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Original Article

Efficacy and safety of open or minimally invasive surgery for spinal trauma and risk factors for postoperative deep vein thrombosis

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Abstract: Objective: To compare the efficacy and safety of open or minimally invasive surgery for spinal trauma (ST) and to analyze the risk factors for postoperative deep vein thrombosis. Method: 220 patients with ST were randomly divided into the control group (N = 110) treated with open surgery and the observation group (N = 110) treated with minimally invasive ST surgery. The clinical efficacy, SF-36 score, ADL scale score and the incidences of postoperative complications, etc. were compared between the two groups, and the risk factors for deep venous thrombosis after surgery were determined by multivariate logistic analysis. Results: The SF-36 and ADL scores of the control group were significantly lower than those of the observation group after treatment. The blood loss, operative time, VAS score, the length of hospital stay, and the time to ground activity of the control group were significantly higher than those of the observation group ($P>0.05$), and the clinical efficacy of the observation group was significantly higher than that of the control group ($P<0.05$). There were differences in the incidences of deep venous thrombosis between the two groups ($P<0.05$). Age ≥60 years old, BMI >23 kg/m^2, DD dimer ≥200 (μg/L), receiving open surgery, operation time >150 min, hospitalization time >11 d, time to get out of bed for the first time >45 h were risk factors for deep venous thrombosis in patients. Conclusion: Compared with open surgery, minimally invasive surgery could effectively reduce complications, improve the clinical efficacy and reduce the risk of deep venous thrombosis in patients.

Keywords: Open surgery, minimally invasive surgery, ST, efficacy, safety

Introduction

Spinal trauma (ST), a common disease in orthopedics, occurs in people of all ages. But it is more common in young and middle-aged people [1]. Oliver et al. [2] showed that about 80% of patients with spinal trauma were between 20 and 60 years old with a male-female ratio of 3.04:1. Other studies have shown that [3] more than 32.6% of ST patients were caused by traffic accidents. Patients with severe ST may have lifelong paralysis, which permanently changes the patient's lifestyle and seriously affects the quality of life [4].

The current treatment is mainly surgery. Traditional open surgery will cause great damage with long recovery time and high economic burden [5]. Therefore, it is necessary to find new therapies. Minimally invasive surgery has been recently used in the treatment of patients with spinal trauma [6]. The surgical wound is small and leaves less damage to the surrounding tissue. By combining the computer with visual technology, the secondary injury to the patient's spine during the operation is effectively reduced [7].

Deep vein thrombosis is a common complication of postoperative orthopedics patients [8]. If thrombus occurs, it will easily cause vascular occlusion. The patient may have pulmonary embolism and cardiac insufficiency [9]. Studies have shown that deep vein thrombosis often occurs in patients during their postoperative rehabilitation period [10]. Previous studies have not shown whether different surgical methods have an effect on deep vein thrombosis.

Therefore, this study explored the clinical efficacy of open surgery and minimally invasive surgery for ST patients and analyzed the risk factors for deep venous thrombosis in patients.

Materials and methods

Patients

In this study, 220 ST patients treated in our hospital were enrolled. The patients were divided into the control group and the observation group according to the random number table method. There were 110 patients in the control group with 68 males and 42 females. There were 110 patients in the group with 73 males and 37 females. All patients were confirmed to be ST by ACR Appropriateness Criteria [11]. This study was approved by medical ethics committee in Gansu Provincial Hospital of Traditional Chinese Medicine and all the patients signed the informed consent.

Inclusion and exclusion criteria

Inclusion criteria: adult patients with confirmed spinal trauma who are scheduled to receive surgical treatment with no deep vein thrombosis; spinal trauma is located between T10 and L3.

Exclusion criteria: patients with coagulation disorders, congenital spinal deformity; patients with infection and bone tuberculosis before admission; patients who have undergone spinal minimally invasive endoscopic surgery artificial disc surgery, vertebral body replacement surgery, etc.; patients have thrombosis before surgery; patients accompanied with malignant tumors or cognitive dysfunctions, or with incomplete clinical data.

Intervention

Patients in the control group were treated with traditional open surgery. The surgeon made an incision that is 5 to 6 inch in length and pulled the muscles to one side in order to see the spine. Then the surgeon could access the spine to remove broken bone or intervertebral disks. The surgeon could also easily place screws, cages, and any bone graft materials necessary to stabilize the spinal bones and promote healing.

Patients in the observation group were treated with minimally invasive ST surgery. During the procedure, a small incision is made and the tubular retractor is inserted through the skin and soft tissues down to the spinal column. This creates a tunnel to the small area where the problem exists. The tubular retractor holds the muscles open (rather than cutting them) and is kept in place throughout the procedure. The surgeon accesses the spine using small instruments that fit through the center of the tubular retractor. Any bone or disk material that is removed exits through the retractor, and any devices necessary for fusion - such as screws or rods - are inserted through the retractor. In order to see where to place the incision and insert the retractor, the surgeon is guided by fluoroscopy. This method displays real-time x-ray images of the patient's spine on a screen throughout the surgery. The surgeon typically views the important structures of the spine during surgery using a microscope. At the end of the procedure, the tubular retractor is removed and the muscles return to their original position.

Outcome measures

Main outcome measures: The effective rates of the two groups one week after treatment were observed (**Table 1**). The quality of life before and one month after treatment was recorded according to the SF-36 score. The total score was 100 points. The higher the score was, the higher the quality of life would be. According to the ADL scale score, the daily activities of the patients before and after treatment were observed. The total score was 100 points. The higher the score was, the more independent living ability of the patients would be.

Secondary outcome measures: the incidence of complications during treatment, such as fever/swelling, surgical incision infection, dyskinesia, deep venous thrombosis, blood loss, the length of hospital stay, the VAS score (1 week after surgery) and the time of first go to ground activities were observed. The postoperative clinical data was collected for analyzing independent risk factors for venous thrombosis.

Statistical analysis

In this study, the collected data was analyzed using the SPSS20.0 software package. The data was plotted using GraphPad Prism 7, and the normal distribution of the data was con-

Table 1. Curative effect classification

Classification	Surface features
Very effective	Wound healing, symptoms disappear, spinal function is normal, life is self-care
Effective	Reduction of trauma, improvement of symptoms, improvement of spinal function, basic self-care of life
Of no avail	The above criteria are all up to date, but no progress has taken place in the patient's condition

Table 2. Analysis of baseline clinical data of patients [n (%)]

Index	Control group (n = 110)	Observation group (n = 110)	t/χ^2	P
Sex				
Male	68 (61.82)	73 (66.36)	0.494	0.482
Female	42 (38.18)	37 (33.64)		
Age (years)	58.4±5.7	59.3±5.2		
≥60	23.25±1.87	23.48±1.77		
<60				
BMI (kg/m^2)	52 (47.27)	59 (53.64)	0.891	0.354
Past history of disease	37 (33.64)	30 (27.27)	1.052	0.305
Hypertension	3 (2.73)	8 (7.27)	2.392	0.123
Diabetes mellitus	25 (22.73)	18 (16.36)	1.416	0.234
COPD				
Coronary disease	70 (63.64)	79 (71.82)	1.684	0.194
Smoking history	40 (36.36)	31 (28.18)		
Yes				
No	12 (10.91)	15 (13.64)	0.38	0.538
History of alcoholism	98 (89.09)	95 (86.36)		
Yes				
No	19 (17.28)	25 (22.73)		
Cause of injury	33 (30.00)	30 (27.27)	1.284	0.864
Natural calamities	18 (16.36)	15 (13.64)		
Traffic accident	22 (20.00)	21 (19.08)		
Violent injury	18 (16.36)	19 (17.28)		
Domicile				
City	87 (79.09)	92 (83.64)	0.749	0.387
Village	23 (20.91)	18 (16.36)		
D-D dimer (μg/L)				
≥200	31 (28.18)	25 (22.73)	0.862	0.353
<200	79 (71.82)	85 (77.27)		

firmed using-KS. The enumeration data (%) was expressed as rate. It was tested by Chi-square and expressed as χ^2. The ranked data was analyzed by rank sum test and expressed as Z. The measurement data was expressed by mean ± standard deviation (mean ± SD) and were analyzed by independent t-test. The intra-group before-after comparison was performed using a paired t-test and expressed as t. Logistic multivariate analysis was used to analyze the risk factors for deep venous thrombosis after surgery. In order to develop the logistic regression model, 8 factors judged potentially most relevant to deep venous thrombosis were selected from the baseline data. Several continuous variables were discretized into groups for convenience of analysis, such as age and BMI. Upon completion of the univariate analysis, factors were selected for the multivariate analysis. Model development and analysis were undertaken using SPSS 20.0. α = 0.05 was chosen as the significance level.

Results

Baseline characteristics

The two groups show no statistical difference in baseline clinical data which included sex, age, BMI, smoking and drinking history, D-D dimer, etc. (P>0.05) (**Table 2**).

Analysis of changes of SF-36 score and ADL score before and after treatment

There was no statistical significant difference in the SF-36 score and ADL score before treatment between the two groups (P>0.05). The SF-36 score and ADL score after treatment were significantly higher than those before treatment (P<0.05). And the scores of the control group were significantly lower than those of the observation group (**Tables 3** and **4**).

Postoperative amount of bleeding, operative time, the VAS score, the length of hospital stay and the time of first go to ground activity

The indicators of the control group were significantly higher than those of the observation group (P<0.05) (**Figure 1**).

Table 3. SF-36 and ADL scores in two groups before and after treatment

Group	SF-36 score			ADL score		
	Pre-treatment	Post-treatment	D	Pre-treatment	Post-treatment	D
Control group (n = 110)	53.18±2.23	72.39±4.08***	19.21±5.22	46.50±5.15	81.07±4.33***	34.57±8.25
Observation group (n = 110)	53.33±2.14	88.43±5.37***	35.10±7.24	47.56±4.84	92.30±5.44***	44.74±10.98
t	0.509	24.944	18.672	1.573	16.94	7.7664
P	0.611	<0.001	<0.001	0.117	<0.001	<0.001

Note: ***indicates significant difference compared to pre-therapy (P<0.001).

Table 4. SF-36 score and ADL score changes between two groups

Grade	Control group (n = 110)	Observation group (n = 110)	t value	*P* value
SF-36 score	19.22±4.48	35.11±5.89	22.521	<0.001
ADL score	34.57±6.83	44.44±6.61	10.891	<0.001

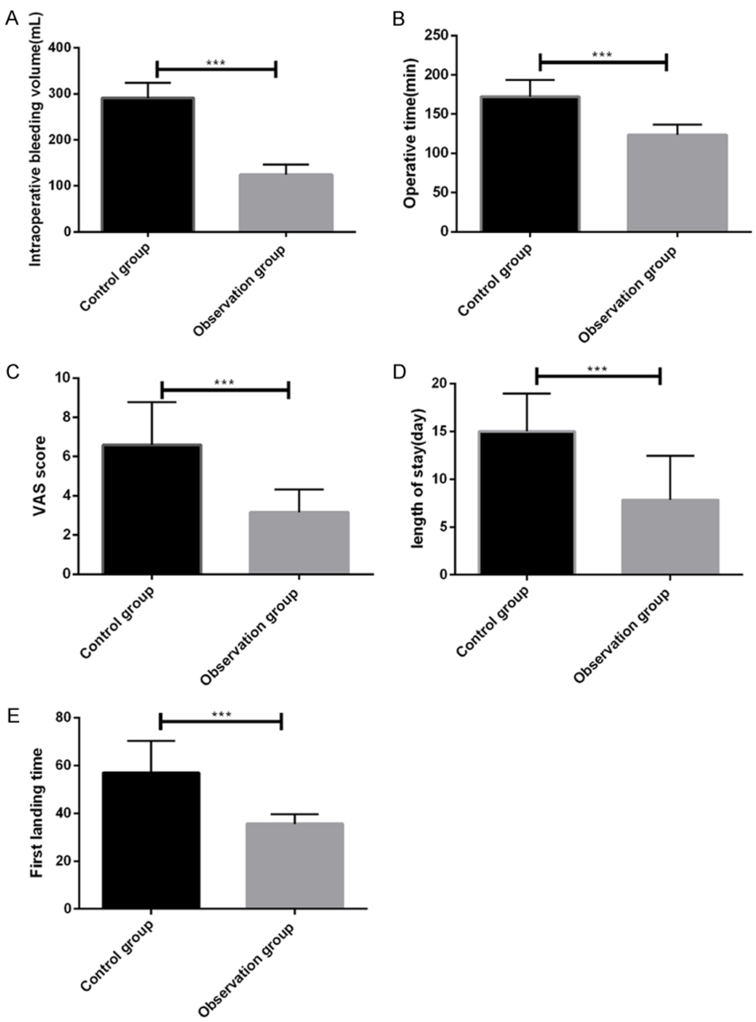

Figure 1. Comparison of intraoperative amount of bleeding, operative time, VAS score, length of hospital stay and the time of first go to ground activity. A. By comparing the amount of bleeding between the two groups, the amount of bleeding in the observation group was significantly lower than that in the control group. B. By comparing the operative time between the two groups, the operative time of the observation group was significantly lower than that of the control group. C. By comparing the VAS scores of between two groups, the VAS scores of the observation group were significantly lower than those of the control group. D. By comparing the length of hospital stay between the two groups, the length of hospital stay of the observation group was significantly lower than that of the control group. E. By comparing the time of first go to ground activity between the two groups, the time of first go to ground activity of the observation group was significantly lower than that of the control group.

Clinical efficacy and complications

Two groups showed significant differences in clinical efficacy and deep vein thrombosis (P<0.05) (**Tables 5**, **6**).

Univariate analysis of patients with deep vein thrombosis

We divided the patients into deep vein thrombosis group and non-deep vein thrombosis group. Through collection of patient clinical data and by univariate analysis, we found that there was no statistical differences in gender, past medical history, smoking history, history of alcohol abuse, cause of injury, place of residence, SF-36 score, ADL score, and VAS score (P>0.05). There were, however, statistical differences between the two groups in age, BMI, DD dimer,

Table 5. Clinical efficacy of patients

Group	Very effective	Effective	Of no avail	χ^2	P
Control group (n = 110)	48 (43.64)	41 (37.27)	21 (19.09)	12.576	0.002
Observation group (n = 110)	69 (62.73)	35 (31.82)	6 (5.45)		

Table 6. Incidences of complications in patients

Group	Fever/swelling	Surgical incision infection	Dyskinesia	Deep venous thrombosis
Control group (n = 110)	12 (10.90)	5 (4.55)	5 (4.55)	27 (24.55)
Observation group (n = 110)	8 (7.27)	2 (1.82)	3 (2.73)	12 (10.90)
χ^2	0.88	1.328	0.519	7.012
P	0.938	0.249	0.471	0.008

treatment plan, intraoperative amount of bleeding, operative time, VAS score, length of hospital stay, and the time of first go to ground activities (P<0.05) (**Table 7**).

Multivariate analysis of deep vein thrombosis

Blood loss during surgery was not a risk factor for deep venous thrombosis in patients. However, age ≥60 years old, BMI >23 kg/m^2, DD dimer ≥200 (μg/L), receiving open surgery, operation time >150 min, hospitalization time >11 d, time to get out of bed for the first time >45 h were risk factors for deep venous thrombosis in patients (**Tables 8** and **9**).

Discussion

ST mainly includes 3 types: bone damage, tissue damage and nerve structure damage [12]. Once spine is injured, patients will experience fractures and hemiplegia, and their quality of life will be seriously affected [12]. Furlan et al. [13] found that the incidence of ST has been increasing yearly. Singh et al. [14] showed that traffic accidents are the most common cause of ST. At present, the ST is mainly treated by surgery in the clinic. But the traditional open surgery brought great trauma to the patient's body. The excessive amount of bleeding in open surgery will aggravate the complications of patients [15], so medical workers need to find better solutions.

In recent years, minimally invasive treatment technology has attracted interests from clinicians in the treatment of tumors and fractures. Compared with open surgery, minimally invasive surgery produces smaller wounds and minimized blood loss. It reduced the muscle and nerve damage without peeling muscles. And the patient's stress response is minimized, thereby accelerating the postoperative recovery of the patient [16].

The SF-36 score was an important parameter to evaluate the patient's life and health status clinically, and its effect was widely recognized in various clinical studies [17]. The ADL score is a scale to assess the patient's independent ability in daily life [18]. Studies have shown that [19] ADL score is clinically used to assess the daily living ability of injured patients and the elderly. In this study, we found that the ADL scores of the two groups before treatment showed no significant difference, but were significantly improved after treatment. It showed that both minimally invasive surgery and open surgery have a better effect on the quality of life and daily life of ST patients. And we found that the two kinds of scores in observation group were significantly higher than those in the control group. We calculated the difference of the two scores in the two groups during the treatment, and found that the observation group showed more differences. In a study by Smith et al. [20], it was shown that minimally invasive surgery can effectively improve the effective rate of ST patients and reduce the amount of blood loss during surgery, which is consistent with our findings. The reason may be that it reduces the possibility of intraoperative massive hemorrhage, and does not require large-scale muscle exfoliatio and the wound can heal faster.

Ang et al. [21] showed that the SF-36 score at 6 months after minimally invasive surgery for spinal stenosis was significantly higher than that of open surgery. Wang et al. [22] also found that the ADL score at 3 months after minimally invasive surgery for skull puncture was significantly higher than that of open surgery. This study suggests that minimally invasive surgery

Table 7. Univariate analysis of deep venous thrombosis

Factor	Deep venous thrombosis group (n = 39)	No deep venous thrombosis (n = 181)	t/χ²	P
Sex				
Male	25 (64.10)	110 (57.59)	0.566	0.452
Female	14 (35.90)	81 (42.41)		
Age (years)				
≥60	29 (74.36)	100 (55.25)	4.831	0.028
<60	10 (25.64)	81 (44.75)		
BMI (kg/m²)	24.58±1.84	23.15±1.62	4.878	<0.001
Past history of disease				
Hypertension	18 (46.15)	93 (51.38)	0.35	0.554
Diabetes mellitus	11 (30.56)	56 (30.94)	0.002	0.964
COPD	1 (2.56)	10 (5.52)	0.592	0.442
Coronary disease	9 (23.08)	34 (18.78)	0.376	0.54
Smoking history				
Yes	29 (74.36)	120 (66.30)	0.954	0.329
No	10 (25.64)	61 (33.70)		
History of alcoholism				
Yes	4 (10.26)	23 (12.71)	0.179	0.672
No	35 (89.74)	158 (87.29)		
Cause of injury				
Natural calamities	8 (20.51)	46 (25.41)		
Traffic accident	12 (30.78)	50 (27.62)	0.63	0.96
Violent injury	6 (15.38)	23 (12.71)		
Fall	7 (17.95)	32 (17.69)		
Other	6 (15.38)	30 (16.57)		
Domicile				
City	23 (79.49)	150 (82.87)	0.252	0.616
Village	16 (20.51)	31 (17.13)		
D-D dimer (μ g/L)				
≥200	23 (58.97)	33 (18.23)	28.069	<0.001
<200	16 (41.03)	148 (81.77)		
Surgical treatment scheme				
Minimally invasive surgery	12 (30.77)	98 (54.14)	7.012	0.008
Open surgery	27 (69.23)	83 (45.86)		
SF-36 score	79.06±7.67	80.07±9.38	0.628	0.53
ADL score	90.74±7.65	88.42±7.61	1.725	0.086
Blood loss during surgery	312.96±94.57	192.66±82.23	8.063	<0.001
Operative time	180.54±8.63	140.42±25.51	9.688	<0.001
VAS score	5.26±2.64	4.84±2.36	0.987	0.325
Length of stay	15.52±0.91	10.29±5.06	6.421	<0.001
Getting out of bed for the first time	66.47±13.70	42.78±10.09	12.418	<0.001

Noteq: COPD: Chronic obstructive pulmonary disease.

can not only improve the quality of life but also daily life ability in ST.

Subsequently, we compared intraoperative amount of blood loss, operative time, length of hospital stay, and the time of first go to ground activity between the two groups during operation. The results showed that blood loss during surgery, operative time, length of hospital stay, and the time to get out of bed for the first time

Table 8. Assignments for factors

Factor	Assignment
Age	≥60 = 1, <60 = 0
BMI	≥23 kg/m^2 = 1, <23 kg/m^2 = 0
D-dimer	≥200 = 1, <200 = 0
Surgical treatment scheme	Open surgery = 1, Minimally invasive surgery = 0
Intraoperative bleeding volume	≥210 ml = 1, <210 ml = 0
Operative time	≥150 min = 1, <150 min = 0
length of stay	≥11 d = 1, <11 d = 0
Getting out of bed for the first time	≥45 h, <45 h

Table 9. Multi-factor analysis of deep venous thrombosis

Factor	β	S.E	Wals	Sig	Exp (B)	EXP (B) 95% C.I.
Age	1.915	0.667	8.241	0.004	6.787	1.677~18.616
BMI	1.228	0.593	4.283	0.039	3.415	3.141~29.588
D-dimer	2.427	0.603	16.199	0.000	11.329	1.357~12.391
Surgical treatment scheme	1.661	0.624	7.088	0.008	5.265	0.774~6.679
Intraoperative bleeding volume	0.733	0.565	1.685	0.194	2.082	2.934~38.156
Operative time	2.382	0.685	12.079	0.001	10.822	0.855~8.356
length of stay	1.644	0.624	6.948	0.008	5.178	3.543~39.661
Getting out of bed for the first time	2.453	0.659	13.869	0.000	11.618	3.543~39.662

were reduced significantly in the observation group compared with the control group. Most ST patients have a large amount of bleeding before admission. Minimally invasive surgery has the characteristics of short operative time and small trauma, which can effectively reduce the amount of intraoperative bleeding, length of hospital stay, and the time of first go to ground activity. Subsequently, we also compared the postoperative VAS scores of the two groups of patients. By comparison, it was found that the VAS score of the control group after treatment was significantly higher than that of the observation group. It was mainly attributed to the smaller wounds caused by minimally invasive surgery. The possibility of secondary injury during surgery was reduced by computer and visual technique. It effectively reduced the occurrence of postoperative pain and the use of analgesics in patients.

Deep vein thrombosis refers to the abnormal condensation of the patient's blood in the deep vein [23]. Regardless of the size of the surgery, it can cause a blood agglutination cascade reaction. Studies have shown that it is most common in patients undergoing spinal surgery. The study of Glotzbecker et al. [24] showed that the incidence of deep venous thrombosis in patients with ST was between 0.3% and 31.0%. In this study, we analyzed 39 patients with deep venous thrombosis in 220 patients who underwent ST surgery. We found that age, BMI, D-D dimer, treatment plan, intraoperative amount of bleeding, operative time, VAS score, length of hospital stay, and the time of first go to ground activities were risk factors for patients with deep vein thrombosis. Previous studies have shown that [25] the incidence rate of deep vein thrombosis gradually increased with the increasing age. It is positively correlated with the age growing. As the age grows, patient's blood vessels will degenerate, resulting in damage of the intima, slow blood flow, blood lipids accumulation and eventually a thrombus [26]. We found that the higher the patient's BMI is, the greater the incidence rate of deep vein thrombosis will be. It may be because slow blood flow is caused by excessive weight. And then thrombosis develops. Numerous studies have shown that [27, 28] differential expression of D-D dimers in perioperative patients with spinal degeneration is very important for the diagnosis of deep venous thrombosis. And studies by Si et al. [29] also showed that monitoring of serum D-D dimer expression in postoperative spinal surgery patients can effectively screen the occurrence of deep vein thrombosis. In this study, through multivariate analysis, we found that the incidence of deep vein thrombosis in patients treated with minimally invasive surgery was significantly lower than that of open surgery patients. This was mainly because exposure time of the wound is shorter during surgery. The inflammatory response and blood loss are minimized. Studies have shown that [30] excessive blood loss during surgery can cause blood concentrate, and coagulation function has been hypercoagulable. Minimally invasive surgery can bring fewer traumas to the patient, thereby reducing the length of hospital stay. The longer the patient stays in bed, the greater incidence rate of deep vein thrombosis will be [31].

However, this study still has some shortcomings. We have not conducted long-term follow-up, thus not compared the effective rate in a long term. Secondly, the surgery is performed by different doctors and may result in inconsistent surgical results. Thirdly, some complications may result from surgical error. We will improve the procedures and conduct long term study to verify the results.

In summary, age ≥60 years old, BMI >23 kg/m^2, DD dimer ≥200 (μg/L), receiving open surgery, operation time >150 min, hospitalization time >11 d, time to get out of bed for the first time >45 h were risk factors for deep venous thrombosis in patients. We also found that minimally invasive surgery can reduce intraoperative amount of bleeding, operative time, length of hospital stay, and time to get out of bed for the first time than those of traditional open surgery, which could also effectively improve the occurrence of complications and clinical efficacy.

Disclosure of conflict of interest

None.

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References

[1] Sundgren PC and Flanders AE. Spinal Trauma and Spinal Cord Injury[M]//Diseases of the Brain, Head and Neck, Spine 2016-2019. Springer, Cham 2016; 187-193.

[2] Oliver M, Inaba K, Tang A, Branco BC, Barmparas G, Schnuriger B, Lustenberger T and Demetriades D. The changing epidemiology of spinal trauma: a 13-year review from a Level I trauma centre. Injury 2012; 43: 1296-300.

[3] Liu P, Yao Y, Liu M, Fan W, Chao R, Wang Z, Liu Y, Zhou J and Zhao J. Spinal trauma in mainland China from 2001 to 2007: an epidemiological study based on a nationwide database. Spine 2012; 37: 1310-1315.

[4] Nas K, Yazmalar L, Şah V, Aydın A and Öneş K. Rehabilitation of spinal cord injuries. World J Orthop 2015; 6: 8-16.

[5] Kumar A, Aujla R and Lee C. The management of thoracolumbar burst fractures: a prospective study between conservative management, traditional open spinal surgery and minimally interventional spinal surgery. Springerplus 2015; 4: 204.

[6] Mcanany SJ, Overley SC, Kim JS, Baird EO, Qureshi SA and Anderson PA. Open versus minimally invasive fixation techniques for thoracolumbar trauma: a meta-analysis. Global Spine J 2016; 6: 186-194.

[7] Theodore K, Park DK and Jeffrey F. Minimally invasive spine surgery in the treatment of thoracolumbar and lumbar spine trauma. Neurosurgical Focus 2014; 37: E11.

[8] Di Nisio M, van Es N and Büller HR. Deep vein thrombosis and pulmonary embolism. Lancet 2016; 388: 3060-3073.

[9] López JA, Kearon C, Lee AY. Deep venous thrombosis. Hematology Am Soc Hematol Educ Program 2004: 439-56.

[10] Germing A, Schakrouf M, Lindstaedt M, Grewe P, Meindl R and Mügge A. Do not forget the distal lower limb veins in screening patients with spinal cord injuries for deep venous thromboses. Angiology 2010; 61: 78-81.

[11] Daffner RH and Hackney DB. ACR Appropriateness Criteria® on suspected spine trauma. J Am Coll Radiol 2007; 4: 762-775.

[12] Sadiqi S, Lehr AM, Post MW, Vaccaro AR, Dvorak MF, Oner FC. Toward a specific outcome instrument for spinal trauma: how to measure function and health. Spine (Phila Pa 1976) 2015; 40: 578-586.

[13] Furlan JC, Sakakibara BM, Miller WC and Krassioukov AV. Global incidence and prevalence of traumatic spinal cord injury. Can J Neurol Sci 2013; 40: 456-464.

[14] Singh A, Tetreault L, Kalsi-Ryan S, Nouri A and Fehlings MG. Global prevalence and incidence of traumatic spinal cord injury. Clin Epidemiol 2014; 6: 309-331.

[15] Aoki M, Abe T, Saitoh D, Hagiwara S and Oshima K. Use of vasopressor increases the

risk of mortality in traumatic hemorrhagic shock: a nationwide cohort study in Japan. Crit Care Med 2018; 46: e1145-e1151.
[16] Year NT. Minimally invasive surgery. Encyclopedia of Nursing & Allied Health 2002; pp19-20.
[17] Kielbergerová L, Mayer O Jr, Vaněk J, Bruthans J, Wohlfahrt P, Cífková R. Quality of life predictors in chronic stable post-stroke patients and prognostic value of SF-36 score as a mortality surrogate. Transl Stroke Res 2015; 6: 1-9.
[18] Prestmo A, Hagen G, Sletvold O, Helbostad JL, Thingstad P, Taraldsen K, Lydersen S, Halsteinli V, Saltnes T and Lamb SE. Comprehensive geriatric care for patients with hip fractures: a prospective, randomised, controlled trial. Lancet 2015; 385: 1623-1633.
[19] Krapp K. Activities of daily living evaluation. Encyclopedia of Nursing & Allied Health, 2002.
[20] Smith WD, Dakwar E, Le TV, Christian G, Serrano S and Uribe JS. Minimally invasive surgery for traumatic spinal pathologies: a mini-open, lateral approach in the thoracic and lumbar spine. Spine (Phila Pa 1976) 2010; 35 Suppl: S338-46.
[21] Ang CL, Tow PB, Fook S, Guo CM, Chen LT, Yue WM and Tan SB. Minimally invasive compared with open lumbar laminotomy: no functional benefits at 6 or 24 months after surgery. Spine J 2015; 15: 1705-1712.
[22] Wang WZ, Jiang B, Liu HG, Li D, Lu C, Zhao Y and Sander JW. Minimally invasive craniopuncture therapy vs. conservative treatment for spontaneous intracerebral hemorrhage: results from a randomized clinical trial in China. Int J Stroke 2009; 4: 11-16.
[23] Ageno W, Mantovani LG, Haas S, Kreutz R, Monje D, Schneider J, Van EM, Gebel M, Zell E and Turpie AG. Safety and effectiveness of oral rivaroxaban versus standard anticoagulation for the treatment of symptomatic deep-vein thrombosis (XALIA): an international, prospective, non-interventional study. Lancet Haematol 2016; 3: e12-21.
[24] Glotzbecker MP, Bono CM, Wood KB, Harris MB. Thromboembolic disease in spinal surgery: a systematic review. Spine (Phila Pa 1976) 2009; 34: 291-303.
[25] Chung WS, Peng CL, Lin CL, Chang YJ, Chen YF, Chiang JY, Sung FC, Kao CH. Rheumatoid arthritis increases the risk of deep vein thrombosis and pulmonary thromboembolism: a nationwide cohort study. Ann Rheum Dis 2014; 73: 1774-80.
[26] Kearon C, Akl EA. Duration of anticoagulant therapy for deep vein thrombosis and pulmonary embolism. Blood 2017; 123: 1794-801.
[27] Baker PM and Keeling DM. A single dose of Low-molecular-weight Heparin (LMWH) invalidates the use of D-dimer as part of a Deep Vein Thrombosis (DVT) diagnostic algorithm. Int J Lab Hematol 2016; 39: e17-e18.
[28] Chi G, Goldhaber SZ, Hull RD, Hernandez AF, Kerneis M, Al KF, Cohen AT, Harrington RA and Gibson CM. Thrombus burden of deep vein thrombosis and its association with thromboprophylaxis and D-Dimer measurement: insights from the APEX trial. Thromb Haemost 2017; 117: 2389-2395.
[29] Si WT, Zhang HG, Sun YB, Bai Y. Correlation analysis on plasma D-dimer level with deep venous thrombosis after spinal surgery. Zhongguo Gu Shang 2014; 27: 405-408.
[30] Shi H, Ou Y, Jiang D, Quan Z, Zhao Z, Zhu Y. Tranexamic acid reduces perioperative blood loss of posterior lumbar surgery for stenosis or spondylolisthesis. Medicine 2017; 96: e5718.
[31] Yang SD, Ning SH, Zhang LH, Zhang YZ, Ding WY and Yang DL. The effect of lower limb rehabilitation gymnastics on postoperative rehabilitation in elderly patients with femoral shaft fracture: a retrospective case-control study. Medicine 2016; 95: e4548.