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Thoracic paravertebral block versus local infiltration anesthesia for percutaneous kyphoplasty to treat osteoporotic vertebral compression fractures combined with intercostal neuralgia: a randomized controlled trial

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Abstract

Background Percutaneous kyphoplasty (PKP) is an effective treatment for osteoporotic vertebral compression fractures (OVCFs) and provides effective pain relief; however, its efficacy is questionable in patients with thoracic OVCFs combined with intercostal neuralgia (IN). This study aims to compare the efficacy and safety of thoracic paravertebral nerve block (TPVB) and local infiltration (LI) anesthesia for PKP to treat thoracic OVCFs combined with IN.

Methods Patients with OVCFs combined with IN scheduled to undergo PKP between January 2021 and June 2022 were randomized into the following groups: TPVB and LI. Intraoperative visual analog scale (VAS) score, patients' anesthesia satisfaction (PAS) score, mean arterial pressure (MAP), and heart rate (HR) were recorded. Follow-up consultations were scheduled at 1 day, 1 month, 3 months, and 6 months postoperatively, recording the demographic characteristics, including surgical information, and complications observed in both groups. The clinical evaluation parameters included the VAS score, Oswestry Disability Index (ODI), and Short Form (SF)-36 score. Radiological evaluation parameters included the anterior vertebral body height ratio (AVBHR) and Cobb's angle of the injured vertebra.

Results Sixty patients were enrolled (30 in each group), with similar clinical and demographic characteristics. The mean intraoperative VAS scores from time points T1 to T5 were significantly lower in the TPVB group [2 (1–2), 3 (2–3), 3 (3–4), 3 (2–3), and 2 (2–2)] than in the LI group [2 (2–3), 4 (3–4), 4 (3–5), 3.5 (3–4), and 3 (3–3)]. The PAS scores were significantly higher in the TPVB group [3(3–3)] than in the LI group [2(2–3)]. The TPVB group demonstrated

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significantly better clinical outcomes than that of the LI group at 1 day postoperatively, as evidenced by higher VAS, ODI, and SF-36 bp scores. The corresponding scores in the TPVB group were 2 (2–2), 20.47 ± 3.14, and 84 (84–84), respectively, and in the LI group were 3 (3–3), 22.53 ± 4.20, and 84 (74–84), respectively ($p < 0.05$). No statistically significant differences in radiological terms were observed between the two groups. No postoperative complications were observed in either group.

Conclusions Compared to LI, TPVB provided better intraoperative and postoperative short-term analgesia with an equivalent safety profile when administered to patients with OVCFs combined with IN.

Trial registration ChiCTR2000035034, 28/07/2020, https//www.chictr.org.cn.

Keywords Percutaneous kyphoplasty, Osteoporotic vertebral compression fractures, Thoracic paravertebral block, Local infiltration, Intercostal neuralgia, Pain

Introduction

Percutaneous kyphoplasty (PKP) is a safe and effective surgical procedure for the treatment of osteoporotic vertebral compression fractures (OVCFs) [1, 2], which can be performed under different anesthesia modalities such as local anesthesia, general anesthesia, and regional anesthesia [3]. Since general anesthesia may increase the risk of adverse anesthetic effects, hospital stay, and cost [4], local anesthesia is widely used in PKP surgery because of its rapid onset, precision, and cost-effectiveness [5]. OVCFs typically cause pain at the fracture site along with radiating discomfort [6–8], including intercostal neuralgia (IN), which complicates diagnosis and effective treatment [9]. PKP is effective in treating OVCFs and providing pain relief [10, 11]; however, its outcomes remain controversial in patients with thoracic OVCFs combined with IN. Studies have shown that patients with thoracic OVCFs combined with IN do not show significant improvement in pain following PKP but instead benefit from analgesics or nerve blocks [12–14]. The mechanism by which thoracic OVCFs causes IN is not fully understood, and possible factors contributing to this condition include sympathetic nerve injury, reduced vertebral height, foraminal stenosis, biomechanical alterations of the facet joints, annular disc tears, and paraspinal muscle strain [15, 16]. Thoracic paravertebral block (TPVB) can achieve anesthesia by blocking the dorsal branch, ventral branch, communicating branch, and sympathetic trunk of the spinal nerve on one side, effectively reducing chest and back pain, IN, and intraoperative pain.

Considering the limited success of PKP performed under local anesthesia for treating thoracic OVCFs with combined IN (considering that the sources of pain, including the combined IN, fracture site pain, and intraoperative pain from PKP manipulation in thoracic OVCFs are innervated by the aforementioned nerves), we hypothesized that PKP under TPVB is a more desirable treatment option for treating thoracic OVCFs with combined IN. Currently, studies comparing the efficacy and safety of TPVB and LI for treating thoracic OVCFs combined with IN are lacking. Therefore, we designed a double-blind, prospective, randomized controlled study to compare the efficacy and safety of TPVB with local infiltration (LI) anesthesia in PKP surgery for the treatment of thoracic OVCFs combined with IN.

We hypothesized that TPVB would achieve better results in relieving postoperative IN and provide better intraoperative pain relief in patients with OVCFs and IN during PKP. The primary outcome was the difference in VAS scores between the TPVB and LI groups during and after PKP. The secondary outcomes were the patients' anesthesia satisfaction (PAS) scores, SF-36 scores, and intraoperative safety parameters between the TPVB and LI groups in the treatment of OVCFs with IN.

Methods

This prospective, randomized controlled study was conducted at Third affiliated Hospital of Wenzhou Medical University in Wenzhou, China, following the CONSORT guidelines. The study protocol was approved by the Institutional Review Board of Third affiliated Hospital of Wenzhou Medical University, and the registration number for the clinical trials is ChiCTR2000035034 (http://www.chictr.org.cn, July 28, 2020; He Shaoqi, M.D.) (Fig. 1).

Study population

In this double-blind, prospective randomized study, 68 patients were selected. The inclusion criteria were as follows: age > 60 years, single-segment compression fracture of the thoracic spine (T8–12), persistent thoracic and intercostal pain significantly affecting daily life, and bone mineral density T-value < – 2.5. Exclusion criteria were as follows: symptoms of neurological deficits in the lower extremities, multiple injuries, preexisting spinal deformities or a previous spinal surgery, clinical or imaging evidence of metastatic bone tumors or multiple myeloma, asymptomatic fractures, systemic or local infections, and severe bleeding disorders.

Intervention

Patients were randomly allocated to the TPVB and LI groups. Computer-generated random number tables

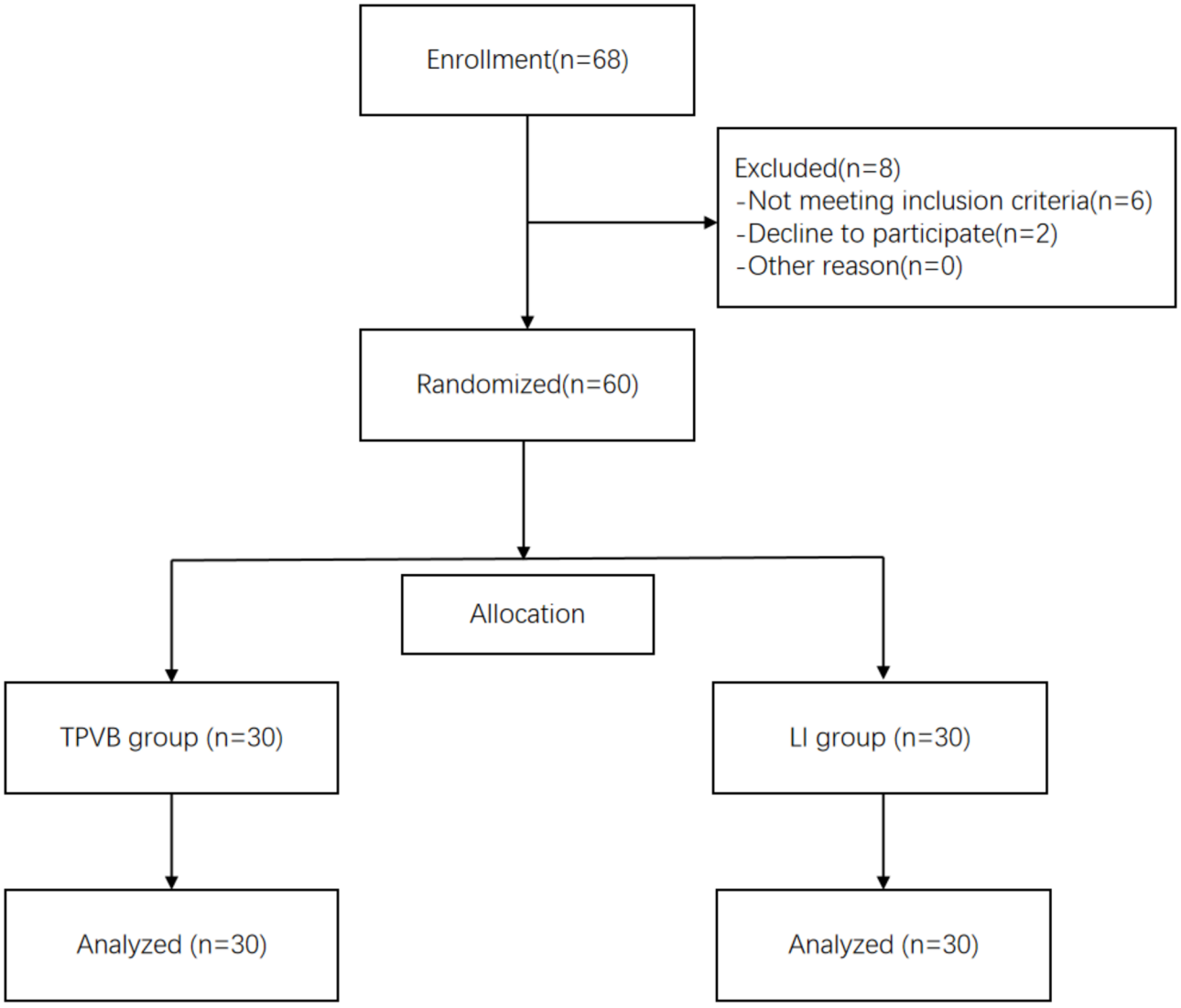

Fig. 1 Patient flow diagram

were used for randomization, and sealed opaque envelopes were used to assign the patients to the treatment groups. Following the randomization process, blocks were administered by an experienced chief anesthesiologist. For blinding purposes, patients were not informed of the type of anesthesia they would receive. All study coordinators, data collection attendants, and patients were blinded to the treatment group assignments.

Before surgery, the patients' pain levels were assessed using VAS scores; function statuses were evaluated through the Oswestry Disability Index (ODI) and Short Form (SF)-36; and imaging investigations were performed including radiography, computed tomography (CT), magnetic resonance imaging (MRI), and dual-energy X-ray absorptiometry. The anterior vertebral body height ratio (AVBHR) and Cobb's angle of the injured vertebra were measured on lateral radiographs. All patients underwent surgery within 3 days of admission to relieve pain, restore vertebral body height, and correct segmental kyphosis. They received calcium supplementation (1000 mg elemental calcium daily), vitamin D (600 IU vitamin D daily), and alendronate sodium (70 mg weekly).

Patients in the TPVB group were monitored with electrocardiography, along with blood pressure, pulse, and oxygen saturation measurements; intravenous access was established upon admission to the operating room. They were placed in a prone position with their chest and iliopsoas elevated to ensure abdominal suspension. The fractured vertebrae were aligned using a C-arm X-ray guidance. A high-frequency linear ultrasonography scanning probe (2–5 MHz, SonoSite S-Nerve, Bothell, Wash, USA) was placed parallel to the ribs and in an oblique axial position relative to the spine. Structures

including the transverse process, transverse costal ligament, and pleura were carefully distinguished on the ultrasound image. The transverse process was strongly echogenic, with a dark shadow present posteriorly, whereas the pleura and lungs were hyperechoic laterally, with the pleural sliding sign clearly visible. The thoracic paravertebral space was identified as the puncture target on ultrasound images, with the puncture point being approximately 1 cm lateral to the ultrasound probe. Local infiltration anesthesia was administered using 5 mL of 1% lidocaine. An 8-cm 18-gauge (Peridural catheter set; B. Braun, Melsungen, Germany) needle was inserted ventrally, guided by ultrasound, parallel to the ultrasound plane. The needle body was kept within the ultrasound field of view, and the needle tip was guided into the thoracic paravertebral space using the lateral intercostal approach. After injecting 5 mL of saline, a weak echogenic mass formed by an increase in extrapleural fluid, as observed on the ultrasound image, and the pleura was observed to depress the lung tissue, confirming that the catheter did not penetrate the blood vessel and total spinal anesthesia did not occur with an experimental dose. A total of 10 mL of 0.5% ropivacaine was administered in separate doses (Figs. 2 and 3D).

Patients in the LI group were placed in the prone position and LI anesthesia was administered using 5 mL of 1% lidocaine into the bone surface at the puncture site, followed by a 10 mL of 0.5% ropivacaine injected around the puncture site.

PKP surgery was performed following anesthesia, and all procedures were conducted using a unilateral puncture approach. A 1 cm skin incision was made lateral to the desired entry point of the pedicle to percutaneously. A trocar (Shandong Guanlong Medicial utensils Co., Ltd., Jinan City, Shandong Province, China) in a cannula was inserted into pedicle at the fractured vertebra through a unipedicular approach as a working channel. After removing the trocar, an balloon was placed into the working channel and slowly inflated to create a low-pressure cavity for cement injection. Inflation continued until the balloon pressures up to 300 psi. Then the balloon was deflated and removed, and poly-(methyl methacrylate) (PMMA) cement (Heraeus Medical, Wehrheim, Germany) was injected into the defect of the fractured body through the cannula under continuous fluoroscopic monitoring. The PMMA insertion was considered complete when it reached the posterior third of the vertebral body or had a potential tendancy of cortical, epidural, and anterior venous cement leakage (Fig. 3). All the surgeries were performed by the same group of physicians. After the surgery, patients were advised to walk with waist protection and engage in back muscles-strengthening exercises.

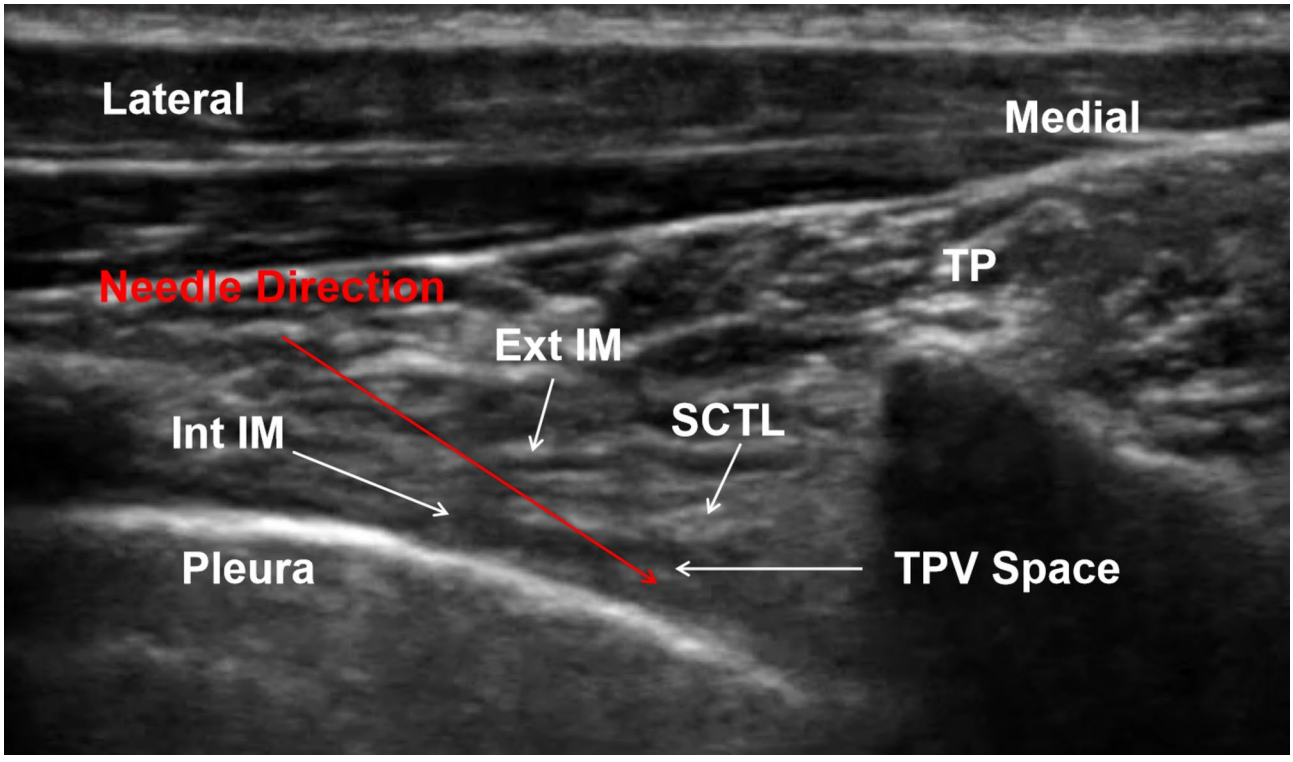

Fig. 2 Ultrasound-guided injection in paramedian view. TP: transverse process; SCTL: superior costotransverse ligament; TPV: thoracic paravertebral; Int IM: internal intercostal muscles; Ext IM: external intercostal muscles

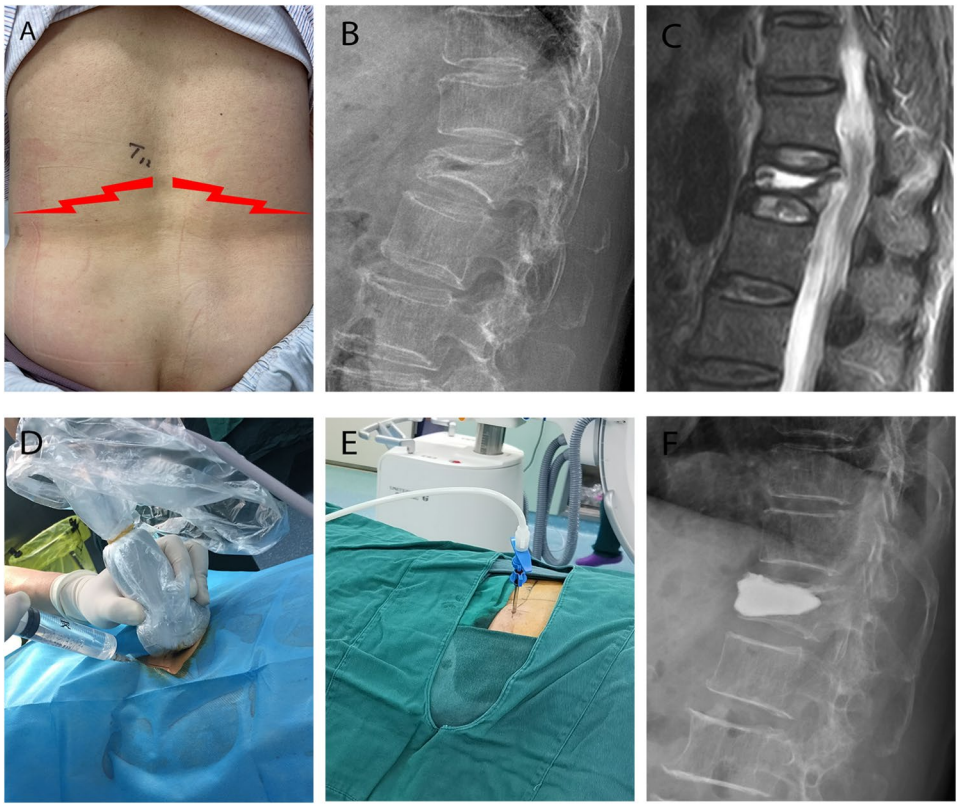

Fig. 3 An 82-year-old woman with an osteoporotic compression fracture at T12 and intercostal neuralgia undergoing percutaneous kyphoplasty under thoracic paravertebral block. **A**: Lightning symbol indicates location of intercostal neuralgia. **B**: Preoperative lateral X-ray shows T12 compression fracture. **C**: Preoperative T2-weighted MRI reveals T12 compression with canal occupation. **D**: Ultrasound-guided thoracic paravertebral block. **E**: Intraoperative view of percutaneous kyphoplasty. **F**: Postoperative lateral X-ray shows well-dispersed cement and restored vertebral height

Outcome assessment

Personnel performing surgery or involved in perioperative management are not involved in postoperative pain assessment or data collection. A data collection attendant, blinded to the study, records the patients' VAS scores at five separate time points during the procedure: after anesthesia (T1), upon puncture needle insertion into the bone (T2), during balloon dilation (T3), at bone cement injection (T4), and at the end of the procedure (T5). The mean arterial pressure (MAP) and heart rate (HR) were measured during the 3-minute period from T0 to T5. Patients' anesthesia satisfaction (PAS) scores (1, very dissatisfied; 2, unsatisfied; 3, general; 4, satisfied; 5, very satisfied) were recorded immediately after the surgery. The operation time, anesthesia time (from the start of anesthesia to the start of surgery), hospital stay, and costs were also recorded.

The patients' VAS, ODI, and SF-36 scores were recorded on the 1st day post-surgery; additionally, SF-36 scores was recorded at 1, 3, and 6months post-discharge. The incidences of perioperative cardiovascular and cerebrovascular events were also recorded. Radiographic and CT assessments were conducted on the 1st day, and at 1, 3, and 6 months postoperatively; the AVBHR and Cobb's angle of the injured vertebrae were measured and calculated on the 1st day postoperatively and at the last follow up. Additionally, the presence or absence of cement leakage was observed.

Sample size

Based on our previous experience with retrospective trials [17], we included 30 patients in each group based on the data from G Power 9.2 software (Heinrich Heine University), with the significance level set at 0.05 and statistical power set at 0.80. We enrolled 68 patients to account for potential participant dropouts.

Statistical analysis

Statistical analyses were performed using the SPSS statistical software (SPSS Inc., Chicago, IL, USA). Continuous data were expressed as mean ± standard deviation or median (interquartile range), and categorical data as frequency (percentage). Between-group comparisons of continuous variables were performed using the independent t-tests or Mann–Whitney U tests, as appropriate, whereas categorical variables were compared using the chi-square tests or Fisher's exact tests. Statistical significance was defined as $p < 0.05$.

Table 1 Demographic data for patients

	TPVB (*n* = 30)	LI (*n* = 30)	t(χ^2)	*p*
Age(years)	76.60 ± 9.12	73.63 ± 5.67	*t* = 1.513	0.136
Sex				
Male/female	5/25	6/24	χ^2 = 0.111	1.000
BMI (kg/m^2)	22.59 ± 3.72	23.40 ± 3.68	*t*=-0.844	0.402
BMD (T value)	-3.09 ± 0.35	-2.99 ± 0.34	*t*=-1.158	0.251
Segments (cases)				
T8	1	2	$\chi2$ = 1.918	0.757
T9	1	2		
T10	2	1		
T11	7	4		
T12	19	21		
ASA			$\chi2$ = 0.800	0.670
I	16	14		
II	12	15		
III	2	1		
Injury time (days)	5.51 ± 10.70	8.14 ± 9.80	*t*=-0.995	0.324

TPVB: Thoracic paravertebral block; LI: Local infiltrative

Table 2 Perioperative conditions between two groups

	TPVB (*n* = 30)	LI (*n* = 30)	t(χ^2)	*p*
Duration of surgery (min)	27.17 ± 5.03	26.40 ± 5.00	*t* = 0.592	0.556
Duration of anesthesia (min)	23.43 ± 3.95	5.97 ± 2.77	*t* = 19.810	< 0.001
Cost (dollar)	4359 ± 941	3911 ± 809	*t* = 1.978	0.053
Hospital stays (days)	5.83 ± 2.00	6.10 ± 2.16	*t*=-0.497	0.621
Leakage rate of cement	6/30	8/30	χ2 = 0.373	0.542

TPVB: Thoracic paravertebral block; LI: Local infiltrative

Results

A total of 68 patients were initially enrolled in the study, however, 6 patients were subsequently excluded based on exclusion criteria, while an additional 2 patients declined to participate. Consequently, the final analysis included a cohort of 60 patients who were randomly assigned between the period of January 2021 and June 2022. (Fig. 1). They were randomly assigned into two groups of 30 individuals each. No significant differences were observed between the two groups in terms of demographics, segments, ASA physical status, or injury time ($p > 0.05$) (Table 1).

No differences in the duration of surgery, hospital stays, costs, or cement leakage, whereas a significant difference in the duration of anesthesia (23.43 ± 3.95 vs. 5.97 ± 2.77) were observed between the two groups ($p > 0.05$) (Table 2). The mean intraoperative VAS scores from T1 to T5 were 2 (1–2), 3 (2–3), 3 (3–4), 3 (2–3), and 2 (2–2) in the TPVB group and 2 (2–3), 4 (3–4), 4 (3–5), 3.5 (3–4), and 3 (3–3) in the LI group, and the PAS scores were 3(3–3) in the TPVB group and 2(2–3) in the LI group, demonstrating significant differences between the two groups ($p < 0.05$) (Table 3). No significant differences in the MAP or HR were observed between the two groups at any time point from T1 to T5 ($p > 0.05$) (Table 3).

In terms of clinical outcomes, the TPVB group demonstrated significantly better results than those of the LI group at the 1st postoperative day, as evidenced by higher VAS, ODI, and SF-36 bp scores. The corresponding scores were 2 (2–2), 20.47 ± 3.14, and 84 (84–84), respectively, in the TPVB group and 3 (3–3), 22.53 ± 4.20, and 84 (74–84), respectively, in the LI group ($p < 0.05$) (Table 4). No statistically significant differences were observed between the two groups in terms of the SF-36 bp scores. However, during the final follow-up, no statistically significant differences in any of the aforementioned clinical outcomes were observed between the two groups (Table 4).

In terms of the radiological results, both groups demonstrated significant improvements in the AVBHR and Cobb's angle at the 1st postoperative assessment and during the final follow up compared to their respective preoperative values. However, no statistically significant differences were observed between the two groups when comparing these variables (Table 4).

No postoperative complications, including atelectasis, pneumonia, pneumothorax, hemothorax, or neuraxial complications, such as epidural injection or total spinal anesthesia, were observed in either group.

Table 3 Comparisons of intraoperative conditions between the two groups

	TPVB (*n* = 30)	LI (*n* = 30)	t(Z)	*p*
VAS				
T1	2(1–2)	2(2–3)	Z = -2.570	0.010
T2	3(2–3)	4(3–4)	Z = -4.702	< 0.001
T3	3(3–4)	4(3–5)	Z = -4.016	< 0.001
T4	3(2–3)	3.5(3–4)	Z = -4.278	< 0.001
T5	2(2–2)	3(3–3)	Z = -5.609	< 0.001
PAS	3(3–3)	2(2–3)	Z = -4.396	< 0.001
MAP(mmHg)				
T1	97.31 ± 16.05	98.39 ± 20.75	t=-0.225	0.823
T2	98.64 ± 15.37	100.25 ± 16.68	t=-0.387	0.700
T3	97.98 ± 14.30	99.50 ± 18.08	t=-0.362	0.719
T4	98.46 ± 15.95	99.88 ± 17.75	t=-0.326	0.745
T5	96.09 ± 13.86	96.43 ± 18.66	t=-0.081	0.936
HR(bpm)				
T1	80.93 ± 14.89	80.37 ± 12.80	t = 0.158	0.875
T2	82.60 ± 14.52	83.33 ± 12.12	t=-0.212	0.833
T3	83.87 ± 14.33	83.37 ± 10.83	t = 0.152	0.879
T4	83.70 ± 15.09	84.77 ± 12.14	t=-0.302	0.764
T5	81.60 ± 12.32	81.83 ± 11.20	t=-0.077	0.939

TPVB: Thoracic paravertebral block; LI: Local infiltrative;

VAS: visual pain analog scale. PAS: patients' anesthesia satisfaction. VAS and PAS values are expressed as medians (25th-75th percentile) or numbers

MAP: mean arterial pressure. HR: heart rate. MAP and HR value are expressed as mean ± SD

Table 4 Comparisons of clinical and radiologic results between the two groups

	TPVB (*n* = 30)	LI (*n* = 30)	t(Z)	*p*
VAS				
Preoperative	5(5–6)	6(5–6)	*Z*=-1.531	0.126
1 day Postoperative	2(2–2) *	3(3–3) *	*Z*=-5.849	< 0.001[#]
6 months Postoperative	2(2–2) *	2(2–2) *	*Z*=-0.278	0.781
ODI				
Preoperative	64.13 ± 5.61	63.80 ± 4.37	*t* = 0.257	0.798
1 day Postoperative	20.47 ± 3.14*	22.53 ± 4.20*	*t*=-2.159	0.035[#]
6 months Postoperative	16.07 ± 2.43*	16.60 ± 2.98*	*t*=-0.759	0.451
SF-36 bp				
Preoperative	22(21–31)	22(21–31)	*Z*=-0.077	0.939
1 day Postoperative	84(84–84) *	84(74–84) *	*Z*=-2.367	0.018[#]
6 months Postoperative	84(84–84) *	84(84–84) *	*Z*=-0.398	0.691
SF-36rp				
Preoperative	25(25–25)	25(25–25)	*Z*=-0.032	0.975
1 day Postoperative	75(75–75) *	75(50–75) *	*Z*=-1.156	0.248
6 months Postoperative	75(75–100) *	75(75–100) *	*Z*=-0.322	0.748
AVBHr (%)				
Preoperative	78.21 ± 12.65	78.99 ± 11.69	*t*=-0.249	0.804
1 day Postoperative	88.35 ± 11.83*	87.85 ± 7.73*	*t* = 0.192	0.849
6 months Postoperative	83.09 ± 11.63*	83.30 ± 9.67*	*t*=-0.076	0.940
The Cobb angle (°)				
Preoperative	16.97 ± 7.18	19.13 ± 8.70	*t*=-1.051	0.297
1 day Postoperative	13.03 ± 6.14*	15.70 ± 7.37*	*t*=-1.522	0.133
6 months Postoperative	16.37 ± 7.03*	19.10 ± 8.86*	*t*=-1.323	0.191

* Repeated measures variance analysis was used for the statistical analysis. There were significant differences ($p < 0.05$) between 1 day Postoperative or 6 months Postoperative and preoperative values of these 2 groups

[#] Independent samples t-test was used for the statistical analysis. There were significant differences ($p < 0.05$) between the 2 groups

TPVB: Thoracic paravertebral block; LI: Local infiltrative; VAS: visual pain analog scale; ODI: Oswestry disability index; SF-36 rp: short-form 36 health survey domains role physical; SF-36 bp: short-form 36 health survey domains bodily pain

Discussion

In this prospective, double-blind, randomized controlled trial, the TPVB group demonstrated significantly better intraoperative pain control and anesthesia satisfaction than that of the LI group for treating patients with thoracic OVCFs combined with IN. Additionally, during the early postoperative period, patients in the TPVB group exhibited better pain and functional scores than those of the patients in the LI group. No significant differences in the mean HR or MAP at any time point were observed between the two groups, indicating that TPVB and LI have similar intraoperative safety.

IN frequently occurs in conjunction with thoracic OVCFs, and although the pain mechanism is not fully understood. Patients with osteoporotic vertebral fractures in the thoracic spine often do not exhibit localized pain or tenderness over the fractured segment [18]. Instead, these patients frequently present with peripheral pain in distal locations, including the chest wall, lower back, iliac crest, groin, and shoulder girdle, termed as non-central line pain [19, 20]. The reason why patients with vertebral fractures experience non-midline pain, even when significant nerve impingement or compression is not evident on MRI scans, remains unknown [16]. Choi et al. suggested that post-fracture vertebral mid-column injuries irritate the extravertebral ligaments of the intervertebral foramen, causing ligamentous edema, distortion, and consequent compression and traction of the intercostal nerves [21]. Chen et al. noted a significant correlation among the percentage of severe thoracic spine fractures or mid-thoracic spine fractures, rate of intervertebral foraminal area reduction, and incidence of intercostal pain [22].

The efficacy of PKP in treating OVCFs is widely recognized by clinicians [23, 24]. Compared with conservative treatment, PKP provides rapid pain relief, reduces bedridden complications, and improves quality of life [25]. In patients with OVCFs combined with IN, PKP can restore vertebral height, correct kyphosis, stabilize fracture, and prevent further vertebral collapse through hyperextension and balloon dilatation. This procedure reduces irritation to the surrounding intervertebral discs and small joints, reduces mechanical loading on the small joints, and widens the intervertebral foramen to reduce irritation to the intercostal nerves, thereby alleviating some of the symptoms of IN [26–28]. However, some scholars have pointed out that some patients do not achieve satisfactory results with PKP. Choi et al. observed that among ten patients with OVCFs combined with IN who underwent vertebroplasty, only 50% of the patients experienced relief from IN following PKP, while the pain still persisted in the remaining patients [21].

The thoracic paraspinal space, located between the head and neck of the ribs, is an anatomical interstitial structure with a nearly wedge-shaped cross-section adjacent to the corresponding vertebrae. This space contains adipose tissue, spinal nerves (intercostal nerves), the dorsal and ventral branches of the intercostal nerves, communicating rami, the sympathetic chain, and intercostal blood vessels [29]. Consequently, LI anesthesia in the thoracic paraspinal space can achieve somatic and sympathetic nerve blockade, providing analgesia and anesthesia to the ipsilateral thoracic wall [30].

TPVB has a wide range of clinical application, including its use in providing anesthesia and analgesia for breast surgery, anesthesia for thoracic and upper abdominal regional surgery, as well as analgesia for multiple rib fractures and postherpetic neuralgia [31–33]. Our previous retrospective study suggested that TPVB is superior to LI anesthesia for providing analgesia during thoracic PKP [17]. In the current prospective study, intraoperative pain control was significantly better in the TPVB group than in the LI group, supporting our previous findings. Additionally, this superior pain control extended into the early postoperative period for patients with OVCFs combined with IN. Furthermore, the benefits of TPVB in postoperative pain control are also reflected in the functional outcomes of patients. In this study, patients in the TPVB group demonstrated significantly better short-term scores in both the SF-36 bp and ODI score compared to those in the LI group. These improved scores indicate that the superior pain management provided by TPVB not only reduces discomfort but also supports better physical function and quality of life in the early recovery period.

The overall complication rate of TPVB is low, with hypotension, bradycardia, pneumothorax, nerve injury, block failure, and total spinal anesthesia being the common adverse effects [34–37]. The results of a meta-analysis by Schnabel et al. [38] revealed that TPVB combined with general anesthesia or TPVB alone provides better perioperative analgesia with fewer adverse effects than other analgesic methods. In this study, no adverse events, such as pneumothorax, hemothorax, epidural spread, or high spinal anesthesia, were observed following TPVB. Moreover, we monitored the MAP and HR during the surgery and observed no significant differences in intraoperative hemodynamics between the TPVB and LI groups, suggesting that the application of TPVB in the treatment of OVCFs combined with IN is relatively safe. Although the cost of thoracic paravertebral block (TPVB) was relatively higher than that of local infiltration (LI) due to the cost of anesthesia and the use of ultrasound equipment, this difference was not statistically significant ($p = 0.053$). Furthermore, there was no significant difference in length of stay between the two anesthesia modalities. These results suggest that both anesthesia modalities are economically viable options to consider.

Limitations

This study had several limitations. First, indications for TPVB during PKP remain controversial. Second, this was a single-center clinical trial with a relatively small sample size and short follow-up period. Third, outcomes may differ across clinical settings or in patients with OVCFs outside the T8–T12 range. In the future, we plan to conduct multicenter studies with larger sample sizes and long-term follow-ups.

Conclusions

Compared to LI, TPVB provided superior intraoperative and postoperative short-term analgesia with an equivalent safety profile when applied to patients with OVCFs combined with IN.

Abbreviations

PKP	Percutaneous kyphoplasty
OVCFs	Osteoporotic vertebral compression fractures IN: intercostal neuralgia
TPVB	Thoracic paravertebral block
LI	Local infiltration
VAS	Visual analog scale
PAS	Patients' anesthesia satisfaction
MAP	Mean arterial pressure
HR	Heart rate
ODI	Oswestry Disability Index
AVBHR	Anterior vertebral body height ratio
CT	Computed tomography
MRI	Magnetic resonance imaging

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Not applicable.

Author contributions

S.H. conceived the study design. C.T. and S.H. supervised the data collection and literature review. H.X. and Z.J. performed the anesthesia. X.Z., G.S., Y.Q., and S.C. collected and analyzed the data. G.S. and Y.Q. prepared Figs. 1, 2 and 3. S.C. and X.Z. prepared Tables 1, 2, 3 and 4. Y.L. drafted the manuscript. S.H. is responsible for this article. All authors reviewed the manuscript.

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Data availability

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Human ethics and consent to participate

The present study was approved by the Human Ethics Committee of Third affiliated Hospital of Wenzhou Medical University (Institutional Review Board number: YSZM2020006), and was registered in the Chinese Clinical Trial Registry in 28/07/2020 (Registration number: ChiCTR2000035034) (https://www.chictr.org.cn/showproj.html?proj=56107). All methods were carried out in accordance with relevant guidelines and regulations. All participants gave written informed consent.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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