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Extremity fractures in patients presenting with traumatic spinal fractures and spinal cord injury

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Abstract

Clinical features of extremity fractures (EFs) in patients presenting with traumatic spinal fractures (TSFs) and spinal cord injury (SCI) have not been investigated. To investigate the clinical features and risk factors for EFs in patients presenting with TSFs and SCI.

Data from 1392 patients presenting with TSFs and SCI in our hospitals between 2001 and 2010 were retrospectively reviewed, among which 165 patients (129 males and 36 females, 37.5 ± 10.6 years old) presented with EFs. The clinical features of EFs have been investigated.

The frequencies of upper limb fractures were significantly higher in the motor vehicle collisions (MVCs) group than in the high-fall group ($P = .012$) and the struck-by-object group ($P = .002$). The frequencies of lower limb fractures were significantly higher in the struck-by-object group ($P = .019$) and the high-fall group ($P = .011$) than the MVCs group. Univariate logistic regression analysis show that being in the 19 to 39 age group ($P = .001$), having a lumbar spinal fracture ($P < .001$) and experiencing a high fall ($P < .001$) were risk factors for EFs. Multivariate logistic regression analysis showed that we should focus on the factors that having a lumbar spinal fracture and experiencing a high fall.

High fall and MVCs were the most common aetiologies for EFs. Having a lumbar spinal fracture and experiencing a high fall were significant risk factors for EFs. We should make early diagnoses and initiate timely treatment according to different patterns of extremity fractures in patients with TSFs and SCI.

Abbreviations: CNY = China Yuan, CT = computed tomography, EFs = extremity fractures, ISS = injury severity scores, MRI = magnetic resonance imaging, MVCs = motor vehicle collisions, SCI = spinal cord injury, SD = standard deviation, TSFs = traumatic spinal fractures.

Keywords: epidemiology, extremity, fracture, risk factor, spine

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1. Introduction

Traumatic spinal fractures (TSFs) are common injuries and are associated with poor functional outcomes.[1–15] The injuries associated with spinal fractures have been examined in previous studies, with the most common associated non-spinal cord injuries being extremity and head injuries.[2–4] Accidental falls and traffic accidents were the most common aetiologies for TSFs. Spinal cord injury (SCI) accounted for 5.6% to 44.3% in patients presenting with TSFs,[1–3,7,11] and the proportions of extremity fractures (EFs) were about 11.8% to 26.3% in patients presenting with TSFs.[1,2] Anderson et al[16] pointed out that 128 (10%) had sustained associated fractures of the extremities and/or pelvis among the 1290 patients who presented with an acute vertebral fracture and SCI. For the 128 patients, the main mechanisms of injury were MVAs (62, 48%) and falls (52, 41%). The findings came from a survey of 1290 patients from USA.

The clinical assessment of SCI patients can be difficult due to altered sensation and motor function. In addition to the neurologic injury, associated injuries to the head, chest, and abdomen often require prompt attention and may distract from a thorough musculoskeletal assessment. Thus, extremity and pelvis fractures may be overlooked.[16] To our knowledge, the clinical features of extremity fractures in patients with TSFs and SCI in China have not been described in previous studies. Our hypothesis was that if there were risk factors of EFs to help us make early diagnosis and treatment. In this study, data from 1392 patients presenting with TSFs and SCI in our hospitals between 2001 and 2010 were retrospectively reviewed. The

purpose of the study was to investigate the risk factors and clinical features of EFs in patients presenting with TSFs and SCI.

2. Materials and methods

2.1. Study population

We retrospectively reviewed data from 1392 patients presenting with TSFs and SCI in our university-affiliated hospitals between January 2001 and December 2010.[1] We made definitive diagnoses of TSFs in all patients using X-rays and computed tomography (CT); magnetic resonance imaging (MRI) was performed if necessary. The medical records of each patient were reviewed to determine the aetiologies of trauma, the location of the vertebral fracture(s), and extremity fractures. Only extremity fractures that resulted from the same injury mechanism as the spinal fractures were included in the analysis. A total of 165 of these patients presented with EFs were included. The patients were divided into 4 groups: ≤19, 19–39, 39–59, and >59 years old. Aetiologies of trauma included high falls (height ≥ 2), low falls (height < 2 m), motor vehicle collisions (MVCs), struck by an object and being hit by others. The patients were divided into 5 groups according to different spine levels: cervical (C) level, thoracic (T) level, lumbar (L) level, cervical + thoracic (C + T) level, and thoracic + lumbar (T + L) level. The study protocol and publication of the study were approved by the committee on ethics and the institutional review board of our institution.

2.2. Statistical analysis

We used SPSS version 22.0 (SPSS, Inc., Chicago, IL) to perform all statistical analyses. We assessed the differences in the sex distributions using Pearson Chi-Squared tests and assessed the differences in the categorical variables using non-parametric test. Risk factors for EFs with TSFs & SCI and Open Fractures were analyzed by binary logistic regression. A P value of <.05 was considered statistically significant.

3. Results

3.1. General characteristics

In total, 3142 patients presenting with TSFs were admitted to our hospitals. Of these patients, 1392 patients (44.3%) presented with TSFs and SCI, and 165 patients presented with EFs (Fig. 1). Among the 165 patients presenting with EFs, there were 129 males and 36 females with a mean age of 37.5 ± 10.6 years old. The most common aetiologies were high falls (n = 111, 67.3%) and MVC (29, 17.6%). The most common fracture sites were lumbar fractures (n = 98, 59.4%) and lower extremity fractures (n = 114, 69.1%) (Table 1). There were 39 patients (23.6%) had been delayed diagnose of the EFs, the mean delayed days were 1.4 ± 0.6. There were 13 patients (11 males and 2 females) presented with open fracture. Multivariate logistic regression analysis showed that multiple fracture was risk factor for open fracture (Table 2).

3.2. Characteristics according to different age and gender groups

The most common age group was the 19–39 years age range (93, 56.4%), and the patients in the 39–59 age group had the largest sex ratio of 4.7. There were no significant differences between the 19–39 and 39–59 age groups in the distribution of spine levels, aetiologies, extremity fractures, ASIA scores, associated injuries, complications, and the mean hospitalizations, costs, and ISS scores (Table 1). The mean age was significantly larger (P = .010) in male (38.6 ± 10.0) than in female patients (33.6 ± 11.6). The frequency of MVCs (P = .005) was significantly higher in female (12, 33.3%) than in male patients (17, 13.2%).

3.3. Characteristics according to different aetiologies

The most common aetiologies were high falls (n = 111, 67.3%) and MVCs (n = 29, 17.6%). The patients in the struck-by-object group had the largest sex ratio of 9.5, and patients in the high-fall group had the second-largest sex ratio of 4.0. There were significant differences among the 3 main etiologies in the distribution of gender (P = .018), extremity fractures (P = .009), ASIA scores (P = .007), and lung-associated injuries (P = .009). There were no significant differences among the 3 main etiologies in the distribution of spine levels (P = .268), head-associated injuries (P = .131), and complications (P = .502).

The frequencies of males were significantly lower in the MVC group than in the struck-by-object group (P = .013) and the high-fall group (P = .016). The frequencies of upper limb fractures were significantly higher in the MVC group than in the high-fall group (P = .012) and the struck-by-object group (P = .002). The frequencies of lower limb fractures were significantly lower in the MVC group than in the struck-by-object group (P = .019) and the high-fall group (P = .011). The frequency of lung-associated injuries was significantly lower in the high-fall group than in the struck-by-object group (P = .005). The frequencies of ASIA A were significantly lower in the high-fall group than in the MVC group (P = .041) and the struck-by-object group (P = .000). The mean ISS scores of high falls were significantly lower than in the struck-by-object group (P = .001) (Table 2).

3.4. Characteristics according to different spine levels

The most common fractured vertebras were lumbar spine levels (n = 98, 59.4%) and thoracic spine levels (n = 23, 13.9%). There were significant differences among the 3 main levels in the distribution of ASIA scores (P = .000), lung-associated injuries (P = .017), head-associated injuries (P = .039), and complications (P = .023). There were no significant differences among the 3 main levels in the distribution of gender (P = .512), aetiologies (P = .116) and extremity fractures (P = .235). There were also no significant differences among the 3 main levels in the mean age, hospitalization, and cost.

The frequencies of ASIA A in the C-level (P = .003) and the T-level (P = .000) were significantly larger than in the L-level. The frequency of lung-associated injuries in the T-level was significantly larger than in the L-level (P = .007). The frequency of head-associated injuries in the C-level was significantly larger than in the L-level (P = .013). The frequency of complications in the C-level was significantly larger than in the L-level (P = .016).

3.5. Risk factors of extremity fractures

Significant differences were observed between the EFs group (n = 165) and the no-EFs group (n = 1227) in the age distribution, spine level location, and etiology location (Table 3). The mean hospitalizations (P = .018), costs (P = .000), lung-associated injuries (P = .036), and ISS scores (P = .000) of patients in the

3142 patients with traumatic spinal fractures in
university-affiliated hospitals between 2001 and 2010

1750 petients excluded
because they didn't have
spinal cord injury

1392 patients with traumatic spinal fractures
and spinal cord injury

1227 patients excluded
because they didn't have
extremity fractures

165 patients with extremity fractures
analyzed in this study

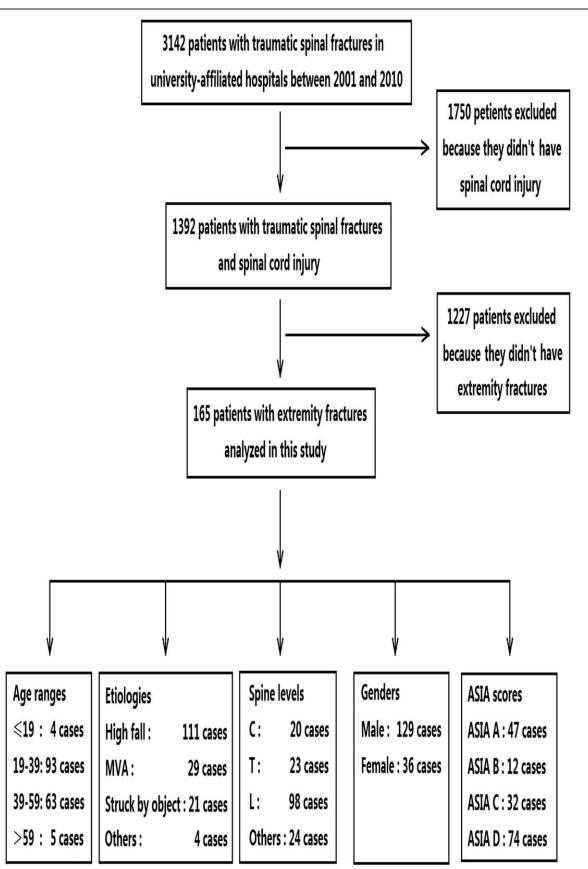| Age ranges	Etiologies	Spine levels	Genders	ASIA scores
⩽19 : 4 cases	High fall : 111 cases	C : 20 cases	Male : 129 cases	ASIA A : 47 cases
19-39: 93 cases	MVA : 29 cases	T : 23 cases	Female : 36 cases	ASIA B : 12 cases
39-59: 63 cases	Struck by object : 21 cases	L : 98 cases		ASIA C : 32 cases
>59 : 5 cases	Others : 4 cases	Others : 24 cases		ASIA D : 74 cases

Figure 1. Patient flow diagram.

Table 1

Characteristics of EFs in patients with TSFs and SCI according to different age ranges.

Age ranges	≤19	19–39	39–59	>59	Total
Total	4	93	63	5	165
Male/Female	3/1 (3.0)	70/23 (3.0)	52/11 (4.7)	4/1 (4.0)	129/36 (3.6)
Spine level					
C	0	10 (10.8)	8 (12.7)	2 (40.0)	20 (12.1)
T	0	14 (15.1)	9 (14.3)	0	23 (13.9)
L	3 (75.0)	39 (41.9)	34 (54.0)	2 (40.0)	98 (59.4)
C+T	1 (25.0)	2 (2.2)	2 (3.2)	0	5 (3.0)
T+L	0	8 (8.6)	10 (15.9)	1 (20.0)	19 (11.5)
Etiologies					
High fall (≥2m)	3 (75.0)	67 (72.0)	38 (60.3)	3 (60.0)	111 (67.3)
MVCs	0	14 (15.1)	14 (22.2)	1 (20.0)	29 (17.6)
Struck by object	1 (25.0)	11 (11.8)	8 (12.7)	1 (20.0)	21 (12.7)
Others	0	1 (1.1)	3 (4.8)	0	4 (2.4)
Extremity fracture					
Upper extremity	0	19 (20.4)	19 (30.2)	1 (20.0)	39 (23.6)
Lower extremity	4 (100.0)	68 (73.1)	39 (61.9)	3 (60.0)	114 (69.1)
Both	0	6 (6.5)	5 (7.9)	1 (20.0)	12 (7.3)
ASIA score					
ASIA A	2 (50.0)	22 (23.7)	22 (34.9)	1 (20.0)	47 (28.5)
ASIA B	0	7 (7.5)	4 (6.3)	1 (20.0)	12 (7.3)
ASIA C	1 (25.0)	20 (21.5)	9 (14.3)	2 (40.0)	32 (19.4)
ASIA D	1 (25.0)	44 (47.3)	28 (44.4)	1 (20.0)	74 (44.8)
Total hospitalisation (d)	43.8±16.4	40.8±53.1	43.4±53.0	47.6±33.6	42.1±51.8
Total cost (×10^4 CNY)	13.3±8.2	8.2±5.9	8.9±7.1	10.8±4.3	8.7±6.4
Associated injuries					
Lung	2 (50.0)	16 (17.2)	19 (30.2)	3 (60.0)	40 (24.2)
Head	0	6 (6.5)	6 (9.5)	1 (20.0)	13 (7.9)
Complications	0	5 (5.4)	7 (11.1)	0	12 (7.3)
ISS scores	32.3±13.5	27.5±9.8	28.6±9.1	36.2±7.6	28.2±9.6

Table 2

Multivariate logistic regression analysis of risk factors for open fractures.

Data	P	OR	95% OR Lower	95% OR Upper
Male/Female	.921	0.917	0.167	5.042
Age	.600	0.983	0.920	1.049
Extremity Fracture	.018			
Lower extremity	.232	0.362	−1.015	0.849
Multiple fracture	0.049	13.958	2.636	1.337
Upper extremity	–	–	–	–
Spine level	.953			
T	.749	0.679	−0.388	1.209
L	.884	1.186	0.171	1.174
Others	.961	1.082	0.079	1.621
C	–	–	–	–
Etiologies	.330			
MVCs	.261	0.48	0.133	1.727
Struck by object + Low fall (<m) +Others	.181	0.214	0.022	2.050
High fall (≥2m)	–	–	–	–
ASIA score	.138			
ASIA A	.021	40.238	3.695	1.603
ASIA B	.999	0.000	−17.884	10482
ASIA C	.391	2.212	0.794	0.925
ASIA D	–	–	–	–
ISS score	.149	0.931	0.844	1.026

Table 3

Characteristics of EFs in patients with TSFs and SCI according to different etiologies.

Etiologies	High fall	MVCs	Struck by object	Others
Total	111	29	21	4
Male/Female	89/22 (4.0)	17/12 (1.4)	19/2 (9.5)	4/0
Mean age	36.6±10.8	39.0±10.3	39.2±9.6	44.3±6.2
Spine level				
C	10 (9.0)	8 (27.6)	1 (4.8)	1 (25.0)
T	13 (11.7)	4 (13.8)	5 (23.8)	1 (25.0)
L	71 (64.0)	13 (44.8)	12 (57.1)	2 (50.0)
C+T	3 (2.7)	1 (3.4)	1 (4.8)	0
T+L	14 (12.6)	3 (10.3)	2 (9.5)	0
Extremity fracture				
Upper extremity	24 (21.6)	13 (44.8)	1 (4.8)	1 (25.0)
Lower extremity	81 (73.0)	14 (48.3)	17 (81.0)	2 (50.0)
Both	6 (5.4)	2 (6.9)	3 (14.3)	1 (25.0)
ASIA score				
ASIA A	22 (19.8)	11 (37.9)	12 (57.1)	2 (50.0)
ASIA B	8 (7.2)	3 (10.3)	1 (4.8)	0
ASIA C	25 (22.5)	2 (6.9)	4 (19.0)	1 (25.0)
ASIA D	56 (50.5)	13 (44.8)	4 (19.0)	1 (25.0)
Total hospitalisation (d)	39.7±52.1	45.4±57.8	49.1±43.9	47.0±48.9
Total cost (×10^4 CNY)	8.3±6.1	8.5±6.3	10.4±7.8	11.9±9.4
Associated injuries				
Lung	19 (17.1)	9 (31.0)	10 (47.6)	2 (50.0)
Head	11 (9.9)	2 (6.9)	0	0
Complications	7 (6.3)	2 (6.9)	3 (14.3)	0
ISS scores	26.5±8.9	30.2±9.5	34.2±11.0	31.0±8.9

Table 4

Univariate logistic regression analysis for EFs in patients presented with TSFs and SCI.

TSFs and SCI	EFs	No-EFs	χ^2/Z	P
Total	165	1227		
Gender				
Male	129 (78.2)	932 (76.0)	−0.630	.529
Female	36 (21.8)	295 (24.0)		
Age ranges				
≤19	4 (2.4)	47 (3.8)	16.165	.001
19–39	93 (56.4)	522 (42.5)		
39–59	63 (38.2)	531 (43.3)		
>59	5 (3.0)	127 (10.4)		
Spine level				
C	20 (12.1)	363 (29.6)	31.591	<.001
T	23 (13.9)	252 (20.5)		
L	98 (59.4)	476 (38.8)		
Others	24 (14.5)	136 (11.0)		
Etiologies				
High fall (≥2m)	111 (67.3)	539 (43.9)	33.370	<.001
Low fall (<2m)	2 (1.2)	164 (13.4)		
MVCs	29 (17.6)	257 (20.9)		
Struck by object	21 (12.7)	205 (16.7)		
Others	4 (2.4)	62 (5.1)		
ASIA score				
ASIA A	47 (28.5)	432 (35.2)	6.711	.082
ASIA B	12 (7.3)	89 (7.3)		
ASIA C	32 (19.4)	156 (12.7)		
ASIA D	74 (44.8)	550 (44.8)		

EFs group was significantly higher than in the no-EFs group (Table 4).

Univariate logistic regression analysis show that being in the 19–39 age group (P = .001), having a lumbar spinal fracture (P < .001), and experiencing a high fall (P < .001) were risk factors for EFs. Multivariate logistic regression analysis showed that we should focus on the factors that having a lumbar spinal fracture and experiencing a high fall (Table 5).

4. Discussion

An important but occasionally overlooked combination is that of spinal fractures and EFs. When patients with an initial diagnosis of TSFs and SCI are admitted to the hospital, we can diagnose EFs through a complete physical and radiographic examination. The most common aetiologies for TSFs were accidental falls and motor vehicle accidents. Additionally, spinal cord injury

Table 5

Characteristics of patients presenting with EFs or not presenting with EFs.

TSFs and SCI	EFs	No-EFs	P
Total	165	1227	
Mean age	37.5 ± 10.6	42.0 ± 13.5	<.001
Total hospitalisation (d)	42.1 ± 51.8	32.1 ± 40.6	.018
Total cost (×10⁴ CNY)	8.7 ± 6.4	6.5 ± 5.4	<.001
Associated injuries			
Lung	40 (24.2)	215 (17.5)	.036
Head	13 (7.9)	96 (7.8)	.980
Complications	12 (7.3)	74 (6.0)	.534
ISS scores	28.2 ± 9.6	19.4 ± 9.7	<.001

accounted for 5.6% to 44.3% in patients presenting with TSFs,[1–3,7,11] and the proportions of extremity fractures (EFs) were about 11.8% to 26.3% in patients presenting with TSFs.[1,2] There were literatures about the frequency of EFs in patients presented with spine trauma or spinal cord injury.[16–18] Comarr et al[17] reported that 156 (11%) patients sustained fractures of the extremities in a group of 1363 patients with traumatic spinal cord injuries. To our knowledge, the clinical characteristics of EFs in patients with TSFs and SCI have not been described in previous studies (Table 6).

In the current study, we report an incidence of 11.9% of EFs associated with TSFs and SCI, which is consistent with previous study.[16] Among the 165 patients presenting with EFs, the most common aetiologies were high falls (67.3%). Anderson et al[16] pointed out that the main mechanisms of injury were MVAs (62, 48%) and falls (52, 41%). The most common fracture sites were lumbar fractures (59.4%) and lower extremity fractures (69.1%). Among the patients presenting with SCI, lower extremity fractures accounted for 82.6% for lumbar fractures, 88.2% for thoracic fractures and 60.0% for cervical spine fractures. Therefore, we can see that patients presenting with thoracic fractures and spinal cord injury were more likely to have lower extremity fractures. The frequencies of upper limb fractures were significantly higher in the MVCs group than in the high-fall group and the struck-by-object group. The frequencies of lower limb fractures were significantly higher in the struck-by-object group and the high-fall group than in the MVCs group. Therefore, we can see that upper limb fractures were more likely to occur in the MVCs group, while lower limb fractures were more likely occur in the struck-by-object group and the high-fall group.

The frequencies of lung-associated injuries, ASIA A and the mean ISS scores were significantly higher in the struck-by-object group than in the high-fall group. The frequencies of head-associated injuries and complications in the C-level were

Table 6

Multivariate logistic regression analysis for EFs in patients presented with TSFs and SCI.

Data	P	OR	95% OR Lower	95% OR Upper
Male/Female	.646	1.102	0.729	1.666
Age ranges	.075			
≤19	.827	1.168	0.290	4.702
19–39	.059	2.504	0.965	6.499
39–59	.215	1.837	0.703	4.802
>9	–	–	–	–
Spine level	.001			
T	.202	1.509	0.802	2.839
L	.000	3.154	1.869	5.324
Others	.001	2.917	1.541	5.520
C	–	–	–	–
Etiologies	.001			
Low fall (<m)	.001	0.086	0.021	0.361
MVCs	.123	0.701	0.446	1.101
Struck by object	.016	0.530	0.316	0.891
Others	.086	0.400	0.140	1.140
High fall (≥2m)	–	–	–	–
ASIA score	.514			
ASIA A	.876	0.966	0.623	1.497
ASIA B	.899	1.045	0.532	2.053
ASIA C	.172	1.390	0.866	2.230
ASIA D	–	–	–	–

significantly higher than in the L-level. The frequencies of ASIA A in the C-level and the T-level were significantly higher than in the L-level. Therefore, we can see that patients in the struck-by-object group and the patients with C-level and T-level fractures presented with far more lung- and head-associated injuries and more severe spinal cord injury. The frequency of lung-associated injuries in the T-level was significantly larger than in the L-level. Patients with thoracic vertebral fractures had a higher frequency of initial pulmonary complications than other patients.[19] We should make early diagnoses and initiate timely treatment according to different patterns of extremity fractures in patients with TSFs and SCI.

In Europe or America, medical insurance is mainly managed by private insurance companies, with the insurance companies paying all or part of the patients' medical expenses. For a level 1 traumecenter, with the introduction of ATLS principle and trauma CT scanning, patients with EFs of high energy trauma should always be scanned from head to pelvis. There is very little risk for overlooking a spinal fracture. But in China, medical insurance is mainly managed by the government; most low-income people and disadvantaged people have to pay out of their own pockets because the rate of medical insurance coverage is low. There are not enough resources available to pay huge medical expenses.[1] So, we should pay much more attention to the physical examination and characteristics of different injuries, and then we carry out targeted inspection. Different countries presented with different culture and development situation, so the fracture pattern of EFs was also different between different countries. Multivariate logistic regression analysis showed that we should focus on the factors that having a lumbar spinal fracture and experiencing a high fall. EFs should be identified in the primary survey of patients presenting with TSFs and SCI, especially the patients presenting with spinal fractures caused by a high fall. Orthopedic doctors should pay much attention to patients presenting with spinal and extremity fractures to prevent secondary lesions when caring for these injured patients. Most trauma specialists pay much attention to the spine and spinal cord and extremity fractures, although there may be misdiagnosis and delayed diagnosis. Thus, trauma specialists should pay much more attention to the patients presenting with spinal fractures and spinal cord injuries, especially patients presenting with EFs, to avoid misdiagnosis and delayed diagnosis.

The present study had many limitations, such as the retrospective study design and the small number of patients. However, we think that the results of this study provide interesting clinical data, which is valuable to primary health care providers in minimizing further complications and mortality in patients despite these limitations.

5. Conclusion

High fall and MVCs were the most common aetiologies for EFs. Being in the 19–39 age group, having a lumbar spinal fracture and experiencing a high fall were risk factors for EFs. Multivariate logistic regression analysis showed that we should focus on the factors that having a lumbar spinal fracture and experiencing a high fall.

Author contributions

Conceptualization: Hongwei Wang.

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