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Original Article

Efficacy and safety of erector spinae plane block for the treatment of osteoporotic vertebral compressive fractures

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Abstract: Objectives: To evaluate the efficacy and safety of erector spinae plane block (ESPB) for the treatment of osteoporotic vertebral compressive fractures (OVCF). Methods: A total of 120 OVCF patients, admitted between March 2022 and September 2022, were enrolled and assigned to either a control group or a research group (n=60 each) in this retrospective study. The control group received conventional analgesic treatment, while the research group was treated with ESPB. Data were collected at three time points: before surgery (T0), after four treatment sessions (T1), and prior to discharge (T2). Pain intensity was assessed using the Short-Form McGill Pain Questionnaire (SF-MPQ), which includes the Pain Rating Index (PRI), Visual Analogue Scale (VAS), and Present Pain Intensity (PPI). Inflammatory markers such as tumor necrosis factor-α (TNF-α), high-mobility group box-1 (HMGB-1), and high-sensitivity C-reactive protein (hs-CRP) were measured. Additional parameters included the number of intramuscular tramadol injections from days 4 to 7, sleep quality using the Pittsburgh Sleep Quality Index (PSQI), quality of life via the 16-item Assessment of Health-Related Quality of Life in Osteoporosis (ECOS-16), and treatment satisfaction. Results: The research group exhibited significant reductions in PRI, VAS, and PPI at T0, T1, and T2 compared to the control group (all $P<0.05$). At T1 and T2, pain scores in the research group were notably lower than those in the control group (all $P<0.05$). Two weeks post-treatment, levels of TNF-α, HMGB-1, and hs-CRP were significantly lower in the research group than in the control group and pre-treatment values (all $P<0.05$). Conversely, the ECOS-16 score was significantly higher in the research group ($P<0.05$). Furthermore, the research group required fewer intramuscular tramadol injections (days 4-7) and reported higher treatment satisfaction (both, $P<0.05$). Conclusions: ESPB for OVCF patients demonstrated significant analgesic benefits, reducing pain, serum inflammatory markers, tramadol injections during days 4-7, and improving sleep quality, quality of life, and treatment satisfaction.

Keywords: Erector spinae plane block, osteoporotic vertebral compressive fractures, efficacy, safety, clinical analysis

Introduction

Osteoporosis is a systemic disorder characterized by reduced bone mass and disruption of bone micro-architecture, often accompanied by increased bone brittleness and a higher risk of fractures [1, 2]. Osteoporotic vertebral compressive fractures (OVCF), the most common type of fracture in osteoporosis, result from vertebral compression, leading to structural changes that decrease spinal stability. This instability causes pain in the thoracic, lumbar, and dorsal regions, as well as restricted mobility, significantly impairing patients' quality of life and shortening their lifespan [3, 4]. Pain control, early mobilization, deformity prevention, and functional restoration are the primary treatment objectives [5].

Currently, conservative treatment typically involves analgesic medications, external fixation braces, and anti-osteoporosis therapy. For patients with severe vertebral compression and inadequate pain relief, percutaneous vertebroplasty (VP) offers faster functional restoration and lower short-term complication rates [6, 7].

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However, there is limited evidence on whether nerve block techniques can benefit patients with OVCF [8].

The erector spinae plane block (ESPB) is a novel nerve block technique where a local anesthetic is injected between the erector spinae muscle and the transverse process of the vertebra. This allows the anesthetic to diffuse and block the ventral, dorsal, and communicating branches of the spinal nerve, alleviating both somatic and visceral pain in the affected region [9-11]. Since its successful use in severe neuropathic pain in the chest and back, ESPB has gained popularity in perioperative analgesia for the spine, chest, abdomen, and hip due to its clear anatomical targeting, ease of ultrasound visualization, and safe puncture pathway [12].

In OVCF patients, vertebral collapse and the formation of pseudojoints can directly stimulate peripheral nerves, causing acute and chronic pain. Additionally, spinal deformities can lead to abnormal muscle contractions, contributing to myofascial inflammation [13, 14]. ESPB not only alleviates local pain by blocking spinal nerve branches but also interferes with the myofascial inflammatory pain pathway, preventing peripheral sensitization [15, 16].

Given its potential, ESPB shows promise for OVCF treatment. However, there is currently insufficient research on the efficacy and safety of ESPB for OVCF. Therefore, this study aims to evaluate the impact of ESPB on pain relief and rehabilitation in OVCF patients.

Materials and methods

General information

This is a retrospective study involving 120 OVCF patients admitted between March 2022 and September 2022. Upon admission, all patients received standardized basic care, treatment, and anti-osteoporosis therapy throughout the study period. Of these, 60 patients in the control group received conventional analgesic interventions, while the remaining 60 patients in the research group received ESPB. The study was approved by the Ethics Committee of Beijing Jishuitan Hospital Guizhou Hospital.

Inclusion and exclusion criteria

Inclusion criteria: (1) Diagnosis of OVCF, as defined by typical clinical symptoms, including pain in the thoracic, lumbar, and dorsal regions, with restricted mobility and increased pain during postural changes [17]. (2) Physical examination findings consistent with OVCF, such as tenderness over the spinous process and paravertebral region at the fracture site. (3) Imaging findings that align with the clinical symptoms and physical examination.

Exclusion criteria: (1) Age under 50 years. (2) Abnormal coagulation function. (3) Infection at the puncture site. (4) Concomitant intervertebral disc herniation, spinal tumors, or spinal tuberculosis. (5) Severe cardiac or pulmonary disorders, liver or kidney insufficiency. (6) Severe gastrointestinal diseases. (7) Mental illness or illiteracy. (8) Mild vertebral compressive fractures with a Visual Analogue Scale (VAS) score ≤3. (9) More than two responsible vertebrae.

Criteria for determining the responsible vertebra

The responsible vertebra typically exhibits local tenderness, with MRI showing edema in the corresponding vertebral body. For patients unable to undergo MRI, bone scintigraphy combined with contrast-enhanced CT imaging is used. If radionuclide concentration is detected in the relevant vertebral segment and CT reveals signs of fracture, the vertebra is considered the responsible one for pain. The responsible vertebra is determined based on clinical manifestations, imaging findings, and the degree of agreement between them.

Treatment methods

Upon admission, all patients underwent standardized basic procedures, treatments, and anti-osteoporosis therapy throughout the study. For patients unable to stand or ambulate due to pain, anti-osteoporosis therapy was initiated only after they regained the ability to stand and move independently. In the research group, in addition to the aforementioned interventions, ESPB was performed once daily for the first 4 days after admission, alternating between the left and right sides. After the 4-day treatment period, both groups were assessed for the need for surgical intervention or continued conservative management [18]. For non-surgical patients in the research group, subsequent treatment consisted solely of basic measures, basic treatments, and anti-osteoporosis therapy, with ESPB discontinued. Surgical patients in

the research group received ESPB twice - on the second and third postoperative days, starting from the left side and then proceeding to the right. If severe pain occurred during treatment (defined as a VAS score of ≥50 on a 100-point scale), 50-100 mg of tramadol was administered via intramuscular injection for pain relief. Tramadol injections were not allowed within 2 hours prior to pain threshold assessments and scoring.

Basic measures included bed rest, external fixation brace application, and oral administration of 200 mg celecoxib capsules twice daily. Basic treatment included two Caltrate (vitamin D3 calcium chewable) tablets twice daily. Anti-osteoporosis treatment consisted of 70 mg oral alendronate sodium once a week.

ESPB procedure: (1) Thoracic ESPB: The patient was positioned prone, and the responsible vertebra was identified. A high-frequency linear array probe was placed 3 cm lateral to the midline of the responsible thoracic vertebra in the sagittal plane. Using ultrasound, the trapezius, rhomboid, erector spinae muscles, and transverse process were visualized. With standard disinfection and draping, the needle was inserted cranial-to-caudal in an in-plane approach. After contact with the transverse process, 1-2 mL of normal saline was injected to confirm the needle position. Aspiration confirmed the absence of blood, cerebrospinal fluid, and gas before anesthetic injection. A successful block was indicated by the local anesthetic spreading within the fascial plane between the transverse process and erector spinae.

(2) Lumbar ESPB: The patient was placed prone to locate the responsible vertebra. A low-frequency convex array probe was placed 3-5 cm lateral to the midline of the responsible lumbar vertebra in the sagittal plane. Under ultrasound, the erector spinae, quadratus lumborum, psoas major, and transverse process were visualized. Using the in-plane technique, the needle was inserted cranial-to-caudal after routine disinfection. Upon contacting the transverse process, 1-2 mL of normal saline was injected to confirm position. After aspiration to confirm the absence of blood, cerebrospinal fluid, or gas, the anesthetic was injected. A successful block was indicated by the spread of the local anesthetic in the fascia between the transverse process and erector spinae.

Nerve block solution: The nerve block solution consisted of 6 mL of 1% ropivacaine hydrochloride (AstraZeneca AB, 75 mg/10 mL), 1 mL of mecobalamin (Eisai Co., Ltd., Japan, 0.5 mg/mL), and 13 mL of normal saline, totaling 20 mL. The procedure was performed alternately on the left and right sides.

Outcome measures

The short-form McGill Pain Questionnaire (SF-MPQ), including the Pain Rating Index (PRI), Visual Analogue Scale (VAS), and Present Pain Intensity (PPI), were assessed at three time points: preoperative (T0), after four treatment sessions (T1), and prior to discharge (T2). The PRI consists of 11 sensory-related and 4 affective-related descriptors of pain. Each descriptor is scored on a scale from 0 to 3, where 0 indicates “no pain”, 1 represents “mild pain”, 2 signifies “moderate pain”, and 3 indicates “severe pain”. The total PRI score is then calculated.

For the VAS, a 100-mm ruler is used, with the zero mark indicating pain-free status (0) and the opposite end representing the worst possible pain (100). The ruler is oriented towards the examiner, and the patient moves the pointer to reflect their pain intensity; the numerical value at the pointer’s position indicates the pain level. For the PPI, a score of 0 signifies no pain, 1 denotes mild discomfort, 2 corresponds to general discomfort, 3 indicates distress, 4 represents severe pain, and 5 signifies extreme pain. Higher scores on all three scales correlate with greater pain intensity.

Serum levels of inflammatory mediators - tumor necrosis factor-α (TNF-α), high-mobility group box-1 protein (HMGB-1), and high-sensitivity C-reactive protein (hs-CRP) - were measured in both groups. Five mL of venous blood was collected preoperatively and two weeks postoperatively. The levels of these inflammatory markers were assessed using enzyme-linked immunosorbent assay (ELISA).

The frequency of intramuscular tramadol injections during the 4-7 day period was recorded for both groups.

Sleep quality and quality of life were evaluated before and two weeks after surgery using the Pittsburgh Sleep Quality Index (PSQI) and the 16-item Health-Related Quality of Life in Oste-

Table 1. Comparison of baseline data

Indicators	Control group (n=60)	Research group (n=60)	χ^2/t	P
Sex			1.429	0.232
Male	21 (35.00)	15 (41.67)		
Female	39 (65.00)	45 (53.57)		
Age (years)	73.02±4.98	73.92±4.59	1.029	0.305
Body mass index (kg/m^2)	22.42±2.57	23.28±2.69	1.791	0.076
Course of disease upon admission (d)	12.40±3.36	12.82±3.47	0.674	0.502
Number of vertebral fractures (n)	2.23±0.95	2.13±0.72	0.650	0.517

oporosis (ECOS-16) questionnaire. The PSQI score ranges from 0 to 21, with higher scores indicating worse sleep quality. The ECOS-16 consists of 16 items, each scored from 1 to 5, with higher scores indicating better quality of life.

Treatment satisfaction was assessed in both groups using a satisfaction questionnaire developed by our hospital. The total score is 100, with scores below 60 indicating dissatisfaction, 60-79 indicating relative satisfaction, and 80-100 indicating high satisfaction.

Statistical methods

Statistical analysis was performed using SPSS 24.0. Count data were expressed as frequency/percentage (n/%), and the chi-square test was used for group comparisons. Measurement data were presented as mean ± standard error of the mean (SEM). The independent-sample t-test was applied for comparisons between groups, while repeated-measures analysis of variance was used to compare data across multiple time points. Pairwise comparisons within groups were conducted using the Bonferroni method. A *P*-value of less than 0.05 was considered statistically significant. The sample size in each group met the minimum requirement of 59 cases. The formula for sample size estimation is as follows:

$$n = \frac{((Z_{1-\alpha/2} + Z_{\beta})^2 \times (p_t(1 - p_t) + p_c(1 - p_c)))}{(p_t - p_c)^2}.$$

Results

Comparison of baseline data

A total of 120 patients with OVCF were enrolled in this study. The control group included 21 male and 39 female patients, while the research group consisted of 15 male and 45 female patients. The mean age of the control group was 73.02 ± 4.98 years, and that of the research group was 73.92 ± 4.59 years. The average body mass index (BMI) in the control group was 22.42 ± 2.57, compared to 23.28 ± 2.69 in the research group. The mean disease duration at admission was 12.40 ± 3.36 days in the control group and 12.82 ± 3.47 days in the research group. The average number of vertebral fractures was 2.23 ± 0.95 in the control group and 2.13 ± 0.72 in the research group. No significant inter-group differences were found in any of the baseline data (all P>0.05; **Table 1**).

Comparison of SF-MPQ scores

No significant differences were observed in PRI, VAS, and PPI scores between the two groups at T0 (all P>0.05). At T1 and T2, significant decreases were noted in the PRI, VAS, and PPI scores for both groups (all P<0.05), with lower scores in the research group compared to the control group (all P<0.05; **Table 2**).

Comparison of serum inflammatory mediators

No significant differences were found in TNF-α, HMGB-1, and hs-CRP between the two groups prior to treatment (all P>0.05). Post-treatment, all these inflammatory markers were significantly reduced (all P<0.05), with lower levels in the research group compared to the control group (all P<0.05; **Table 3**).

Comparison of cumulative frequency of intramuscular tramadol injections during the 4-7-day period

The research group exhibited a significantly lower cumulative frequency of intramuscular tramadol injections during the 4-7-day period compared to the control group (P<0.05; **Figure 1**).

Table 2. Comparison of SF-MPQ scores

Indicators	Control group (n=60)	Research group (n=60)	t	P
PRI				
T0	18.38±4.35	18.47±3.33	0.127	0.899
T1	7.12±1.72*	5.62±1.30*	5.389	<0.001
T2	3.05±0.98**,#	2.13±0.85**,#	5.493	<0.001
VAS				
T0	68.48±6.23	69.35±7.84	0.673	0.502
T1	39.73±3.02*	35.35±3.46*	7.387	<0.001
T2	14.20±2.77**,#	10.17±2.54**,#	8.306	<0.001
PPI				
T0	3.90±0.88	4.07±0.92	1.034	0.303
T1	2.83±0.85*	2.32±1.10*	2.842	0.005
T2	1.30±0.91**,#	0.92±0.56**,#	2.755	0.007

Note: SF-MPQ, short-form McGill Pain Questionnaire; PRI, Pain Rating Index; VAS, Visual Analogue Scale; PPI, Present Pain Intensity. * indicates P<0.05 and ** represents P<0.01 compared with T0; # denotes P<0.05 compared with T1.

Table 3. Comparison of serum inflammatory mediators

Indicators	Control group (n=60)	Research group (n=60)	t	P
TNF-α (μg/L)				
Before treatment	74.97±9.13	75.90±6.87	0.630	0.530
After treatment	45.18±4.58	26.38±3.16	26.171	<0.001
HMGB-1 (μg/L)				
Before treatment	14.25±2.80	13.57±2.78	1.335	0.185
After treatment	9.68±2.51	6.83±1.92	6.986	<0.001
hs-CRP (mg/L)				
Before treatment	34.77±7.67	36.82±5.93	1.638	0.104
After treatment	21.15±5.83	13.18±5.40	7.769	<0.001

Note: TNF-α, tumor necrosis factor-α; HMGB-1, high-mobility group box-1 protein; hs-CRP, high-sensitivity C-reactive protein.

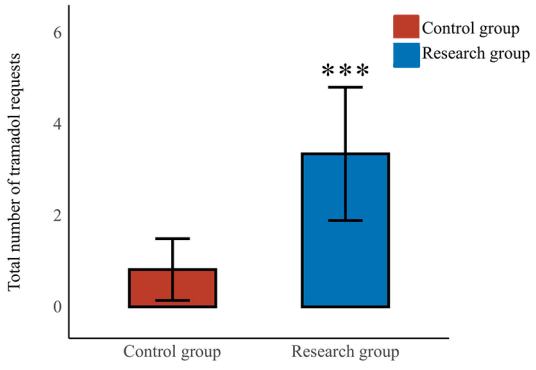

Figure 1. Comparison of cumulative frequency of intramuscular tramadol injections during the 4-7-day period in both groups. *** indicates P<0.001 compared with the control group.

Comparison of sleep quality

No significant difference in the PSQI score was observed between the two groups prior to treatment (P>0.05). Post-treatment, the PSQI score significantly decreased in both groups (P< 0.05), with a more pronounced reduction in the research group (P<0.05; **Figure 2**).

Comparison of quality of life

Before treatment, no significant difference was found in the ECOS-16 scores between the two groups (P>0.05). After treatment, ECOS-16 scores increased significantly in both groups (P< 0.05), with the research group showing a greater improvement compared to the control group (P<0.05; **Figure 3**).

Comparison of treatment satisfaction

In the control group, 20 patients were very satisfied, 27 were relatively satisfied, and 13 were dissatisfied. In the research group, 29 patients were very satisfied, 27 were relatively satisfied, and 4 were dissatisfied. The overall satisfaction

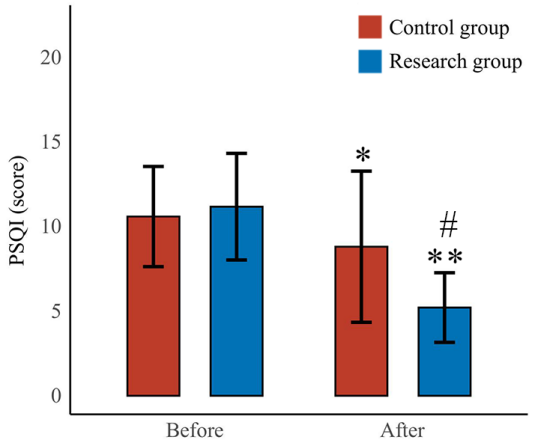

Figure 2. Comparison of sleep quality in the two groups. PSQI, Pittsburgh Sleep Quality Index. * indicates P<0.05 and ** represents P<0.01 *versus* before treatment; # denotes P<0.05 versus the control group.

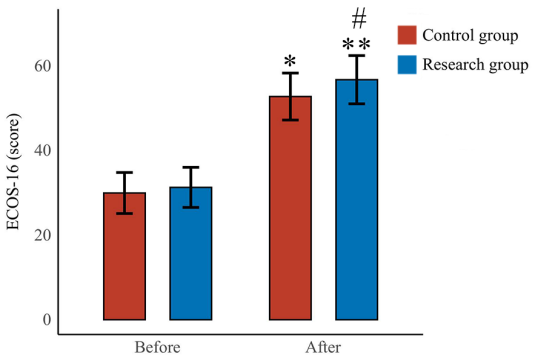

Figure 3. Comparison of quality of life in the two groups. ECOS-16, 16-item Assessment of Health-Related Quality of Life in Osteoporosis. * indicates P<0.05 and ** represents P<0.01 *versus* before treatment; # denotes P<0.05 versus the control group.

rate was significantly higher in the research group (93.33% vs. 78.33%, P<0.05, **Table 4**).

Discussion

Osteoporosis, a chronic metabolic and inflammatory disorder, predisposes patients to OVCF. This condition not only causes severe pain, potentially leading to limited mobility, postural changes, and height loss, but also increases mortality risk [19, 20]. While percutaneous VP for OVCF helps alleviate pain, restore spinal stability, and enhance function, many patients still experience persistent low back pain post-treatment, and the procedure is not suitable for all patients [21]. Research on the clinical benefits of ESPB in OVCF remains limited, with most studies focusing on its application in OVCF patients undergoing VP, rather than in non-VP patients. This study provides relevant analyses and detailed results on this topic.

Numerous studies have explored pain management in OVCF patients. For instance, Liu et al. [22] demonstrated that a cocktail injection (ropivacaine and compound betamethasone) in OVCF patients undergoing VP significantly relieved pain, reduced the risk of residual pain on days 1 and 7 post-surgery, and lessened patients' dependence on painkillers. Similarly, Chen et al. [23] found that teriparatide effectively alleviated pain and improved quality of life in postmenopausal women with OVCF, though it is associated with a higher incidence of adverse events. Additionally, Seah et al. [24] reported that early and late cement augmentation in OVCF patients can relieve pain after VP surgery, with early augmentation being more effective for patients experiencing significant pain within 2-4 weeks post-surgery.

Our study indicates that ESPB has a remarkable analgesic effect, surpassing traditional interventions in pain relief for OVCF patients. The main mechanisms of pain in these patients include skeletal, neural, soft tissue factors, and osteoporotic pain. Fractures directly stimulate sensory nerves in the periosteum or adjacent tissues, displace intervertebral discs and vertebral appendages, and disrupt the protective support of surrounding tissues. Osteoclast-mediated bone resorption and trabecular microfractures increase the functional load on the vertebral body, spinal nerve roots, and intervertebral discs, exacerbating pain [25]. The posterior branches of spinal nerves are closely linked to chronic spinal pain, and ESPB can effectively block these branches, alleviating tension in the erector spinae and relieving pain in the chest, lumbar region, and back, which explains the pain reduction observed in OVCF patients under ESPB intervention [26].

Ju et al. [27] also reported that ESPB applied to OVCF patients significantly relieves pain and dysfunction after VP, aids rapid bowel function recovery, and improves quality of life, findings consistent with our study. In our research, serum levels of TNF-α, HMGB-1, and hs-CRP were significantly reduced in OVCF patients undergo-

Table 4. Comparison of treatment satisfaction

Indicators	Control group (n=60)	Research group (n=60)	χ^2	P
Very satisfied	20 (33.33)	29 (48.33)		
Relatively satisfied	27 (45.00)	27 (45.00)		
Dissatisfied	13 (21.67)	4 (6.67)		
Overall satisfaction	47 (78.33)	56 (93.33)	5.551	0.019

ing ESPB, indicating that this intervention has a superior inhibitory effect on inflammatory responses. All three markers are known pro-inflammatory factors associated with osteopathy. Specifically, TNF-α mediates osteoporosis pathophysiology, bone injury repair, chronic immune-inflammatory osteopathy, and spinal cord injury; HMGB-1 influences osteoporosis through the Toll-like receptor 4 pathway, and hs-CRP is a known risk factor for fractures, particularly in elderly men [28-30]. This study also analyzed the impact of ESPB on these inflammatory indices in OVCF patients.

Furthermore, patients undergoing ESPB required fewer intramuscular tramadol injections over the 4-7 day period compared to those receiving traditional analgesics, demonstrating ESPB's potential to reduce opioid use. Additionally, OVCF patients who received ESPB showed significant improvements in sleep quality (as measured by the PSQI) and quality of life (as assessed by the ECOS-16), suggesting that ESPB is more beneficial for enhancing both sleep quality and overall well-being. This improvement is likely due to the reduction in pain and suppression of inflammatory responses, which promote effective recovery, reduce the risk of inflammation-associated infections, and ultimately improve patients' sleep and quality of life. Moreover, patients receiving ESPB reported significantly higher overall treatment satisfaction than those receiving analgesic treatment.

Despite the promising findings, there are several limitations to this study. The sample size was relatively small, which may limit the generalizability of the results. Besides, the follow-up period was short, and long-term effects of ESPB on pain relief, functional recovery, and inflammation in OVCF patients were not assessed. Further studies with larger sample size and extended follow-up are needed to evaluate the lasting benefits of ESPB.

In conclusion, ESPB for OVCF patients significantly reduces pain scores (PRI, VAS, PPI), decreases inflammatory mediators, lowers the need for tramadol injections during the 4-7 day period, and improves sleep quality, quality of life, and overall treatment satisfaction.

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Disclosure of conflict of interest

None.

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