delay in diagnosis of TLS fractures can result in up to an eightfold increase in neurologic deficits. Clinicians caring for acutely injured patients must rely on diagnostic techniques to be efficient and accurate so as to minimize the time to diagnosis and interventions. Often, blunt trauma patients that present acutely will undergo multidetector computed tomographic (MDCT) scans without increased radiation, time, or cost. Magnetic resonance imaging (MRI) also plays a role in screening and evaluating patients for neurologic injury, ligamentous injury, and the need for operative intervention. The relevant questions regarding screening of the acute blunt trauma patient for TLS injuries are as follows:

1. What is the appropriate imaging modality to screen patients for TLS injuries?
2. Which trauma patients require radiographic screening for TLS injuries?
3. Does a patient who is awake and alert without distracting injuries require radiologic workup to rule out TLS injuries?
**PROCESS**

**Identification of References**
A search of the National Library of Medicine and the National Institutes of Health database and MEDLINE was performed using PubMed (www.pubmed.gov). The search identified articles in the English language that addressed the screening or identification of TLS injury from March 2005 to December 2011. Articles that were categorized as review articles, letters to the editor, editorials, commentaries, and case reports were excluded from the query. Thirty-seven articles were distributed to the committee. Twelve of those articles were thought to be pertinent to the construction of the updated guidelines. An additional nine articles referenced in the previous Practice Management Guideline (PMG) were referenced to revise and validate the updated guidelines. An evidentiary table was then constructed using the 21 references (Supplemental Digital Content, Table 1 http://links.lww.com/TA/A201).

**Quality of the References**
Articles were classified in accordance with the Eastern Association for the Surgery of Trauma (EAST) primer on evidence-based medicine that was published in 2000. Articles are categorized as Class I, II, or II.
- Class I: Prospective randomized clinical trial (no class I data exist).
- Class II: Prospective clinical studies or retrospective analyses based on reliable data such as cohort, observational, prevalence, or case-control studies (14 references).
- Class III: Retrospectively collected data based on database or registry review, case series, or expert opinion (7 references).

Recommendations were then classified as Level 1, 2, or 3 according to the following definitions as defined by the EAST primer on evidence-based medicine:

**Level 1**
- The recommendation is convincingly justifiable based on the available scientific information alone. This recommendation is usually based on Class I data; however, strong Class II evidence may form the basis for a Level 1 recommendation, especially if the issue does not lend itself to testing in a randomized format. Conversely, low-quality or contradictory Class I data may not be able to support a Level 1 recommendation.

**Level 2**
- The recommendation is reasonably justifiable by available scientific evidence and strongly supported by expert opinion. This recommendation is usually supported by Class II data or a preponderance of Class III evidence.

**Level 3**
- The recommendation is supported by available data but adequate scientific evidence is lacking. This recommendation is generally supported by Class III data. This type of recommendation is useful for educational purposes and in guiding future clinical research.

**RECOMMENDATIONS**

**Level 1**
1. When imaging is deemed necessary, MDCT scans with axial collimation should be used to screen for and diagnose, as MDCT scans are superior to plain films in identifying TLS fractures.

**Level 2**
1. Patients with back pain, TLS tenderness on examination, neurologic deficits referable to the TLS, altered mental status, intoxication, distracting injuries, or known or suspected high-energy mechanisms should be screened for TLS injury with MDCT scan.
2. ii. In blunt trauma patients with a known or suspected injury to the cervical spine, or any other region of the spine, thorough evaluation of the entire spine by MDCT scan should be strongly considered owing to a high incidence of spinal injury at multiple levels within this population.
3. Patients without complaints of TLS pain that have normal mental status, as well as normal neurological and physical examinations may be excluded from TLS injury by clinical examination alone, without radiographic imaging, provided that there is no suspicion of high-energy mechanism or intoxication with alcohol or drugs.

**Level 3**
1. MRI should be considered in consultation with the spine service for MDCT findings suggestive of neurologic involvement and of gross neurologic deficits.

**SCIENTIFIC FOUNDATION**
EAST published PMGs for the screening of thoracolumbar spine fracture in 2007. The trend for screening blunt trauma patients for TLS injuries in major trauma centers has transitioned almost exclusively to the use of MDCT scans during the past several years. In addition, 12 new articles regarding screening for TLS injury have been released since the guidelines were published. With the transformation of practice patterns, the evolution of CT technology with regard to accuracy and digital capabilities and the additional publications, a reevaluation of the literature and an update to the previously published guidelines, was essential. The most significant alteration is the elimination of plain radiographs from the screening algorithm for TLS fractures. In accordance, the update endorses the use of MDCT scans for screening as a Level 1 recommendation owing to the preponderance of respective Class II evidence. Furthermore, with the advances in CT software technology and the ability to reconstruct body MDCT scans to screen for TLS injuries, the use of CT scout films was antiquated and therefore removed from the recommendations. Other modifications include the removal of specified high-energy mechanisms as well as recommendations regarding professional authority pertaining to clinical examinations and radiographic interpretation. These recommendations were extracted to comply with strictly evidence-based guidelines.

**MDCT SCAN: THE CRITERION STANDARD FOR SCREENING OF TLS INJURIES**
It is the current standard of care at most major trauma institutions to use MDCT scans to image the head, cervical spine, chest, abdomen, and pelvis to diagnose injuries in...
patients sustaining blunt trauma. Modern MDCT scanners have
detectors that concurrently collect image data from multiple
angles. Current software technology allows the collected data to
be reformatted or reconstructed to create precise images without
the need for additional imaging or radiation to the patient. The
quality of the images obtained from the screening body scans,
coordinated with the ability to construct sagittal and coronal
views of the TLS, provides accuracy that negates the need to
repeat focused vertebral imaging. The American College of
Radiology Practice Guideline for the Performance of Computed
Tomography of the Spine suggests that the CT slice thickness
should be no greater than 3 mm for evaluation of the TLS. Di-
agnostic reconstruction can then be created from these images.
Thinner slices can be attained; however, these are more often
used for evaluating spinal fusions, lumbar disc space, or facet
degeneration.10

Early generation single-slice CT scanners lacked the accuracy to diagnose fractures in the transverse plane. CT scan
was historically introduced and promoted as a complementary
examination to traditional x-ray films. It was used to visualize
the extent and the stability of vertebral fractures in regions
where the axis was difficult to appreciate with x-ray films. CT
scans could also elucidate regions that were poorly visualized
on plain films, in particular the upper thoracic and cervico-
thoracic junctions. It was additionally useful for identifying
fractures that were questionable on plain film.11–13 As the
use of CT scans to evaluate for TLS fractures increased and
the technology and software improved, concerns began to
emerge about the inadequacy of plain films. In the early 1990s,
Fontijn et al.11 and Ballock et al.14 published separate studies
that demonstrated a concern for the accuracy of plain radiog-
raphy in the diagnosis of TLS fractures, and in particular, burst
fractures. Ballock et al. reported data that 25% of the burst
fractures would have been misdiagnosed as compression fractures by plain films alone.

In 2003, Hauser et al.15 published prospective data based
on 222 patients that had both plain radiography and 5-mm helical CT scan images to evaluate for TLS fractures. The sensitivity of CT scan was 97% compared with 58% for plain radiographs, and chronic fractures could be differentiated from acute fractures. There were no unstable fractures that were
missed, and most of the missed fractures were transverse pro-
cess and spinous process fractures (SPFs). CT scan also sig-
nificantly decreased the time to TLS clearance from 12 hours
to 48 hours to approximately 3 hours with CT scan.

Sheridan et al.12 also published in 2003 using 2.5-mm reformatte,
CT images from scans of the chest, abdomen, and
pelvis to evaluate 1,915 patients. Forty-three patients had spinal
fractures, and plain films missed 42% of these fractures. The
sensitivity for thoracic fractures was 97% for CT scan versus
62% for plain films. For lumbar fractures, the sensitivity was
95% versus 86% for plain films. Of the total 19 fractures that
were missed by plain films, 3 fractures (15.7%) were unstable,
and the remaining were transverse process or SPFs. Wintermark
et al.16 also showed the sensitivity for diagnosis of unstable
fractures by plain film to be 33.3% as compared with 97.2% by
2.5-mm slice CT scan. In 2004, Roos et al.17 subsequently
reported the sensitivity of reformatted CT images with 3-mm
slices as 98% with a specificity of 97%.

Herzog et al.18 published a very eloquent study in 2004
in which 70 blunt polytrauma patients were imaged with con-
ventional radiographs, 5-mm slice CT scan, 3-mm slice CT
scan, and then 5-mm and 3-mm slices with multiplanar recon-
struction (MDCT scan). The respective sensitivities for tho-
racic fractures were 57.1%, 85.7%, 100%, 95.2%, and 100%.
For lumbar spine fractures, the sensitivities were 75%, 83.3%,
91.7%, 100%, and 100%, respectively. The respective unstable
thoracic fracture sensitivity was 57.1%, 85.7%, 85.7%, 100%,
and 100%. The unstable lumbar fracture sensitivity was 76.9%
for conventional radiographs and 100% for all CT method-
ology. They concluded that overlapping thin-slice MDCT scans
were far superior to conventional radiographs as well as single-
slice CT imaging.

Several subsequent studies followed including one by
Brandt et al.19 in 2004. Although the study was retrospective
and small in number (n = 55), they revealed that 24% of TLS fractures were not seen on plain films and 9% of those missed
were unstable vertebral body fractures. Also in 2004, Mejia
et al.20 calculated a 59% sensitivity with plain films in com-
parison with 99% sensitivity with CT scan in 1,576 patients
who were screened. Three percent of the fractures that were
missed by plain film were considered unstable and required
treatment. Berry et al.21 showed a 73% versus 100% sensi-
tivity for plain films in comparison with CT. In addition,
16.7% of missed fractures were unstable compression or
burst fractures. Antevil et al.22 calculated a 71% versus 100%
sensitivity for plain films in comparison with CT. Smith
et al.23 published a dismal 54% versus 100%, respectively,
and also calculated sensitivity for plain film diagnosis of un-
stable thoracic spine fractures to be only 75%, while plain
film sensitivity of unstable lumbar fractures was even less
at 63%. More recently, Pouw et al.24 published a study with
620 patients evaluating pelvic fractures and TLS fractures.
The sensitivity of plain films for TLS fractures was only 22%.
The sensitivity of fracture identification for vertebral
body fractures was 40% for thoracic spine and 76% for lum-
bar spine.

In summation, the sensitivity of plain films for diag-
nosing all TLS fractures ranged from 22% to the best pub-
lished value of 75% in comparison with 95% to 100% in
MDCT scans (Table 1). Most fractures missed by plain film
imaging were transverse process fractures (TPFs) and SPFs.
TPFs have been associated with scoliosis in rare cases, but
they do not lead to vertebral column instability and rarely
impact therapeutic interventions.25–27 Providers should rec-
ognize that it requires a high energy mechanism to fracture
a transverse process. These injuries have a concomitant asso-
ciation with injury to the abdominal viscera, the retro-
peritoneum, the vertebral column, long bones, the cranium,
pelvic fractures, and the genitourinary system.24,28–30 SPFs
can result in vertebral column instability in some circum-
stances, but most are not clinically relevant.31,32 TPFs and
SPFs can both increase morbidity secondary to pain, muscle
spasm, and decreased mobility. However, the most con-
cerning issue regarding the decreased sensitivity of plain
films is the number of missed unstable fractures. The publi-
cations reviewed classified unstable fractures as those in-
volving the vertebral bodies, namely, compression fractures,
TABLE 1. Sensitivity of CT Scan and Plain X-Ray Study for Thoracolumbar Spinal Fractures

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Class of Data</th>
<th>No. Patients</th>
<th>Sensitivity of CT, %</th>
<th>Sensitivity of X-Ray Study, %</th>
<th>Sensitivity of CT for Unstable Fractures, %</th>
<th>Sensitivity of X-Ray Study for Unstable Fractures, %</th>
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<tr>
<td>Hauser CJ</td>
<td>2004</td>
<td>II</td>
<td>215</td>
<td>97</td>
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<td>100</td>
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<tr>
<td>Wirtzmark M</td>
<td>2003</td>
<td>II</td>
<td>100</td>
<td>78</td>
<td>32</td>
<td>97.2</td>
<td>33.3</td>
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<tr>
<td>Sheridan R</td>
<td>2003</td>
<td>II</td>
<td>78</td>
<td>95–97</td>
<td>62–86</td>
<td>100</td>
<td>—</td>
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<tr>
<td>Herzog</td>
<td>2004</td>
<td>II</td>
<td>70</td>
<td>100</td>
<td>57–75</td>
<td>100</td>
<td>57–77</td>
</tr>
<tr>
<td>Mejia V</td>
<td>2004</td>
<td>II</td>
<td>1,576</td>
<td>94–98</td>
<td>58–59</td>
<td>100</td>
<td>—</td>
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<tr>
<td>Berry GE</td>
<td>2005</td>
<td>III</td>
<td>103</td>
<td>100</td>
<td>73</td>
<td>100</td>
<td>93</td>
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<tr>
<td>Antevil JL</td>
<td>2006</td>
<td>III</td>
<td>573</td>
<td>100</td>
<td>71</td>
<td>100</td>
<td>—</td>
</tr>
<tr>
<td>Smith R</td>
<td>2009</td>
<td>II</td>
<td>59</td>
<td>89</td>
<td>37</td>
<td>100</td>
<td>63–75</td>
</tr>
</tbody>
</table>

Nonspinal traumatic injuries are also associated with TLS fractures, either as a distraction to the physical examination or as a marker of the severity of mechanism.3,4,6,43–47

There are multiple mechanisms of injury that have been identified as being highly correlated with TLS fractures. These include falls greater than 10 feet, ejection from a motor vehicle, motorcycle crashes, high-velocity injuries, and pedestrians struck by motor vehicles.3,4,43,47,48–50,66

Patients with alterations in sensorium from traumatic head injury, shock, or intoxication may not have a reliable clinical examination, and therefore, radiologic screening is essential.1,3,4,35,37,43,45,51,52

The majority of the literature supports the notion that TLS fractures may be asymptomatic, yet several studies suggest that clinical examinations can be highly sensitive for patients with reliable physical examinations.3,4,27,35,37,43,45,52

Terregino et al.35 found that in conscious patients with a normal mental status and no distracting injuries, the absence of back pain or tenderness had a 95% negative predictive value for TLS fractures. Yet, Sava et al.53 prospectively compared physical examination findings with plain films in 537 patients with reliable mental status examinations and found clinical examination to be only 80% sensitive in the identification of TLS fractures. Cooper et al.1 reported a review of 183 TLS fractures in patients who were neurologically intact with a Glasgow Coma Scale (GCS) score between 13 and 15. Thirty-one percent of these patients were recorded as having no pain or tenderness, yet all had fractures. The evidence would suggest that many of these fractures are not truly asymptomatic but rather are occult fractures that are missed owing to the presence of intoxication or an unreliable physical examination.

There is considerable evidence to support the notion of performing radiographic screening on the basis of mechanism alone regardless of clinical examination findings. Anderson et al.35 retrospectively evaluated 310 major TLS fractures to document the correlation of mechanism with TLS fractures despite negative findings on clinical examination. Frankel et al.14 and Holmes et al.45 designed separate prospective studies that defined screening criteria for TLS fractures that included mechanism and applied these criteria to 2,844 total patients with blunt traumatic mechanisms. The sensitivity and negative predictive value of their screening criteria was 100%.

The caveat to the preceding studies is that plain films were used as screening for TLS injuries. With the transition to CT scans, it is plausible that the increased sensitivity may
result in the diagnosis of occult asymptomatic fractures not previously identified with plain films. In 2011, Inaba et al.54 published a prospective study on blunt trauma patients with a reliable mental status that received body CT scans, which allowed screening of the TLS. Clinical examination was 48% sensitive for all TLS fractures and 79% sensitive for clinically significant fractures, defined as those requiring an orthotic or surgery. Currently, this is the only known study that compares clinical examination to CT scan findings. Although the data are impressive, the key limitation of this study (as pointed out by the authors in the article) is that globally asymptomatic patients did not receive imaging, regardless of mechanism. This raises the possibility that there may have been even more false-negative examination results than the collected data suggest.

Most blunt trauma patients at major trauma centers receive screening body scans that also evaluate for TLS fractures with MDCT technology. However, there are certainly a significant number of patients who can be excluded for injury by clinical examination. It remains the recommendation of the PMG Guideline Committee based on the reviewed literature that patients with a reliable mental status and negative clinical examination result can be excluded by physical examination without the need for MDCT imaging. However, if a high-energy mechanism is confirmed or suspected, the patient should be screened for TLS injuries via MDCT scan or transferred to a trauma center with MDCT scan capabilities.

**THE ROLE OF MRI IN SCREENING FOR TLS INJURIES**

MRI does not currently offer any advantage over CT scans, and it is actually less sensitive with respect to identifying spinal osseous injuries. Although MRI is useful for evaluating marrow edema as in compression fractures, MDCT scan should be obtained first to evaluate for fractures. MRI is more useful to evaluate spinal cord injury, ligamentous injury, hematomas, disk involvement, and facet joint involvement.55,56 Ligamentous injury of the TLS without fracture is extremely rare, but the phenomenon does exist.1,2,5,57-59 The indication for MRI of the TLS after blunt trauma includes the evaluation of gross neurologic deficits, MDCT findings suggestive of neurologic involvement, and neurologic examination findings despite the absence of radiographic abnormalities.5,58,60-61 The thoracolumbar “burst” fracture occurs approximately 14% to 48% of the time, and a neurologic deficit is present in 65% of patients. The soft tissue components of the injury, including ligamentous disruption, are not reliably visualized with CT scans and therefore typically warrant an early MRI.62-65 Several studies have demonstrated the deleterious effects of delayed treatment in neurologic outcomes and recovery.2-9 Therefore, it is the recommendation of the PMG Committee that either the orthopedic or the neurosurgical spine service be consulted on patients with the previously mentioned findings before obtaining an MRI as to not delay potential emergent therapeutic interventions which could be based on physical examination findings alone or MDCT imaging.

**SUMMARY**

There have been no prospective, randomized studies to evaluate the screening of TLS injuries in blunt trauma patients. However, there is significant Class II and Class III data that demonstrate the superior sensitivity of MDCT scan in comparison with plain films for the diagnosis of TLS fractures. Furthermore, there are data that justify concerns regarding the financial implications as well as the radiation exposure involved with using MDCT scans for TLS screening. MDCT scans are the eventual outcome if a TLS injury is diagnosed or even suspected, and most blunt trauma patients already require body CT scans to screen for injuries in the chest, abdomen, and pelvis. MDCT technology has evolved so that modern CT scanners use computer software to reformat axial collimated images into sagittal views, coronal views, and three-dimensional imaging. This has allowed the single admitting series of CT scans to be reformatted for a more accurate evaluation and diagnosis of TLS injuries. Neither there have been any publications that have addressed long-term follow-up to identify missed TLS injuries nor have there been any studies that have evaluated the incidence of TLS fractures in clinically benign patients with significant mechanisms of injury. Thus, the true incidence of TLS injury is not known. CT scans are not 100% sensitive, but as a whole, the evidence has shown that radiographs of the TLS are inadequate.

The 2012 updated recommendations regarding the screening for thoracolumbar spinal injuries in blunt trauma patients establish that MDCT scans should be considered the criterion standard imaging modality for the screening of TLS injuries. As stated in the previous guidelines, all blunt trauma patients with clinical symptoms, altered mental status, distracting injuries, neurologic deficits, or significant traumatic mechanisms should receive a MDCT scan to evaluate for TLS injuries. If MDCT scans are not available, the practitioner should consider transferring the patient to the closest trauma facility with MDCT scan capabilities. In accordance, patients with normal and reliable examination results, without any evidence or concern for altered mental status, intoxication, or significant mechanism, may be evaluated clinically and excluded from injury without the need for imaging. Practitioners who elect to use plain films for TLS screening should fully acknowledge and accept the limitations of plain films in relation to the clinical scenario, the mechanism, and the evidence-based recommendations that have been extrapolated in this publication.

The PMGs for the screening of TLS injuries in blunt trauma were established to assist practitioners in the screening, diagnosis, and management of TLS injuries in blunt trauma patients. These are evidence-based guidelines that should be used in accordance with clinical judgment. Individual scenarios, resource availability, and clinical variations may need to be taken into consideration when determining ultimate screening algorithms.

**FUTURE INVESTIGATIONS**

Future studies should prospectively evaluate blunt trauma patients who have sustained significant mechanisms
with screening MDCT scans, regardless of physical examination findings, to identify the true sensitivity and positive predictive value of the clinical examination as well as the true incidence of TLS injury in blunt trauma patients.

DISCLOSURE

The authors declare no conflicts of interest.

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