Delay in diagnosis of thoracolumbar fractures

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Abstract

The time interval between the date of trauma and the diagnosis of vertebral column fractures hinders management and increases liability. We have examined the features and implications of this delay. 585 consecutive thoracolumbar fractures (2005-2016), were considered; 382 (65.30%) were males and 203 (34.70%) females. Mean age was 51 yr. Fall from a height (187; 31.97%), simple fall (147; 25.13%) and road accidents (111; 18.97%) were the most frequent causes of trauma. Physical exertion caused 8.38% (N=49). 142 patients (24.27%) were not diagnosed on the injury day (mean = 3.2 days). Delay was longer in females (mean = 5.5 *vs*. 2.7 days) and shorter in falls from a height (mean = 2.3) or road accidents (2.8). Mean age of diagnosed on the injury day differed from those diagnosed in the first month (49.2 *vs* 60.1). Plain X-ray signs were found in 7 misdiagnosed cases (46.6%). Delay was more frequent in low mineralization cases. Diagnostic delay of spine fractures is frequent. Some risk profiles can help to reduce it. Careful emergency X-ray examination is encouraged, as well as early magnetic resonance imaging in risk profiles.

Introduction

In western countries, thoracolumbar fractures are common conditions. Mostly caused by falls and road or occupational accidents,[1] low bone quality and osteoporosis are important underlying factors.[2,3] Not all fractures are diagnosed on the day of injury, leaving patients exposed to inappropriate treatment and rendering them vulnerable to complications. Some studies suggest that more than 50% of vertebral fractures are silent and often are undiagnosed.[4,5] Others have pointed out that 34-55% are not detected, depending upon the radiological procedure used.[6-8] Causes of misdiagnosis can also be related to the degree of adherence to diagnostic protocols or the availability of imaging techniques. But, in addition, there are other non-medical factors which have not been studied extensively, such as the failure to seek/obtain immediate medical assistance, or the underscoring of certain mechanisms (*i.e*. physical efforts) as a possible cause of significant injuries.

In this study, we focused on analyzing the time between the injury and the moment when the fracture was definitively diagnosed, trying to identify both medical and non-medical factors that could be responsible for this delayed health care.

Materials and Methods

We retrospectively reviewed thoracolumbar fractures treated at our Hospital between January 2006 and December 2017. The exclusion criterion was pathological fracture caused by tumor or infection. Age, gender, kind of injury and radiological studies were collected. Densitometries, carried-out shortly after the accident, were also retrieved. Definite diagnosis in all cases was confirmed by MRI (Figure 1). We retrospectively examined the spine X-rays of misdiagnosed cases, taken in the Emergency Department (Figure 1). The revision was performed by a radiologist and a spine surgeon. The main X-ray findings were classified as negative, positive or not valuable. The quality of the positive findings was classified as either uncertain or certain. The statistical analysis was performed using IBM-SPSS®, Statistics 22.0 software. Differences in days of delay of several categories were tested by means of one-way ANOVA, after Kolmogorov-Smirnov test of normality. Non-parametric tests (Kruskal-Wallis, Mood's median test) were used in cases that did not follow a normal distribution. Kolmogorov-Smirnov tests were used to assess whether the data were normally distributed. If the data were normally distributed, differences in diagnostic delay were tested using one-way ANOVA; otherwise, non-parametric tests (Kruskal-Wallis, Mood's median test) were used.

Results

Sample size and etiology of vertebral fractures

The database provided a total of 610 patients, but enough data was only available in 585 cases to assess whether there was a delay in diagnosis or not. Hence, this subsample was selected for the analysis.

382 cases (65.3%) were males (mean age = 47 yr.) and 203 (34.7%) females (mean age = 60.2 yr.). Mean age of patients was 51 yr., SD=15.9. 57.75% of the cases (N=82) were occupational accidents.

Fall from a height (187 patients, 31.97%: 158 males and 29 females), a simple fall (147, 25.13%:57 males and 90 females) and road accidents (111, 18.97%: 78 males and 33 females) were the most common causes of spinal fractures. Physical exertion was the cause of 8.38% (49 patients: 30 males and 19 females) of spinal fractures. Other types of events (*e.g.* sports accidents, physical aggression) were responsible for 10.77% (63 patients: 41 males and 22 females) of the fractures. In 4.79% (28: 18 males and 10 females) of the patients, no etiology was identified.

Males suffered fractures more frequently than did females; however, the incidence of fractures from a simple fall (from standing height), were more common in females (61.22%) than they were in males (38.68%). Fractures caused by falling from a height mostly involved males (84.49%), rather than females (15.51%). Fractures as a result of traffic accidents were more frequent in males (70.27%) than in females (29.63%).

Densitometry after the accident (N=228) found 123 patients with low spine mineralization (53.95%).

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Time from injury to diagnosis

142 patients (24.3%) were diagnosed on a day other than the day of the traumatic event (mean delay = 3.2 d, SD=10.2). The longest delay was 115 d. Among the delayed diagnosis fractures (DDF), 52.1% (74 cases) were identified within one week, 36.6% (52 cases) were identified within one month, 9.85% (14 cases) were identified between one and three months, and two cases (1.40%) were diagnosed >3 months after the injury date. On average, fractures were diagnosed later among females (5.5 d) than they were among males (2.7 d) (Table 1). In the low-mineralization group, 47 patients (20.61%) were diagnosed later, whereas in the normal group there was a delay in 31 (13.6 %). Nevertheless, this difference does not reach levels of statistical significance (Chi square: P=0.168) (Table 2).

Etiology of injuries and diagnosis delay

The etiology influenced the likelihood of diagnosis delay. Fractures resulting from physical exertion and simple falls had a mean delay of 6 d and 4.3 d, respectively. On average, fractures were diagnosed earliest when the cause was a fall from a height (2.3 d), a road accident (2.8 d) or other events (3.2 d). Diagnosis delay did not differ significantly between occupational and non-occupational fractures.

Delay diagnosis and age

The age of the patient and duration of diagnosis delay were found to be associated (Table 3). Young patients were usually diagnosed on the day of the injury. The average age of those diagnosed on the injury day was significantly lower than the ages of those diagnosed within the first week or month (7.6 yr. and 10.9 yr. difference, respectively; P<0.001).

Health care and analysis of spine X-rays

In 22 (15.5%) of the cases in which fracture identification was delayed, the patient sought medical attention in the days before the diagnosis. Five patients sought medical attention more than twice. All these 22 patients complained of backache. Rest and anti-inflammatory drugs were prescribed. In none of these cases was CT or MRI performed on the date of the injury; the diagnosis was based only on plain X-ray and clinical examination. In 13 cases, medical records, including emergency X-ray examinations, could be retrieved. The patients received attention in Emergency Departments; however, after X-rays and clinical examination, the diagnosis was backache or thoracolumbar contusion. In 9 cases, the patient first obtained assistance at more than one hospital. In one case, the patient sought assistance at two emergency departments, but the fracture was not diagnosed. A retrospective examination of the spine X-rays, taken in the emergency department, found that in 7 cases (46.6%) there were certain signs of fractures that could have been identified. In those cases, the main findings were: anterior wedging, disruption of anterior cortical of vertebral body, loss of definition of the superior endplate and posterior body height loss (Tables 4-6). It was difficult to evaluate the vertebral fractures because of the low quality of the radiographs (9 cases) or structures superimposition (1 case).

Discussion

The incidence of misdiagnosis of spine fractures varies among studies. Poonnoose *et al*.[9] reported 36% of missed thoracolumbar spine injuries. Meldon and Moettus,[10] communicated a rate of 19.5%. In women aged ≥60 yr, a retrospective radiological evidence of fracture was found in 14%. However, only 50% of the contemporary X-ray reports mentioned these fractures.[11,12] Others have reported the incidence of false-negative radiological diagnosis to be between 27% and 45% in postmenopausal women.[13]

Therefore, misdiagnosis of a spinal fracture is an important health problem. Considering that delayed care is equivalent to denied care, a crucial factor is the time interval before the fracture is diagnosed. This delay, rarely analyzed in the literature, is the main objective of our investigation.

A 3-weeks period is considered as the cut-off value for classifying a spinal fracture as neglected, because the development of fibrosis in the injured segment makes operative intervention difficult after this time. Thus, the concept of "neglected fracture" emerges as an element that can lead to difficult or lengthy surgical management and, possibly, to neurologic complications and liability.[14]

According to this cut-off, in our sample, 28 cases (4.78% of total; 19.71% of all DDF) were neglected fractures. This is a high incidence, with two negative consequences. On the one hand, a poor evolution is expected and, on the other, a 3-weeks delay is unacceptable for an appropriate standard of care.

Reid *et al*.[13] reported that the delayed diagnosis time for thoracolumbar spine fractures was caused by 1) failure to take X-rays (*e.g.* low quality, artifacts) or lack of medical request, 2) fractures missed on X-rays, and 3) failure of patients to seek medical attention. Indirect factors such as intoxication, multiple injuries, level of consciousness, or multiple levels of spinal injury also contribute to the delayed diagnosis of spinal fractures.

We can also classify the delay into two types: Medical and non-medical. The medical group includes the two first Reid categories, where mistakes, insufficiencies or obstacles could exist in the health care provided. The non-medical type is linked to factors such as the patient attitude to seeking assistance and availability or organization of health care provided.

Table 1. Time from injury to diagnosis.

Variable	Results
Interval, N (%)	
1-7 days	74 (52.1)
7 days -1 month	52 (36.6)
1-3 month	14 (9.9)
More than 3 months	2 (1.4)
Sex, mean delay in days (SD)	
Male	2.8 (10.2)
Female	4.0 (10.2)
Total	3.2 (10.2)

Table 2. Delay and spine mineralization.

	Gender					Spine mineralization		
	Osteoporosis	Osteopenia	Normal	Total		Yes	No	Total
Male, n (%)	16 (7.02)	43 (18.86)	76 (33.33)	135 (59.21)	Low, n (%)	47 (20.61)	76 (33.33)	123 (53.95)
Female, n (%)	29 (12.72)	35 (15.35)	29 (12.72)	93 (40.79)	Normal, n (%)	31 (13.60)	74 (32.46)	105 (46.05)
Total, n (%)	45 (19.74)	78 (34.21)	105 (46.05)	228 (100.00)	Total, n (%)	78 (34.21)	150 (65.79)	228 (100.00)

Chi square: P=0.1681

Most of the studies about missed or delayed fractures have focused on the cases in which assistance was sought. However, there is little information about the patients who did not seek medical assistance for a time after the injury.

In our study, there was proof of previous medical consultation in only 15.5% of the patients with delayed diagnosis. Therefore, Reid's third category represents the majority of delayed cases. This finding calls for more extensive health education about the issue. Programs designed to inform the population about the risk of spinal fractures should be adopted, in order to encourage individuals to seek medical attention even after seemingly minor injuries.

Reid's first and second categories have been the almost exclusive focus of studies investigating misdiagnosed spinal fractures. Reasonably, an accurate diagnostic protocol should avoid mistakes.

Clinical examination is considered to be the first step in detecting a fracture. The sensitivity and specificity of clinical examinations for thoracolumbar spine fractures were reported to be 48.2% and 84.9%, respectively, for all fractures, and 78.6% and 83.4%, respectively, for those that were clinically significant.[15] About 52% of patients with thoracolumbar fractures had a negative clinical diagnosis. It could be due to clinical obstacles linked to the patient's condition, which can render the diagnosis of a spine fracture very difficult. Patients suffering from multiple injuries are often affected by altered mental status,[16] which makes their evaluation difficult and can hinder spine fracture identification.[17]

Thus, clinical examination has significant limitations in the suspicion and diagnosis of thoracolumbar fractures.

The second step in diagnosis is conventional radiography, including anteroposterior (AP) and lateral films of the spine.[18] Wedge deformity is a key X-ray feature associated to compression fracture and is visible in the lateral view. It appears as a loss of height of the anterior aspect of the vertebral body (usually <50%) with preservation of the height of the posterior aspect body. A discrepancy of >2 mm is considered significant, except at T12-L1, where the height difference might be normal.[18]

Another important X-ray sign in PA radiography is a loss of definition in the superior endplate, with a normal interpediculate distance. Additional findings can include disruption of the posterior vertebral body line, loss of the posterior vertebral body height and retropulsion of fracture fragments.[18] Widening of the interpediculate distance relative to the interpediculate

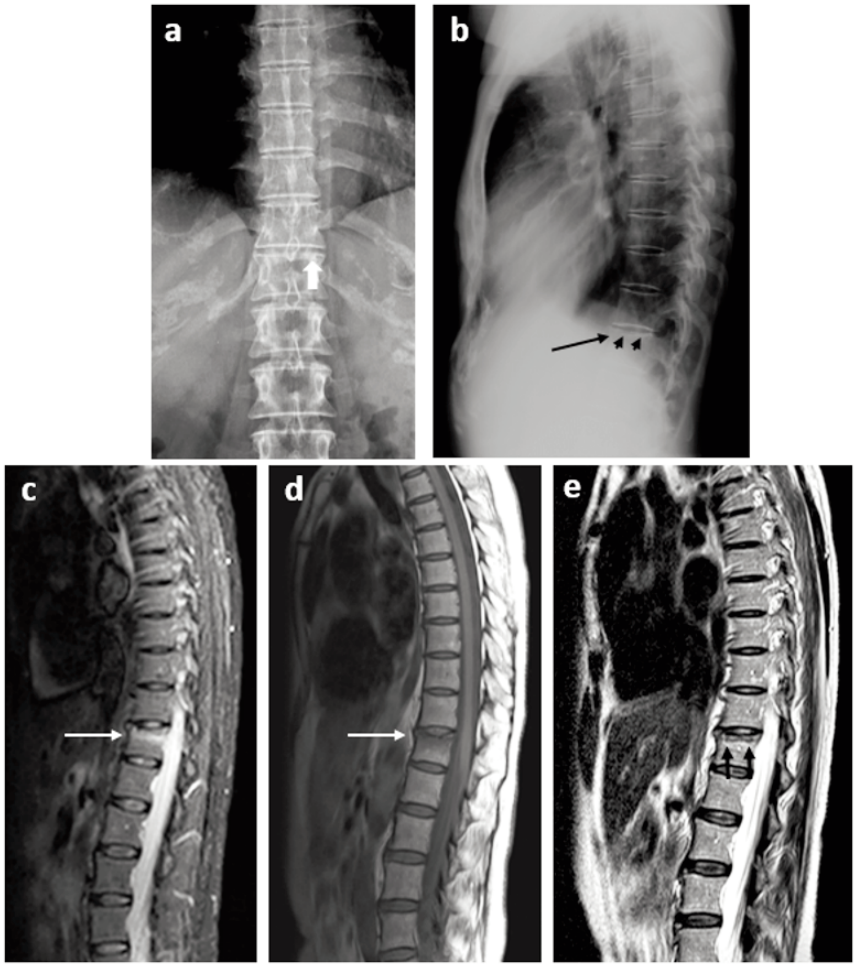

Figure 1. AP (a) and lateral (b) spine X-rays on the date of injury of a patient that had an undiagnosed fracture. It shows loss of definition of superior endplate of the 12th thoracic vertebra (white arrow in a), anterior cortical disruption (black arrow in b), and anterior wedging (black arrowheads in b). Those findings were not identified in the emergency department. MRI (9 days after the accident): Sagittal STIR (c), T1 (d) and T2 (e). Images show a band-like bone marrow edema in the superior endplate of 12th thoracic vertebra (arrows in c and d) and a defined line of fracture (black arrows in e).

Table 3. Delay diagnosis and age.

Delay diagnosis	N (patients)	Mean of age
No delay	443	49.20
1-7 days	74	56.81
7 days-1 month	52	60.08
1-3 months	14	56.93
>3 months	2	52

Significant differences: No delay vs. 1-7 days = 7.6 year (P<0.0001). No delay vs. 7 days -1 month = 10.9 year (P<0.0001)

Table 4. Analysis of spine X-rays.

X-rays findings	DAC	DPC	AW	PBHL	LDSE	IPDW	ISPDW	OF	PSTW
Negative	3	11	3	3	5	11	11	11	11
Positive	9	1	10	10	6	0	0	0	0
Not valuable	1	1	0	0	2	2	2	2	2

distance of the vertebrae above and below the affected level (on an AP radiograph) is indicative of posterior column disruption and instability. Increased distance between the spinous processes on the AP film is the other observed characteristic caused by distraction of the posterior column. Indirect indicators include loss of the psoas stripe or widening of paraspinal soft tissue and rib or sternal fractures.

However, the sensitivity and the specificity of plain film in the diagnosis of thoraco-lumbar fractures in patients who have sustained minor trauma are low. Karul *et al*.[19] found that AP and lateral radiographs had a sensitivity of 49.2%, a specificity of 54.7%, a positive predictive value of 62.7%, a negative predictive value of 41.1% and an accuracy of 51.4%.

A combination of plain films and semi-quantitative methods produced a false-negative fracture rate of 25.8%. The rate of false-positive fractures was 6.3%.[20]

Another important diagnostic tool is the Computed Tomography (CT). The sensitivity and specificity CT scout vary among studies. Some have reported 98.7% and 99.7%, respectively.[21] Semi-quantitative methods to classify vertebral fractures based on CT scout views can slightly improve the sensitivity.[22]

Multidetector CT scan (MDCT) is used primarily when conventional radiographic evidence is subtle or there is a discrepancy between radiographic findings and neurologic status.[18] Karul *et al*.[19] reported that MDCT detected 60.7% of suspected fractures. Another study found that 13% of the patients were correctly diagnosed as having osteoporotic fractures in the official report.[23] A retrospective analysis of selected CT scans of the chest and abdomen indicated that the reporting rate was about 89%. Only 11% of such fractures were not reported and, subsequently, missed.[24]

Nevertheless, CT sensitivity can be lower in osteoporosis. The sensitivity of axial CT images for vertebral osteoporotic fracture was 0.35.[23]

The local environment, in particular the availability of high quality multiplanar reconstructions and an understanding of the potential for missed incidental vertebral compression fractures, has a significant influence on the rate at which incidental vertebral compressions go undetected.[24] Krueger *et al*.[25] reported an 11% incidence of missed injuries and, to avoid missing an occult spinal injury, recommended CT in cases of isolated lumbar transverse process fracture. Others have recommended imaging the entire spine for evidence of noncontiguous lesions.[26]

Due to its high spatial resolution and high soft tissue contrast, MRI is clearly superior to all other imaging techniques in demonstrating bone marrow edema, ligamentous ruptures, posttraumatic disc herniations, epidural hemorrhage and spinal cord injuries.[18]

MRI is effective in distinguishing between acute and chronic fracture, unlike radiography, which has poor sensitivity for acute injuries.[27] Other important MRI features include the detection of occult fractures and bone contusion or edema. An "occult fracture" is either radiographically unapparent or demonstrates subtle abnormalities that are missed at initial interpretation.[28] "Bone contusions" are injuries, which include bleeding, infarction and edema, caused by microscopic compression fractures of trabecular bone.[27]

The availability of MRI is crucial to increase the detection rate for vertebral fractures and it is considered as the gold standard in spine fracture diagnosis. Other techniques, such as lateral and AP absorptiometry imaging of the spine, coupled with selective follow-up radiographies, can accurately identify elderly women that have vertebral deformity consistent with moderate or severe fracture, but greater caution is necessary when evaluating vertebrae in the presence of adjacent disc space osteoarthritis.[29] Perhaps a good knowledge of sensitivity and specificity of clinical and complementary examinations would be the best way to avoid mistakes in fracture identification. It has been described that adherence to protocols can reduce missed injuries and hence late complications.[30]

In the present work, it was found that the lack of indication of CT or MRI at the time when the patient first received assistance was the main cause of neglected fractures. All the Hospitals had CT immediately availability, with MRI also being available on request in a few hours or days. Therefore, the lack of such resources is not the main factor behind the misdiagnosis in our cases. Perhaps the low level of clinical suspicion and the overestimation of diagnostic power of plain X-rays are the principal reasons why the fractures remained unidentified.

We retrospectively identified significant findings of fracture in X-ray plain films in 46.66% of non-diagnosed cases, which reflects the importance of an accurate X-ray analysis in the emergency department; in particular, when there is a clinical suspicion, or the patient falls into a risk group. Our study revealed that being female, having suffered a simple fall and being aged >50 yr. were factors that placed the patient at a high risk for misdiagnosis or delay in spine fracture identification.

Probably CT or MRI are the most effective methods of identifying spinal fractures when the patient seeks assistance. Cases in Reid's first and second categories can be reduced if an appropriate clinical-radiological diagnostic protocol is instituted.

However, in the third category, the diagnosis of a spinal fracture does not depend upon medical protocols or the availability of diagnostic imaging. One of the more striking findings of this work was the high incidence of patients who did not seek medical assistance on the same day as the injury. The patient only sought medical attention in the days before diagnosis in 22 (15.5%) of the cases in which fracture identification

Table 5. Quality of findings.

Quality of findings	N. fractures	%
Negative	2	13.33
Not valuable	1	6.66
Certain	7	46.66
Uncertain	5	33.33
Total	15 (13 patients)	100

Table 6. Quality of findings (by vertebra).

Level	Negative	Not valuable	Certain	Uncertain	Total
D12			4	1	5
D4				1	1
D5	1				1
D6		1			1
D7				1	1
L1	1		2	1	4
L2				1	1
L4			1		1
Total	2	1	7	5	15

was delayed. These cases (Reid's third category) are not medically neglected fractures. Other non-medical patient-related factors might be in the origin of the delay.

Thus, the way to avoid diagnostic delay should come from educational programs that increase public awareness of the importance of seeking medical assistance. Backache after physical exertion, or a simple fall, should raise, in the mind of the patient, the possibility of a spinal fracture, even after minor trauma. The risk factors or patient profiles identified in our study can help health professionals to increase the suspicion of fracture occurrence in most cases. According to our results, it would be tempting to conclude that low spine mineralization is a marker of diagnostic delay, because it is observed more frequently in osteopenic/osteoporosis patients than in normal population. Nevertheless, this difference does not reach levels of statistical significance (Chi square: P=0.168). Perhaps, future works with more cases could clarify the precise relation, if it exists, between delay in diagnosis and bone mineralization.

In this study, we did not investigate whether the grade of the fracture (AO classification or others) contributed to the delay in diagnosis. We assumed that high-grade fractures are the easiest to identify, concluding that an analysis based on the grade of the fracture might be of little value. Our primary interest was the delay associated with low-grade fractures, which might be the most difficult to diagnose, yet constitute the vast majority of the cases.

Conclusions

Delayed diagnosis of spine fractures is a real public health problem. Causes include not only neglected fractures, but elements related with failing to seek or provide health assistance. We identified some profiles (according to age, gender, etiology, etc.) that can help to avoid undesirable delays and misdiagnosis. Clinical suspicion, in particular in these patient profiles, accurate X-ray indication, protocol and interpretation and educational programs to increase public awareness of the importance of seeking medical assistance, appear as measures to avoid misdiagnosis and minimize diagnostic delay.

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