

# **Management of Thoracolumbar Spinal Injury**

Essay

Submitted in Partial Fulfillment of  
the Master Degree in General Surgery

**By**

**MOHAMMEDREFAATHAMMOUDA**

(M.B.B.Ch)

**Supervised by**

**Prof. Dr. Ali Khodir Ali Khodir**

Professor of Neurosurgery

Al\_Azhar faculty of Medicine

**Prof.Dr. Ibrahim GamilEwais**

Assistant Professor of Neurosurgery

Al\_Azhar faculty of Medicine

**Prof.Dr. Mohammed Esmat  
Abd\_Elghany**

Assistant Professor of Onchosurgery

Al\_Azhar faculty of Medicine

**Dr. Mohamed Hasan Mansour**

Lecturer of Neurosurgery

Al\_Azhar faculty of Medicine

**Al\_Azhar University**

**Faculty of Medicine**

2013

# الصدرية والقطنية

توطئة للحصول على درجة الماجستير  
فى الجراحه العامه

الطبيب / محمد رفعت حمودة  
بكالوريوس

الدكتور / علي خضير علي خضير

كلية - جامعة الأزهر

الأستاذ الدكتور / إبراهيم جميل عويس

كلية - الأزهر

/

كلية - الأزهر

/

كلية - الأزهر

كلية

الأزهر

**بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِیْمِ**

(... رَبِّ أَوْزَعْنِي أَنْ أَشْكُرَ نِعْمَتَكَ الَّتِي

أَنْعَمْتَ عَلَيَّ وَعَلَى وَالِدَيَّ

وَأَنْ أَعْمَلَ صَالِحاً تَرْضَاهُ وَأُدْخِلَنِي

بِرَحْمَتِكَ فِي عِبَادِكَ الصَّالِحِينَ )

**صدق الله العظيم**

النمل... آية رقم ١٩



## Acknowledgment

*First and foremost, I feel always indebted to **Allah**, the Most Merciful, Who gives me power to accomplish this work,*

*I would like to express my deepest appreciation and sincere gratitude to **Prof. Dr. Ali Khodir Ali Khodir**, Professor of Neurosurgery, Faculty of Medicine – Al-Azhar University -, for his sincere help, constant encouragement, constructive criticism, and valuable guidance, I was truly honoured to work under his supervision.*

*I wish also to express my great gratitude and utmost appreciation to **Prof. Dr. Ibrahim Gamil Ewais** assistant Professor of Neurosurgery, Faculty of Medicine – Al-Azhar University, for his valuable suggestions and instructions during the progress of this work,*

*I feel deeply indebted to **Dr. Mohamed Hasan Mansour**, lecturer of Neurosurgery, Faculty of Medicine – Al-Azhar University, for his active cooperation, deep concern, enthusiastic encouragement, the effort and time he has devoted to the fulfillment of this work,*

*I would like also to thank **Prof. Dr. Mohammed Esmat Abd\_Elghany**, Assistant Professor of Onchosurgery, Faculty of Medicine – Al-Azhar University, for his great efforts and support during this work,*

*I would like also, to acknowledge the support and cooperation offered to me continuously by senior staff and colleagues at the department of Neurosurgery, Al-Azhar University.*

*I owe special thanks to **my Family** for their care, patience and continuous encouragement.*

*Finally I'm deeply indebted to **my beautiful fiancée** who gave me much supportive gentle encouragement.*

*Mohammed Refaat Hammouda*

## ***CONTENTS***

<b><i>SUBJECT</i></b>	<b><i>PAGE NO</i></b>
<b><i>INTRODUCTION</i></b> .....	1
<b><i>AIM OF THE WORK</i></b> .....	3
<b><i>DEVELOPMENTAL SPINAL ANATOMY</i></b> .....	4
<b><i>ANATOMY OF LUMBAR SPINE</i></b> .....	14
<b><i>BIOMECHANICS</i></b> .....	41
<b><i>PATHOPHYSIOLOGY</i></b> .....	47
<b><i>CLINICAL PRESENTATION</i></b> .....	51
<b><i>INVESTIGATION</i></b> .....	58
<b><i>SURGICAL MANAGEMENT</i></b> .....	63
<b><i>SUMMARY</i></b> .....	99
<b><i>REFERENCES</i></b> .....	101
<b><i>ARABIC SUMMARY</i></b> .....	--

## ***LIST OF TABLES***

<i><b>Subject</b></i>	<i><b>Page No</b></i>
<b>Table (1):</b> Clinical characteristics of 150 consecutive microendoscopic discectomy patients.....	83
<b>Table (2):</b> Modified Macnab criteria used to assess clinical outcome in 150 consecutive patients undergoing microendoscopic discectomy.....	84
<b>Table (3):</b> Mean operative times, complications, mean hospital stay, and mean time to return to work for 150 consecutive patients undergoing microendoscopic discectomy .....	84

## *LIST OF FIGURES*

<i>SUBJECT</i>	<i>PAGE NO</i>
<p><b>Figure (I-1):</b> Formation of bilaminar germ disc from the embryoblast. The epiblast is adjacent to the amniotic cavity, and the hypoblast is adjacent to the blastocyst cavity.</p>	5
<p><b>Figure (I.2):</b> Formation of neural tube and dorsal root ganglion (axial view). A, Elevation of ectoderm creates neural folds that invaginate and ultimately fuse to form a neural tube. B, Neural crest cells form from lateral edges of these neuroectodermal cells, migrate toward the underlying mesoderm, and give rise to cranial nerve ganglia, spinal ganglia, and dorsal root ganglia (DRG).</p>	5
<p><b>Figure (I-3):</b> Sagittal representation showing initial stages of formation of notochord. The notochordal process becomes canalized and breaks through the caudal aspect of the ectoderm. This allows transient communication between the yolk sac and the amniotic cavity through the neurenteric canal.</p>	5
<p><b>Figure (I. 4):</b> Conversion of somite to sclerotome and dermatomyotome (axial view). The paraxial mesoderm organizes into segments called somitomeres, which subsequently become somites beginning by approximately day 20. Each somite undergoes further specialization into the sclerotome, myotome, and dermatome by the beginning of the fourth week. A portion of the sclerotome surrounds the notochord and becomes the vertebral body and posterior elements. The dorsolateral aspect of the somite forms the dermomyotome, which differentiates into the myotome medially and the dermatome laterally. The dermatomes give rise to the dermis of the neck, back, and ventral and lateral trunk, and the myotomes form the deep back muscles and abdominal muscles.</p>	8
<p><b>Figure (I. 5):</b> Coronal representation of formation of the vertebral column from adjacent sclerotome segments. A, Each sclerotome is divided by sclerotomic fissure into a cranial and a caudal portion. The cranial half of one sclerotome segment fuses with the caudal half of the adjoining segment, ultimately giving rise to the primordium of the vertebral body (centrum). B, Some of the notochordal tissue eventually disappears, whereas other notochordal cells remain and become the precursor of the intervertebral disc. The segmental nerve, which was originally located at the center of the sclerotome, comes to lie between adjacent centra, opposite the intervertebral disc. The segmental vessels come to lie over the middle of the centrum.</p>	9

<b><i>SUBJECT</i></b>	<b><i>PAGE NO</i></b>
<p><b>Figure (I.6):</b> Schematic representation of mammalian vertebrae development. (A), Notochord is surrounded by axial mesenchyme with the segmental vessels located between adjacent sclerotomes. The dermomyotome forms from the dorsolateral aspect of the somite. (B), Differentiation of axial mesenchyme into dense perichordal disc, which becomes the intervertebral disc, and loose perichordal disc, which becomes the centrum. The costal element is located lateral to the future intervertebral disc. Note the relationship of the segmental vessels to the future centrum: they originally lie between adjacent sclerotomes but ultimately come to lie at the mid-point of the centrum, which is composed of cranial and caudal portions of adjacent sclerotomes. (C), Differentiation of notochord into the mucoid streak and the nucleus pulposus. The notochordal cells at the center of the dense perichordal disc persist as the precursor of the future intervertebral disc (nucleus pulposus).</p>	11
<p><b>Figure (I. 7):</b> Developmental stages of a typical vertebra: membranous (A), chondrification (B), ossification (C), and at birth (D). The sclerotome that surrounds the notochord forms the membranous vertebral column. This is converted to a cartilaginous model via the process of chondrification, in which the cartilaginous centrum is formed by two centers and each half of the neural arch is formed by one center. Each costal process is chondrified separately.</p>	13
<p><b>Figure (II. 1):</b> Lumbar vertebra superior view.</p>	17
<p><b>Figure (II. 2):</b> 3<sup>rd</sup> and 4th lumbar vertebrae: posterior view.</p>	18
<p><b>Figure (II. 3):</b> Left lateral view (partially sectioned).</p>	20
<p><b>Figure (II. 4):</b> Intervertebral disc.</p>	22
<p><b>Figure (II. 5):</b> Spinal nerve roots exit.</p>	24
<p><b>Figure (II. 6):</b> Endoscopic view showing the thoracolumbar fascia as an avascular heavy band of interwoven fibers.</p>	28
<p><b>Figure (II. 7):</b> The paravertebral muscles of the lumbar spine are seen as a moderately vascular muscle bundle.</p>	28
<p><b>Figure (II. 8):</b> Illustration of triangular working zone: A, exiting root that forms anterior boundary of triangular working zone; B, triangular working zone; C, traversing root.</p>	29
<p><b>Figure (II. 9):</b> Endoscopic view of annular surface in triangular working zone. Note the loose/woven adipose tissue on the surface of annulus.</p>	29

<i><b>SUBJECT</b></i>	<i><b>PAGE NO</b></i>
<b>Figure (II. 10):</b> Intraoperative photo demonstrating presence of superficial veins on surface of annulus.	30
<b>Figure (II. 11):</b> Endoscopic view of content of spinal canal (A) and herniated lumbar disc(B).	33
<b>Figure (II. 12):</b> Photograph demonstrating arteries and venous system of nerve root and A.V. anastomosis.	34
<b>Figure (II. 13):</b> Illustration showing origin of segmental arteries of lumbar spine.	34
<b>Figure (II. 14):</b> Ligamentous structures of ventral dura and nerve root.	36
<b>Figure (II. 15):</b> Gross anatomy of annulus fibrosus and NP in young cadaver specimen. The nucleus has been injected with methylene blue. Note, however, the thickness of the annulus fibrosus anteriorly and posterolaterally.	37
<b>Figure (II. 16):</b> Endoscopic view of NP in a 45-yr-old male following interdiscal injection of diluted indigo carmine. Note the unstained partially collagenized nucleus mixed with stained soft nuclear tissue.	38
<b>Figure (II. 17):</b> Endoscopic view of capsular ligamentum flavum complex, which appears as an avascular structure.	40
<b>Figure (II. 18):</b> View of ventral surface of posterior longitudinal ligamentum (PLL).	40
<b>Figure (III. 1):</b> 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. Nucleus pulposus, however, tends to move in the opposite direction as the annulus fibrosus bulge when an eccentric load is borne (solid to dashed outline).	43
<b>Figure (III. 2):</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.	45
<b>Figure (VI. 1):</b> Myelogram lat. film showing L <sub>4-5</sub> disc	58
<b>Figure (VI. 2):</b> Non contrast axial CT showing left posterolateral L <sub>4-5</sub> disc prolapse.	59

<b>SUBJECT</b>	<b>PAGE NO</b>
<b>Figure (VII. 1):</b> MED system of dilators, K-wire, tubular retractor, and flexible arm assembly.	68
<b>Figure (VII. 2):</b> Standard video equipment used for the MED procedure.	68
<b>Figure (VII. 3 ):</b> Endoscopic assembly for the MED system.	69
<b>Figure (VII.4):</b> Instruments used to perform MED procedure. Bayoneted instruments and a long, thin, tapered drill simplify the procedure.	70
<b>Figure (VII.5):</b> Operating room set-up for MED procedure. Fluoro, fluoroscopy.	71
<b>Figure (VII. 6):</b> <b>A</b> , illustrations showing initial dilator in place sweeping paraspinal musculature off lamina, <b>B</b> , sequential dilators for muscle splitting approach, and <b>C</b> , tubular retractor with endoscope in place.	74
<b>Figure (VII 7):</b> Illustration of endoscopic image on the video monitor showing the initial image orientation to be incorrect ( <b>A</b> ) Proper orientation is achieved by turning the gold ring on the endoscopic assembly so that the V-shaped indicator ( <b>B</b> ) is in the same position on the video monitor as the endoscope is within the tubular retractor. At completion ( <b>C</b> ), the medial anatomy is at 12 o'clock and the lateral anatomy is at 6 o'clock on the video screen to give the surgeon proper orientation for performing MED.	76
<b>Figure (VII.8):</b> ( <b>A</b> ) hemilaminotomy being preformed with a Kerrison punch, ( <b>B</b> ) removal of ligamentum flavum with up-going curette, ( <b>C</b> ) exposure of dura and traversing nerve root, and ( <b>D</b> ) removal of disc herniation under retracted nerve root.	79
<b>Figure (VII .9):</b> Patient outcomes as defined by the modified MacNab criteria showing data from 150 consecutive cases performed using the MED system.	85
<b>Figure (VII. 10):</b> <b>A</b> , the spinolaminar junction target for localization is highlighted. <b>B</b> , a fluoroscopically guided percutaneous Steinman pin is placed at this target.	89
<b>Figure (VII.11):</b> Serial dilators are sequentially placed to dilate the dorsal musculature and fascia. This process is confirmed by lateral fluoroscopy (inset).	90
<b>Figure (VII.12):</b> Working channel and endoscope docked in place with drilling of the bony lamina	91
<b>Figure (VII.13):</b> <b>A</b> , a small, angled curette used to define the laminar edge. <b>B</b> , Kerrison punches and drills are used to continue the bony decompression.	92
<b>Figure (VII.14):</b> <b>A</b> , the working channel and endoscope are angled to provide a wide contralateral view. <b>B</b> , this allows for a near circumferential decompression of the central spinal canal to the level of the contralateral lateral recess	93
<b>Figure (VII. 15):</b> Summary of the outcome by clinical symptoms (Sx) between the MEDL and open-surgery groups. Dist, distance.	98

## INTRODUCTION

**F**ractures and dislocations of the spine are serious injuries that most commonly occur in young people (**Willis Cahoon Campbell et al, 2003** ).

Vertebral fractures of the thoracic and lumbar spine are usually associated with major trauma and can cause spinal cord damage that result in neural deficits. Each vertebral region has unique anatomical and functional features that result in specific injuries. (**George Timothy Reiter, 2011**).

The incidence of spinal cord injury is approximately 40 cases per million populations per year. However, this estimate is based on older data from the 1990s as there has not been any new overall incidence studies completed (**National Spinal Cord Injury Statistical Center , 2011** ).

The ideal classification for thoracolumbr 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 (**Patel et al, 2003**).

Proper management of thoracolumbar injuries is predicated on a thorough understanding of the involvement of the structural and neural tissues. An extensive physical examination should be performed and neurologic status should be documented upon initial presentation. Concomitant injuries should be assessed, and the patient's overall physical condition should be optimized promptly (**Singh R et al, 2009**).

The combination of plain radiographs, computed tomography (CT) scan, and magnetic resonance imaging (MRI) allows bony and ligamentous injuries to be defined. The analysis of the radiological studies should be based on biomechanical concepts. The information obtained from these studies allows for

---

---

## *Introduction*

---

classification of the injuries and identification of unstable injuries, and it aids in selection of the proper instrumentation to adequately stabilize the bony elements (Dosch JC et al, 2007 ).

The aim of spinal injury treatment is the restoration of spinal physiology, with relief of pain and restoration of stability without neurological damage (Maravilla et al, 1978 ).

The goals of operative treatment are to decompress the spinal cord canal and to stabilize the disrupted vertebral column. Gaebler et al reported that early decompression and stabilization procedures within 8 hours of injury allowed for a higher rate of neurologic recovery (Gaebler C et al, 1999 ).

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 (Maravilla et al, 1978 ).

## **AIM OF THE WORK**

**T**he aim of the work is to discuss the management of the thoracolumbar spinal injury.

## ***DEVELOPMENTAL SPINAL ANATOMY***

### ***The preembryonic period (weeks 0 To 3 )***

The preembryonic period. Which begins at fertilization and continues for approximately 3 weeks, is characterized by the development of the bilaminar germ disc (Fig. I. 1). The bilaminar germ disc is converted to the trilaminar germ disc during the next stage, the embryonic period. (*Sadler T.W. 2000* )

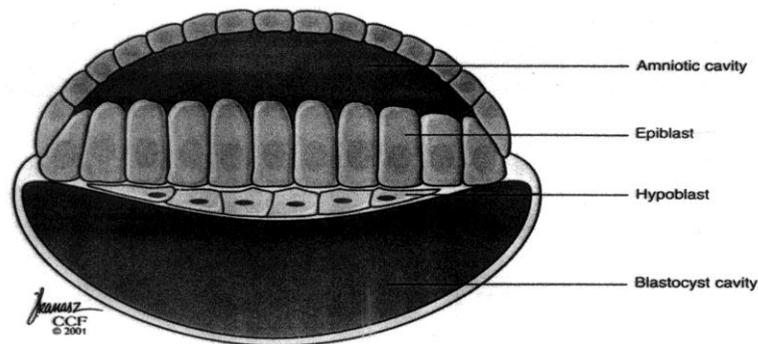
### ***The embryonic period (weeks 3 to 8)***

The third week of gestation is characterized by the processes of gastrulation and neurulation. Gastrulation is the process of the formation of all three embryonic germ layers : ectoderm , mesoderm , and endoderm.

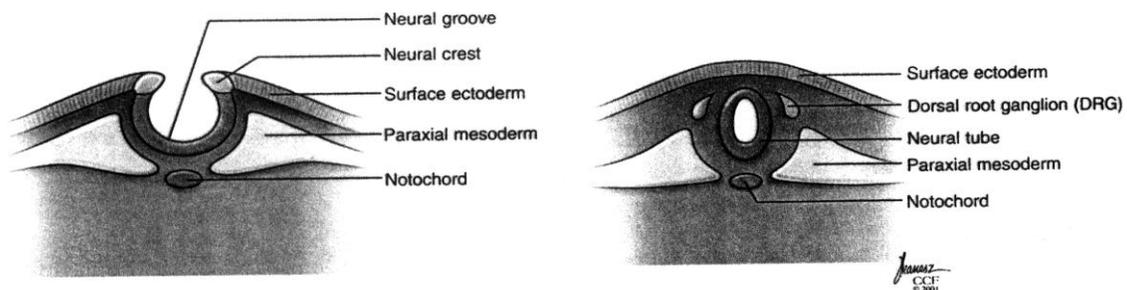
Neurulation, which is initiated in the latter half of the third week. Is a process of folding that converts the neural plate, a thickening of the ectoderm overlying the notochord, to the neural tube (Fig I. 2) (*Larsen W.J. 2001* )

### ***Notochord***

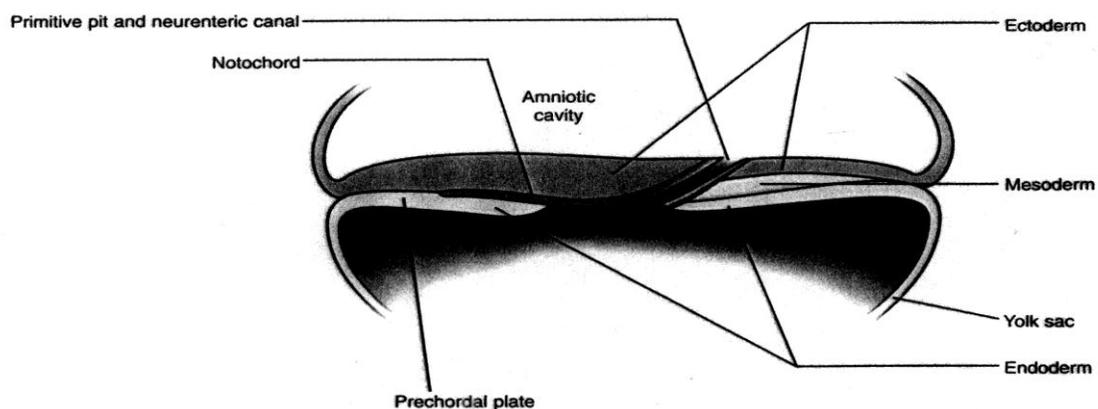
From the primitive pit, a rod-like process of cells called the notochordal process moves cranially up to the prechordal plate by day 20. The notochordal process, which is the precursor of the skeletal axis, becomes canalized and caudally breaks through the ectodermal surface at the primitive node. The tube then opens ventrally starting at the level of the pit and proceeds cephalad. The yolk sac therefore transiently communicates with the amniotic cavity through the opening at the pit called the neurenteric canal (Fig. I. 3). After the tube opens, it is converted to a central ventral bar of mesoderm called the notochordal plate, which detaches from the endoderm by day 22 to 24 and becomes entirely contained within the mesoderm. It then forms a solid cylinder of cells to form the definitive notochord (*Sadler T. W. 2000*).



**Figure (I-1):** Formation of bilaminar germ disc from the embryoblast. The epiblast is adjacent to the amniotic cavity, and the hypoblast is adjacent to the blastocyst cavity. (Courtesy Cleveland Clinic, Division of Education, © 2001.)



**Figure (I.2):** Formation of neural tube and dorsal root ganglion (axial view). A, Elevation of ectoderm creates neural folds that invaginate and ultimately fuse to form a neural tube. B, Neural crest cells form from lateral edges of these neuroectodermal cells, migrate toward the underlying mesoderm, and give rise to cranial nerve ganglia, spinal ganglia, and dorsal root ganglia (DRG). (Courtesy Cleveland Clinic, Division of Education, ©2001.)



**Figure (I-3):** Sagittal representation showing initial stages of formation of notochord. The notochordal process becomes canalized and breaks through the caudal aspect of the ectoderm. This allows transient communication between the yolk sac and the amniotic cavity through the neurenteric canal. (Courtesy Cleveland Clinic, Division of Education, ©2001.)