Review Article

A simplified treatment algorithm for treating thoracic and lumbar spine trauma

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Context: Current treatment of TLST should consider injury morphology, neurological status, clinical status (pain and disability) and also multimodal radiological evaluation (MMRE) with CT, MRI and dynamic/ standing plain radiographs.

Methods: A narrative literature review was performed to propose a treatment algorithm to guide the management of thoracolumbar spinal trauma (TLST). In order to classify injuries and surgical indications, we utilized the two most recent classification systems (TLICS and new AO spine classification) and related recent literature.

Results: Injuries were categorized into three groups according to stability: 1) Stable injuries, 2) Potentially unstable injuries/ delayed instability or 3) Clearly unstable injuries. Stable injuries included most of AO type A fractures without neurological deficit, mild clinical symptoms and without risk factors for late deformity. Potentially unstable injuries generally included patients without neurological deficits but with some risk factors for late deformity or with severe clinical symptoms. Surgery may be recommended in this group. Finally, clearly unstable injuries are those with spinal dislocations and/ or with neurological deficits, especially in the setting of persistent neural tissue compression, requiring early surgical treatment.

Conclusions: The proposed treatment algorithm is intended to help surgeons select the best treatment modality for their patients, categorizing injuries according to their main characteristics into one of these three groups. Further studies addressing the reliability and safety of this algorithm are necessary.

Keywords: Thoracic trauma, Lumbar trauma, Classification, Treatment, Algorithm

Introduction

Treatment of thoracic and lumbar spinal trauma (TLST) can be simplistically divided into non-operative or surgical treatment, even though both have many specific nuances.¹⁻³ A critical step in the decision making process is injury classification.¹⁻³ Historically, many classification systems have been proposed and evolved throughout the years.⁴⁻⁹ However, none have achieved total acceptance due to limitations and flaws, such as low reliability, lack of consensus in some morphologic descriptors, reliance on plain radiographs, and an exclusion of clinical information most notably neurological injury.⁴⁻⁹

To address these limitations, Spine Trauma Study Group proposed in 2005 a new system named TLISS

(Thoracolumbar Injury Severity Scale), which was based on three main factors for deciding the best treatment option: 1) injury mechanism, 2) posterior ligamentous complex (PLC) status and 3) neurological status.³ This system was soon modified due to the low reliability of injury mechanism, which was replaced for injury morphology, with a new classification system named as TLICS (Thoracolumbar Injury Classification and Severity Score).¹⁰ Although it is likely the most used classification for TLST today, with many studies addressing its good reliability and safety, the TLICS was criticized for poor reliability in injury morphology description and imprecise description of the PLC complex status.¹¹⁻¹⁴ Another important criticism of the TLICS is that some injuries treated non surgically, notably burst fractures without neurological deficits, may require later surgical treatment for local kyphosis and/ or severe pain on follow-up.¹⁵⁻¹⁷

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In this context, the AO Spine Study Group proposed a new morphological classification for TLST, also including neurological status and clinical modifiers.² Injuries were described in three major groups, based on CT scan findings: type A (compression injuries of the vertebral body, characterized by failure of the anterior structures under compression), type B (within failure of posterior or anterior tension band) and type C, with severe vertebral displacement/ dislocations.²

Acute treatment of TLST can either be non-operative or surgical depending on fracture morphology, neurology and ligamentous integrity. Abbasi Fard *et al.* have proposed a new definition for spinal instability.¹⁹ Injuries may be classified as stable or unstable, but instability may be “immediate” or “delayed”.¹⁹ Immediate or clear instability refers to those patients who are at risk of acute mechanical pain or acute neurological deterioration, unable to support any acute load with their spines. Delayed instability refers to those patients who are at risk of spine deformity and also progressive pain worsening, but whose spine may support some acute physiological load, such as walking and sitting.

With this concept in mind, it may be possible to develop a simplified, clinically relevant algorithm to help surgeons in the management of acute TLT may include. The objective of this paper is to review the current literature on TLT treatment and propose a new algorithm considering the concepts noted above.

Methods

A narrative literature review was performed to propose a treatment algorithm to help in the management of thoracolumbar spinal trauma (TLST). To describe the injuries and surgical indications, we based on two most recent classification systems (TLICS and new AO spine classification) and related recent literature.

The data obtained after the revision of these papers were discussed according to the concept of instability published by Abbasi Fard *et al.*, where injuries were grouped according to instability status:¹⁹

- (i) Stable injuries
- (ii) Potentially unstable injuries/ delayed instability
- (iii) Clearly unstable injuries (immediate instability)

Results

TLICS studies

A recent systematic literature review had suggested that the TLICS is reliable and safe for guide treatment of acute TLST.²⁰ However, controversy remains as some studies have reported problems in the treatment of burst fractures without neurological deficits (TLICS

score of less than 4 points) that may need surgery for persistent pain or progressive deformity.²⁰⁻²³

Joaquim *et al.* reported the results of the prospective application of the TLICS.¹⁷ Patients with 5 or more points had benefits from surgical treatment with regards to neurological status (the majority of patients with incomplete deficit had some improvement).¹⁷ However, after a mean follow-up of 6.7 months, two of 37 patients (5%) with a TLICS of less than 4 points required surgical treatment for back pain and progressive mild kyphosis.¹⁷

Hitchon *et al.* reported in a retrospective cohort study that, from 68 neurologically intact patients with thoracolumbar (T11-L2) burst fractures treated non-surgically with a TLICS score of 2 points, 18 patients (26.4%) required surgery due to pain limiting mobilization.²² Patients who required surgery had a greater Load Sharing Classification (LCS) (6.9 ± 1.1) compared to those with had a successful clinical treatment (5.8 ± 1.3 , $P = 0.006$).²² Additionally, they were also slightly more kyphotic ($8^\circ \pm 10$) and stenotic ($52 \pm 14\%$) than those who did not require surgery ($3^\circ \pm 7$ and $63 \pm 12\%$).²² They proposed that about a quarter of their patients with a TLICS of 2 points would require surgical treatment, suggesting that these injuries are potentially unstable in some cases, such as those with greater kyphosis, stenosis and important vertebral bone fragmentation.

Azhari *et al.* reported the results of a prospective study of patients with a TLICS of less than four points that, among 124 patients who underwent initial non-operative treatment, 14 (11.3%) required late surgery for intractable pain.²¹ These patients who required surgery had a higher canal compression rate (67.4 versus 49.4 in the non-operative group, $P < 0.001$) and were younger (33.4 versus 51.4 years, $P < 0.003$).²¹ The authors proposed that patients with a TLICS of less than 4 who had severe canal compression would have benefits of surgical treatment, especially if they were young adults.

New AO spine classification

New AO Classification system published in 2013 had the objective to develop a widely accepted and comprehensive morphological classification system and also improving the poor morphological injuries characterization in the TLICS.² It divides injuries in three major groups, A, B and C, as explained previously. In the original study describing the classification, 40 cases were classified twice by an international panel, reporting substantial (0.72) reliability for groups' identification.²

Yacoub *et al.* evaluated retrospectively the reliability of the new AO Spine Classification in 54 TLST cases treated according to the TLICS.²⁴ Two researchers classified the injuries retrospectively twice, within an interval of eight weeks from each assessment. The reliability for injury subgroups was poor (kappa index ranging from 0.16 to 0.85) compared with the reliability for groups (kappa index for groups A, B and C was, respectively, 0.75, 0.7 and 0.85), suggesting that as complexity increases, reliability worsens. The safety analysis was limited due to the low level of concordance among all evaluations, but type B and C injuries were generally operated whereas type A injuries were treated conservatively or surgically according to the presence of neurological deficits.

Kaul *et al.* reported the results of a multicentre study comparing the reliability (intra and interrater evaluation) of the TLICS and the new AO Spine classification.²⁵ Fifty consecutive acute TLST cases were distributed to eleven surgeons from six different institutions and then classified according to both classifications. The same assessment was performed after six weeks, after randomly rearrangement of the cases. The Fleiss Kappa coefficient was used to evaluate reproducibility and the Spearman rank order correlation. For the TLICS system parameters, the interrater and intrarater reliability (K) was 0.43 ± 0.01 and 0.59 ± 0.16 for fracture morphology, respectively (both moderate). For the PLC status, the interrater and intrarater reliability was 0.47 ± 0.01 and 0.55 ± 0.15 , respectively (also moderate). For total score of the TLICS, the K was 0.29 ± 0.01 (inter) and 0.44 ± 0.10 (intra), with just fair to moderate reliability. On the other hand, for grading fracture type according to the new AO Subtype, there was a moderate interrater agreement ($K = 0.59 \pm 0.1$) and a substantial intrarater agreement ($K = 0.68 \pm 0.13$). For neurological status, near perfect intra and interrater agreement was obtained for both TLICS and the new AO system. The authors concluded that the AO Spine Classification had a better reliability for identifying fracture morphology compared with the TLICS. They also proposed that clinical studies addressing the systems are necessary.

Spinal instability

White and Panjabi defined stability as the ability of the spine to maintain under physiological loads relationships between the vertebrae such a that there is neither damage to the spinal cord nor the nerve root, as well as no deformity nor pain.²⁶ This premise is still valid, but incorporating the new concept of immediate versus delayed instability proposed by Abbasi Fard *et al.* is of

paramount importance for considering a better management of TLST.¹⁹ Clearly unstable injuries must be surgically stabilized as soon as possible, but patients with potentially unstable injuries or those with delayed instability may not require surgical fixation. Understanding these distinctions is important for avoiding unnecessary surgical interventions and their intrinsic morbidity and costs. To differentiate these three groups (stable, potentially unstable and clearly unstable injuries), incorporating additional patient characteristics, such as pain status, and MMRE is extremely important. Persistent pain and difficulty ambulating after TLT are considered a failure of non-operative treatment and surgery is well indicated.²² Additionally, although many radiological characteristics of burst fractures were potentially associated with a worse outcome in some case series, such as severe canal compression, decrease of vertebral body height, increasing the interpedicular distance, higher load sharing score, among others, their usefulness in the indication for surgical treatment are still debated, controversial and were not incorporated in the TLICS nor in the new AO spine classification.^{20–23}

Discussion

The goals of surgical treatment of TLST are to prevent further neurological injury, providing long term instability, correct deformity and misalignment and potentially avoid severe pain.^{2,3,15,27} Given these goals, we must incorporate into the treatment of TLST not only injury morphology and neurological status, but also clinical status such as pain and disability as well as information obtained in MMRE (CT scan, MRI, dynamic exams and also standing plain radiographs, when necessary). Finally, before defining the best treatment option, surgeons must also consider other variables, such as age, ankylosis, body habitus, comorbidities, among other individual features.

To characterize injury stability the following variables must be included:

- (i) **Morphological characteristics** using all available radiological modalities: CT scan, dynamic exams, standing plain radiographs and MRI studies. The new AO Classification System is probably the best way to characterize injury morphology, but it is only based on CT scan information.
- (ii) **Neurological status**
- (iii) **Clinical status (pain intensity and ability to walk)**

Treatment is then considered according to the final classification, grouping injuries in one of the following (Figure 1):

- (i) **Stable injuries:** are treated non-operatively.

Figure 1 Simplified algorithm to help surgeons in the treatment of acute TLST.

- (ii) **Potentially unstable injuries:** non-operative treatment with close clinical and radiological follow-up; surgery considered in the setting of severe pain, ambulatory dysfunction, progressive deformity or late neurological deficits.
- (iii) **Clearly unstable injuries:** are treated surgically.

Description of groups' characteristics (Table 1):

(i) Stable injuries

This group includes most of the fractures not associated with any degree of vertebral dislocation, without any spine misalignment, without facet subluxation or luxation, without or with only minor canal compression and without any degree of increasing distance of the spinous process. The diagnosis can be made preferentially with CT scan but an MRI may be used to discharge a suspect ligamentous injury, spinal hematoma or disc herniation. Standing plain radiographs may also be performed to rule out occult ligamentous injury and to evaluate the effect of the body weight in the fracture site.

Injury Morphologies: The main morphologies included in this group are minor facet fractures without any dislocation, transverses and spinous process fractures, compression fractures, burst fractures with mild canal compression (less than 50°) and without any associated injury in the facet joints. It includes the morphologies A0 and A1, as well as some

A2, A3 and A4 subtypes of the new AO Spine Classification.

Neurological status: All patients must be neurologically intact to be considered as having a stable injury pattern.

Treatment: Pain medication when necessary, with clinical and radiological follow-up in an outpatient setting, with or without prescribing a brace.

(ii) Potentially unstable injuries

This group includes borderline injuries where there is no evidence of the best treatment modality and evident instability is not diagnosed. Differentiating this group from stable and clearly unstable injuries may require a complete evaluation of all radiological and clinical variables.

Morphologies: a multitude of injury morphologies are included in this group. The most prevalent may include:

- 1) Compression (A1 and A2) or burst fractures (A3 and A4) with mild increase of the distance of the adjacent spinous processes or with severe vertebral body comminution. Neurologically intact patients.
- 2) Burst fractures (A3 and A4) with moderate or severe canal compression (more than 50°) but without neurological deficits,
- 3) Burst fractures (A3 and A4) with some diastases of the facet joints but without subluxation and without neurological deficits,
- 4) Bone Chance-type fractures (pedicular fractures without any degree of displacement and without MRI signs of ligamentous injury) (some AO Type B1 fractures),
- 5) Hyperextension fractures with increased disc space height but without neurological deficits and without displacement/ fractures of the posterior elements (some AO Type B3 fractures).

The majority of type B injuries of the new AO Spine Classification (within failure of posterior or anterior tension band) without neurological deficits and without displacement may be included in this group. Of note, although they have the potential for long term deformity, many patients may also have bone healing and may be treated non-surgically. This group requires not only CT scan, but also MRI to potentially identify suspected ligamentous injuries.¹² Importantly, standing plain radiographs are critical to evaluate effect the body weight in the spinal alignment.

Neurological status: Potentially unstable injuries require that patients are neurologically intact. Otherwise, these injuries would be better classified as clearly unstable injuries (neurological instability).

Treatment: Initially, these injuries may be treated non-surgically. However, in the setting of vertebral

Table 1 Summary of the main characteristics of stable, potentially unstable and clearly unstable injuries.

	Stable Injuries	Potentially Unstable Injuries	Clearly Unstable Injuries
Morphologies	Minor facet, transverses and spinous process fractures without any dislocation, Compression fractures, burst fractures with mild canal compression (less than 50°) and without any associated injury in the facet joints and without severe vertebral body comminution	Compression/ burst fractures with mild increased of the spinous process distance Burst fractures with moderate or severe canal compression (more than 50°) Burst fractures with some diastases of the facet joints but without facet subluxation Burst fractures with severe comminution Bone Chance-type fractures (pedicular fractures without any degree of displacement and without MRI signs of ligamentous injury) Hyperextension fractures with increasing of the disc space without neurological deficits and without displacement of the posterior elements	Distractive or rotational injuries, with vertebral dislocation, spinal misalignment, facet subluxation or luxation, total canal occlusion, clear and evident increasing in the distance of the spinous processes.
AO Classification Morphologies	A0 and A1 subtypes Some A2, A3 and A4 subtypes	Some A2, A3 and A4 subtypes B1, B2 and B3 subtypes without displacement	Type C injuries with or without deficits Some A2-4 and B1-3 in the setting of neurological deficits
Neurological Status	Neurologically intact	Neurologically intact Mild radicular symptoms	Neurologically intact Complete or Incomplete Neurological deficits (exception: splashing injuries without compression) Moderate or severe radicular symptoms specially those refractory to pain medication Patients may have mild to severe pain, considering injury morphology
Clinical Symptoms	Mild pain Pain controlled by analgesics Able to ambulate	Mild pain Pain controlled by analgesics Able to ambulate (severe and refractory pain may be considered as a sign of instability and early surgical treatment may be considered)	
Radiological Diagnosis	CT scan, MRI and dynamic/ standing plain radiographs may be recommended	CT scan, MRI and dynamic/ standing plain radiographs	CT scan. MRI may be necessary to evaluate soft tissue compression or neurological deficits not explained by CT scan findings
Treatment	Non-operative treatment Pain medication With or without a brace	Non-operative treatment Pain medication Preferentially with a brace Surgical treatment: in the setting of severe worsening of back pain, progressive deformity especially in the setting of worsening of clinical symptoms, new vertebral dislocation, incapacity to walk due to pain and severe clinical impairment after the spine injury	Early surgical fixation is recommended for stabilize the spine and, when necessary, realigned it and decompress the neural tissue
Follow-up	Regular follow-up	Close clinical and radiological follow-up Advice for the risk of late surgical intervention	Regular clinical and radiological follow-up

translation in standing or dynamic radiographs or when associated with refractory pain, difficult to ambulate or leaving the bed, early surgical treatment may be

considered. In cases of progressive deformity during the radiological follow-up, delayed surgical treatment may also be offered, notably in symptomatic patients.

(iii) Clearly unstable injuries

This group comprises almost all fractures with associated vertebral dislocation (AO type C) and the majority of TLST with concomitant spinal cord or nerve injuries. It includes distractive and rotational morphologies, with vertebral dislocation, facet subluxation or luxation, important canal compromised or clearly increasing in the distance of the adjacent spinous processes.

Additionally, patients with other fractures or ligamentous injuries, without dislocation, but with neurological deficits (incomplete or complete or even radicular deficits) may be considered for early surgical treatment, especially if there is persistent neural tissue compression. This group also includes patients with burst fractures with concomitant neurological deficits, traumatic disc herniation or evident posterior ligamentous injuries (such as subluxated or injured facet joints).

Neurological status: In patients with spinal injuries without dislocation, such as burst fractures, the presence of neurological deficits is an indication for early surgical treatment, especially in incomplete cases in an attempt to improve recovery and reestablish neurological stability.

Treatment: Surgical fixation is recommended, to stabilize the spine and, when necessary, reestablish the alignment and decompress the neural tissue.

Conclusions

Our algorithm divides injuries in three groups in an attempt to simplify TLST management. Non-operative treatment is accepted for minor injuries and surgical intervention is well established for the majority of traumatic dislocations. There are, however, many inconsistencies about the best treatment of “intermediate” injuries. For these injuries, closer clinical and radiological follow-up are necessary. Additionally, there is no singular radiological feature (such as canal compression, burst comminution, loss of vertebral body height, among many others already proposed) nor classification system able to predict isolated the outcome of TLST. Considering this, grouping these injuries may improve the chances of an appropriate treatment, especially when considering patient specific characteristics (such as age, comorbidities, ankylosis, etc). Even though this treatment algorithm is not a classification system, further clinical studies evaluating the reliability and safety of our proposal are necessary.

Acknowledgements

No funds were received in support of this study. No benefits in any form have been or will be received from a commercial party related directly or indirectly

to the subject of this manuscript. The authors have no financial interest in the subject of this article. The manuscript submitted does not contain information about medical device(s).

Disclaimer statements

Contributors None.

Funding None.

Conflicts of interest Authors have no conflict of interests to declare.

Ethics approval None.

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