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Ultrasound-Guided Paravertebral Block Combined with Local Infiltration Anesthesia Versus Local Infiltration Alone in Percutaneous Vertebroplasty for Osteoporotic Vertebral Compression Fractures: A Retrospective Cohort Study

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Abstract

This retrospective cohort study evaluated the perioperative outcomes of ultrasound-guided paravertebral nerve block (PVB) combined with local infiltration anesthesia versus local infiltration alone in 84 patients undergoing percutaneous vertebroplasty (PVP) for osteoporotic vertebral compression fractures. Patients were allocated to the PVB group (n = 42) or control group (n = 42). The PVB group demonstrated significantly lower intraoperative mean arterial pressure (116.2 ± 10.9 vs 131.9 ± 14.7 mmHg, P < 0.001, Cohen's d = 1.21) and heart rate (80.9 ± 8.6 vs 87.4 ± 6.4 bpm, P = 0.0002). Postoperative Visual Analogue Scale scores were significantly lower in the PVB group at 0, 6, and 12 hours (all P ≤ 0.001) but not at 24 hours (1.26 ± 0.80 vs 1.29 ± 0.64, P = 0.697). The PVB group had shorter operative time (31.4 ± 11.1 vs 41.1 ± 6.1 min, P < 0.001) and hospital stay (median 5 vs 8 days, P = 0.001). Bone cement leakage occurred in 9.5% versus 14.3% of patients (P = 0.736). In conclusion, ultrasound-guided PVB may provide better intraoperative hemodynamic stability and reduce early postoperative pain within 12 hours, though analgesic benefits appear time-limited. These findings should be interpreted cautiously given the retrospective design.

Introduction

With the aging population, the incidence of osteoporotic vertebral compression fractures (OVCF) is increasing annually, becoming a common orthopedic condition that severely impacts the quality of life of elderly patients [1]. Percutaneous vertebroplasty (PVP) and percutaneous kyphoplasty (PKP) are currently the preferred minimally invasive surgical treatments for OVCF, capable of rapidly relieving pain and improving patient mobility [2, 3]. However, perioperative anesthetic management poses significant challenges, as these procedures typically require the prone position and involve painful manipulations such as vertebral puncture and pressurized bone cement injection [4, 5].

Currently, anesthesia options for PVP/PKP include general anesthesia, neuraxial blockade, local infiltration anesthesia, and various regional nerve block techniques [6, 7]. While simple local infiltration anesthesia is easy to perform, its intraoperative analgesic effect is often inadequate, potentially leading to patient discomfort and hemodynamic fluctuations [8]. Paravertebral nerve block (PVB) involves injecting local anesthetic into the paravertebral space to block the spinal nerves emerging from the intervertebral foramina, providing ipsilateral segmental somatic and sensory nerve blockade [9, 10]. With the increasing availability of ultrasound guidance, PVB is being more widely used in spinal surgery due to improved precision and safety [11, 12].

Previous studies have suggested that ultrasound-guided PVB for PVP/PKP may provide superior intraoperative analgesia compared to local anesthesia alone [13–15]. However, most studies are small-sample, single-center reports with short-term observations, and systematic retrospective analyses remain limited [16]. Therefore, this study aims to retrospectively analyze the clinical data of OVCF patients who underwent PVP at our institution over a five-year period, comparing the perioperative outcomes of ultrasound-guided PVB combined with local anesthesia versus local anesthesia alone.

Methods

Study Design and Patients This single-center retrospective cohort study was conducted at Hangzhou Xiaoshan Hospital of Traditional Chinese Medicine. The study protocol was approved by the institutional ethics committee (IRB-2026-200, approved September 10, 2026). Due to the retrospective nature of the study, the requirement for written informed consent was waived.

We retrospectively reviewed clinical data from patients with OVCF who underwent PVP between July 2021 and July 2026. Inclusion criteria were: (1) age ≥ 50 years; (2) clinically diagnosed OVCF confirmed by imaging; (3) underwent PVP under ultrasound-guided PVB or local infiltration anesthesia; (4) complete clinical records. Exclusion criteria were: (1) ASA classification ≥ IV; (2) coagulopathy or active anticoagulation; (3) infection at puncture site; (4) severe posterior vertebral wall destruction; (5) pathological fractures; (6) allergy to local anesthetics; (7) incomplete data.

Based on the anesthesia technique recorded in medical records, patients were allocated to two groups: the PVB group received ultrasound-guided bilateral PVB combined with local infiltration, while the control group received local infiltration anesthesia alone. The choice of anesthesia technique was determined by the anesthesiologist based on patient factors and clinical judgment, not by randomization.

Anesthesia Techniques PVB group: After standard monitoring, patients received ultrasound-guided bilateral PVB using a high-frequency linear probe (6–13 MHz). Under real-time guidance, 20–30 mL of 0.15%–0.25% ropivacaine was injected into the paravertebral space at the target level(s). After 15–20 minutes, block effectiveness was confirmed by pinprick test. Local infiltration with 5–10 mL of 1% lidocaine was performed at the surgical site. (Fig. 1).

Control group: Local infiltration anesthesia was performed using 5–10 mL of 1% lidocaine injected layer by layer from skin to periosteum at the surgical site and along the puncture trajectory.

In both groups, rescue analgesia (intravenous sufentanil) was administered if patients experienced significant pain or hemodynamic instability during surgery.

Surgical Procedure All PVP procedures were performed by the same team of experienced spine surgeons using the transpedicular approach under fluoroscopic guidance. Operative time was defined as the duration from skin incision to wound closure, excluding anesthesia preparation time.

Outcome Measures Primary outcomes: (1) Intraoperative MAP and HR (recorded as mean values during surgery); (2) Postoperative VAS scores at 0, 6, 12, and 24 hours. Secondary outcomes: (1) Operative time (skin incision to wound closure); (2) Length of hospital stay (admission to discharge); (3) Postoperative complications including nausea/vomiting, drowsiness, bone cement leakage, and other adverse events.

Statistical Analysis Statistical analysis was performed using SPSS 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were tested for normality using the Shapiro-Wilk test. Normally distributed data were expressed as mean ± standard deviation and compared using independent samples t-test (with

Welch's correction for unequal variances). Non-normally distributed data were expressed as median (interquartile range) and compared using Mann-Whitney U test. Categorical data were expressed as number (percentage) and compared using chi-square test or Fisher's exact test as appropriate. Effect sizes were reported as Cohen's d for continuous variables and odds ratios for categorical variables. For multiple comparisons of VAS scores across time points, Bonferroni correction was applied. All tests were two-sided, with $P < 0.05$ considered statistically significant. Post-hoc power analysis was performed to assess study power for detecting the observed effect sizes. A detailed patient selection flow diagram is presented in Fig. 2.

Results

Patient Characteristics A total of 84 patients met the inclusion criteria and were included in the analysis (PVB group: n = 42; Control group: n = 42). Baseline characteristics are presented in Table 1. The two groups were well balanced in terms of age, sex distribution, BMI, and ASA classification (all $P > 0.05$).

Table 1
Baseline Characteristics of Patients

Variable	PVB Group (n = 42)	Control Group (n = 42)	Test Statistic	P-value	SMD
Age (years)	72.43 ± 6.21	73.57 ± 7.60	t = − 0.75	0.453	0.17
BMI (kg/m²)	23.72 ± 1.67	23.69 ± 1.47	t = − 0.08	0.938	0.02
Male/Female	12/30 (28.6%)	14/28 (33.3%)	$\chi^2 = 0.06$	0.813	—
ASA I/II	9/33	15/27	OR = 2.04	0.227	—

*Data are presented as mean ± SD or n (%). *P < 0.05. SMD = Standardized Mean Difference; ASA = American Society of Anesthesiologists.*

Intraoperative Hemodynamics The PVB group demonstrated significantly lower intraoperative MAP (116.2 ± 10.9 vs 131.9 ± 14.7 mmHg, mean difference − 15.7 mmHg, 95% CI: −21.2 to − 10.2, $P < 0.001$, Cohen's d = 1.21) and HR (80.9 ± 8.6 vs 87.4 ± 6.4 bpm, mean difference − 6.5 bpm, 95% CI: −9.7 to − 3.2, $P = 0.0002$, Cohen's d = 0.85) compared to the control group (Table 3).

Table 3
Comparison of Intraoperative and Postoperative Outcomes Between Groups

Outcome	PVB Group (n = 42)	Control Group (n = 42)	Difference (95% CI)	P-value	Effect Size
MAP (mmHg)	116.2 ± 10.9	131.9 ± 14.7	−15.7 (− 21.2 to − 10.2)	< 0.001*	d = 1.21
HR (bpm)	80.9 ± 8.6	87.4 ± 6.4	−6.5 (− 9.7 to − 3.2)	0.0002*	d = 0.85
Operative time (min)	31.4 ± 11.1	41.1 ± 6.1	−9.7 (− 13.5 to − 5.9)	< 0.001*	d = 1.08
Hospital stay (days)	5 (3–7)‡	8 (4–13)‡	Median diff = − 3	0.001*	—

*Data are presented as mean ± SD or median (IQR). *P < 0.05. ‡Non-normally distributed, analyzed with Mann-Whitney U test. MAP = mean arterial pressure; HR = heart rate.*

Postoperative Pain Scores Postoperative VAS scores are presented in Table 2. The PVB group had significantly lower VAS scores at 0 hour (1.90 ± 0.53 vs 2.48 ± 0.67, P < 0.001), 6 hours (1.81 ± 0.40 vs 2.24 ± 0.62, P = 0.001), and 12 hours (1.60 ± 0.66 vs 2.07 ± 0.56, P = 0.001) postoperatively. However, at 24 hours, there was no significant difference between groups (1.26 ± 0.80 vs 1.29 ± 0.64, P = 0.697). After Bonferroni correction for multiple comparisons, the differences remained significant at 0, 6, and 12 hours (corrected P < 0.05) but not at 24 hours (corrected P = 1.000).

Table 2
Comparison of Postoperative Pain Scores Between Groups

Time Point	PVB Group (n = 42)	Control Group (n = 42)	Mean Diff (95% CI)	P-value	Corrected P	Cohen's d
0 hour	1.90 ± 0.53	2.48 ± 0.67	−0.57 (− 0.83 to − 0.31)	< 0.001*	0.0003*	−0.94
6 hours	1.81 ± 0.40	2.24 ± 0.62	−0.43 (− 0.65 to − 0.21)	0.001*	0.002*	−0.83
12 hours	1.60 ± 0.66	2.07 ± 0.56	−0.48 (− 0.74 to − 0.21)	0.001*	0.003*	−0.78
24 hours	1.26 ± 0.80	1.29 ± 0.64	−0.02 (− 0.33 to 0.28)	0.697	1.000	−0.03

*Data are presented as mean ± SD. *P < 0.05. Corrected P = Bonferroni-corrected P-value (×4 for 4 time points). VAS = Visual Analogue Scale.*

Operative Time and Hospital Stay The PVB group had significantly shorter operative time (31.4 ± 11.1 vs 41.1 ± 6.1 min, mean difference − 9.7 min, 95% CI: −13.5 to − 5.9, P < 0.001, Cohen's d = 1.08) and length of hospital stay (median 5 days [IQR: 3–7] vs 8 days [IQR: 4–13], P = 0.001) compared to the control group (Table 3).

Postoperative Complications Postoperative complications are summarized in Table 4. Nausea and vomiting occurred in 3 patients (7.1%) in the PVB group versus 8 patients (19.0%) in the control group (P = 0.194). Bone cement leakage was observed in 4 patients (9.5%) in the PVB group versus 6 patients (14.3%) in the control group (P = 0.736). No patients in either group experienced drowsiness or other serious complications. The overall complication rates did not differ significantly between groups.

Table 4
Comparison of Postoperative Complications Between Groups

Complication	PVB Group (n = 42)	Control Group (n = 42)	P-value	OR (95% CI)
Nausea/Vomiting	3 (7.1%)	8 (19.0%)	0.194	0.33 (0.08–1.27)
Drowsiness	0 (0%)	0 (0%)	—	—
Bone cement leakage	4 (9.5%)	6 (14.3%)	0.736	0.63 (0.17–2.35)

Data are presented as n (%). OR = Odds Ratio. Fisher's exact test used for nausea/vomiting; chi-square test for bone cement leakage.

Discussion

In this retrospective cohort study of 84 patients undergoing PVP for OVCF, we found that ultrasound-guided PVB combined with local infiltration anesthesia was associated with better intraoperative hemodynamic stability, reduced early postoperative pain (within 12 hours), shorter operative time, and shorter hospital stay compared to local infiltration anesthesia alone. However, the analgesic benefits of PVB did not persist to 24 hours postoperatively, suggesting a time-limited effect.

The observed hemodynamic benefits of PVB are consistent with its mechanism of action. By blocking the spinal nerves at the segmental level, PVB provides more complete analgesia of the surgical area compared to local infiltration, which primarily blocks superficial tissues [10, 12]. This more effective blockade may attenuate the sympathetic stress response to surgical stimuli, resulting in more stable intraoperative MAP and HR [9]. In our study, the PVB group had 16 mmHg lower MAP and 6 bpm lower HR, both statistically and clinically significant differences with large effect sizes (Cohen's d = 1.21 and 0.85, respectively). For elderly patients with cardiovascular comorbidities, such hemodynamic stability may reduce perioperative risk.

The pain reduction observed with PVB was significant at 0, 6, and 12 hours but not at 24 hours. This time-limited effect is pharmacologically plausible, as the duration of action of ropivacaine 0.15%–0.25% is typically 4–8 hours for surgical anesthesia [17]. The single-injection technique used in our study would not provide prolonged analgesia beyond this window. The lack of difference at 24 hours suggests that the benefits of PVB are primarily intraoperative and early postoperative, and additional strategies (e.g., continuous catheter techniques or multimodal analgesia) may be needed for prolonged pain control.

The shorter operative time in the PVB group (9.7 minutes less) may reflect better patient cooperation due to more effective analgesia. Patients experiencing less pain may be more still during surgery, allowing more efficient puncture and cement injection. The clinical significance of a 10-minute reduction in operative time is debatable, but in the context of elderly patients with limited physiological reserve, any reduction in surgical duration may be beneficial.

The shorter hospital stay in the PVB group (median 5 vs 8 days) is an interesting finding that requires careful interpretation. While effective analgesia may facilitate earlier mobilization and discharge, hospital stay is influenced by many factors beyond pain control, including local discharge practices, patient comorbidities, and social factors. The non-normal distribution of hospital stay (wide range from 1 to 22 days) suggests substantial variability that may reflect these multifactorial influences.

Regarding safety, the overall complication rates were low and not significantly different between groups. Bone cement leakage occurred in 9.5% of PVB patients versus 14.3% of controls, which is within the range reported in the literature [18, 19]. No serious PVB-related complications (pneumothorax, vascular puncture, epidural spread) were observed, consistent with the safety profile of ultrasound-guided techniques [11, 12].

Limitations This study has several limitations. First, the retrospective design is inherently subject to selection bias and confounding. The choice of anesthesia technique was not randomized but determined by clinical judgment, which may have introduced systematic differences between groups. Although the two groups were well balanced in baseline characteristics including age, unmeasured confounders cannot be excluded. Second, this was a single-center study with a relatively small sample size (n = 42 per group). While post-hoc power analysis indicated adequate power (> 80%) to detect the observed effect sizes, the study may be underpowered to detect smaller but clinically meaningful differences, particularly for complications. Third, pain assessment was limited to 24 hours postoperatively. We did not evaluate longer-term pain outcomes, functional recovery, or patient satisfaction. Fourth, we did not systematically record postoperative analgesic regimens or rescue analgesic consumption, which are important confounders for pain assessment. Fifth, bone cement leakage was assessed based on medical record documentation rather than systematic radiological evaluation, which may have led to under-ascertainment of leakage events. Finally, we used a single MAP and HR value per patient rather than analyzing hemodynamic variability or specific time points.

Conclusion

In conclusion, ultrasound-guided PVB combined with local infiltration anesthesia may provide better intraoperative hemodynamic stability, reduce early postoperative pain (within 12 hours), and shorten operative time and hospital stay compared to local infiltration anesthesia alone in PVP surgery for OVCF. However, the analgesic benefits appear to be time-limited, with no significant pain reduction at 24 hours postoperatively. Given the retrospective design and other methodological limitations, these findings

should be interpreted cautiously. Prospective randomized controlled trials with longer follow-up and comprehensive outcome assessment are needed to confirm these observations.

Declarations

Ethics approval and consent to participate:

This study was approved by the Institutional Review Board of Hangzhou Xiaoshan District Hospital of Traditional Chinese Medicine (approval number: IRB-2026-200, approved September 10, 2026). Due to the retrospective nature of the study and the use of anonymized data, the requirement for written informed consent was waived.

Consent for publication:

Not applicable.

Competing interests:

The authors declare that they have no competing interests.

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Author Contribution

Conceptualization: LKZ□LL; Data curation: LKZ; Formal Analysis: JWQ; Methodology: JWQ□CML; Project Administration: CML; Visualization: LKZ□Writing– Original Draft: JWQ; Writing– Review & Editing: LKZ;All authors reviewed the manuscript.

Data Availability

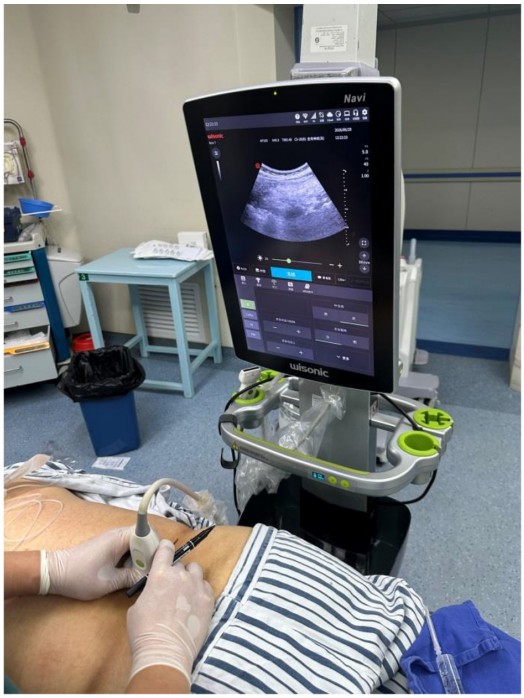
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Figures



a Localization under ultrasound before puncture



b Ultrasound-guided paravertebral block needle insertion

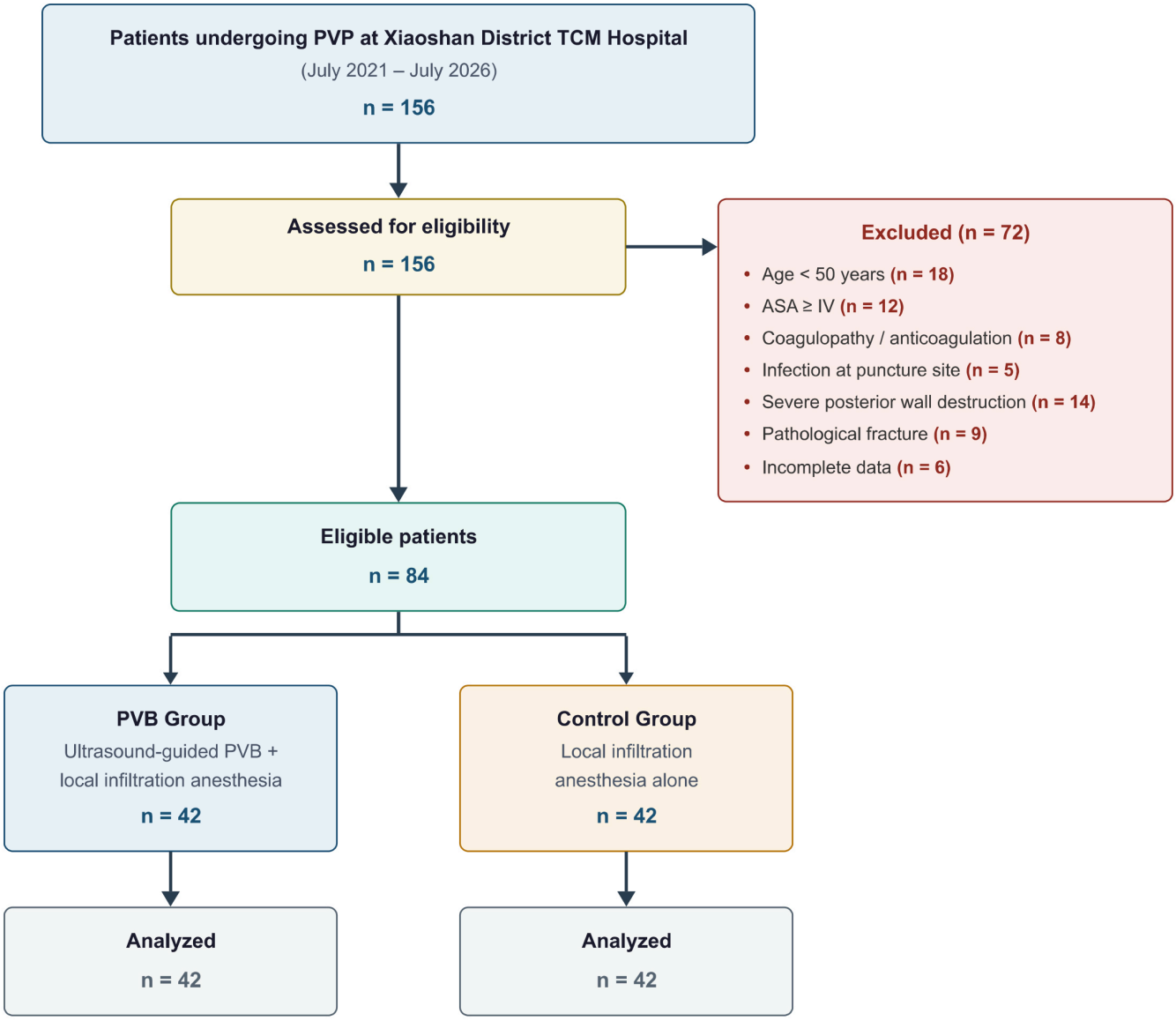
Figure 1. Ultrasound-guided paravertebral nerve block technique. (a) Localization and marking under ultrasound guidance before puncture. (b) Needle insertion under real-time ultrasound guidance.

Figure 1

See image above for figure legend

Figure 2. Patient Selection Flow Diagram

Flow diagram of patient enrollment, allocation, and analysis



PVB = paravertebral block; **PVP** = percutaneous vertebroplasty; **ASA** = American Society of Anesthesiologists; **TCM** = traditional Chinese medicine.

Figure 2

See image above for figure legend

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