ECRONICON OPEN ACCESS

EC ORTHOPAEDICS
Editorial

Stable Compression Fractures of the Thoracic Spine in Children: The Value of Secondary Radiographic Signs

NK Sferopoulos*

Department of Pediatric Orthopaedics, "G. Gennimatas" Hospital, Thessaloniki, Greece

***Corresponding Author:** NK Sferopoulos, Department of Pediatric Orthopaedics, "G. Gennimatas" Hospital, Thessaloniki, Greece.

Received: December 01, 2022; **Published:** December 03, 2022

The purpose of this editorial is to perform an extensive review of the literature about stable (simple) compression fractures of the thoracic spine in children, to indicate that diagnosis may be easily delayed or missed, to emphasize the value of the secondary radiographic signs, and to present illustrative cases.

Fractures of the thoracic spine account for 25 - 30% of spinal injuries in children. Thoracic vertebrae (T) are defined by their articulations with the ribs, while the thoracic cage offers an inherent stability of the thoracic spine, requiring larger forces to cause bony injury to this region of the spine [1]. It has been found that high traumatic stresses are usually distributed in the anterior column of the spine in children, predisposing this area to fracture [2,3]. Stable compression fractures resulting in wedging, primarily in the sagittal plane with loss of anterior vertebral height, are the most common fracture pattern [4,5], while the posterior half of the vertebral body, the posterior osseous components, and the posterior ligamentous complex are by definition intact [6-9]. Stable compression fractures are significantly more prevalent in the non-junctional (T2-T10) than in the junctional (T1, T11, or T12) thoracic segments [10-12].

Axial load with a degree of flexion is the common traumatic mechanism of the stable compression fractures of the thoracic spine, while the percentage of lost height defines the severity of injury. The majority of compression injuries in children occur as the result of high energy trauma, such as falls from a height or climbing stage [13]. They may also be due to sporting impact injuries, motor vehicle crashes, and to child abuse in younger patients. In the thoracolumbar spine, childhood injuries have a potential for physeal separation of the endplate, the superior endplate being more common, which is akin to Salter-Harris Type I fractures of the long bones, and disk spaces are usually not disrupted [14,15]. Considering that a degree of anterior wedging is normal in children and that the cause of these injuries, such as a fall, is fairly common, it is at times necessary to make a radiographic differential diagnosis of the traumatic wedging from a normal variant, Scheuermann's kyphosis, or an old injury [16-18].

The traumatic force required to create a stable compression fracture of the thoracic spine is often enough to result in additional injuries. Multiple spinal fractures may be evident in 30 - 40% of children with a diagnosed fracture of the thoracolumbar spine [19]. Fractures of the ribs or sternum as well as pulmonary, visceral, vascular and neurologic injuries may also occur. Older patients tend to have more than one lesion, moreover, the more damaged a spine is, the more likely is a missed injury of the thoracic spine [20-22].

After the airway, breathing and circulation have been assessed and stabilized; a history of the mechanism of injury may indicate the risk of thoracic spine injury. Clinical examination can localize pain to the site of the fracture in acute injuries, but absence of pain in the back does not exclude injury [1]. Since thoracic and lumbar spine injuries are most commonly seen in children > 9 years of age, it may be appropriate to apply adult clinical decision rules to the pediatric population [23,24]. An alert, cooperative patient without pain, localized tenderness, ecchymoses and deformity in the thoracic region of the spine can be evaluated without radiographs [25,26]. In addition, symptoms and signs of a spinal fracture may be obscured by a painful injury elsewhere in the body or when the patient is im-

mobilized in the backboard [15,27,28]. It has been reported that the most common clinical finding in children with thoracolumbar spinal fracture is local tenderness [29]. The sensation of respiratory arrest at the moment of injury has been considered as a predictive factor for thoracolumbar fractures. This 'breath arrest' sign should be integrated into the assessment grids in pediatric medical and surgical emergency units [30].

The vast majority of compression fractures are stable and early detection is difficult because the clinical examination may provoke little pain. This argues in favor of screening children with thoracolumbar trauma with radiographs, regardless of clinical symptoms. However, a low fracture rate of 5.6% has been detected following injuries of the thoracolumbar spine in children and adolescents. With regard to the expected stable fracture morphology and the absent surgical consequences, the indication for emergency radiographs should be provided restrictively. In addition, children are at inherently higher risk from exposure, because of both the highly radiosensitive region and the longer life expectancy. No national pediatric guidelines are currently available to inform clinicians whether an imaging examination would be beneficial or not in asymptomatic trauma patients [1,31-36].

Radiographs often show relatively subtle findings because the vertebrae are still cartilaginous, and consequently incompletely visualized. A fractured thoracic spine should be considered as a stable injury only when there is minimal to moderate anterior height loss (< 50%) and intact posterior cortex of the vertebral body. Direct or indirect primary radiographic signs of fractures and of potential instability should be carefully evaluated in the anteroposterior (AP) and lateral views of the thoracic spine taken in the emergency unit [37]. The direct primary signs include the cuneiform aspect or a decrease in the anterior and lateral height of one or several vertebrae compared to the adjacent levels. The height of each vertebral body should be assessed anteriorly and posteriorly, and a difference of more than about 3 mm treated as pathological. Similar comparisons can be made with regard to interpedicular distance and interspinous spacing. The indirect primary radiographic signs include a retracted displacement of the posterior vertebral wall, a loss of congruence of the posterior joint surfaces, or a scoliotic posture resulting from muscle contracture [1,38-42].

Careful scrutiny of the plain radiographs is always prudent; however, computed tomography (CT) will nearly always be used to clarify any suspected bone lesions in higher definition than radiographs. Plain radiographs have been interpreted as pathological in only 26% of the children who had a thoracolumbar fracture [30]. The sensitivity of plain radiographs has been reported to be 70% for pediatric spinal trauma, whereas it was 100% for CT scanning [43].

Magnetic resonance imaging (MRI) of acute thoracolumbar spinal injuries allows excellent evaluation of the neurologic and soft tissue structures [44-48]. Owing to recent advances in imaging techniques that permit greater spatial resolution and more detailed imaging of tissue, MRI now affords effective visualization of injury to the ligaments, intervertebral disk, bones, and spinal cord after trauma. MRI is the imaging modality of choice in pediatric thoracolumbar fractures associated with neurological deficits [49-52]. MRI can visualize both cartilaginous and cancellous bone lesions, which may produce functional symptoms, explaining the pain phenomena on radiographically obscure lesions [53]. The presence of bone bruising (contusion) of the vertebral body without other bony lesions has been considered as an indirect imaging sign of a benign vertebral injury [54]. It has been reported that radiographs missed 22% of fractures when compared to MRI in children with thoracolumbar trauma [30]. However, the information that may be obtained from a MRI must be weighed against the increased time and expense of the study, as well as the risks associated with sedation, when necessary [55]. According to the literature, the use of CT or MRI of the thoracic spine without IV contrast as the initial screening examination of children younger than 16 years of age with suspected thoracic spine trauma is controversial but may be appropriate [36].

Secondary signs may also prove significant information in the radiographic investigation of the pediatric thoracic spine following acute injury. A paravertebral (paraspinal) haematoma associated with widening of the mediastinum may be present, and blood in the pleural space may be seen as a pleural cap [1]. On the AP radiograph, mediastinal soft tissue shadows may be widened by the paravertebral haematoma. The linear thoracic paravertebral shadow was primarily described in 1942 as an enigma to radiologists and other clinicians

[56,57]. The left paravertebral line (stripe) is a feature of frontal chest radiographs, which is more commonly seen than the right one. This radiographic displacement of the paravertebral contour is of great importance in the diagnosis of lesions involving the thoracolumbar spine. The most common associated pathologic entities may be haematoma from vertebral fractures, spinal inflammatory disorders, malignancy, mediastinal pathology or trauma, etc. The left paravertebral line and the lateral margin of the descending aorta should be clearly distinguished from one another [58-61]. A displaced fracture of the thoracic spine may occasionally produce significant widening of the mediastinal shadow on the AP chest radiograph. The clinical and radiographic findings may be similar to that of an aortic injury. In adults, the radiographic differential diagnosis between vascular and skeletal injuries associated with mediastinal widening may be impossible [62,63]. It has been shown that a widened mediastinum on chest radiographs after trauma is not a specific finding of aortic rupture [64-66]. In these cases, the upper thoracic spine should be examined closely on the initial frontal chest radiograph for evidence of fracture. If a fracture of the upper thoracic spine is identified, an aortic rupture is unlikely in the absence of clinical signs and symptoms supporting this diagnosis [67]. Children with clinical and radiographic findings consistent with mediastinal haematoma mimicking or due to aortic rupture have also been reported [68,69].

Intestinal obstruction may be mechanical and non-mechanical (functional). The latter, may be partial or complete and it is also called ileus or paralytic (adynamic) ileus. Paralytic ileus is a major clinical concern that may lead to severe patient morbidity in orthopaedic surgery and trauma patients. It may commonly occur postoperatively, usually following spinal or chest surgery, joint replacement, or even minor orthopaedic procedures [70-72]. Retroperitoneal trauma and haemorrhage, spine or rib fractures, severe trauma outside the abdomen, or the application of a plaster jacket may also be complicated with paralytic ileus [73,74]. In adults, acute pelvic or lumbar spine fractures have been recognized as a potential cause of acute retroperitoneal or extrapleural haemorrhage [75-78]. However, cases with paralytic ileus associated with compression fractures of the thoracic spine have rarely been reported [79,80]. Compression fractures, especially in the elderly and patients on long-term corticosteroid therapy, should be considered in the differential diagnosis in cases presenting with an acute abdomen and any magnitude of lower back pain [81].

Fractures of the lower thoracic and upper lumbar spine may be complicated with intraabdominal injuries in up to 50% of pediatric trauma cases [82]. In children suffering from thoracolumbar fractures after motor vehicle collisions, especially when they had abdominal wall ecchymoses, the most common findings at laparotomy were hollow viscus injury, mesenteric tear, and solid organ injury [83]. Pediatric abusive thoracolumbar fractures complicated by fatal retroperitoneal haemorrhage have also been reported [84,85].

In children and neonates, localized, transitory paralysis in a segment of gut secondary to regional events, such as retroperitoneal haematoma due to fractures of the lower thoracic or lumbar spine, may also be diagnosed. The resultant focal paralytic ileus, involving one or two loops of small or large bowel (sentinel loop), due to peritoneal irritation, may be suspected from gaseous distention of isolated segments of intestine in the upright AP abdominal radiograph [86,87].

In stable thoracic compression spinal fractures, conservative treatment with bed rest, and cast or brace immobilization should be the treatment of choice in children. After adequate analgesia is obtained, mobilization in a thoracolumbosacral orthosis is started and continued for 6 weeks. Favorable outcomes, absence of significant deformity, and persistent stability have been reported [88-91]. Long-term studies have suggested modest remodeling capacity of compression fractures occurring in childhood. Asymmetric growth at the endplates seems to allow some correction in the wedged alignment over time in the skeletally immature patient. Thoracic fractures have a higher remodeling potential than lumbar fractures and it is easier to correct a thoracic kyphosis, than a lumbar one, decreasing compressive forces with an antikyphotic brace [92-94]. In addition, compensatory mechanisms in adjacent structures have been suggested for children and adolescents, which exclude the only hypothesis of bone remodeling [95]. It may be prudent to conclude that early diagnosis and management as well as long-term follow-up are imperative [96-98]. Stable vertebral fractures in childhood with no neurologic deficits at injury do not render more degenerative changes than can be expected according to age, but they are associated with more Schmorl's nodes at adjacent disc levels [99].

Four illustrative cases with stable compression fractures of the thoracic spine are presented. Anterior wedging with loss of less than 50% of the anterior vertebral body height, and an intact posterior half of the vertebral body were evident in all patients. They were all treated conservatively and an uneventful healing was reported in all of them.

Patient 1: A 10 year-old boy injured his back after a fall on it from his skateboard a week ago. Restriction from physical activities was the only offered treatment. He was referred due to persistent back discomfort. On physical examination, a localized area of tenderness was evident over the midthoracic spine. A lateral radiograph was only performed, which indicated a compression fracture with mild anterior wedging of the vertebral body of T8 (Figure 1).

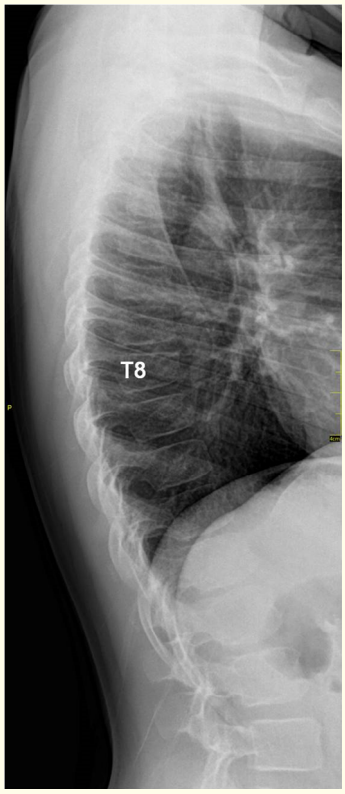


Figure 1: *Stable compression fracture with anterior wedging of T8 in a 10 year-old boy.*

Patient 2: A 12 year-old boy injured his back after a fall on it trying a bicycle (overhead or scissors) kick in football. On physical examination, an area of tenderness was evident over the midthoracic spine. A lateral radiograph indicated a compression fracture with mild anterior wedging of the vertebral body of T6. Lateral displacement of the left paraspinal line was evident on the frontal chest radiograph (Figure 2).

Patient 3: A 13 year-old boy injured his back after a fall from a tree. On physical examination, an extensive area of tenderness was evident over the midthoracic spine. A lateral radiograph indicated compression fractures with anterior wedging of the vertebral bodies of T5 to T8. Lateral displacement of both paraspinal lines was detected on the frontal chest radiograph (Figure 3a). Complete remodeling was evident 21 years later (Figure 3b).

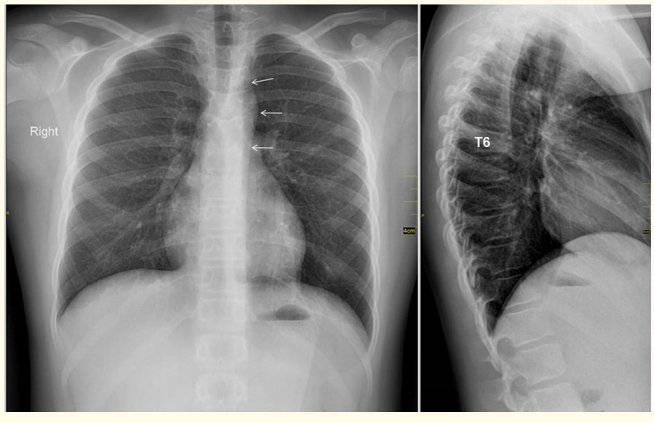
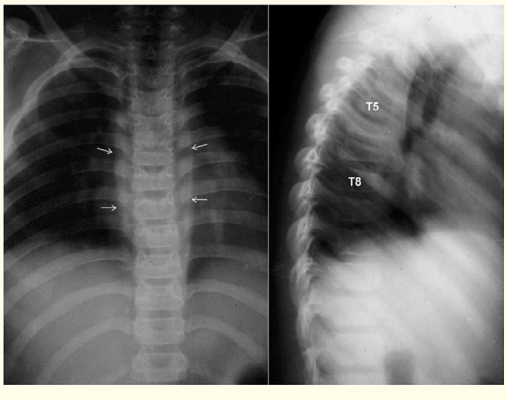
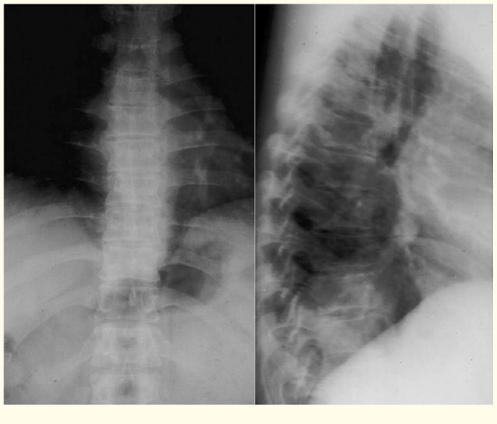


Figure 2: *Stable compression fracture with anterior wedging of T6 in a 12 year-old boy. Bulging of the left paraspinal line (arrows), lateral to the aortic arch, was evident on the frontal chest radiograph.*



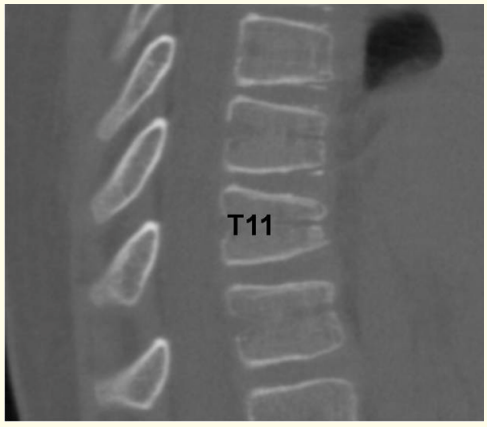
a



b

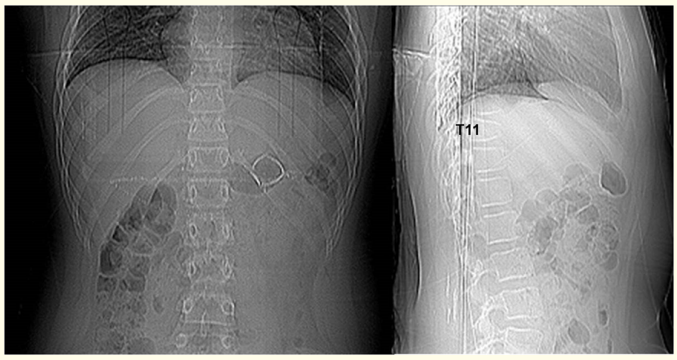
Figure 3: *Stable compression fractures with anterior wedging of T5 to T8 in a 13 year-old boy. Bulging of both paraspinal lines (arrows) due to paravertebral haematomas secondary to vertebral body fractures, with no evidence of lateral wedging, was evident on the frontal chest radiograph (a). Complete remodeling of the compression deformity 21 years later (b).*

Patient 4: A 10 year-old girl fell off the trampoline landing flat on her back. On physical examination, an area of tenderness was evident over the lower thoracic spine. AP and lateral radiographs indicated a compression fracture with anterior wedging of the vertebral body of T11. Sagittal CT views also showed slightly wedged anterior part of T9 and T10 (Figure 4a). The difference of the assessed height between the anterior and posterior vertebral body cortex of T9 and T10 was more than 3 mm, which is more likely due to the traumatic injury. However, a secure differential diagnosis between fracture and a normal variant could only be based on the potential finding of bone bruising (contusion) on both vertebrae on the MRI, although this would not have required any specific additional treatment. Axial CT view of T11 indicated mild displacement of the hemidiaphragm from the prevertebral haematoma on the right side (Figure 4b). A potential focal paralytic ileus (sentinel loop) was diagnosed on the AP and lateral scanograms. Gas accumulation was more pronounced in the colon than the small bowel (Figure 4c). There were no imaging findings of air-fluid levels, elevated diaphragm, and mechanical obstruction. Examination by a pediatric surgeon indicated diminished bowel sounds, including a reduction in the loudness, tone, and regularity of the sounds. No abdominal pain or abnormal clinical symptoms and signs were diagnosed. Elimination of all oral intake, continuous intravenous hydration, and check serum electrolyte levels was the initial management. Bowel function recovered within a couple of days, and the diet was advanced to a clear liquid diet and then to regular solid food within a few days.



a

b



c

Figure 4: *Stable compression fracture with anterior wedging of T11 in a 10 year-old girl. Sagittal CT view indicated compression fracture with anterior wedging of T11 and mild anterior wedging of T9 and T10 (a). Axial CT indicated slight displacement of the hemidiaphragm (arrow) by the prevertebral haematoma on the right side at the level of the T11 (b). Vertebral vascular foramina, also known as Hahn canal or cleft, were evident in the midline of the posterior aspect of the vertebral bodies in both sagittal and axial CT views. AP and lateral scanograms indicated a potential sentinel loop of paralytic ileus (c).*

In conclusion, plain radiographs are the first line of diagnosis of stable compression fractures of the thoracic spine, and they can be used either as the definitive diagnostic investigation or to guide further investigation. The relative high prevalence of children with minimal anterior wedging, in stable compression fractures, underscores the need for comprehensive history and physical examination. Considering that the most valuable information in such cases is based on the lateral radiograph, the value of AP radiograph is often underestimated. The aim to obtain the required diagnostic information using the minimum radiation dosage in children was evident in patient 1, in whom the thoracic spine was evaluated only with the lateral radiograph. However, the AP radiograph of the thoracic spine may provide useful secondary signs in acute stable compression fractures. That was evident in patients 2 and 3, in whom lateral displacement of the paraspinal line was diagnosed on the left and both sides, respectively. In addition, a sentinel loop was diagnosed in patient 4 on both the AP and lateral views. Radiographs showing a distended segment of bowel have constantly been observed at our service in children with acute lower thoracic or lumbar fractures. A short segment of temporary paralytic ileus was the potential diagnosis in all cases. Bowel rest was the only offered treatment. It should be emphasized that in stable compression fractures of the thoracic spine in children, the AP view should be carefully evaluated for secondary signs of an acute vertebral fracture, such as displacement of the paraspinal lines and dilated, gas-filled loops of the intestines.

Bibliography

1. Priyadarshi H and Soundappan SSV. "Spinal injury". In: Cameron P, Browne GJ, Mitra B, Dalziel S, Craig S, Eds. Textbook of paediatric emergency medicine. 3rd edition. Elsevier (2019).

2. Reynolds R. "Pediatric spinal injury". *Current Opinion in Pediatrics* 12.1 (2000): 67-71.

3. Sairyo K., *et al*. "Three-dimensional finite element analysis of the pediatric lumbar spine. Part I: pathomechanism of apophyseal bony ring fracture". *European Spine Journal* 15.6 (2006): 923-929.

4. Holmes JF., *et al*. "Epidemiology of thoracolumbar spine injury in blunt trauma". *Academic Emergency Medicine* 8.9 (2001): 866-872.

5. Carreon LY., *et al*. "Pediatric spine fractures: a review of 137 hospital admissions". *Journal of Spinal Disorders and Techniques* 17.6 (2004): 477-482.

6. Denis F. "The three column spine and its significance in the classification of acute thoracolumbar spinal injuries". *Spine (Phila Pa 1976)* 8.8 (1983): 817-831.

7. Kaye JJ and Nance EP Jr. "Thoracic and lumbar spine trauma". *Radiologic Clinics of North America* 28.2 (1990): 361-377.

8. Voth M., *et al*. "Thoracic and lumbar spinal injuries in children and adolescents". *Unfallchirurg* 116.12 (2013): 1062-1068.

9. Donnally III CJ., *et al*. "Vertebral compression fractures". In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing (2021).

10. Siminoski K., *et al*. "Anatomical distribution of vertebral fractures: comparison of pediatric and adult spines". *Osteoporosis International* 23.7 (2012): 1999-2008.

11. Kraus R., *et al*. "Fractures of the thoracic and lumbar spine in children and adolescents". *Unfallchirurg* 116.5 (2013): 435-441.

12. Junewick JJ., *et al*. "Pediatric thoracic spine injuries: a single-institution experience". *American Journal of Roentgenology* 203.3 (2014): 649-655.

13. Hegenbarth R and Ebel KD. "Roentgen findings in fractures of the vertebral column in childhood examination of 35 patients and its results". *Pediatric Radiology* 5.1 (1976): 34-39.

14. Aufdermaur M. "Spinal injuries in juveniles. Necropsy findings in twelve cases". *Journal of Bone and Joint Surgery. British Volume* 56.3 (1974): 513-519.

15. Basu S. "Spinal injuries in children". *Frontiers in Neurology* 3 (2012): 96.

16. Sorensen KH. "Scheuermann's juvenile kyphosis". Copenhagen: Munksgaard (1964).

17. Newton PO and Luhmann SJ. "Thoracolumbar spine fractures". In: Flynn JM, Skaggs DL, Waters PM Eds. Rockwood and Wilkins' Fractures in children. 8th edition. Philadelphia: Wolters Kluwer (2015).

18. Saul D and Dresing K. "Epidemiology of vertebral fractures in pediatric and adolescent patients". *Pediatric Reports* 10.1 (2018): 7232.

19. Brandser EA and el-Khoury GY. "Thoracic and lumbar spine trauma". *Radiologic Clinics of North America* 35.3 (1997): 533-557.

20. Vaccaro AR., *et al*. "Noncontiguous injuries of the spine". *Journal of Spinal Disorders* 5.3 (1992): 320-329.

21. Wang H., *et al*. "Epidemiology of traumatic spinal fractures: experience from medical university-affiliated hospitals in Chongqing, China, 2001-2010". *Journal of Neurosurgery: Spine* 17.5 (2012): 459-468.

22. Rush JK., *et al*. "Associated injuries in children and adolescents with spinal trauma". *Journal of Pediatric Orthopaedics* 33.4 (2013): 393-397.

23. Dogan S., *et al*. "Thoracolumbar and sacral spinal injuries in children and adolescents: a review of 89 cases". *Journal of Neurosurgery* 106.6 (2007): 426-433.

24. Babu RA., *et al*. "Pediatric thoracolumbar spinal injuries: The etiology and clinical spectrum of an uncommon entity in childhood". *Neurology India* 65.3 (2017): 546-550.

25. Meldon SW and Moettus LN. "Thoracolumbar spine fractures: clinical presentation and the effect of altered sensorium and major injury". *Journal of Trauma* 39.6 (1995): 1110-1114.

26. Kirkpatrick AW and McKevitt E. "Thoracolumbar spine fractures: is there a problem?" *Canadian Journal of Surgery* 45.1 (2002): 21-24.

27. Reid DC., *et al*. "Etiology and clinical course of missed spine fractures". *Journal of Trauma* 27.9 (1987): 980-986.

28. Maiat VV. "Errors and difficulties in diagnosis of compression fractures of the spine". *Khirurgiia (Mosk)* 4 (1975): 120-122.

29. Santiago R., *et al*. "The clinical presentation of pediatric thoracolumbar fractures". *Journal of Trauma* 60.1 (2006): 187-192.

30. Leroux J., *et al*. "Early diagnosis of thoracolumbar spine fractures in children. A prospective study". *Orthopaedics and Traumatology: Surgery and Research* 99.1 (2013): 60-65.

31. Ruffing T., *et al*. "X-ray of the thoracic and lumbar spine in injured children and adolescents: Incidence, fracture rates and therapeutic consequences". *Unfallchirurg* 121.1 (2018): 30-36.

32. American College of Radiology. ACR Appropriateness Criteria® Radiation Dose Assessment Introduction, (2018).

33. Sullivan J. "Fractures of the spine in children". In: Green N, Swiontkowski MF, Eds. Skeletal trauma in children. Philadelphia: WB Saunders (1994).

34. Ogden J. "Skeletal injury in the child". 3rd edition. New York: Springer (2000).

35. Junkins EP Jr., *et al*. "The clinical presentation of pediatric thoracolumbar fractures: a prospective study". *Journal of Trauma* 65.5 (2008): 1066-1071.

36. American College of Radiology. ACR Appropriateness Criteria®: Suspected Spine Trauma (2018).

37. Dormans JP., *et al*. "Pediatric spine trauma". In: Akbarnia BA, Yazici M, Thompson GH, Eds. The growing spine. Berlin: Springer-Verlag (2011).

38. Hubbard DD. "Injuries of the spine in children and adolescents". *Clinical Orthopaedics and Related Research* 100 (1974): 56-65.

39. Harris JH Jr. "Radiographic evaluation of spinal trauma". *Orthopedic Clinics of North America* 17.1 (1986): 75-86.

40. Miniaci A and McLaren AC. "Anterolateral compression fracture of the thoracolumbar spine. A seat belt injury". *Clinical Orthopaedics and Related Research* 240 (1989): 153-156.

41. Triantafyllou SJ and Gertzbein SD. "Flexion distraction injuries of the thoracolumbar spine: a review". *Orthopedics* 15.3 (1992): 357-364.

42. Matejka J., *et al*. "Seat-belt and chance fractures of the thoracolumbar spine". *Zentralblatt fur Chirurgie* 135.2 (2010): 149-153.

43. Antevil JL., *et al*. "Spiral computed tomography for the initial evaluation of spine trauma: A new standard of care?" *Journal of Trauma* 61.2 (2006): 382-387.

44. Lee HM., *et al*. "Reliability of magnetic resonance imaging in detecting posterior ligament complex injury in thoracolumbar spinal fractures". *Spine (Phila Pa 1976)* 25.16 (2000): 2079-2084.

45. Kerslake RW., *et al*. "Magnetic resonance imaging of spinal trauma". *British Journal of Radiology* 64.761 (1991): 386-402.

46. Pizones J., *et al*. "Impact of magnetic resonance imaging on decision making for thoracolumbar traumatic fracture diagnosis and treatment". *European Spine Journal* 20.3 (2011): 390-396.

47. Barcelos AC., *et al*. "Reliability of the evaluation of posterior ligamentous complex injury in thoracolumbar spine trauma with the use of computed tomography scan". *European Spine Journal* 25.4 (2016): 1135-1143.

48. Srinivasan V and Jea A. "Pediatric thoracolumbar spine trauma". *Neurosurgery Clinics of North America* 28.1 (2017): 103-114.

49. Sledge JB., *et al*. "Use of magnetic resonance imaging in evaluating injuries to the pediatric thoracolumbar spine". *Journal of Pediatric Orthopaedics* 21.3 (2001): 288-293.

50. de Gauzy JS., *et al*. "Classification of chance fracture in children using magnetic resonance imaging". *Spine (Phila Pa 1976)* 32.2 (2007): E89-E92.

51. Looby S and Flanders A. "Spine trauma". *Radiologic Clinics of North America* 49.1 (2011): 129-163.

52. Salgado Á., *et al*. "MRI reliability in classifying thoracolumbar fractures according to AO classification". *Orthopedics* 36.1 (2013): e75-e78.

53. Lee JY., *et al*. "Assessment of injury to the thoracolumbar posterior ligamentous complex in the setting of normal-appearing plain radiography". *Spine Journal* 7.4 (2007): 422-427.

54. Scheunemann D., *et al*. "Clinical relevance of 'bone bruise' detected by MRI following spinal injuries in children". *Unfallchirurg* 108.8 (2005): 638-644.

55. Franklin DB 3rd., *et al*. "The role of computed tomography and magnetic resonance imaging in the diagnosis of pediatric thoracolumbar compression fractures". *Journal of Pediatric Orthopaedics* 39.7 (2019): e520-e523.

56. Brailsford JF. "The linear thoracic paraspinal shadow. Editorial". *Radiology* 39.2 (1942): 229.

57. Millard DG. "Displacement of the linear thoracic paraspinal shadow of Brailsford. An early sign in osteomyelitis of the thoracic spine". *American Journal of Roentgenology Radium Therapy and Nuclear Medicine* 90 (1963): 1231-1235.

58. Eklöf O., *et al*. "Malignant versus benign paravertebral widening in children". *Pediatric Radiology* 11.4 (1981): 193-201.

59. Whitten CR., *et al*. "A diagnostic approach to mediastinal abnormalities". *Radiographics* 27.3 (2007): 657-671.

60. Gibbs JM., *et al*. "Lines and stripes: where did they go? From conventional radiography to CT". *Radiographics* 27.1 (2007): 33-48.

61. Marano R., *et al*. "Cardiac silhouette findings and mediastinal lines and stripes: radiograph and CT scan correlation". *Chest* 139.5 (2011): 1186-1196.

62. Gopalakrishnan KC and el Masri WS. "Fractures of the sternum associated with spinal injury". *Journal of Bone and Joint Surgery. British Volume* 68.2 (1986): 178-181.

63. Bolesta MJ and Bohlman HH. "Mediastinal widening associated with fractures of the upper thoracic spine". *Journal of bone and joint surgery. American Volume* 73.3 (1991): 447-450.

64. Heiberg E. "Superior mediastinal widening from spine fractures mimicking aortic rupture on chest radiographs". *American Journal of Roentgenology* 152.6 (1989): 1340.

65. Stark P. "Aortic rupture or mediastinal hematoma?" *American Journal of Roentgenology* 153.1 (1989): 195.

66. Lee J., *et al*. "Noncorrelation between thoracic skeletal injuries and acute traumatic aortic tear". *Journal of Trauma* 43.3 (1997): 400-404.

67. Dennis LN and Rogers LF. "Superior mediastinal widening from spine fractures mimicking aortic rupture on chest radiographs". *American Journal of Roentgenology* 152.1 (1989): 27-30.

68. Fleisher AG., *et al*. "Mediastinal hematoma mimicking aortic rupture". *Journal of Pediatric Surgery* 21.5 (1986): 445-446.

69. Trachiotis GD., *et al*. "Traumatic thoracic aortic rupture in the pediatric patient". *Annals of Thoracic Surgery* 62.3 (1996): 724-732.

70. Skucas J. "Advanced imaging of the abdomen". London: Springer-Verlag (2006).

71. Daniels AH., *et al*. "Paralytic ileus in the orthopaedic patient". *Journal of the American Academy of Orthopaedic Surgeons* 23.6 (2015): 365-372.

72. Mattei P and Rombeau JL. "Review of the pathophysiology and management of postoperative ileus". *World Journal of Surgery* 30.8 (2006): 1382-1391.

73. Karabin JE. "Retroperitoneal hemorrhage: With special reference to the accompanying paralytic ileus". *The American Journal of Surgery* 56.2 (1942): 471-479.

74. Weledji EP. "Perspectives on paralytic ileus". *Acute Medicine and Surgery* 7.1 (2020): e573.

75. Hurt AV., *et al*. "Prolonged ileus after severe pelvic fracture". *American Journal of Surgery* 146.6 (1983): 755-757.

76. Morita S., *et al*. "Arterial embolization of an extrapleural hematoma from a dislocated fracture of the lumbar spine: a case report". *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine* 17 (2009): 27.

77. Fu CY., *et al*. "The effect of angioembolization for life-threatening retroperitoneal hemorrhage in patients with pelvic fracture". *American Journal of Emergency Medicine* 37.4 (2019): 603-607.

78. Nakao S., *et al*. "Radiological classification of retroperitoneal hematoma resulting from lumbar vertebral fracture". *European Journal of Trauma and Emergency Surgery* 45.2 (2019): 353-363.

79. Margetts EL. "Paralytic ileus-an unusual sequela of spinal fracture from electroencephalotherapy". *Canadian Medical Association Journal* 75.9 (1956): 749-750.

80. Jeanneret B and Holdener HJ. "Vertebral fractures and abdominal trauma. A retrospective study based on 415 documented vertebral fractures". *Unfallchirurg* 95.12 (1992): 603-607.

81. Treadwell EL., *et al*. "Thoracolumbar compression fractures presenting with an acute ileus". *Journal of the National Medical Association* 82.9 (1990): 669-672.

82. Roche C and Carty H. "Spinal trauma in children". *Pediatric Radiology* 31.10 (2001): 677-700.

83. Beaunoyer M., *et al*. "Abdominal injuries associated with thoraco-lumbar fractures after motor vehicle collision". *Journal of Pediatric Surgery* 36.5 (2001): 760-762.

84. Webb M., *et al*. "Abusive pediatric thoracolumbar fracture due to forced hyperextension: Case report, biomechanical considerations, and review of the literature". *Journal of Forensic Sciences* 65.6 (2020): 2023-2029.

85. Dudley MH and Garg M. "Fatal child abuse presenting with multiple vertebral and vascular trauma". *Journal of Forensic Sciences* 59.2 (2014): 386-389.

86. Franken EA Jr., *et al*. "Paralysis of the small bowel resembling mechanical intestinal obstruction". *Gastrointestinal Radiology* 5.2 (1980): 161-167.

87. Lee HJ. "Plain abdominal radiography in infants and children". *Korean Journal of Pediatric Gastroenterology and Nutrition* 14.2 (2011): 130-136.

88. Kathrein A., *et al*. "Management of injuries of the thoracic and lumbar vertebrae in children". *Orthopade* 28.5 (1999): 441-450.

89. Parisini P., *et al*. "Treatment of spinal fractures in children and adolescents: long-term results in 44 patients". *Spine (Phila Pa 1976)* 27.18 (2002): 1989-1994.

90. Moller A., *et al*. "Vertebral fractures in late adolescence: a 27 to 47-year follow-up". *European Spine Journal* 15.8 (2006): 1247-1254.

91. Spiegl UJ., *et al*. "The conservative treatment of traumatic thoracolumbar vertebral fractures". *Deutsches Ärzteblatt international* 115.42 (2018): 697-704.

92. Pouliquen JC., *et al*. "Vertebral growth after thoracic or lumbar fracture of the spine in children". *Journal of Pediatric Orthopaedics* 17.1 (1997): 115-120.

93. Karlsson MK., *et al*. "A modeling capacity of vertebral fractures exists during growth: an up-to-47-year follow-up". *Spine (Phila Pa 1976)* 28.18 (2003): 2087-2092.

94. Jarvers JS., *et al*. "Injuries of the thoracolumbar spine in children". *Orthopade* 45.6 (2016): 472-483.

95. Angelliaume A., *et al*. "Conservative treatment of pediatric thoracic and lumbar spinal fractures: outcomes in the sagittal plane". *Journal of Pediatric Orthopaedics B* 26.1 (2017): 73-79.

96. Clark P and Letts M. "Trauma to the thoracic and lumbar spine in the adolescent". *Canadian Journal of Surgery* 44.5 (2001): 337-345.

97. Slotkin JR., *et al*. "Thoracolumbar spinal trauma in children". *Neurosurgery Clinics of North America* 18.4 (2007): 621-630.

98. Daniels AH., *et al*. "Pediatric thoracolumbar spine trauma". *Journal of the American Academy of Orthopaedic Surgeons* 21.12 (2013): 707-716.

99. Möller A., *et al*. "A vertebral fracture in childhood is not a risk factor for disc degeneration but for Schmorl's nodes: a mean 40-year observational study". *Spine (Phila Pa 1976)* 32.22 (2007): 2487-2492.

Volume 13 Issue 11 November 2022