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*Original Article*

# Efficacy of anterior-posterior decompression on thoracolumbar spine fracture with spinal cord injury and analysis of risk factors for postoperative deep vein thrombosis

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**Abstract:** Objective: To investigate the efficacy of anterior-posterior decompression on thoracolumbar spine fracture (TSF) and spinal cord injury (SCI), and assess hazard factors for postoperative deep vein thrombosis (DVT) through logistics regression. Methods: A retrospective analysis was made on 130 patients with TSF and SCI admitted to our hospital between Jan 2018 and Jan 2020. Specifically, 72 were treated with anterior decompression (experimental group) and 58 were posterior decompression (control group). The intraoperative blood loss, procedure time, hospitalization, incision size, tactile and motor scores, injured vertebral body height, Cobb angle and complications were observed. Patients were grouped based on DVT occurrence. The risk factors were assessed through logistics regression. Results: In comparison to experimental group, the intraoperative blood loss, procedure time and incision size in the control group were lower (P<0.05), while the hospitalization time was shorter (P<0.05). After treatment, the tactile and motor scores were improved 3 months after operation, and the experimental group was better (P<0.05). Additionally, injured vertebral body height and Cobb angle increased, and the experimental group was higher (P<0.05). Incidence of postoperative complications revealed no marked difference (P>0.05). Logistics regression analysis manifested that ASIA rating, diabetes, obesity and age were tied to postoperative DVT. Conclusion: Anterior decompression therapy can effectively improve the clinical outcome of patients with thoracolumbar spinal fractures and spinal cord injury on the improvement of tactile and motor functions, but posterior decompression is better than anterior surgery in terms of bleeding, incision length, operating time, and hospital stay. Surgical treatment needs to be selected according to the condition of patients. Furthermore, it was identified that ASIA rating, history of diabetes, obesity and age are risk factors affecting patients with postoperative lower extremity DVT.

**Keywords:** Anterior-posterior decompression, thoracolumbar spine fracture, spinal cord injury, deep vein thrombosis, risk factor analysis

## Introduction

As modern urban infrastructure develops, more people are engaged in the construction and transportation industries [1]. This increases falling injuries and traffic accidents. Statistics reveal that thoracolumbar spine fractures (TSF) account for about 50%-70% of spine fractures, of which about 10%-20% are burst fractures, which are relevant to the anatomical and biomechanical characteristics of the spine [2]. TSF combined with spinal cord injury (SCI) is a familiar and frequently-occurring occurrence seen in clinical orthopaedics [3]. The thoracolumbar spine refers to T11-L2 spinal segments at the intersection of two physiological curvatures, and is a stress concentration area [4]. Fractures here often cause spinal cord or cauda equina injury, so this segmental spinal fracture with SCI is called TSF and SCI [5]. Without timely targeted treatment, patients may have neurological dysfunction and even limb paralysis, which will directly affect their life [6].

From a worldwide point of view, TSF treatment has changed from traditional palliative therapy to active surgeries, and the latter is more effective than the former [7]. In this way, acute symptoms can be cured and the spinal pressure can be relieved, so as to improve the spine stability

**Table 1.** Clinical data

| Factor | control group (n=58) | experimental group (n=72) | *P*-value |
|---|---|---|---|
| Age | | | 0.605 |
| ≥40 (n=48) | 20 | 28 | |
| <40 (n=82) | 38 | 44 | |
| Gender | | | 0.451 |
| Male (n=72) | 30 | 42 | |
| Female (n=58) | 28 | 30 | |
| Course of disease | | | 0.480 |
| ≥3 d (n=65) | 27 | 38 | |
| <3 d (n=65) | 31 | 34 | |
| Past medical history | | | |
| Hypertension (n=34) | 14 | 20 | 0.639 |
| Diabetes (n=26) | 11 | 15 | 0.791 |
| Fractured vertebral segment | | | 0.410 |
| L4-L5 (n=40) | 20 | 20 | |
| L5-S1 (n=90) | 38 | 52 | |

and reduce the SCI and disability rate [8]. At the moment, surgery has become a familiar and crucial method for spinal fracture, especially anterior and posterior therapy [9]. Anterior fixation can fully and obviously expose the fracture site of patients, has a larger surgical field of vision, can quickly break bone and soft tissue protruding into the spinal canal, and can reduce spinal cord and nerve injury caused by poor visual field [10]. Posterior fixation is the earliest and most frequently-used method, with less procedure time and bleeding [11]. While TSF classification and treatment is still disputed, no agreement has yet been reached among experts and scholars. Anterior surgery has obvious decompression effect on patients, but it is not conducive to treating spinal injury or dislocation, and there are internal fixation failure and correction loss after operation [12]. Although the posterior surgery can restore the injured vertebral body height, physiological curvature and spinal stability, there still remains incomplete decompression of spinal canal [13].

We investigated the application of anterior-posterior decompression in TSF and SCI patients, and assessed the risk factors of DVT, so as to provide reference for clinical treatment options.

## Methods and data

### *Clinical data*

We conducted a retrospective analysis of 130 patients with TSF and SCI admitted to Affiliated Hospital of Yan'an University between January 2018 and January 2020. Therefrom, 72 were treated with anterior decompression (experimental group) and 58 were treated with posterior decompression (control group). Inclusion criteria: Patients met the diagnostic criteria for TSF in actual orthopedics [14], as determined by imaging; Patients had clear grading criteria (ASIA grade); the fracture segment was T11-L2, the history of trauma was clear, the course of the disease did not exceed 7 d, and the clinical data were complete. Exclusion criteria: Patients with tumors; pathological or old fractures; patients with osteoporotic fractures; patients with congenital organ defects; <18 years old; patients who were unable to tolerate the procedure or medication; pregnant and nursing women; or patients taking psychiatric medications. Ethical approval No. 2017120473.

### *Surgical methods*

All patients underwent surgical treatment. The main protocol for the control group (posterior decompression) was: The patient was operated in the right lateral position via a thoracoabdominal approach. Different incisions were made according to the different fracture segments. Along the patients' 12 ribs, an incision was made in an arc from the anterior lower part to the left anterior superior iliac spine. The superficial and deep fascia and ribs were separated and then removed, and finally the intercostal nerve was ligated. The fracture and adjacent vertebrae were exposed. The fracture body was gradually removed with a bone knife and biting forceps under subtotal resection. After thorough removal of debris and disc tissue from the fracture site, T12, L1, and L2 were exposed and a bone groove was opened at the junction of the upper and lower normal intervertebral foramina of the injured vertebra. The bone groove was 8-10 mm wide and a good bone graft bed was prepared. Using the bone groove as an example, a pedicle screw was inserted into the injured vertebral body. The treatment plan of experimental group (anterior decompression) was: Patients were in prone position.

**Table 2.** Perioperative indicators and hospital stay

| Group | Intraoperative blood loss (mL) | Procedure time (min) | Hospital stay (d) | Incision length (cm) |
|---|---|---|---|---|
| control group (n=58) | 359.53±40.45 | 199.08±19.59 | 15.03±1.99 | 14.06±2.02 |
| experimental group (n=72) | 601.58±41.73 | 246.33±14.91 | 17.15±1.79 | 15.27±3.89 |
| t value | 33.323 | 15.609 | 6.366 | 2.167 |
| *P*-value | <0.001 | <0.001 | <0.001 | 0.032 |

**Table 3.** Tactile and motor scores

| Group | Tactile scores | | Motor scores | |
|---|---|---|---|---|
| | Before treatment | After treatment | Before treatment | After treatment |
| control group (n=58) | 42.35±3.09 | 55.09±3.94 | 38.66±3.93 | 54.46±4.89 |
| experimental group (n=72) | 43.02±3.30 | 63.43±5.78 | 38.51±3.84 | 69.34±4.88 |
| t value | 0.862 | 9.056 | 0.189 | 16.342 |
| *P*-value | 0.390 | <0.001 | 0.850 | <0.001 |

**Table 4.** Postoperative vertebral height and Cobb angle

| Group | Vertebral height | | Cobb angle | |
|---|---|---|---|---|
| | Before treatment | After treatment | Before treatment | After treatment |
| control group (n=58) | 1.51±0.33 | 2.17±0.52* | 21.45±3.21 | 9.92±2.11* |
| experimental group (n=72) | 1.57±0.43 | 2.07±0.53* | 21.48±3.11 | 9.72±2.03* |
| t value | 0.450 | 0.424 | 0.675 | 0.458 |
| *P*-value | 0.653 | 0.672 | 0.501 | 0.640 |

Note: *denotes a difference in comparison to before treatment (P<0.05).

Taking the injured vertebra as center, operators vertically opened up the median chest and lower back with the injured vertebra as the center, cut it layer by layer until it was separated, and exposed fracture and nearby vertebral bodies (injured vertebral body and two nearby vertebral bodies). After C-arm machine location, pedicle screws were fixed into the adjacent upper and lower vertebral pedicle of the injured vertebra, and the injured lamina was removed. Spinal cord compression was tested at any time. L-shaped push rod was inserted into the spinal canal of RG patients, and the fracture pieces were correctly pushed forward until reduction.

Postoperative management: The wound drainage tube and closed drainage fluid of thoracic cavity were removed if <30 ml. The brace is generally worn for 3-6 months, which can only be removed after radiographic examination proves that the bone fusion is reliable.

*Outcome measures*

*Main outcome measures:* (1) Perioperative indicators, blood loss, operation time and incision length during operation were assessed. (2) The tactile and motor scores were assessed by ASIA grading standard. Grade A (complete injury): Sacral segment losses motor or sensory function; Grade B (incomplete injury): Sensory function remains below the nerve plane (such as sacral segment S4-S5), without motor function; Grade C (incomplete injury): Motor function exists below the plane (most key muscle strength < grade 3); Grade D (incomplete injury): Motor function remains as well (strength > grade 3); Grade E: Sensory and motor functions were normal. Each group of key muscles has 5 points. The tactile score is divided into the key points of human body, totally 56 points: 0 points for disappearance, 1 point for abnormality and 2 points for normality, which was assessed before and 3 months after treatment. (3) Incidence of postoperative DVT was counted. Diagnostic criteria: sudden swelling, pain, mild fever, increased skin temperature and soft tissue tension of affected limbs. Patients with incomplete injury will have local pain, which will be aggravated after exercise, and symptoms of raised affected limbs will be alle-


**Figure 1.** Images of patients before and after treatment.

viated. Patients were enrolled to occurrence and non-occurrence groups. The independent risk factors of postoperative DVT were assessed through logistics regression.

*Secondary outcome measures:* (1) Comparison of clinical indicators, including age, gender, course of disease, past medical history and fractured vertebral segment. (2) Comparison of complications, like the cases of complications after treatment. (3) Injured vertebral body height and Cobb angle 3 months after operation.

*Statistical analysis*

Data were processed via SPSS 20.0 and visualized via GraphPad Prism 8 software. Specifically, the measurement data were presented using the mean ± standard deviation, with independent samples t-tests for between-group comparisons and paired t-tests for within-group comparisons, all expressed as t. The counting data were expressed as rates and assessed via chi-square test, while the rank data were evaluated via rank sum test, expressed as Z. The risk factors were assessed via logistic regression. Hosmer-Lemeshow test was conducted to correct the discrimination and goodness-of-fit of ROC curve. P<0.05 is statistically different.

## Results

*Clinical data comparison*

Clinical data such as age, gender, course of disease, past medical history and fractured vertebral segment revealed no statistical difference between groups (P>0.05, **Table 1**).

*Intraoperative blood loss, procedure time, hospitalization and incision size*

The blood loss, operation time and incision size in the control group were less than experimental group, with a statistical difference (P<0.05). Moreover, hospitalization time in the control group was shorter (P<0.05, **Table 2**).

*Tactile and motor scores*

Data revealed that there was no dramatic difference in the tactile and motor scores before treatment between groups (P>0.05). While after treatment, the scores increased (P<0.05). Further, the scores in experimental group were higher (P<0.05, **Table 3**).

**Table 5.** Complications

| Group | DVT | Back pain | Infection | Pneumothorax | Total incidence |
|---|---|---|---|---|---|
| control group (n=58) | 9 | 3 | 1 | 2 | 25.86% |
| experimental group (n=72) | 14 | 2 | 1 | 4 | 29.17% |
| $\chi^2$ value | 0.340 | 0.498 | 0.023 | 0.324 | 0.175 |
| *P*-value | 0.560 | 0.480 | 0.877 | 0.569 | 0.676 |

**Table 6.** Assignment

| Factor | Assignment |
|---|---|
| Age | ≥60=0, <60=1 |
| Sex | Male =0, female =1 |
| Course of disease | ≥3 d =0, <3 d =1 |
| Hypertension | Yes =0, no =1 |
| Diabetes | Yes =0, no =1 |
| Fractured vertebral segment | L4-L5 =0, L5-S1 =1 |
| ASIA rating | Grade A =0, B =1, C =2, D =3. |
| Obesity | BMI <24=0, BMI ≥24, =1 |
| Operation modes | Anterior decompression =0, posterior decompression =1. |

*Postoperative vertebral height and Cobb angle*

In this research, we compared the postoperative vertebral body height and Cobb angle between groups. It revealed that there was no marked difference in vertebral body height and Cobb angle between both groups of patients after treatment (P>0.05). The postoperative vertebral body height was higher and the Cobb angle was lower in both groups compared with the pre-treatment period, with obvious differences (P<0.05). What's more, further analysis revealed no obvious difference in postoperative vertebral body height, Cobb angle after treatment in the experimental group of patients compared with the control group (P>0.05, **Table 4**). Besides, we show the images of patients before and after treatment (**Figure 1**).

*Incidence of postoperative complications*

The results revealed no statistically significant difference in the total complication rate between groups (P>0.05, **Table 5**).

*Risk factors of postoperative DVT*

The incidence of DVT was counted, and patients were enrolled to groups and assigned values (**Table 6**). Univariate analysis revealed that the course of disease, ASIA rating, diabetes history, obesity and age were tied to postoperative DVT (P<0.05, **Table 7**). Then, the indexes with differences were included in the logistics regression analysis, and tested through the backward LR method. Age (OR: 63.479, 95% CI: 7.970-505.600), history of diabetes (OR: 9.575, 95% CI: 1.618-56.67), ASIA rating (OR: 7.208, 95% CI: 2.627-19.777) and obesity (OR: 0.028, 95% CI: 0.004-0.179) were independently tied to postoperative DVT (P<0.05, **Table 8**). Not only that, ROC curve was drawn to verify the value of each index in predicting postoperative DVT. It turned out that age, ASIA rating and obesity were highly valuable (P<0.01, **Figure 2**). Finally, the risk prediction equation Logit (P) = -5.081+2.259× history of diabetes +1.975× ASIA rating +-3.566× obesity was established based on the high-value indicators, and the goodness-of-fit was tested by Hosmer-Lemeshow (P=0.498). AUC of clinical efficacy of RA patients was 0.889 determined by the established model (**Figure 3**, 95% CI: 0.812-0.967, P<0.001), which is ideal.

## Discussion

Along with the emergence of transportation and construction industry, the morbidity of fractures caused by traffic accidents or falling injuries is growing annually [15]. TSF, a familiar fracture injury, is the transitional segment between thoracic physiological curvature and lumbar physiological curvature. Because the

**Table 7.** Univariate analysis

| Factor | Occurred (n=23) | Not occurred (n=107) | *P*-value |
|---|---|---|---|
| Age | | | <0.001 |
| ≥60 (n=17) | 10 | 7 | |
| <60 (n=113) | 13 | 100 | |
| Gender | | | 0.733 |
| Male (n=72) | 12 | 60 | |
| Female (n=58) | 11 | 47 | |
| Course of disease | | | 0.038 |
| ≥3 d (n=65) | 16 | 49 | |
| <3 d (n=65) | 7 | 58 | |
| History of hypertension | | | 0.607 |
| Yes (n=34) | 7 | 27 | |
| No (n=96) | 16 | 80 | |
| History of diabetes | | | 0.015 |
| Yes (n=26) | 9 | 17 | |
| No (n=104) | 14 | 90 | |
| Fractured vertebral segment | | | 0.646 |
| L4-L5 (n=40) | 8 | 32 | |
| L5-S1 (n=90) | 15 | 75 | |
| ASIA rating | | | 0.001 |
| A (n=22) | 10 | 12 | |
| B (n=24) | 6 | 18 | |
| C (n=50) | 4 | 46 | |
| D (n=34) | 3 | 31 | |
| Obesity | | | <0.001 |
| BMI <24 (n=30) | 14 | 16 | |
| BMI ≥24 (n=100) | 9 | 91 | |
| Surgical plans | | | 0.560 |
| Anterior decompression (n=72) | 14 | 58 | |
| Posterior decompression (n=58) | 9 | 49 | |

**Table 8.** Logistics regression

| Factor | β | S.E, | Wals | Sig. | Exp (B) | 95% CI |
|---|---|---|---|---|---|---|
| Age | 4.151 | 1.059 | 15.371 | <0.001 | 63.479 | 7.97-505.6 |
| Course of disease | 1.398 | 0.8 | 3.054 | 0.081 | 4.046 | 0.844-19.405 |
| History of diabetes | 2.259 | 0.907 | 6.201 | 0.013 | 9.575 | 1.618-56.67 |
| ASIA rating | 1.975 | 0.515 | 14.711 | <0.001 | 7.208 | 2.627-19.777 |
| Obesity | -3.566 | 0.943 | 14.31 | <0.001 | 0.028 | 0.004-0.179 |

spine in this segment of the back is not protected by the thorax or ribs, from the biomechanical point of view, the relatively vertical area of the thoracolumbar spine at risk of high-intensity injury and is prone to burst fracture [16]. Moreover, owing to the special physiological and anatomical structure of thoracolumbar spine, the sagittal diameter and coronal diameter of spinal canal are relatively small, and it is easy to cause spinal cord compression and injury [13].

TSF treatment is still a debatable method. The major schemes are anterior decompression and posterior decompression in clinical practice [17]. Posterior surgical treatment is a relatively mature scheme, which has less surgical trauma and blood loss, simple operation and quick postoperative recovery. It is the most frequently-used and vital scheme for TSF and SCI [18]. From this, when the spinal cord is compressed in front, posterior surgery can't take out the broken tissue pieces that are compressed in front of the cord, and only indirect decompression can be performed [19]. As medical level and anterior surgery technology develop, the clinical scheme of anterior surgery for TSF was put forward [11]. Even without the extensive use of posterior surgery, the anterior scheme is effective [20]. Research has proved that anterior intervertebral support bone grafting or internal fixation can not only restore the height of the injured vertebra and the physiological and anatomical morphology of the spine, but also provide the largest space for the spinal canal and intervertebral foramen. It is beneficial to recovery of the spinal cord and nerve root function [21]. While we compared the clinical efficacy of anterior-posterior decompression, we found that the blood loss, procedure time, hospitalization and incision size of the control group were all less than experimental

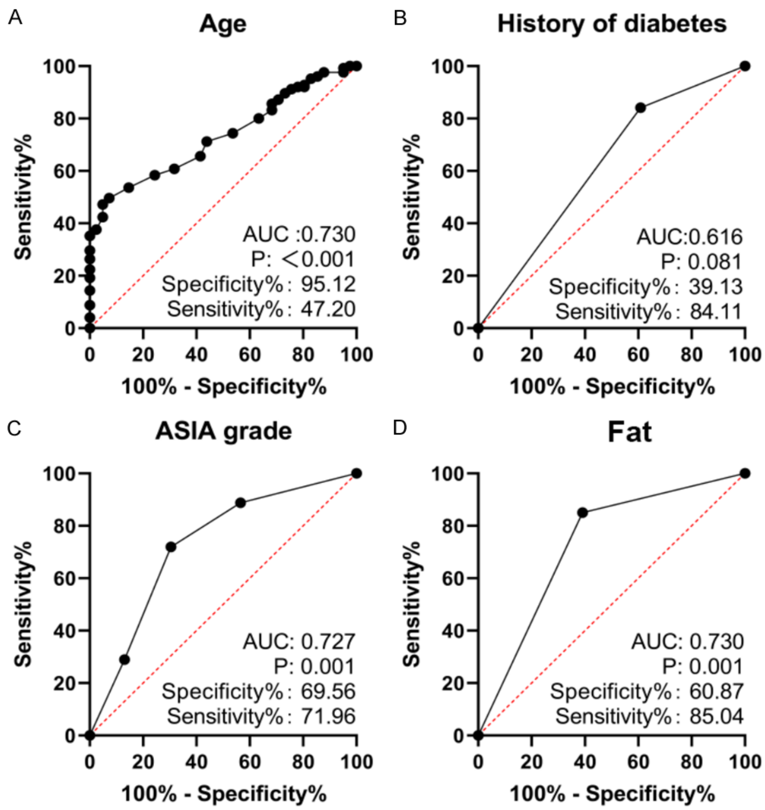


**Figure 2.** Value of ASIA rating, diabetes history, obesity and age in DVT. A. Predictive value of ASIA rating in DVT; B. Predictive value of diabetes history in DVT; C. Predictive value of obesity in DVT; D. Predictive value of Fat in DVT; Note: AUC: area under the curve.

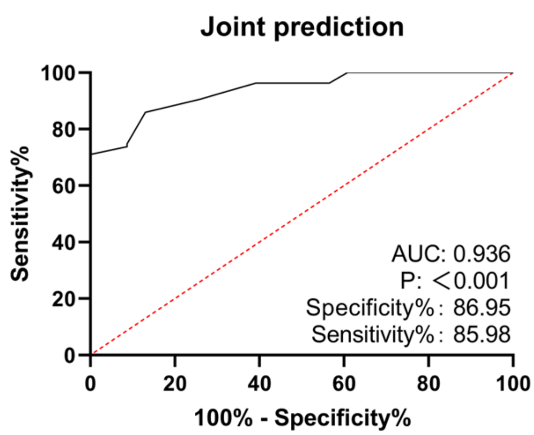


**Figure 3.** ROC curve of DVT predicted by risk prediction equation. Note: AUC: area under the curve.

group. In comparison to the control group, the tactile and motor scores of the experimental group were higher; the vertebral height and Cobb angle were higher 3 months after operation. Besides, incidence of postoperative complications was not different between groups. The effect of anterior decompression is higher than that of posterior decompression, and it will not increase the incidence of complications. In a meta-analysis by Zhu et al. [19], a posterior approach was found to be more effective for root canal decompression, operative time and perioperative blood loss, which is consistent with the results of our study. However, their study found no difference in the outcome of anterior and posterior decompression therapy in patients with thoracolumbar fractures, which is inconsistent with the findings of our study. Besides, Li et al. [22] also found consistent results of anterior-posterior decompression therapy in patients with thoracolumbar fractures. We believe that this may be related to the sample size. In addition, anterior decompression surgery for TSF combined with spinal cord injury can effectively remove fracture fragments and disc tissue and reduce stress in fracture patients as opposed to posterior treatment. The posterior decompression surgery, on the other hand, has certain limitations in the operation and cannot effectively remove the anteriorly compressed spinal cord tissue, and therefore has poor results.

In the end, we assessed DVT, which is the most familiar complication after operation. Statistics show that the incidence of DVT is as high as 40%-80% in SCI patients without anticoagulation prevention [23]. Patients were divided into groups. Logistics regression analysis revealed that ASIA rating, diabetes history, obesity and age were independently tied to postoperative DVT. Patients with complete damage in ASIA rating have serious injuries, and the postoperative recovery of diabetic is slow, and they were unable to get out of bed quickly, which increases DVT risk [24]. Obesity and age have been proven to be risk factors of DVT in previous studies [25]. Thus, we should routinely check the venous color Doppler ultrasound of lower limbs before and after surgery, screen carefully, prevent thrombosis early, detect problems early and treat them promptly, and if necessary, perform anticoagulation treatment during perioperative period to avoid thrombosis.

Nevertheless, there are still some limitations to this study. Firstly, the sample size is not large enough, so the statistics may be insufficient. Secondly, this is retrospective research, but we haven't followed the patients for a long period. Hence, we need to carry out randomized controlled trials to follow patients for a long time, so as to improve our research.

Given all of that, anterior decompression therapy can effectively improve the clinical outcome of patients with thoracolumbar spinal fractures and spinal cord injury on the improvement of tactile and motor functions, but posterior decompression is better than anterior surgery in terms of bleeding, incision length, operating time, and hospital stay. The surgical treatment needs to be selected according to the condition of patients. In addition, it was identified that ASIA rating, history of diabetes, obesity and age as risk factors affecting patients with postoperative lower extremity DVT.

## Disclosure of conflict of interest

None.

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