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Paravertebral block analgesia during surgical stabilization for rib fractures patients under conscious state: a single-arm, pilot study and post-hoc analysis

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Abstract

Background Paravertebral block (PVB) is commonly used for analgesia postoperatively while rarely as anesthesia during surgical stabilization for rib fractures. This study aimed to explore the feasibility and safety of PVB analgesia alone during surgical stabilization for patients with multiple rib fractures (MRF) under conscious state.

Methods This prospective single-arm pilot study was conducted in patients with MRF who schedule for surgical stabilization using PVB analgesia in Shanghai Sixth People's Hospital Affiliated to Shanghai Jiao Tong University School of Medicine between September 2019 and September 2020. The outcomes were the vital signs, postoperative pain and nausea and vomiting (PONV). Those who underwent general anesthesia (GA) during the same period were included for post hoc analysis.

Results Eighteen patients (aged 62 ± 10.64 years; 8 males) were enrolled. The vital signs, including SpO_2, systolic blood pressure, diastolic blood pressure, heart rate, respiratory rate, of the patients at baseline, perioperative, intraoperative, and postoperative day 1 were kept normal. The postoperative numerical rating scale (NRS) pain scores at 6, 12, and 24 h were 2.67 ± 1.36, 2.44 ± 0.80, and 2.33 ± 0.86, respectively, which were improved compared with baseline (5.78 ± 1.00). No PONV, postoperative morbidity, pulmonary infections, or incision infections were observed. Additionally, post-hoc analysis for the comparison of patients who underwent GA with PVB (in the pilot study) showed a similar number of rib fracture fixation ($P = 0.06$) and analgesic effect ($P = 0.06$) after operation, while a significantly shorter total length of hospital stay ($P < 0.01$), postoperative hospital stay ($P < 0.01$), lower dose of sufentanil citrate use ($P < 0.01$),and total costs($P < 0.03$)in patients who underwent PVB.

Conclusions PVB analgesia during surgical stabilization for MRF under a conscious state might be feasible and safe. Compared with GA, PVB analgesia might reduce the dose of narcotics, shorten the length of hospital stay, and reduce the cost of hospitalization.

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Keywords Surgical stabilization, Multiple rib fractures, Conscious state, Paravertebral block, Pilot study

Background

Rib fractures are usually treated conservatively, but some specific cases can require operation [1]. The surgical stabilization for rib fractures in flail chest injury is beneficial over conservative management [2]. Surgical stabilization for multiple rib fractures (MRF) without a flail chest also shows many advantages, such as faster healing, better pain management, and better physical function [3, 4]. A multicenter randomized controlled trial showed that operative treatment may benefit patients with MRF without other injuries [5]. Therefore, surgical stabilization for rib fractures should be considered for chest wall stabilization and as an analgesic modality [6]. Indeed, as pain improves, patients with MRF who receive surgical stabilization have a better quality of life [7]. Although surgical stabilization is a low-risk operation [8], several physicians and surgeons are still reluctant to perform it [9]. The reasons incudes the fear of trauma from operation and general anesthesia (GA), which usually involves tracheal intubation and combined intravenous-inhaled anesthesia [10]. While, surgical stabilization of rib fractures can now be performed in a minimally invasive manner [11–13], the issue of GA remains.

Previous studies have found that the thoracic episodic blocks (TEB) and the intercostal nerve block (ICNB) both can effectively improve the degree of pain after rib fracture. The advantages of TEB such as the benefits on analgesia, reduce mortality and postoperative pulmonary ventilation made it has long been seen as the gold standard in analgesic management of traumatic rib fractures. But meta-analyses have demonstrated that the effects of TEB, such as unavoidable bilateral blockade, headache, nerve injury and urinary retention, questioning the utility of this technique in the setting of traumatic rib fractures [14]. Intercostal nerve blocks can significantly reduce pain, but it is worth noting that additional methods are recommended for long-term pain control due to the short-acting nature of intercostal blocks [15]. It is associated with a high risk of systemic absorption of local anaesthetic and the risk of pneumothorax. The randomized controlled trials have demonstrated that patients receiving PVB have improved analgesia and functional pulmonary outcomes when it compared with systemic analgesia alone and little difference in clinical efficacy or safety has been demonstrated when it compared with thoracic epidural analgesia in the peri-operative setting [16]. Therefore, we chose PVB as the analgesic option for SSRF patients.

Paravertebral block (PVB) has been used for analgesia after thoracic surgery for many years [17–19], but it can also be used for surgical anesthesia [20]. Indeed, PVB for surgical anesthesia at the thoracic and lumbar vertebrae level is associated with less pain during the immediate postoperative period, lower postoperative nausea and vomiting, and greater patient satisfaction compared with GA [20]. PVB can also be used for thoracoscopic surgery [21]. PVB combined with sedation has been used in breast cancer surgery [22]. PVB with moderate sedation is feasible for percutaneous nephrolithotomy [23]. The authors previously reported using PVB combined with a laryngeal mask and sedation in surgical stabilization of rib fractures without tracheal intubation [24]. However, using a laryngeal mask involves some level of sedation to avoid the anxiety associated with the mask, and using a laryngeal mask can injure the trachea and nearby structures [25]. PVB has not been used for surgical stabilization of rib fractures in patients in a conscious state without a laryngeal mask.

Therefore, this study aimed to explore the feasibility of PVB during surgical stabilization for patients with MRF in the conscious state preliminarily.

Methods

Study design and participants

This prospective single-arm pilot study enrolled patients scheduled for surgical stabilization of rib fractures in Shanghai Sixth People's Hospital Affiliated to Shanghai Jiao Tong University School of Medicine between September 2019 and September 2020. The study was approved by the Ethics Committee of Shanghai Sixth People's Hospital Affiliated to Shanghai Jiao Tong University School of Medicine (approval # 2020-036-(1)). Informed consent forms were obtained from patients or their legal guardians. The trial was regeistered at ClinicalTrial.gov(ID: NCT 04536311).

The inclusion criteria were (1) American Society of Anesthesiologists (ASA) I-II, (2) 18–80 years of age, (3) body mass index (BMI) < 30 kg/m^2, (4) unilateral MRF ($n \leq 5$ ribs) with at least one rib dislocation, (5) no other severe trauma (e.g., pulmonary contusion, pneumothorax, or hemothorax), and (6) preoperative arterial partial pressure of oxygen (PaO_2) > 60 mmHg and partial pressure of carbon dioxide ($PaCO_2$) < 50 mmHg. The exclusion criteria were (1) difficult airway, (2) history of esophageal reflux, (3) myasthenia gravis, (4) gastrointestinal ulcer or bleeding, (5) asthma or chronic obstructive pulmonary disease, (6) contraindications to nerve block (e.g., coagulation dysfunction, puncture site infection, tumor, serious deformity, or allergy to local anesthetics, 7) multiple trauma, 8) severe craniocerebral injury, 9) spinal cord injury, or 10) pelvic fracture.

Fig. 1 Paravertebral block in the anesthesia preparation room

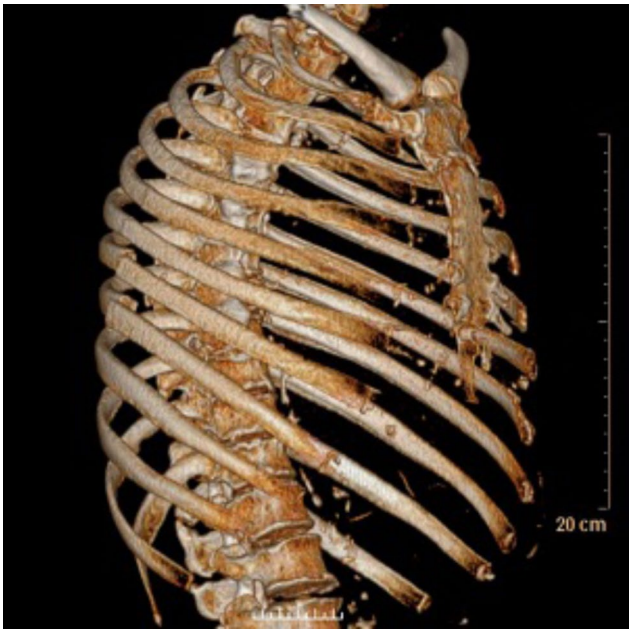

Fig. 2 Rib fractures were shown using chest computed tomography and three-dimensional reconstruction

The patients in the same period(between September 2019 to September 2020) who underwent internal fixation of rib fractures under GA (intravenous anesthesia and endotracheal intubation) were included for post hoc analysis. The inclusion and exclusion criteria were the same as those who underwent PVB.

Intervention

PVB was conducted by the same group of anesthesiologists 30–60 min before operation in the anesthesia preparation room [23] (Fig. 1). The segments of the nerve block were determined (one to three segments) based on the location and number of rib fractures. An ultrasound-guided, single-point injection of 0.375% ropivacaine (10–15 mL, total dosage ≤ 200 mg) was used. In cases of posterior rib fracture, PVB was combined with erector spinae plane block (same concentrations and methods as above). The anesthesiologist would test the anesthetic effect of the nerve block to ascertain whether the operation could be carried out immediately. If the blocking effect was unsatisfactory, laryngeal mask airway or endotracheal intubation was used, and the participants would be dropped out. Oxygen (2 L/min) was delivered through a nasal catheter. The patient's electrocardiogram (ECG), noninvasive blood pressure, pulse oxygen saturation (SpO2), and other vital signs were monitored throughout the procedure. In the operating room, the anesthesiologist evaluated the participant's psychological state. According to their degree of anxiety, sedation was achieved, if necessary, by administering dexmedetomidine hydrochloride (1 μg/kg administered over a 10-minute period, and then maintained at 0.2–0.7 μg/kg/h) or midazolam (0.03–0.04 mg/kg) using target-controlled infusion pumps. The patient's state was monitored and in each case the sedation was sufficient before the full dose of sedation was administered and consequently infusion of the sedation was terminated. Sufentanil citrate (5–10 μg) was given intravenously according to the degree of pain during the operation.

The surgical incision was made depending on the position and number of rib fractures. The same group of surgeons performed all operations. The surgical incision mainly relies on the display of three-dimensional CT images of rib fractures (Fig. 2), and sometimes ultrasound is also used for exploration.

The patients were placed in the standard 90° lateral position. The angle of the operating table was adjusted appropriately to facilitate the exposure of the surgical field. In patients with anterior rib fractures, the surgical incision was made along the lateral edge of the pectoralis major. In patients with lateral (or axillary) rib fractures, the incision was made at the median axillary or anterior latissimus dorsi. In patients with posterior rib fractures, the incision was made from the scapula corner through the auscultation triangle to the medial edge of the scapula. The same surgeons completed the operation (Fig. 3) under anesthesia monitoring. All patients had a small incision of approximately 5–7 cm. The muscle-sparing method was used to expose the rib fracture, and internal fixation was performed using the proper instruments [24]. During the operation, the surgeon evaluated the anesthetic effect on the nerve block area. If muscle contraction affected the operation or the participant

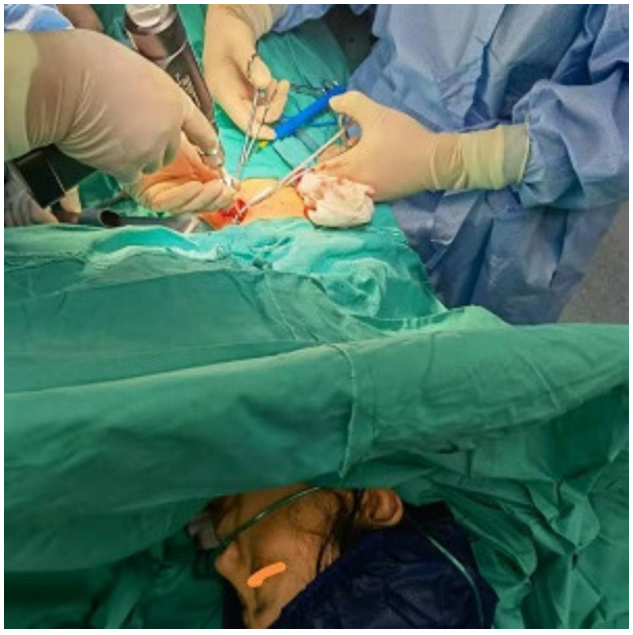

Fig. 3 Surgical stabilization of the rib fractures

experienced unbearable pain, 1% lidocaine was added to the incision site. A drainage tube with negative pressure was used to drain subcutaneous and intramuscular effusion, and pleural drainage was used if necessary. The GA procedures are described in the Supplementary Materials. The baseline characteristics were recorded, including sex, age, fracture localization, fracture side, and number of fractures, American Society of Anesthesiologists grade.

Outcomes

The outcomes were the vital signs, postoperative pain, PONV. The time to leave operation room (min), postoperative fasting time, length of postoperative hospital stay, drainage, morbidity, pulmonary infection, incision infection were also observed for safety. The vital signs, including pulse oxygen saturation (SpO_2), arterial blood gas partial pressure of oxygen (PaO_2) and partial pressure of carbon dioxide ($PaCO_2$, systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR), and respiratory rate (RR) in the perioperative period, were recorded. The anesthesia time, the operation time, and the blood loss were also recorded. A numerical rating scale (NRS) was used to evaluate pain at 6, 12, and 24 h postoperatively. An NRS was also used to assess postoperative nausea and vomiting (PONV) at 12, 24, and 48 h postoperatively. All intraoperative and postoperative complications (including anesthesia-related complications) and the total length of hospital stay, postoperative length of hospital stay, and total hospitalization costs were recorded.

Statistical analysis

SPSS 23.0 (IBM, Armonk, NY, USA) was used for data analysis. The continuous variables were described as means ± standard deviations. The continuous variables were tested using Student's t-test for those with a normal distribution or the Mann-Whitney U-test for those non-normally distributed. The categorical variables were described as numbers and percentages [n (%)]. A post hoc comparison was performed between patients who received GA and PVB (those with only rib fractures were not included). Two-sided $P < 0.05$ were considered statistically significant.

Results

Twenty patients were enrolled to undergo PVB for surgical stabilization of rib fractures. Two patients were converted to laryngeal masks. The remaining 18 patients, including three with other fractures (two with clavicular fracture and one with cervical transversus fracture), were included (Fig. 4). All displaced rib fractures were fixed, and all surgeries were successful. The average age of the 18 patients was 62 ± 10.64 years, with 8 males. The localization of fractures were lateral rib fractures ($n = 7$), anterior rib fractures ($n = 8$), and posterior rib fractures ($n = 3$) (Table 1). The three patients with posterior rib fractures also received erector spinae muscle block in addition to PVB. 1% lidocaine with a total dose of 100 mg was added to the incision site in three cases who experienced muscle contraction that affected the operation or unbearable pain.

The vital signs, including SpO_2, SBP, DBP, HR, RR, of the patients at baseline, perioperative, intraoperative, and postoperative day 1 were kept normal (Table 2). The postoperative pain (NRS) scores at 6, 12, and 24 h were 2.67 ± 1.36, 2.44 ± 0.80, and 2.33 ± 0.86, respectively, which

Table 1 Baseline characteristics

Characteristics, $n = 18$	Value
Sex	
Male	8 (44.44%)
Female	10 (55.56%)
Age (years)	57.9 (38–74), 62 ± 10.64
Side	
Right	10 (55.56%)
Left	8 (44.44%)
Localization	
Anterior	8 (44.44%)
Lateral	7 (38.89%)
Posterior	3 (16.67%)
Number of fractured ribs	3.00 ± 0.84
Pain score (numerical rating scale)	5.78 ± 1.00
American Society of Anesthesiologists grade	
I	2
II	16

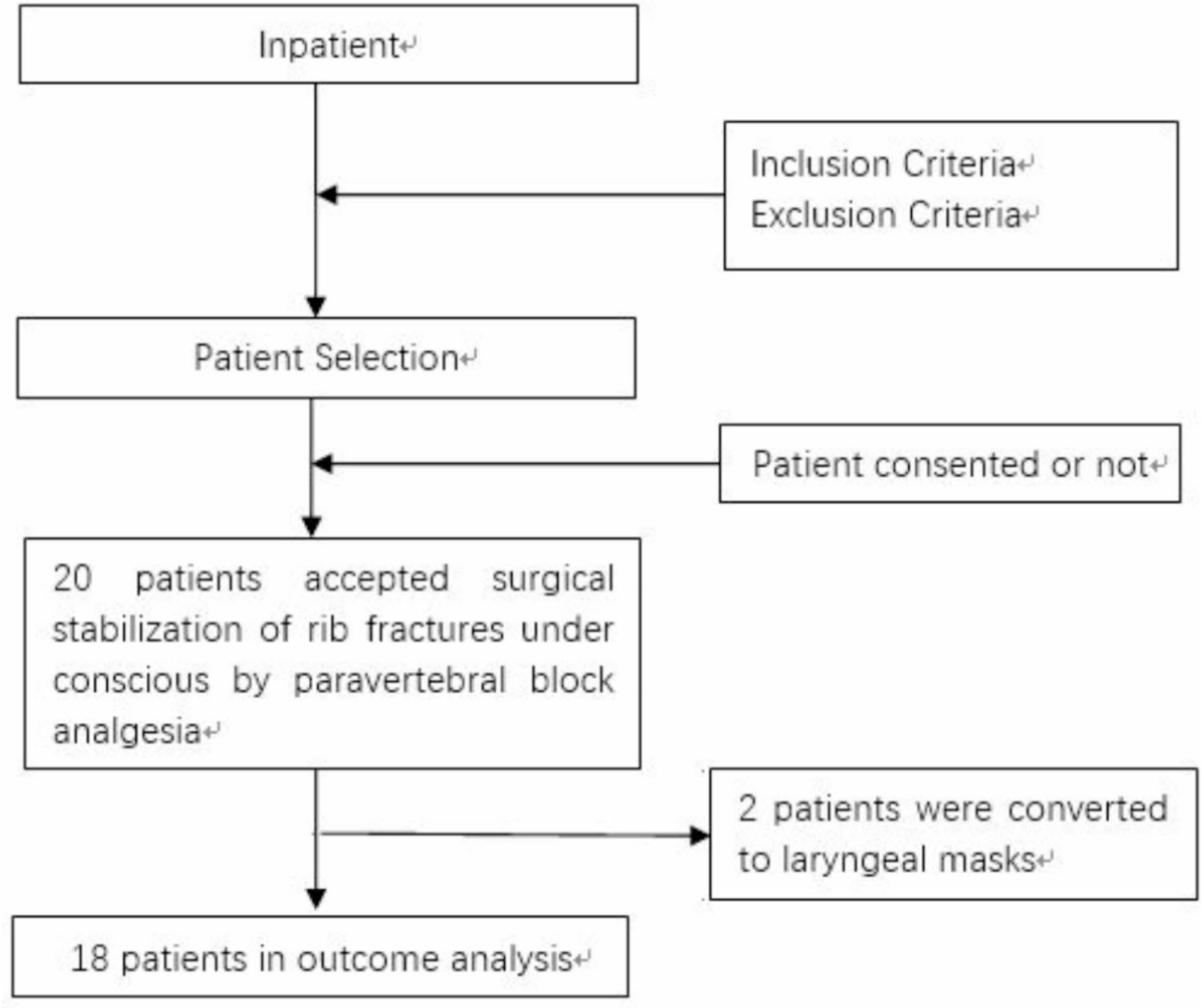

Fig. 4 Flowchart of the patients screened

were improved compared with baseline (5.78 ± 1.00). No PONV occurred (NRS scores at 6, 12, and 24 h were all 0) after the operation. The anesthesia time, operation time, blood loss during the operation, time to leave the operating room, postoperative hospital stay, and postoperative drainage volume were 57.28 ± 14.76 min, 45.94 ± 13.40 min, 46.11 ± 19.44 ml, 11.33 ± 5.38 min, 2.72 ± 1.25 days, and 84.72 ± 57.25 ml, respectively. All patients required drainage between the rib surface and the muscle space, but none required thoracic drainage. No postoperative morbidity, pulmonary infections, incision infections occurred (Table 3).

Additionally, post hoc analysis showed no significant differences in the preoperative clinical characteristics between patients who received PVB ($n = 15$) and GA ($n = 15$) or in surgical stabilization of rib fractures (all $P > 0.05$) (Table 4). Furthermore, there were no significant differences in the number of fixed rib fractures between

Table 2 Vital signs

Vital signs	Baseline	Anesthesia begins	Operation begins	During operation	Operation over	Postoperative day 1
SpO_2 (%)	97.02 ± 2.00	98.33 ± 1.75	99.67 ± 0.77	99.61 ± 0.77	99.72 ± 0.67	98.22 ± 0.94
Systolic blood pressure (mmHg)	128.78 ± 18.94	132.94 ± 14.98	124.83 ± 12.71	121.61 ± 15.98	122.17 ± 12.78	131.67 ± 10.31
Diastolic blood pressure (mmHg)	77.83 ± 12.12	80.11 ± 8.66	75.22 ± 10.56	72.17 ± 7.96	72.33 ± 9.34	77.22 ± 4.43
Heart rate (times/min)	80.94 ± 10.26	79.72 ± 11.33	75.22 ± 11.76	75.5 ± 10. 63	73 ± 9. 51	74 ± 4.91
Respiratory rate (times/min)	18.7 ± 2.23	17.0 ± 1.37	16.17 ± 1.58	15.56 ± 1.38	15.5 ± 1.04	16 ± 1.28

Table 3 Postoperative pain, PONV and safety

Outcomes	Value
Pain score (numerical rating scale, NRS)	
Baseline	5.78 ± 1.00
6 h after operation	2.67 ± 1.36
12 h after operation	2.44 ± 0.80
24 h after operation	2.33 ± 0.86
Postoperative nausea and vomiting	
12 h after operation	0
24 h after operation	0
48 h after operation	0
Time to leave operation room (min)	11.33 ± 5.38
Postoperative fasting time (h)	0
Length of postoperative hospital stay (days)	2.72 ± 1.25
Drainage (ml)	84.72 ± 57.25
Morbidity	0
Pulmonary infection	0
Incision infection	0
Anesthesia time (min)	57.28 ± 14.76
Operation time (min)	45.94 ± 13.40
Blood loss (ml)	46.11 ± 19.44

the PVB and GA groups (3.13 ± 0.74 vs. 3.67 ± 0.67, $P = 0.06$), but the anesthesia time (54.53 ± 12.59 vs. 76.13 ± 15.58 min, $P < 0.01$), operation time (44.13 ± 11.36 vs. 61.27 ± 13.64, $P < 0.01$), blood loss (42 ± 15 vs. 54 ± 7 ml, $P < 0.01$), and dosage of sufentanil (3.67 ± 3.99 vs. 26.23 ± 17.84 mg, $P < 0.01$) in the PVB group were significantly lower than in the GA group. There were no significant differences between the two groups on the first day after the operation. The postoperative comparison showed that the total length of hospital stay (5.07 ± 1.28 vs. 7.67 ± 1.91, $P < 0.01$), postoperative length of hospital stay (2.53 ± 0.64 vs. 4.80 ± 1.47, $P < 0.01$), and total hospitalization costs (31,447 ± 7142 vs. 41,925 ± 12,664 ¥, $P = 0.03$) in the PVB group were lower than in the GA group. There were no significant differences in vital signs between the two groups. It was no significant difference in the pain improvement between PVB group to GA group on the first day after surgery (3.6 ± 1.06 vs. 3 ± 0.53, $P = 0.06$) (Table 5).

Discussion

This suggested that PVB during surgical stabilization of rib fractures in the conscious state might be feasible and safety. In addition, the post hoc analysis showed that, compared with GA, surgical stabilization of rib fractures under PVB might reduce the dose of narcotics, shorten the length of hospital stay, and reduce the cost of hospitalization. These findings might help minimize the risks of anesthesia during surgical stabilization of rib fractures.

In this study, in order to ensure the anesthesia effect for the surgery of posterior rib fractures, a combination of erector spinae plane block was performed with PVB. Since there were only 3 this kind of patients and PVB was main used alone in the remaining 15 patients, it does not

Table 4 Basic characteristics (post hoc analysis)

Variables	PVB, $n = 15$	GM, $n = 15$	*P*-value
Sex			0.27
Male	6	10	
Female	9	5	
Age (years)	56.8 ± 10.75	58.4 ± 10.50	0.72
Side			0.27
Left	6	10	
Right	9	5	
Location			0.11
Anterior	6	8	
Lateral	7	2	
Posterior	2	5	
Number of fractured ribs	3.13 ± 0.74	3.67 ± 0.67	0.06
SpO_2 (%)	96.7 ± 2.03	96.2 ± 0.94	0.17
PaO_2 (mmHg)	98.7 ± 22.91	91.1 ± 5.75	0.52
$PaCO_2$ (mmHg)	44.7 ± 6.38	44.5 ± 2.73	0.95
Systolic blood pressure (mmHg)	125.27 ± 16.05	124 ± 7.68	0.93
Diastolic blood pressure (mmHg)	77.27 ± 11.23	79.8 ± 7.67	0.31
Heart rate (times/min)	81 ± 11.20	77.53 ± 7.22	0.57
Respiratory rate (times/min)	19.07 ± 1.75	18.6 ± 1.30	0.41
Pain score (numerical rating scale)	5.93 ± 0.80	6.06 ± 0.79	0.58
American Society of Anesthesiologists			0.65
I	2	4	
II	13	11	

Table 5 Post hoc analyses

Variables	PVB	GM	*P*-value
Anesthesia time (min)	54.53 ± 12.59	76.13 ± 15.58	< 0.001
Operation time (min)	44.133 ± 11.36	61.27 ± 13.64	< 0.001
Blood loss (ml)	42 ± 15.21	54 ± 6.87	< 0.001
Number of fixation	2.87 ± 0.74	3.33 ± 0.49	0.06
Dose of sufentanil citrate	3.67 ± 3.99	26.23 ± 17.84	< 0.001
Start of anesthesia			
SpO_2 (%)	98.133 ± 1.81	98.07 ± 2.94	0.53
Systolic blood pressure (mmHg)	132.07 ± 15.27	120 ± 16.37	0.08
Diastolic blood pressure (mmHg)	80.8 ± 8.27	71.4 ± 13.37	0.98
Heart rate (times/min)	79.93 ± 12.10	76.077 ± 12.62	0.57
Respiratory rate (times/min)	17.07 ± 1.44	16.73 ± 2.15	0.58
Before operation			
SpO_2(%)	99.6 ± 0.83	99.2 ± 0.86	0.13
Systolic blood pressure (mmHg)	125.8 ± 9.49	101.33 ± 9.15	< 0.01
Diastolic blood pressure (mmHg)	76.2 ± 7.97	59.07 ± 11.29	< 0.01
Heart rate (times/min)	75.87 ± 12.38	67.67 ± 9.24	0.07
Respiratory rate (times/min)	16.47 ± 1.06	8.6 ± 1.12	< 0.01
During the operation			
SpO_2(%)	99.6 ± 0.74	99.6 ± 0.74	1
Systolic blood pressure (mmHg)	121.07 ± 13.79	96.33 ± 8.55	< 0.01
Diastolic blood pressure (mmHg)	72.4 ± 7.11	57.33 ± 9.04	< 0.01
Heart rate (times/min)	76.93 ± 11.09	70.67 ± 10.33	0.15
Respiratory rate (times/min)	15.87 ± 0.83	9.53 ± 1.36	< 0.01
After the operation			
SpO_2(%)	99.67 ± 0.72	93.497 ± 23.109	0.16
Systolic blood pressure (mmHg)	122.13 ± 11.48	102.897 ± 7.54	< 0.01
Diastolic blood pressure (mmHg)	72.13 ± 9.88	59.33 ± 8.63	< 0.01
Heart rate (times/min)	73.93 ± 10.15	67.13 ± 17.92	0.39
Respiratory rate (times/min)	15.67 ± 0.72	9.6 ± 1.12	< 0.01
Postoperative day 1			
SpO_2 (%)	98.20 ± 0.94	97.74 ± 1.63	0.47
Systolic blood pressure (mmHg)	131.13 ± 8.18	120 ± 16.96	0.07
Diastolic blood pressure (mmHg)	76.53 ± 4.27	74.27 ± 11.84	0.13
Heart rate (times/min)	73.73 ± 5.02	75.4 ± 10.46	0.79
Respiratory rate (times/min)	16 ± 1.36	19.73 ± 5.51	0.11
NRS changes (preoperative - postoperative day 1)	3.6 ± 1.06	3 ± 0.53	0.06
Total days in hospital (days)	5.07 ± 1.28	7.67 ± 1.91	< 0.01
Length of postoperative hospital stay (days)	2.53 ± 0.64	4.8 ± 1.47	< 0.01
Total drainage (ml)	78.33 ± 56.27	146.33 ± 79.54	0.02
Total costs (¥)	31,447.90 ± 7142.33	41,925.3 ± 12,664.37	0.03
At discharge			
SpO_2 (%)	97.53 ± 1.30	97.33 ± 2.32	0.95
Systolic blood pressure (mmHg)	133.47 ± 21.70	142 ± 19.73	0.25
Diastolic blood pressure (mmHg)	81.73 ± 12.01	84.93 ± 7.95	0.47
Heart rate (times/min)	68.13 ± 11.16	76.27 ± 12.76	0.09
Respiratory rate (times/min)	18.2 ± 2.04	20.6 ± 4.53	0.21

affect the conclusion of this study. The authors previously reported the successful use of PVB with a laryngeal mask for surgical stabilization of rib fractures [26]. Still, whether surgical stabilization of rib fractures can be performed in the conscious state using PVB without a laryngeal mask has yet to be confirmed. The main concern was that sufficient analgesia was required to control the pain from exposure to the rib fracture during operation and avoid serious respiratory complications. Traditionally, PVB was used only as an adjuvant for local analgesia after GA. It produces ipsilateral somatosensory and sympathetic blocks, which are effective for anesthesia as well

as for the management of pain originating from a unilateral point of the chest and abdomen, but with fewer side effects (e.g., urinary retention and hypotension) compared with thoracic epidural block [27]. Thoracic PVB, under a conscious state or moderate sedation, has been used in operation for the mammary gland [28], stomach [29], and kidneys [23]. This study is the first to report the application of PVB in patients undergoing surgical stabilization of rib fractures while conscious or under moderate sedation.

The main concern with PVB in the conscious state is the conversion to intubation or laryngeal mask, which occurred in two patients in the present study. These low rates can be attributed to multiple factors. First, previous reports showed that patients with a high BMI had higher conversion rates during the operation [30], but patients with a high BMI were excluded. Second, the patients with lung contusion, pneumothorax, or hemothorax were excluded. Third, operation started 30–60 min after the nerve block to prevent the loss of analgesia with time. Concurrently, depending on the degree of pain and the ECG monitoring indicators, small doses of sufentanil citrate were administered to enhance the analgesic effect if necessary.

Whether sedative drugs should be used during anesthesia without intubation is uncertain. Long surgical procedures are more likely to require sedative agents due to the need to maintain the patient in a fixed position for a long period, as well as the need to avoid the influence of anxiety on respiratory movement. Considering the respiratory inhibitory effects of these drugs, intraoperative monitoring of indicators, such as the respiratory rate, should be conducted. The safety and efficacy of dexmedetomidine in other types of thoracic operation have been confirmed [31, 32]. In this study, 12/18 of the patients were given sedative drugs (dexmedetomidine or midazolam) intraoperatively with no anesthesia-associated adverse events. Furthermore, large doses of sedative drugs were not required since the mean operative time was only 45.94 min.

As patients were in a conscious state, they recovered to the supine position independently after the completion of operation. Furthermore, as there was no endotracheal intubation, the patients had shorter stays in the anesthesia recovery room, as previously shown [33]. These patients returned to the ward earlier than those under GA. Intravenous GA is associated with PONV [34], but as no intravenous anesthetic was used in the present study, none of the patients in the PVB group experienced PONV, nor were there any reports of sore throat or hoarseness since no laryngeal mask was used, which is known to have a potential for throat injury [25]. Furthermore, although there are significant differences of the vital signs, especially of blood pressure and respiratory rate, due to the inhibitory effect of anesthetic drugs on respiration and circulation, no serious complications, such as death, fever, incision infection, or pulmonary infection, occurred. However, as the anesthetic wears off after surgery, comparing the differences between the patient's vital signs, clinical manifestations, and other research indicators after surgery still has certain clinical values. We found through the comparison between the PVB group and the GA group that for suitable cases, using our anesthesia method can achieve surgical effects equivalent to general anesthesia (similar number of fracture fixation and pain relief), while avoiding nausea and vomiting caused by general anesthesia drugs and throat discomfort caused by tracheal intubation.

The use of PVB or TEA combined with other block anesthesia methods for thoracoscopic lung surgery has been reported in clinical practice [35], and studies have shown that PVB has the advantage of fewer side effects compared to TEA [36]. However, although this type of surgery uses tubeless (such as large mesh mask airway, or nasal cannula ventilation or facial mask ventilation), a certain dose of general anesthesia drugs is still required to maintain a certain degree of patient sedation, and BIS is also needed to check the depth of anesthesia to prevent excessive anesthesia and prevent accidents. And our study mainly focuses on SSRF performed using PVB method while maintaining the patient's consciousness state. Oxygen supply is only provided through nasal cannula, achieving true tubelessness and reducing the dosage of general anesthesia drugs. Future research needs to be based on PVB combined with one or more anesthesia methods, such as incision infiltration, anterior serratus block anesthesia, intercostal nerve block anesthesia, and erector spinae plane block for SSRF according to the patient–s rib fracture condition, in order to cover a wider range of surgical procedures.

There are some limitations to this study. First, it was a small pilot clinical trial, and future studies involving larger cohorts are warranted to assess the advantages and disadvantages of this technique comprehensively. Second, due to limitations of the maximum drug dose, the thoracic paravertebral nerve was only blocked at two segments. The single-dose injection was used to avoid repeated punctures, reducing the risk of pneumothorax or other incidents. Third, because of limitations to the scope of the PVB, the maximum number of rib fractures was five consecutive ribs. Fourth, each site of rib fracture was closely distributed. Finally, patients with multiple injuries were not included in this study due to the infancy of the technique applied.

Conclusions

This pilot study suggests that surgical stabilization of rib fractures under PVB in the conscious state is feasible. It can significantly improve the surgical experience of the patients by avoiding side effects associated with endotracheal intubation and intravenous anesthesia drugs. This technique may represent a novel enhanced recovery after operation protocol for rib fracture operations.

Abbreviations

PVB	Paravertebral block
MRF	Multiple rib fractures
PONV	Pain and nausea and vomiting
GA	General anesthesia
NRS	Numerical rating scale
CT	Computed tomography
SBP	Systolic blood pressure
DBP	Diastolic blood pressure
HR	Heart rate
RR	Respiratory rate
BIS	Bispectral Index

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13019-025-03397-8.

Supplementary Material 1

Supplementary Material 2

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Not applicable.

Author contributions

Weiming Wu and Yi Yang carried out the studies and its design. Weiming Wu and Xiaoyun Gao collecting data, performed the statistical analysis and drafted the manuscript. Weigang Zhao and Penghao Liu participated in acquisition, analysis, or interpretation of data and draft the manuscript. All authors read and approved the final manuscript.

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Data availability

All data generated or analyzed during this study are included in this published article [and its supplementary information files].

Declarations

Ethics approval and consent to participate

The study was approved by the Ethics Committee of Shanghai Sixth People's Hospital Affiliated to Shanghai Jiao Tong University School of Medicine (approval #2020-036-(1)). Witten informed consent were obtained from patients or their legal guardians. Clinical registration: www.clinicaltrials.gov (#NCT04536311). I confirm that all methods were performed in accordance with the relevant guidelines. All procedures were performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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