

# **UPDATE MANAGEMENT OF THORACOLUMBAR SPINAL INJURY**

Essay

*Submitted in Partial Fulfillment of  
the Master Degree in General Surgery*

By

**MOHAMED MOHIB HAFEZ**

M.B.B.CH

Supervisors

**Prof. Dr. Fateen Abdelmenem  
Anos**

Professor of General Surgery  
Ain Shams faculty of Medicine

**Dr. Ahmed El sayed Morad**

Lecturer of General Surgery  
Ain Shams faculty of Medicine

**Ain Shams University**

**Faculty of Medicine**

٢٠٠٧

## **ACKNOWLEDGMENT**

*I would like to express my profound gratitude to Professor Doctor/ Fateen Abdelmenem Anos, Professor of General Surgery, Faculty of Medicine, Ain Shams University for his most valuable advises and support all through the whole work and for dedicating much of his precious time to accomplish this work.*

*I am also grateful to Doctor/ Ahmed El Sayed Morad, Professor of General Surgery, Faculty of Medicine, Ain Shams University for his unique effort, considerable help, assistance and knowledge he offered me through out the performance of this work.*

*Last but not least, I would like to express my deepest thanks and gratitude to each one helped me to finish this work.*

# LIST OF CONTENTS

Title	Page No.
<b>INTRODUCTION</b> .....	١
<b>AIM OF THE WORK</b> .....	٣
<b>SURGICAL ANATOMY OF THE THORACIC AND LUMBAR VERTEBRAE</b> .....	٤
<b>BIOMECHANICS OF THE VERTEBRAL COLUMN</b> .....	٤٦
<b>CLASSIFICATION OF SPINAL INJURY</b> .....	٧١
<b>DIAGNOSIS OF THORACOLUMBAR SPINAL INJURY</b> .....	٩٣
<b>MANAGEMENT OF THORACOLUMBAR SPINAL INJURY</b> .....	١١٣
<b>CONCLUSION</b> .....	٢٢٨
<b>REFERENCES</b> .....	٢٣٦
<b>ARABIC SUMMARY</b>	

## LIST OF TABLES

Tab. No.	Title	Page No.
<b>Table (١):</b>	The thoracolumbar injury and severity score (TLISS) .....	٨٧
<b>Table (٢):</b>	The thoracolumbar injury classification and severity score (TLICS) .....	٩٠
<b>Table (٣):</b>	Glasgow coma scale.....	٩٦
<b>Table (٤):</b>	Key muscle group used in Asia motor source evaluation of spinal cord injury .....	٩٧
<b>Table (٥):</b>	Muscle grading chart .....	٩٧
<b>Table (٦):</b>	The thoracolumbar injury and severity score (TLISS) .....	١٢٨
<b>Table (٧):</b>	The thoracolumbar injury classification and severity score (TLICS) .....	١٢٩

## LIST OF FIGURES

Fig. No.	Title	Page No.
<b>Figure (١):</b>	Vertebral column: upper cervical vertebrae (occiput to C٢), lower cervical vertebrae (C٣-C٧), thoracic vertebrae (T١-T١٢), lumbar vertebrae (L١-L٥), sacrum, and coccyx .....	٥
<b>Figure (٢):</b>	Eighth thoracic vertebra; superior aspect <sup>(٥٨)</sup> .....	٨
<b>Figure (٣):</b>	Eighth thoracic vertebra; superior, from the right side.....	٩
<b>Figure (٤):</b>	Twelfth thoracic vertebra; superior, from the right side.....	٩
<b>Figure (٥):</b>	Third lumbar vertebra; superior aspect <sup>(٥٨)</sup> .....	١٠
<b>Figure (٦):</b>	Third lumbar vertebra; superior, from the right side .....	١٠
<b>Figure (٧):</b>	Superior view of an isolated lumbar vertebra.....	١٤
<b>Figure (٨):</b>	Pedicle entrance point in thoracic spine at intersection of lines drawn through middle of inferior articular facet and middle of insertion of transverse processes (١ mm below facet joint). .....	١٦
<b>Figure (٩):</b>	Pedicle entrance point in lumbar spine at intersection of two lines. On typical bony crest it is ١ mm below articular joint. ....	١٧
<b>Figure (١٠):</b>	The intervertebral foramen. ....	١٩
<b>Figure (١١):</b>	Illustration of measurements of the thoracic spine. ....	٢٠
<b>Figure (١٢):</b>	Illustration of Measurement of the lumbar spine.....	٢١
<b>Figure (١٣):</b>	Diagram to show the blood supply to a vertebra as seen from below and from behind. ....	٢٣
<b>Figure (١٤):</b>	Anterior longitudinal ligament and ligamentum falavum.....	٢٦
<b>Figure (١٥):</b>	Posterior longitudinal ligament. ....	٢٨
<b>Figure (١٦):</b>	The sinuvertebral nerves.....	٣٠
<b>Figure (١٧):</b>	Transverse section at intervertebral disc and ligaments.....	٣١

## LIST OF FIGURES

Fig. No.	Title	Page No.
Figure (١٨):	Intervertebral disc ,ligamentum falvum and articular capsule of zygapophyseal joint.....	٣٢
Figure (١٩):	Median section of vertebral column and ligaments.....	٣٢
Figure (٢٠):	Longitudinal view of lumbar spine show normal disc size and morphology.....	٣٥
Figure (٢١):	Spinal cord, spinal canal and spinal nerves .....	٤٠
Figure (٢٢):	Spinal cord within its membranes .....	٤١
Figure (٢٣):	Inferior end of the dural sac.....	٤١
Figure (٢٤):	Spinal cord and prevertebral structures .....	٤٢
Figure (٢٥):	Formation of spinal nerves .....	٤٢
Figure (٢٦):	Transverse section through the spinal cord. ....	٤٣
Figure (٢٧):	Oblique view of the dura removed. Note that the dorsal and ventral roots enter the spinal cord as a series rootlets.....	٤٥
Figure (٢٨):	Uncinate process (arrow) and its relation to the rostral-dorsal-lateral aspect of the vertebral body and exiting nerve root.....	٤٧
Figure (٢٩):	Vertebral body shape. Note the dorsally directed concavity.....	٤٨
Figure (٣٠):	Diagrammatic axial section of the spinal cord demonstrating the somatotopic orientation of spinal tracts. ....	٥١
Figure (٣١):	A, Transverse pedicle width versus spinal level. B, Sagittal pedicle width versus spinal level. C, Transverse pedicle angle versus spinal level. D, Sagittal pedicle angle versus spinal level <sup>(٢٥)</sup> .....	٥٢
Figure (٣٢):	Eccentrically borne load results in annulus fibrosus bulging on the concave side of the resultant spinal curve, and annulus fibrosus tension is present on the convex side of the curve.....	٥٣

## LIST OF FIGURES

Fig. No.	Title	Page No.
<b>Figure (୩୩):</b>	<b>A</b> , Relative lever arm (moment arm) length of ligaments causing flexion (or resisting extension). <b>B</b> , Ligaments and their effective moment arms. Note that this length depends on the location of the instantaneous axis of rotation (●). An “average” location is used in this illustration. ALL indicates anterior longitudinal ligament; PLL, posterior longitudinal ligament; LF, ligamentum flavum; CL, capsular ligament; ISL, interspinous ligament. ....	୦୬
<b>Figure (୩୪):</b>	The components of the three columns of the thoracolumbar spine .....	୬୩
<b>Figure (୩୫):</b>	Subtypes of compression fracture.....	୮୪
<b>Figure (୩୬):</b>	Subtypes of burst fracture.....	୮୮
<b>Figure (୩୭):</b>	Seat-belt injury .....	୮୯
<b>Figure (୩୮):</b>	Fracture-dislocation injuries. ....	୯୦
<b>Figure (୩୯):</b>	Thoracolumbar injury severity score (TLISS).....	୯୦
<b>Figure (୪୦):</b>	<b>A</b> , Axial CT and <b>B</b> , CT sagittal reconstruction showing an L <sub>୧</sub> burst fracture in a patient without neurologic deficit.....	୯୯
<b>Figure (୪୧):</b>	T <sub>୧୨</sub> -weighted sagittal MRI indicating a T <sub>୧୨</sub> flexion-compression deformity in a ୩୩-year-old male following a motorcycle accident.....	୧୦୦
<b>Figure (୪୨):</b>	Dermatome distributions .....	୧୦୧
<b>Figure (୪୩):</b>	Examination of perianal skin for sensation in cervical cord injury.. ....	୧୦୧
<b>Figure (୪୪):</b>	Bulbocavernosus reflex .....	୧୧୧
<b>Figure (୪୫):</b>	Anal wink Contracture of external sphincter caused by pinprick.....	୧୧୧
<b>Figure (୪୬):</b>	<b>A</b> and <b>B</b> , Translational injury of T <sub>୧୨</sub> on L <sub>୧</sub> in ୩୧-year-old patient with complete paraplegia.....	୧୦୧

## LIST OF FIGURES

Fig. No.	Title	Page No.
Figure (45):	<b>A and B, Chance fracture of L<sup>5</sup> and compression fracture of L<sup>4</sup> in 20-year-old polytrauma patient without neurological deficit.</b>	102
Figure (46):	<b>A and B, Burst fracture of L<sup>5</sup> in 19-year-old patient involved in motor vehicle accident.</b>	102
Figure (49):	<b>A and B, Unstable burst fracture of L<sup>1</sup> in 19-year-old patient, with incomplete paraparesis.</b>	103
Figure (50):	CT scan shows complete disruption of normal spinal alignment, with "double margin" sign at T <sup>12</sup> - <sup>13</sup>	106
Figure (51):	CT scan shows significant <b>canal compromise</b> from retropulsed bone at L <sup>1</sup> level	107
Figure (52):	Lateral MRI of burst fracture	112
Figure (53):	Coma position—note that the spine is rotated.	115
Figure (54):	Supine position—if patient is supine the airway must be secure, and if consciousness is impaired, the patient should be intubated.	116
Figure (55):	Lateral position—two hands from a rescuer stabilise the shoulder and left upper thigh to prevent the patient from falling forwards or backwards.	116
Figure (56):	Development of personnel and hand positions used when log rolling a patient from the supine to the lateral position.	117
Figure (57):	Prone position—compromises respiration.	117
Figure (58):	Spinal board with head bolsters and straps.	121
Figure (59):	Patient on spinal board—close-up view to show the semirigid collar, bolsters and positioning of the straps.	122
Figure (60):	Patient being removed from a vehicle with a semirigid collar and spinal immobiliser in position.	122
Figure (61):	A coordinated spinal lift	123
Figure (62):	Scoop stretcher.	123



## LIST OF FIGURES

Fig. No.	Title	Page No.
Figure (٦٣):	Chest radiograph on the day of injury in a ٣٠ year old motorcyclist with a T٦ fracture and paraplegia.....	١٣٠
Figure (٦٤):	a) Supine abdominal x ray demonstrating the double lumen sign (gas inside and outside the bowel) in an acute perforated gastric ulcer occurring in a tetraplegic ٥ days post-injury. b) Supine decubitus view showing massive collection of free gas under the anterior abdominal wall.....	١٣٥
Figure (٦٥):	Electrically-powered turning and tilting bed in (upper) supine position and (lower) left lateral position..	١٣٦
Figure (٦٦):	Stryker frame .....	١٣٧
Figure (٦٧):	Pressure marks over sacrum and posterior iliac crests. Relief of pressure over these areas must be continued until marks have faded. In this patient this was achieved after only three days of bed rest with appropriate positioning.....	١٣٨
Figure (٦٨):	Extensive sacral and trochanteric pressure sores.....	١٣٩
Figure (٦٩):	The infusion system consists of a programmable pump and catheter.....	١٤٣
Figure (٧٠):	Postural reduction of burst and distraction injuries. ....	١٤٨
Figure (٧١):	Closed reduction and hyperextension casting of thoracolumbar fractures.....	١٤٩
Figure (٧٢):	Fracture remodeling.....	١٥٠
Figure (٧٣):	Intraoperative visualization of the neural elements is achieved with an ultrasound probe. ....	١٥٥
Figure (٧٤):	(A),(B) Harrington rod fixation for thoracic fractures supplemented with sublaminar and interspinous wires .....	١٥٨
Figure (٧٥):	Segmental fixation allows the surgeon to neutralize the overall length of the spinal segment .....	١٥٩
Figure (٧٦):	Upper and lower hook patterns used primarily in the thoracic segments but sometimes in the thoracolumbar segments. ....	١٦١

## LIST OF FIGURES

Fig. No.	Title	Page No.
Figure (٧٧):	Anteroposterior and oblique lateral plain radiographs of a <b>TSRH</b> construct placed to stabilize a midthoracic fracture. Sublaminar hooks, rods, and cross-links were used.....	١٦٢
Figure (٧٨):	Plain radiographs of an <b>Isola</b> construct. ....	١٦٣
Figure (٧٩):	A through G. Many different hook placements have been used with universal instrumentation.....	١٦٥
Figure (٨٠):	Proximal fixation patterns. ....	١٦٧
Figure (٨١):	Extended pedicle screw patterns.....	١٦٨
Figure (٨٢):	Short-segment pedicle instrumentation (SSPI) patterns. ....	١٦٩
Figure (٨٣):	Compression construct patterns.....	١٦٩
Figure (٨٤):	Anterior instrumentation for burst fracture treatment .....	١٧٣
Figure (٨٥):	Lateral MRI of burst fracture.....	١٧٤
Figure (٨٦):	An appropriately sized coupler is applied. ....	١٧٥
Figure (٨٧):	Titanium mesh cage.....	١٧٦
Figure (٨٨):	Longitudinal section through the lumbar spine .....	١٧٩
Figure (٨٩):	Insertion of the first screw and the polyaxial dumping element. ....	١٨٨
Figure (٩٠):	Insertion of the first screw (Three-dimensional model) .....	١٨٨
Figure (٩١):	Insertion of the bone graft after partial corpectomy and discectomy (Three-dimensional model) .....	١٨٩
Figure (٩٢):	Fixation of the anterior fixation plate (Three-dimensional model) .....	١٨٩
Figure (٩٣):	Endoscopic monosegmental anterior reconstruction T١١–T١٢ with bone graft and anterior fixation plate .....	١٩٠
Figure (٩٤):	Diaphragmatic anatomy at the thoracolumbar junction and the position of the portals.....	١٩٢

## LIST OF FIGURES

Fig. No.	Title	Page No.
Figure (٩٥):	Localization of the target area and the skin incisions.....	١٩٣
Figure (٩٦):	Intraoperative setup of the operation team and equipment .....	١٩٤
Figure (٩٧):	Intraoperative view of the thoracolumbar junction. ....	١٩٦
Figure (٩٨):	Surgery is performed under direct vision through an open but minimally invasive approach.....	١٩٨
Figure (٩٩):	Operating set-up. The SynFrame is mounted onto the operating table and the retractors and thoracoscope are fixed onto the ring.....	١٩٩
Figure (١٠٠):	Male patients following left-sided and right sided many thoracotomies for fractures of the ١١ <sup>th</sup> and ٧ <sup>th</sup> thoracic vertebrae respectively .....	٢٠٢
Figure (١٠١):	Biplane fluoroscopy/angiography room.....	٢٠٤
Figure (١٠٢):	Needle placement and location .....	٢٠٥
Figure (١٠٣):	Needle placement and location .....	٢٠٦
Figure (١٠٤):	Cement injection with a ١ mL syringe.....	٢٠٦
Figure (١٠٥):	Lateral roentgenogram for percutaneous vertebroplasty .....	٢٠٧
Figure (١٠٦):	CT scan of a patient who experienced paraplegia following vertebroplasty as a result of a large fracture.....	٢٠٧
Figure (١٠٧):	..... Position of IBT (Inflatable bone tamp) in vertebral body .....	٢١٠
Figure (١٠٨):	..... Inflation of IBT (Inflatable bone tamp) .....	٢١٠
Figure (١٠٩):	..... Filling of the vertebral body starts anteriorly .....	٢١١
Figure (١١٠):	..... Completed cementing of vertebral body .....	٢١١
Figure (١١١):	Photographs showing parts of the Signus ConKlusion internal fixator system, originally designed for minimally invasive surgery.....	٢١١
Figure (١١٢):	Images demonstrating the sequence of events during the essential first steps of percutaneous pedicle screw implantation.....	٢١٥

## LIST OF FIGURES

Fig. No.	Title	Page No.
<b>Figure (١١٣):</b>	Intraoperative photograph showing four pedicle screws fully advanced to their final position under lateral fluoroscopy.....	٢١٧
<b>Figure (١١٤):</b>	Final result after percutaneous fixation of an unstable L١ fracture shown in (top left) lateral and (top right) anteroposterior plain x-rays and (bottom) thin-cut postoperative CT scans.....	٢١٨

## **LIST OF ABBREVIATIONS**

<b>CC</b>	Capacitive coupling
<b>CMF</b>	Combined magnetic fields
<b>DC</b>	Direct current
<b>IC</b>	Inductive coupling
<b>PEMF</b>	Pulsed electromagnetic fields
<b>PLC</b>	Posterior longitudinal complex
<b>SCIWORA</b>	Spinal cord injury without radiological abnormality
<b>TLICS</b>	Thoracolumbar injury classification and severity score
<b>TLISS</b>	Thoracolumbar injury severity score
<b>VATS</b>	Video assisted thoroscopic surgery

## INTRODUCTION

Fractures and dislocations of the spine are serious injuries that most commonly occur in young people<sup>(1)</sup>.

Vertebral fractures of thoracic and lumbar spine are usually associated with major trauma and can cause spinal damage that result in neural deficits<sup>(2)</sup>.

Kraus et al. estimated that each year 80,000 people in 1 million sustain a spinal cord injury. Of those who die within 1 year of their accidents, 90% die on route to the hospital. With the development of regional trauma centers and increased training of paramedics and emergency medical technicians, the chances of survival after serious spinal cord injury have increased<sup>(3)</sup>.

Overall, 80% of patients with a spinal cord injury who survive the first 24 hours are still alive 10 years later compared with 98% of patients of similar age and sex without spinal cord injury<sup>(4)</sup>.

The ideal classification for thoracolumbar fractures must be simple yet complete, and it must reflect an understanding of the mechanism of injury, correspond to anatomic pathology. It also should determine the treatment options, and be relevant to the prognosis. With the advent of the 3 columns classification of spinal anatomy, a more precise analysis of spinal stability was made possible. Knowing which columns are intact, can

better enable the clinician to interpret the integrity of the spine as a load bearing column<sup>(r)</sup>.

Proper management of thoracolumbar injuries is predicated on a thorough understanding of the involvement of the structural and neural tissues. Initial evaluation includes a complete and thorough clinical Examination<sup>(t)</sup>.

Appropriate use of imaging modalities (plain X-rays in different and special views, computed tomography, and magnetic resonance imaging) provides additional information, allowing classification of the spinal injury, assessment of spinal stability and prognosis of recovery of neurologic deficits<sup>(t)</sup>.

The aim of spinal injury treatment is the restoration of spinal physiology, with relief of pain and restoration of stability without neurological damage<sup>(e)</sup>.

For many years, surgical measures were restricted to laminectomy, but experience in recent years has clearly shown that the best method of decompression of neural structures is rapid and perfect reduction of fracture or dislocation<sup>(e)</sup>.