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An Update Review of Epidemiology, Anatomy, Classification, Management and Outcome of pediatric Thoracolumbar Spine Trauma

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Abstract

Context: The incidence of vertebral column and spinal cord damage in children in the current century is greater than ever. Thoracolumbar fractures are extra numerous in teenagers, the most common reasons are falling from a height and motorcycle accidents. The current study aimed at designing a straightforward assessment of the epidemiology, anatomy, biomechanics, and clinical detection and managing plans for children with thoracolumbar traumas.

Evidence Acquisition: Totally, 85 articles conducted from 1970 to 2016 were studied. A total of 63 articles were included in the current pediatric evaluation. But, based on the philosophy of the current study, just newly published studies from 2000 on spinal trauma epidemiology, classification, and management were included.

Results: Spinal fractures in pediatrics characterize 1% or 2% of all pediatric fractures, and most of the damage comprise the cervical spinal column. The mainstream of thoracolumbar spinal column fractures in the children happen at the age of 14 to 16 years. The most common damaged zone of the spine is T4 to T12, followed by T12 to L2 based on the patients' age and type of radiologic classification of trauma, and conservative or surgery treatments may be used for the fractures.

Conclusions: Forceful use of computed tomography (CT) scan and magnetic resonance imaging (MRI) can classify delicate thoracolumbar damages and involvement of neural components and offer prognostic data in children with possible neurologic recovery, especially in SCIWORA (spinal cord injury without radiographic abnormality) type of injury. Currently, classification of the thoracolumbar injury and severity scales (TLISS) is generally useful in the adults by means of trauma to define non-operative vs. operative management of spine fractures. This classification is newly considered in the pediatric population, and there are reports on the outstanding validity of this system, similar to adults. Usually, various stable fractures can be cured conservatively, while unstable fractures need surgical stabilization.

Keywords: Pediatric, Thoracolumbar, Spine, Trauma

1. Context

The incidence of vertebral column and spinal cord damage in children in the current century is higher than ever, as a consequence of the multiplicity, rise in sporting actions, and the growing number of vehicle accidents (1). Spinal trauma in the pediatric population offers an exclusive challenge. The disappointment outline of the problem in children- owing to distinct biomechanics and structure- is dissimilar to that of adults (2, 3).

The mechanism of damage in children differs by the age. In younger children under 9 years old, the main source of damage is falling (> 75%). In youngsters of 10 to 14 years, vehicle accidents (40%) are the most important reason of spine trauma. In teenagers of 15 to 17 years, motor vehicle accidents comprise the foremost origin of spine damages (> 70%), and there is similarly a rise in sporting correlated spinal injury (4-6).

Even if thoracolumbar fractures are infrequent in children, the resultant injury after this kind of damage is substantial, and there might also be injury to interior structures or abdominal vascular constructions. The prevalence of thoracolumbar fractures are high in teenagers, the most common reasons are falling from a height and motorcycle accidents. The identification and handling are dissimilar in the pediatric population, owing to the fundamental physiognomies of the thoracolumbar spinal column (6, 7).

Though spinal damage happen rarely, a postponement in the revealing of thoracolumbar disturbance can have distressing outcomes for a child. The literature validated that the damage to the thoracolumbar spinal column can be often hidden and lead to considerable complications (8, 9). Timely diagnosis over a watchful, detailed physical investigation, and appropriate employment of radiography significantly can prevent undesirable consequences (10). The current study aimed at designing a straightforward assessment of the epidemiology, anatomy, biomechanics, and clinical detection, and managing plans for children with thoracolumbar traumas.

2. Evidence Acquisition

In the current study, Medline, PubMed, and Ovid data bases were searched using the following keywords: pediatric, spine, trauma, spinal cord, thoracolumbar, surgery, and spinal fusion. The inclusion criteria comprised of journals that described an analysis about epidemiology, anatomy, classification, management, and outcome of thoracolumbar spine trauma in pediatric patients (age < 18 years). Exclusion criteria were: 1) non-English literature, 2) patients older than 18 years, and 3) articles published before 2000. There was few studies in this field. Totally, 85 articles from 1970 to 2016 were extracted out of which 63 articles were enrolled in the current study. But, based on the philosophy of the current study, just the newly published articles, after 2000, on spinal trauma epidemiology, classification, and management were studied.

3. Results

3.1. Epidemiology

Spine trauma is comparatively infrequent in child (11). Spine fractures comprise 2% to 5% of severe spinal damage. Spinal fractures in pediatrics characterize 1% to 2% of all pediatric fractures, and most of such damage comprise the cervical spinal column. Multilevel spine traumas include 6% to 23.8% of children with spinal trauma (12) and the thoracic spinal column is rarely part of the injury (13).

The mainstream of thoracolumbar spinal column fractures in the children happen in the age range of 14 to 16 years. Most often the damaged zone of the spine is T4 to T12, followed by T12 to L2. Some authors found that in children below 15 years old, the mainstream of spinal trauma happened in persons above 12 years old, typically are falling and motorcycle accidents. Neurologic damage happened in 14% with multilevel vertebral fractures, which recently increased to 35%. Some studies indicated that motor vehicle accidents were the most common cause of spine fractures in pediatrics aged 10 to 16 years, followed by falling and sports damage (14, 15).

3.2. Associated Anatomy

New findings regarding the anatomy of child spine is vital to considerate the diverse damage forms. The epidemiologic variances among adult and pediatric spine trauma could be clarified by inadequate ossification, unfused synchondrosis, bigger comparative percentage of head to body mass, and general augmented ligamentous laxity (16). Undeveloped intervertebral discs convey energy more proficiently to contiguous levels, and the related incapability of unformed bone to fight traumatic distortion might explain the high occurrence of multilevel damage in child (17) similar to that of the incidence of SCIWORA (spinal cord injury without radiographic abnormality) in the populace.

Ossification of the epiphysis starts at 7 - 8 years of age. At the age of 12 to 15 years, these centers make the epiphyseal ring, which is completed by the age of 21 to 25. Fractures overpass the disk in the undeveloped spine cross, nearly absolutely over the growth region of the physis. Longitudinal growth of the vertebral bodies happens by endochondral ossification on the end plate. Particularly, the spinal cord lays off at L3 at natal and progressively transfers to the adult L1-2 about 2 months after birth (16, 17).

One of the main variances among the spine of youngsters and adults is the anatomic organization of the intervertebral discs of spine (17). At birth, these discs create unevenly 1/3 of the spine height. Undeveloped discs include concentric lamellae covered to make a fibrous ring named annulus fibrosis, a core of gelatinous nucleus pulposus, and 2 cartilaginous articular plates. The nucleus pulpous of the spine in the youngsters is extremely hydrophilic, which makes it as an actual stress absorber. It constitutes nearly 40% of the cross sectional part of the disc (18, 19). The cartilaginous end plates are in straight interaction with the trabecula of the vertebrae, permitting the transmission of nutrients and liquid to the disc. The annulus fibrosis purposes such as a fibrous shell to the intervertebral disc, sharing contact forces by strong intervertebral connection. This permits axial loads to be diffused and engrossed outward through the disc. At the age of 7 years, the nucleus pulposus starts to be substituted by collagen and reduces in elasticity, producing load dynamics to be spread more straight to the margin of the vertebral endplates. This procedure speeds up through the life as discs miss their resistance and height (17, 18, 20).

Twelve thoracic and 5 lumbar vertebrae are the essential fundamental components that aid to guard the spinal cord in the thoracolumbar section (19, 20). Each vertebra contains a frontal body linked to a posterior arch through inferior, superior, and transverse vertebral processes. Development is persistent at all vertebral planes till the age of 2 years, once the lumbar vertebrae initiate growing in equally lateral and anterior-posterior spans more than the thoracic components, in reaction to the bigger axial weight bearing that attends aggregate upright physical motion. Primarily, the newborn spine forms a humble, constant, convex curving, nonetheless as it develops, it regresses to a lordotic curve in the cervical area, and far along in the lumbar section. This is coextensive by the advancement of refining muscular power and tone of the cervical and lumbar paraspinous strengths (19). This practical construction permits restricted segmental flexibility of separate vertebra, and provides the substantial perpendicular constancy contrary to external injury powers. Undeveloped vertebrae are originally wedge-shaped, with a notching of the anterior body illustrative of fetal notochord fragments. The end plates sink above the superior feature of respectively vertebral body, and stay alienated by an area of endochondral ossification that continues till sexual maturity and ultimate epiphyseal closing (18). This endochondral region characterizes the frailest basic component of the ligamentous compound, and consequently, is the most common location of damage in the developing child. These harms can be actually understated, with the identification frequently neglected pending future in lifetime once defects of bony growth come to be obvious (21). Regularly, it is formerly also late to take helpful act, and the child is gone by long-lasting fundamental or practical damage. This happens often in child sportspersons who thrust the restrictions of presentation at the possibility of damage (10, 19, 21).

3.3. Biomechanical Possessions

The pediatric spine is dissimilar to that of the adults in numerous ways, and this can affect newborns and younger children with flexion and extension damage. They have proportionately bigger skulls matched by their bodies and have immature cervical musculature (22). They similarly have innate ligamentous laxity, elasticity, and imperfect ossification (23). Their facet joints are minor and horizontal sloping, causing superior flexibility and less strength (6, 23). Due to these biomechanical variances, younger children are likely to have less fractures and more occurrence of SCIWORA.

Hyperextension combined with the hypermobility of the child spinal column can cause brief displacement followed by impulsive reduction, leading to an injured spinal cord, however, a normal spine in radiographies (6, 24). Even though SCIWORA happens up to 20% in children, it drops intensely to less than 1% in adults. Once exposed to extraordinary strain, the adult spine is more probable to agonize breaking of bones and split of ligaments in contrast with those of the pediatrics, in which distortion and coming back to normal arrangement is more common (24, 25).

Inadequate ossification, a diverse vertebral shape, the head comparative ratio to the body, and ligamentous laxity explanation for a dissimilar injury configuration match with those of adults. The young discs are more resilient to trauma than young bones and convey high energy to contiguous levels producing multi-level involvement (11, 26).

Anatomic studies confirmed that fractures of the undeveloped spine cross the growth region of the physis compared with long bone physeal fractures. In flexion–distraction type damage of the spine, a Salter-Harris type injury might happen over the fragile physis. But, since it happens through a physis, the cure is outstanding, unlike a related damage in the adult (27).

3.4. Organization and Fracture Types

3.4.1. Compression Fractures

Vertebral compression fractures constitute up to 75% of the total thoracolumbar fractures and are defined as disturbance of the anterior spinal column by undamaged middle and posterior parts. The common mechanism of injury is an axial loading that allocates the compressive energy above the anterior part of vertebral endplates. Neurological damage is infrequent (28). Associated rises in the pressure of the posterior ligamentous composite originally counter attack augmented flexion. Sustained application of aggregate power can overwhelm this confrontation, causing the interruption of the posterior ligamentous complex and formation of an unstable compression fracture (28, 29).

The intervertebral disc acts as a critical character in the origins of compression fractures. Powers that surpass the capability of undeveloped discs to reimburse can cause the split of the nucleus pulposus over the endplate and into the central spongiosa of the vertebral body. Compression fractures are the most common kind of vertebral fracture (29).

3.4.2. Burst Fracture

Burst fractures are the consequence of compressive loading, and sometimes with flexion, more than simple vertebral compression. This fracture falls out in disintegration, with radial dislodgment of the bone. Burst fractures, in description, contain equally anterior and middle column disappointment, however, might be measured stable if the posterior column leftovers are undamaged. The superior end plate is the most frequently complicated, generally on the thoracolumbar junction. Posterior column disturbance is probable by severe compressive powers (30, 31).

In an unbalanced burst fracture, the posterior column is interrupted as a consequence of the disruption forces that supplement forced flexion. Neurological discrepancies are variable and associated with the degree of spinal canal compromise (31).

3.4.3. Flexion-Distraction Fractures

This is an excruciating horizontal fracture of the vertebrae over the body neural arch and pedicle. The posterior ligamentous complex is totally distracted in strain, whereas the anterior column is complicated in proportion to the amount of the damaging forces. The mechanism of injury contains extraordinary energy rotational flexion powers entered into an axis anterior to the vertebral body (Figures 1, 2, 3).

The primary explanation by chance left a pure osseous injury; however, it is applied to comparable damage concerning combined osteoligamentous or pure soft-tissue damage (32). Therefore, today chance fractures are referred to the seatbelt fracture injury irreplaceable in young children (31, 32). Stability is reliant on the grade of participation of the anterior spinal column. Interruption of the ALL (anterior longitudinal ligament) makes this damage extremely unstable in flexion. Deprived of the association of the ALL, nervous involvement is remarkably infrequent, stated in less than 10% of patients. Related abdominal structure injury is common and subsequently, abdominal subjects are compacted among the restrictive seatbelt and the anterior vertebral body (33, 34).

3.4.4. Translational Fractures

Damages at translational level result in damage of all 3 spinal columns and disturb the arrangement of the spinal channel and thus relocate the neural components in the transverse plane. This cluster, displays the highest frequency of related neurologic discrepancies (34).

3.4.5. Flexion-Rotation Fractures

The posterior ligaments damage beside the facet capsules disrupts the vertebral body and disc, and then, distract all 3 spinal columns. Throughout displacement, the superior articulating facet of the vertebrae lower to the level of damage is broken on one side and the contralateral facet capsule nosedives in disruption. Ruptures of the transverse process and rib are usually related to flexion and rotation fractures (34, 35).

3.4.6. Shear Fractures

Generally, the spine is keen on extension by following disturbance of the ALL, and the annulus is split or dithered as pretentious vertebrae interpret anterior or posterior, compared with the remnants of the vertebral column. Uncertainty, the superior vertebrae clippers anteriorly, its posterior components frequently break and stay behindhand as the spinal cord and nerves are compacted by grip beginning the anterior movement of the vertebral body crossways the static superior end plate of the inferior vertebral body. Dural tears, paraplegia, and gross instability are common consequences of shear fractures (35, 36).

3.4.7. Hyperextension Fracture

Compression happens to the posterior column whereas tension disturbs ALL and the anterior feature of the annulus fibrosis. With particular sufficient strength, ALL can be avulsed off the anterior vertebral surface with bony fragments, producing anterior and middle column disappointment. Breakage of the parts interarticularis or lamina similarly have remained defined (36, 37).

3.4.8. Apophyseal Ring Fractures

The apophyseal ring is committed to the annulus fibrosis; here is an osteocartilaginous part that exists among the body and apophyseal ring, which is reasonably fragile and vulnerable to repetitive strains. Apophyseal ring ruptures frequently result from exciting a weighty thing, however, they might similarly arise after damages due to falling (34, 37). Identification is established by magnetic resonance imaging (MRI) and computed tomography (CT) scan to find meticulous site and structure of the injury. In the pediatric spine, the growing zone in the body is established in the endplates. Distraction of this zone can simply happen by modest shearing forces. This fracture is characteristically realized in the teenage and presents a herniated disc with a radicular pain (37).

3.4.9. Spinal Cord Injury Without Radiographic Abnormality

A complete spinal cord injury without a related fracture happens in 19% to 34% of all pediatric spine traumas. A study assessed the elastic possessions of the pediatric spinal channel, which can be overextended up to 5 cm, however, the cord can lone be strained 0.63 mm before the split. Closely, 44% of patients through SCIWORA had complete injuries, whereas only 31% of pediatric with fractures or dislocations had complete injuries of the cord (38-40).

3.4.10. Posterior Limbus Injury

Fractures over vertebral apophasis are typically disturbing injuries and are classically established in teenagers. The most frequently exaggerated level is L4-L5. These fractures are labelled as a possible reason of SCIWORA, though this declaration remains unverified (34, 40).

Fractures secondary to child abuse: Vertebral body subluxation with or without breakage has great specificity aimed at child abuse if the history of trauma is vague or unpredictable with the damage. A recent systematic review

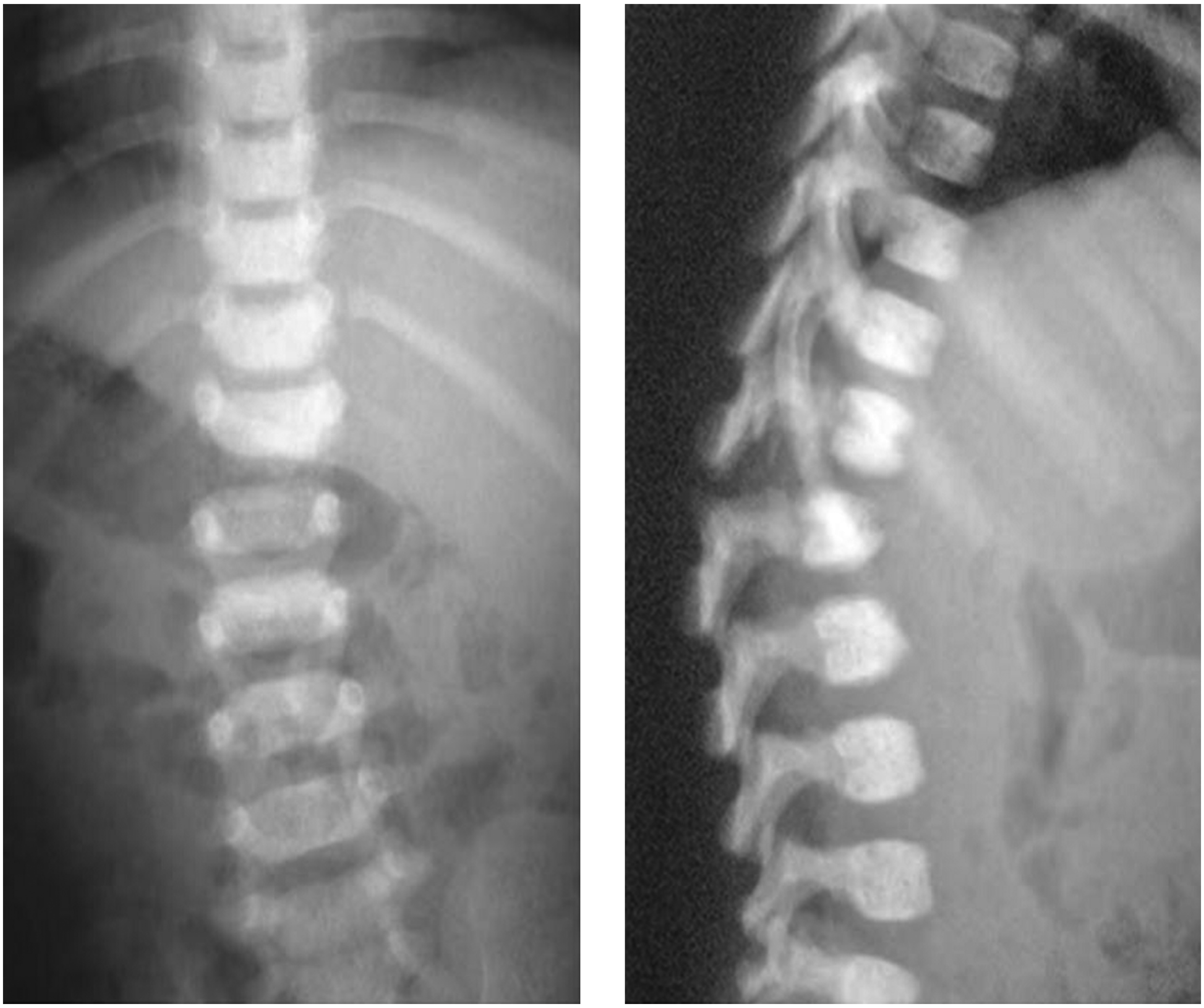

Figure 1. AP and Lateral X-ray of an Infant Offered a Thoracolumbar Fracture-Dislocation Caused by Trauma, the alignment of the vertebral column is typically changed.

reported that all patients with spine trauma produced by abuse were locally discovered by examination, specifically lumbar kyphosis or thoracolumbar bulge (41).

3.5. Injury Based of Child Age

Newborns: The under 2-year age cluster has correspondingly greater crania and weak cervical musculature, which donate to a great focus of gravity. Head trauma due to collision with immovable objects, typically a dashboard, is usually related to spinal damages in this age (42, 43).

A retrospective study on more than 1100 children with thoracolumbar spine trauma comprised 11% of emergency section patients by a delayed diagnosis of damage (44). Late presentations similarly related to a rareness of findings (39).

The means of these risks, anatomic benefits with similar great elasticity of the discs, comparatively strong ligamentous connections, and fast remediation communicate some defense against spine injury. Thoracolumbar SCIWORA has an occurrence up to 50% in such patients, matched to less than 1% in adults (45, 46).

3.5.1. Less Than 12 Years Old

These children were developed from the maximum heavy newborn to a lesser core of gravity by powered abdominal musculature. Lordosis of the cervical and lumbar vertebrae nowadays substitutes the kyphosis main alignment of the baby spine. The thoracolumbar junction is now suitable for the point of maximum movement in the thoracolumbar spine. Discs start to collagenize, permitting the transmission of more injury powers to the ver-

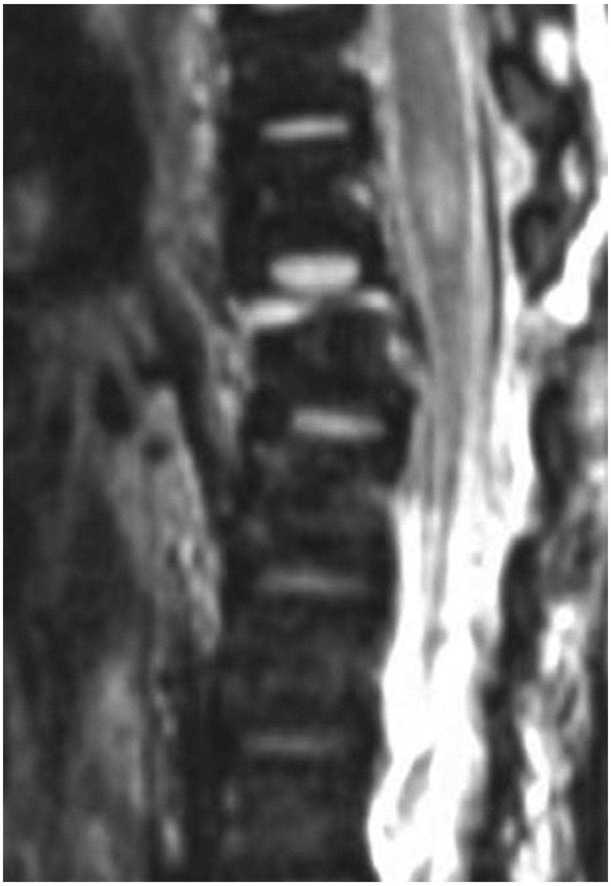

Figure 2. The T2 Signal MRI of the Patient Revealed Thoracolumbar Injury with a Vertebral Fracture and Spinal Cord Compression

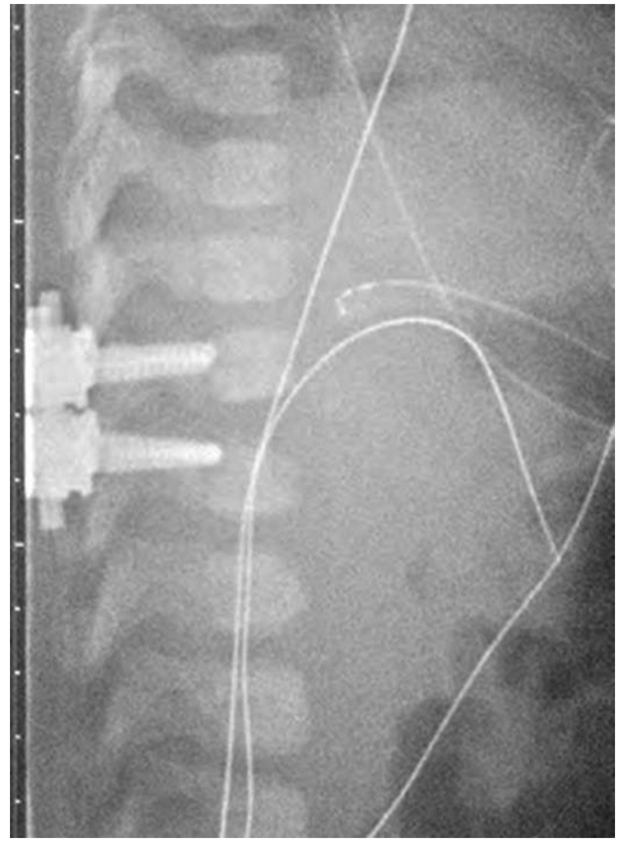

Figure 3. The Patient Is Operated with an Open Reduction and Fusion with Small Pedicle Screw Fixation

tebral body that initiate the course of ossifying the ring apophasis. Enhanced motor regulator and aggregate individuality increase the probable injury dangers as this group becomes more dynamic in sports and outdoor reinforcement (45).

The seatbelt injury is public in this age range and well recognized in the texts. Children above 4 years old have expanded child care seats; however, do not have established iliac crests to attend as anchor points for lap belts (46, 47).

3.5.2. Above 12 Years Old

The teenage group has the maximum accident rate and injury outlines are consistent with those of adults. SCIWORA is infrequently observed in this age range (43-45).

3.6. Diagnostic Lines

Primary images are generally simple X-rays focused on zones of clinically marked trauma or

regions of pain triggered in physical examination (48).

Complete thoracic and lumbar AP and lateral spine imaging are a least to perceive bony disturbance.

Patients who are extremely suspicious for thoracolumbar injury should be kept in the flat position on a firm board till a lateral X-ray can approve standard orientation and intervertebral space. A normal lateral cannot eradicate all opportunities of damage; however, normal results of the physical examination can permit the patient to experience careful consideration of restrictive efforts (49).

Oblique imaging is rarely needed to assess traumatic injury and can require significant movement of the patient. CT or MRI should be conducted if here is a great doubt about damage, or plain films are unsuitable, predominantly through the upper thoracic spine. Data recommend that the whole spinal column of a child must be imaged if damage is existing at one level (50). Early use of CT assessment should be evaded as defects might be lost owing to the axial direction of vertebral fractures even by tinny slice method (48, 49).

3.6.1. Computed Tomography

CT is advanced considerably and today high speed sensitive scans of the vertebral column can be obtained with a minimum of effort and without movement of the patient (18). Classification based on CT scan results can similarly permit some expectations concerning constancy of the damaged spine and essential for fast or late interference. CT scan should be understood in performance through thoracolumbar spine radiographs as anomalies cannot be identified irrespective of the dimension of imaging slices on CT scan (49, 51).

3.6.2. Magnetic Resonance Imaging

MRI is more universally applied as trauma centers advance capability by imaging and revealing the ligamentous and soft-tissue damage. MRI is the imaging of choice to detect SCIWORA. It is quite valuable to evaluate damages to the bone, soft-tissue, and spinal cord, and similarly to forecast spinal constancy. In children, quick use of MRI is suggested (49). Restrictions on its consumption in trauma persevere (51). The precondition is a steady patient who can continue immobility for lengthy periods.

3.7. Treatment

Classification of the thoracolumbar injury and severity scales (TLISS) is generally useful in the adults with trauma to define non-operative vs. operative management of spine fractures (50, 52). This classification is newly considered in the pediatric population, and there are reports of outstanding validity of this system similar to that of adults. Usually, various stable fractures can be cured conservatively, while unstable fractures need surgical stabilization. There are numerous diverse braces that can be produced to gain thoracic and lumbar restriction for conservative supervision. The TLSO (thoracolumbosacral orthosis) can be used to reach this effect. Aimed at upper thoracic spine fractures among T1 and T4, a SOMI (sterno-occipital-mandibular immobilizer) brace can be used. Length of bracing treatment is influenced by the injury and surgeon; nonetheless, it is classically at least 90 days. Operating stabilization for unbalanced lumbar fractures can be regularly achieved through a posterior method. Teenagers can frequently become stable through adult-like instruments as the pediatric spine extents adulthood at about 9 years old. But, younger children have minor pedicles, and therefore pedicle screw insertion might be needed. They likewise have minor spinal channels, thus placement of sublaminar hooks is not harmless. Correspondingly, rhBMP2 is used in children to endorse bone fusion as they regularly have an actual incomplete quantity of the obtained bone autograft (53, 54). Surgery by posterior or anterior stabilization is suggested in teenagers who are close to skeletal adulthood with above 30° of kyphosis for lumbar compression fractures (55) or uncertainty that the patient had a previous laminectomy. Stabilization and adjustment of the deformity can be talented with pedicle screw concepts. Burst fractures can be cured conservatively once there is no neural damage. Conservative management typically includes hyperextension casting for 2 or 3 months and orthosis for a supplementary 6 to 12 months. Surgical interference is comparatively designated with above 50% loss of body height. Up to 50% of canals compromise from bone fragments, or above 30° of kyphosis. Definitive clues for surgical decompression and fusion comprise neurological deficits or else advanced kyphosis (56). Unstable injuries are the most frequently operational injuries. The process contains posterior instrumentation and fusion 1 or 2 levels above and below the level of injury (27). Traditional management of apophyseal ring fractures involve rest, analgesics, physical motion change, and physical rehabilitation; but, it is seldom effective and surgery of the limbus fragment is generally mandatory. Operation is prepared through a posterior approach to take away the fragments and sometimes with a laminectomy (57). In the case of bony chance fracture, conservative management comprises of case immobilization for 2 to 3 months followed by the recommended bracing (27, 57). Surgical stabilization is directed with progressive neurological discrepancy or displacement above 17° of kyphosis. The surgery technique comprises of posterior instrumentation and fusion of 1 or 2 levels above and below the level of injury (56, 57); in fracture dislocation surgery anterior combined decompression and fusion might be obligatory although the prognosis is poor in patients with complete spinal cord injury (27).

3.8. Outcomes

Rescue of neurologic task subsequent a severe traumatic spinal cord injury happens by an expressively larger frequency in children than adults, even though the possibility for great morbidity remnants in spite of the restoration probable for the pediatric spine. The global death rate varies from 6.8% to 28% in some literature, and once matched with parallel trauma patients deprived of cervical spine injury and persons with cervical damage are more expected to expire in the emergency section or admitted to the intensive care unit (ICU) (58, 59).

As a final point, the pediatric spine did not agonize deformities of the thoracolumbar area in the long-term post-surgical consequence, as management of thoracolumbar fractures in the worldwide literature is extremely debatable (59).

4. Conclusions

Forceful use of CT scan and MRI can classify mild thoracolumbar damage and involvement of neural components and offer prognostic data in children with possible neurologic recovery, especially in SCIWORA type of injury. Currently, TLISS is generally useful in the adults by means of trauma to define non-operative vs. operative management of spine fractures. This classification is newly considered in the pediatric population, and there are reports of outstanding validity of this system similar to those of adults. Usually, various stable fractures can be cured conservatively, while unstable fractures need surgical stabilization. Conventional, against surgical management of diverse types of fractures, rely on the stability of the fracture and the neurological position of the patient. Once operating mediation is designated, it is harmless and effective in the pediatric population, and consequences in terms of fusion and neurological status are respectable.

Footnotes

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