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Randomized Controlled Trial

Erector Spinae Plane Block Provided Comparable Analgesia as Thoracic Paravertebral Block Post Pediatric Nuss Procedure for Pectus Excavatum: A Randomized Controlled Trial

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Background: Thoracic paravertebral block (TPVB) is frequently used to treat pain following a pediatric Nuss procedure but is associated with various undesirable risks. The erector spinae plane block (ESPB) also provides postoperative analgesia, which is purported to be easier to administer and has a favorable safety profile. However, it remains unknown whether ESPB provides analgesia comparable to the TPVB technique post pediatric Nuss procedure.

Objective: This study aimed to compare the analgesic effects of ultrasound-guided ESPB and TPVB in children undergoing the Nuss procedure.

Study Design: A prospective, randomized, noninferiority trial.

Setting: A university hospital in the People's Republic of China.

Methods: A total of 68 children aged 4 to 18 scheduled for the Nuss procedure were enrolled in the study. They were randomly assigned to receive a single-injection ultrasound-guided bilateral T5-level ESPB or TPVB with 0.5 mL/kg of 0.25% ropivacaine post anesthesia induction. All patients received postprocedure multimodal analgesia. The primary outcomes were pain scores at rest and 24 hours postprocedure. The secondary outcomes included total rescue morphine milligram equivalents, emergence agitation, chronic postprocedure pain, and side effects.

Results: The median difference in pain scores at rest 24 hours postprocedure was 0 (95% CI, 0 to 1), demonstrating the noninferiority of ESPB to TPVB. In addition, the difference in oral morphine milligram equivalents at 24 hours postprocedure was -4.9 (95% CI, -16.7 to 7.9) with the ESPB group consuming median (interquartile range) 37.7 mg (12–53.2) vs 36.9 mg (23.9–58.1) for the TPVB group. We concluded that the non-inferiority of ESPB with regard to opioid consumption as the 95% CI upper limit of 7.9, which was within the predefined margin of 10. We found no significant differences in pain scores at rest or during coughing, incidences of chronic postoperative pain, emergence agitation, or side effects.

Limitations: We did not evaluate the effect of analgesic protocols on patient-centric outcomes, such as resuming functional status and emotional wellbeing. Also, the sample size is small to some extent.

Conclusions: Preoperative ESPB, when combined with multimodal analgesia, was noninferior in analgesic effect compared with TPVB in terms of pain scores and opioid consumption in pediatric patients undergoing the Nuss procedure.

Key words: erector spinae plane block, thoracic paravertebral block, pectus excavatum, pain management

Trial registration: ClinicalTrials.gov (NCT05034601)

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Pectus excavatum, also known as sunken chest, is a relatively common congenital chest wall deformity in children (1). At present, the Nuss procedure is the most widely used minimally invasive repair for pectus excavatum. In this procedure a stainless steel bar or bars are placed under the sternum under thorascopic guidance to reform the chest wall's depression (2). The procedure can cause substantial and prolonged postoperative pain because of the traction and detachment of intercostal muscles during surgery, as well as the stretching and compression of the chest wall (3). Pain management for these patients generally depends on standard institutional practices rather than standardized treatment regimens, as there is currently no consensus on the optimal approach for pain management (4).

The majority of pain management strategies for the Nuss procedure utilize multimodal analgesia (3,5) which is associated with improved analgesia, fewer adverse effects, and fewer complications. Although epidural analgesia is considered the gold standard for postoperative pain management, it is not without risks and failures (6). Another common analgesic strategy is perioperative thoracic paravertebral block (TPVB) (7), but this involves the risk of puncturing adjacent structures, leading to pneumothorax or vascular or neural tissue injury (8). A more recent alternative has emerged: erector spinae plane block (ESPB), in which local anesthetics are injected beneath the iliocostalis, longissimus, and spinalis muscles in order to block the spinal nerve branches (9). ESPB is less invasive and simpler to perform than TPVB; it provides adequate analgesia and a low complication rate and has been successful in children undergoing thoracotomy (10).

However, it remains unclear if the benefits associated with ESPB would persist in the setting of a robust multimodal analgesic regimen after Nuss repair for pectus excavatum. Herein, this randomized noninferiority study was designed to rigorously assess whether ESPB can provide analgesia comparable to that of TPVB in children undergoing the Nuss procedure.

Methods

Patients and Study Design

Our study follows the Consolidated Standards of Reporting Trials (CONSORT) Guidelines (11). The study protocol was approved by the local Ethics Committee (2021866) and registered at ClinicalTrials.gov (NCT05034601). Children 4–18 years old who were scheduled to undergo elective Nuss surgery from September 25, 2021 through March 23, 2023 were prospectively recruited into the study. Patients were not enrolled if they had coagulation dysfunction, allergies to the study drugs, or an infection that was systemic or local at the site of injection. Patients were also excluded if they did not understand Chinese Mandarin. Informed written consent was obtained from the legal guardians of all study patients before enrolment.

Randomization and Blinding

The children were allocated 1:1 into either the ESPB or TPVB group using random numbers generated in IBM SPSS Statistics 25.0 (IBM Corporation). One investigator, who was blinded to the study design, prepared sealed, opaque envelopes containing the random numbers. On the morning of surgery, another investigator opened the sealed envelopes and, based on the number shown, allocated patients to either the ESPB or TPVB group. Patients and their parents were blinded to their allocation. One anesthesiologist prepared the local anesthetics and performed all nerve blocks in this study. The procedure was performed by a surgeon blinded to group allocation. Investigators who did the postprocedure follow-up, or who analyzed the data, were also blinded to group allocation.

Anesthesia

The procedure was conducted under general anesthesia. After oxygen inhalation, the following anesthetics were administered intravenously: midazolam (0.05 mg/kg), fentanyl (3 μg/kg), propofol (2.5 mg/kg), and cisatracurium (0.2 mg/kg). Patients were then intubated and given inhaled sevoflurane at 1–1.5 minimum alveolar concentration. During the procedure, remifentanil was continuously administered intravenously at doses ranging from 0.1 to 0.3 μg/kg/min in order to provide intraoperative analgesia and maintain hemodynamic parameters within 20% of baseline levels. At 20 minutes before the end of surgery, hydromorphone (10 μg/kg) was administered intravenously to prevent postoperative pain, along with ondansetron hydrochloride (0.1 mg/kg) intravenously to prevent postoperative nausea and vomiting.

Regional Anesthesia

After anesthesia induction, ultrasound-guided TPVB or ESPB was performed with patients in the lateral decubitus position. In the TPVB group, the vertebrae, spinous and transverse processes at vertebral

level T5, and the paravertebral space at the same level were identified using a 6 to 12 MHz linear ultrasound probe (Anesus M9, Mindray Bio-Medical Electronics). A nerve block needle (21G, 50 mm [UniPlex Nanoline]) was inserted into the paravertebral space (Fig. 1a). After perforating the costotransverse ligament, 0.25% ropivacaine (0.5 mL/kg) was injected in 5-mL doses after negative aspiration. Proper distribution of local anesthetics into the paravertebral area was visible as anterior migration of the pleura. The same procedure was applied on the contralateral side.

ESPB was performed as described by Forero, et al (Fig. 1b) (12). The probe was positioned longitudinally over the transverse T5 process. After identifying the interfascial plane beneath the iliocostalis, longissimus, spinalis, trapezius, and rhomboid muscles, a nerve block needle (21G, 50 mm [UniPlex Nanoline] was inserted into the tissue via an in-plane approach in a caudocephalad direction until it contacted the transverse process. Careful saline hydrodissection was used to ensure that the tip was in the correct position, and then a bolus of 0.25% ropivacaine (0.5 mL/kg) was injected into the fascial layer. The same procedure was applied on the contralateral side.

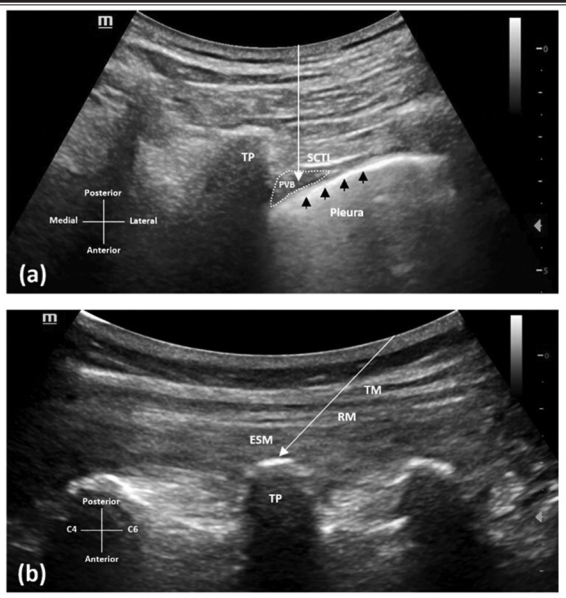

Fig. 1. *Examples of ultrasound guidance for (a) paravertebral nerve block or (b) erector spinae plane block in this study. White arrows indicate the needle tip location; black arrows, the pleura; and the dotted line, the area subject to paravertebral blockade.*
ESM, erector spinae muscle; PVB, paravertebral blockade; RM, rhomboid muscle; SCTL, superior costotransverse ligament; TM, trapezius muscle; TP, transverse process.

Multimodal Postoperative Analgesia

At 30 minutes before the end of the procedure, a patient-controlled analgesia pump was implanted. The pump was programmed to deliver sufentanil (4 µg/kg) and granisetron (0.2 mg/kg) in saline continuously at 1 mL/hr, and as a 0.5-mL bolus upon patient activation, with a lockout interval of 15 minutes and maximum dosing of 4 mL/hr). In addition, patients received acetaminophen (15 mg/kg) orally 4 times per day, corresponding to a maximum dose of 2 grams per 24 hours. They could also receive supplemental opioids, if necessary, either by direct injection or via the patient-controlled pump. The total postoperative intravenous and oral opioids were converted to oral morphine milligram equivalents for analysis (13).

Outcomes

The primary outcome of our study was the pain score during rest at 24 hours postprocedure, with scores determined by the Numeric rating Scale (NRS-11) from 0 to 10 points. The study also examined the following secondary outcomes: total rescue morphine milligram equivalents at 24 and 48 hours postprocedure; pain score at rest or during coughing at 3, 6, 12, 24, and 48 hours postprocedure; emergence agitation at 5, 15, and 30 minutes postextubation; total intraprocedure dose of sufentanil and remifentanil; time to first analgesia request; time until first mobilization; block-related adverse events such as infection at the injection site, pneumothorax, vascular puncture, local anesthetic toxicity, as well as postprocedure nausea and vomiting; and chronic pain at 3 months postprocedure, as assessed by telephone or during an outpatient visit using the Brief Pain Inventory (14).

Sample Size Calculation

A pilot study with 12 patients, who were not included in the full study, showed that mean pain scores during rest at 24 hours postprocedure were 2.8 in the ESPB group and 2.3 in the TPVB group. We defined an acceptable noninferiority margin as 1.3 according to previously published data (15). We calculated a minimum sample size of 18 patients in each group with a one-sided α level of 0.025 and a power of 80% to detect noninferiority in pain. The sample size was then powered to 90%, thus, 68 patients were required, with an anticipated dropout rate of 20% and a puncture failure rate of 10%. PASS 11.0 software

(NCSS Statistical Software) was used to calculate the sample size.

Statistical Analysis

For the noninferiority evaluation, we calculated the 95% CI of the median differences in NRS-11 scores using the Hodges-Lehman estimator (16,17). If the upper bound of the one-sided 95% CI was smaller than 1.3 (based on ESPB minus TPVB), we planned to conclude that the ESPB was noninferior to the TPVB in terms of the NRS-11 scores. Additionally, the noninferiority of ESPB with regard to opioid consumption was similarly tested by comparing the limits of a 95% CI to a predefined noninferiority margin of 10 mg oral morphine milligram equivalents (18).

Data for secondary outcomes were assessed for normal or skewed distribution using histograms and quantile-quantile plots. Normally distributed data were expressed as means and SDs, while skewed data were presented as median and interquartile range. Intergroup differences were assessed for significance using Student's t test if the data were normally distributed; otherwise, differences were assessed using Pearson's χ^2 test or Fisher's exact probabilities test. Differences in nonparametric data were assessed using the Mann-Whitney U test. All statistical analyses were performed using IBM SPSS Statistics 26.0 (IBM Corporation). Differences were considered statistically significant if they were associated with a P value < 0.05.

Results

It was initially expected that patients could be included within one year, but the process was postponed to March 2023 because of the COVID-19 pandemic. Of the 85 patients screened for eligibility, one did not satisfy the inclusion criteria and 16 declined to participate. Accordingly, a total of 68 patients were included in the study; the flowchart is detailed in Fig. 2. All patients completed a 3-month follow-up, either on an outpatient basis or by telephone. Demographic data and surgical data were comparable between the 2 groups (Table 1).

The difference in median pain scores at rest at 24 hours postprocedure was 0 (95% CI, 0 to 1), which was lower than the prespecified limit for noninferiority, $\Delta = 1.3$ (Fig. 3). These results indicate that, under the trial conditions, ESPB was noninferior to TPVB on the primary outcome.

The patients who received ESPB consumed more opioids (37.7 mg [12–53.2 mg]) vs the TPVB group (36.9 mg [23.9-58.1 mg] at 24 hours postprocedure. However, the difference in morphine milligram equivalents was -4.9 (95% CI, -16.7 to 7.9) (based on ESPB minus TPVB); the upper limit of the 95% CI for this difference was 7.9, which was within the predefined noninferiority margin of 10 (Fig. 4).

There were minimal differences between the 2 treatment groups in other outcomes; these also did not reach statistical significance (Table 2), including emergence agitation in the postanesthesia care unit, total morphine milligram equivalents at 24 or 48 hours postprocedure, NRS-11 scores at rest or during coughing at 3–48 hours postprocedure (Fig. 5), the time of the first postoperative analgesia request, or the time of first ambulation.

All blocks were successfully completed under ultrasonography. No obvious complications, such as bleeding at the puncture site or intravascular injection, were observed. Postprocedure complications did not differ significantly between the groups. One patient in the TPVB group suffered pneumothorax, and one patient in each group suffered plate migration after discharge. The incidence of chronic postprocedure pain was also similar between the 2 groups.

Discussion

This randomized, noninferiority study provided evidence that ultrasound-guided ESPB at the T5 level can provide analgesia comparable to that of TPVB after pediatric Nuss surgery. Thus, ESPB may be a safe and effective alternative to TPVB that offers the advantages of being easier to perform with a lower risk of tissue damage. These ESPB advantages led us to design this noninferiority study rather than explore whether it provides superior analgesia to TPVB. To our knowledge, this is the first trial to compare ESPB with TPVB for postoperative analgesia in pediatric Nuss operations.

A previous case report showed that adult patients with complex medical histories of pectus excavatum repair obtain benefit from bilateral ESPB when thoracic epidural placement was either contraindicated or unsuccessful (19). Our study adds to a growing body of literature demonstrating decreased opioid use and lower pain scores when bilateral ESPB is performed as part of a perioperative analgesic regimen; this is consist with other studies that showed promising analgesic effects of ESPB in pediatric Nuss procedures (20). The analgesic effectiveness of the 2 blocks were statistically comparable in our investigation; either nerve block led to median scores that were never higher than 4 on an

11-point NRS-11 scale from 3 to 48 hours postprocedure. In addition, the two nerve blocks were associated with similar total morphine milligram equivalents at 24 and 48 hours. This was in accordance with the result of other studies in adults that found ESPB to be noninferior to TPVB for providing analgesia post thoracoscopic surgery (21,22).

At the same time, we also noted that ESPB was inferior to TPVB in terms of pain score and analgesic rescue consumption in some other noninferiority trials (23). One might acknowledge weaker analgesia with ESPB since local anesthetic indirectly spreads from the erector spinae plane rather than being directly deposited into the paravertebral space.

There is fierce debate on the extent of ESPB spread. Adhikary, et al (9) reported solution distribution into the paravertebral space and epidural space, whereas Ivanusic, et al (24) reported that almost no solution reached the paravertebral space. However, due to the anatomical and physiological differences between adult and pediatric populations, it is inappropriate to extrapolate data from an adult sample to a pediatric population. Pediatric cadaveric anatomy evidence indicates that local anesthetic can anteriorly, through the intertransverse connective tissue, spread into the thoracic paravertebral space and intercostal spaces in neonates and children (25), with some studies suggesting that epidural diffusion is also possible (26). Many characteristics of the deep fascia may influence the extent of injectate spread and the clinical effectiveness of fascial plane blocks. A thicker aponeurotic fascial plane may represent a greater physical barrier to local anesthetic diffusion, and a thin epimysial fascial layer might make diffusion easier (27). The more elastic pediatric spine, coupled with the less dense ligaments and cartilaginous laminae, could allow a local anesthetic to have a more favorable spread in infants (28). Greater spread causes wider anesthetic coverage and also is more clinically effective. We speculated this may be the reason for the better analgesia of ESPB in pediatric surgery.

The results from our study suggest noninferiority for ESPB with regard to opioid consumption, since the 95% CI upper limit of 7.9 was less than a minimal clinically important difference (10 mg). Besides, we found a tendency, albeit nonsignificant, toward a higher morphine milligram equivalent consumption at 24 hours

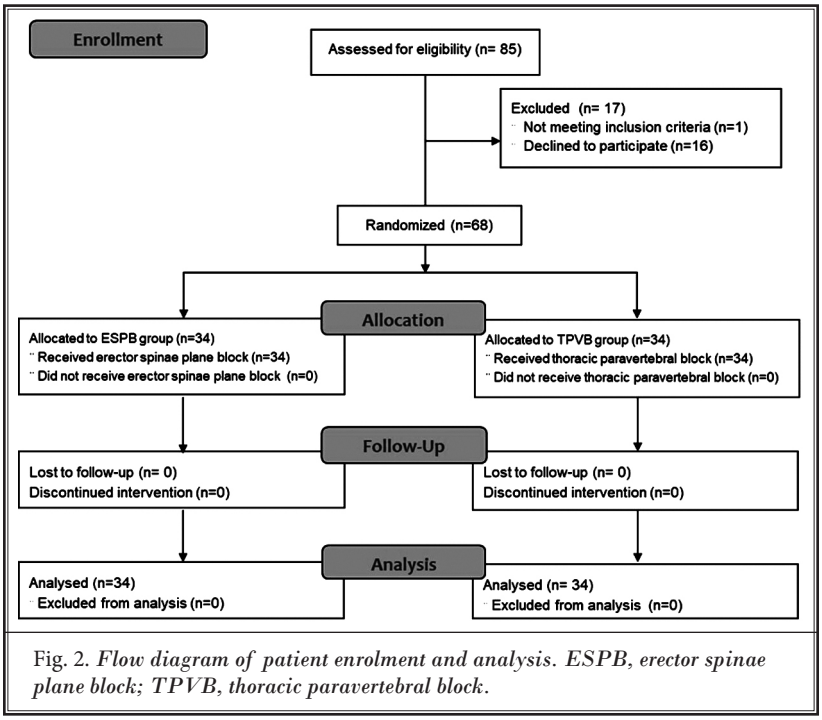

Fig. 2. *Flow diagram of patient enrolment and analysis. ESPB, erector spinae plane block; TPVB, thoracic paravertebral block.*

Table 1. *Baseline characteristics of the study patients.*

	Group ESPB n = 34	Group TPVB n = 34	*P* value
Age, y	11.7 ± 3.9	11.2 ± 3.2	0.613
Weight, kg	40.7 ± 13.3	38.2 ± 13.4	0.381
Gender, boys	29 (85%)	25 (74%)	0.369
Height, cm	154.5 (146.3–169.3)	155 (131–167.8)	0.585
BMI, kg/m^2	16.6 ± 3.2	16.1 ± 2.0	0.056
ASA physical status I II III	 2 (6%) 32 (94%) 0 (0%)	 1 (3%) 31 (91%) 2 (6%)	0.614
Duration of anesthesia, min	142 (112.3–159)	145.1 (103.5–163)	0.783
Duration of operation, min	55.5 (39.8–96.3)	58.0 (45–96.3)	0.492
Recovery room, h	0.9 (0.6–1.2)	1.0 (0.7–1.3)	0.791
Extubation time, min	12 (6.8–20)	10 (7–15.8)	0.658

Values are mean ± SD, number (proportion) or median (interquartile range). ESPB, erector spinae plane; TPVB, thoracic paravertebral block; BMI, body mass index; ASA, American Society of Anesthesiologists

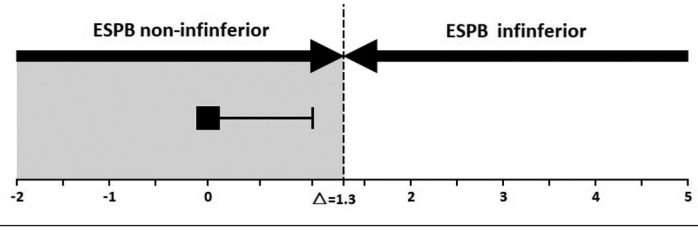

Fig. 3. *Noninferiority plot for difference in median resting pain score between the ESPB and TPVB groups at 24 hours postprocedure. Dashed lines indicate a noninferiority margin (△) of 1.3. Block indicates differences in median 24-hour resting pain scores and error bars indicate 95% CIs for differences between groups. Grey area indicates zone of oninferiority.*
ESPB: erector spinae plane block; TPVB: thoracic paravertebral block.

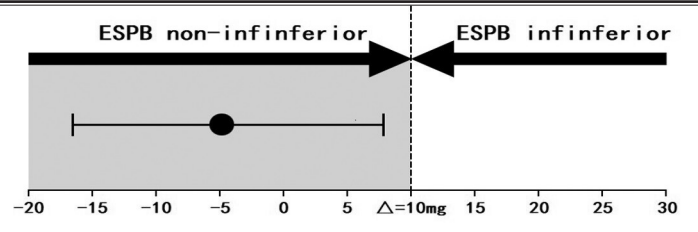

Fig. 4. *Noninferiority plot for difference in median oral morphine milligram equivalents between the ESPB and TPVB groups at 24 hours postprocedure. Dashed lines indicate a noninferiority margin (△) of 10 mg. Block indicates differences in median 24 hour morphine milligram equivalent consumption and error bars indicate 95% CIs for differences between groups. Grey area indicates zone of noninferiority.*
ESPB: erector spinae plane block; TPVB: thoracic paravertebral block.

in the ESPB group. Of note, the large width of the confidence intervals for morphine milligram equivalent consumption in the ESPB group translates to high variability in analgesia capacity of ESPB in our study.

It is difficult to confirm whether nerve blocks were performed after general anesthesia for safety and comfort, so we did not assess the loss of cutaneous sensation as part of our measurements. In a study of volunteers aged > 18 years, cutaneous loss of sensation after ESPB also showed highly variable results (29). This might have been caused by local anesthetic diffusion after interfascial block, which varies with patient position, anatomical variations, and pressure on the compartment as a result of muscle tone (30). In our study, all pediatric patients were mechanically ventilated in the lateral decubitus position, with all blocks performed by the same anesthesiologist at the same level. Even so, postoperative morphine milligram equivalent consumption varied considerably. This corresponds with the results from healthy volunteers. Thus, future research is required to investigate the diffusion of local anesthesia after ESPB in pediatric patients, as well as further exploring how to achieve better analgesic efficacy with ESPB.

One patient in the TPVB group developed a pneumothorax on the first day postprocedure; his symptoms improved after closed thoracic drainage. It was noted that the pneumothorax in this patient did not develop until several hours after the block, meaning that we cannot exclude a surgical cause. Although it is an effective technique for achieving adequate postoperative analgesia, many clinicians hesitate to use TPVB because of the close proximity of the paravertebral space to the pleura.

We also conducted a questionnaire survey for anesthesiologists consisting of simple questions about stress during TPVB operations (Supplementary Text 1). Two-thirds of them reported experiencing stress during TPVB, mainly related to the inability to obtain clear positioning and concerns about complications. Conversely, ESPB in neonates and adolescents appears to be exceptionally safe in terms of ease and speed of administration (almost 80% took 10 minutes or less), has a fast learning curve, and thus may be more accessible to a wider range of anesthesia providers (31,32). Per our literature review, nearly 300 children who received ESPB developed no complications (32). Despite all this, the benefits of regional anesthesia for pediatric surgery must be carefully weighed against the potential risks, particularly as these blocks are generally performed on anesthetized children.

Emergence agitation is a common phenomenon in children recovering from general anesthesia. An emergence agitation reaction increases the risk of injuring the surgical repair and the caregivers (33). Possible causes include rapid awakening in unfamiliar settings, pain, etc. The 2 types of nerve block in our study were associated with a nearly average rate of emergence agitation of 18%–21%, which is similar to that of children undergoing thoracoscopic surgery involving paravertebral nerve block (17.2%), but lower than that of children undergoing thoracoscopic surgery involving only general anesthesia (41.4%) (34). These comparisons suggest the clinical value of regional blocks for preventing emergence agitation.

Table 2. *Comparison of secondary outcomes between patients who received erector spinae plane or thoracic paravertebral block*

	Group ESPB n = 34	Group TPVB n = 34	*P* value
Oral morphine equivalents 24-48 h; mg	19.3 (5.8-42.4)	23.3 (14.2-39.8)	0.270
Total intraoperatively sufentanil dosage; ug.kg-1	0.5 (0.4-0.6)	0.5 (0.5-0.6)	0.469
Total intraoperatively remifentanil dosage; ug.kg-1	9.6 (6.8-16.9)	9.9 (6.5-16)	0.898
Time to first analgesic; h	1.5 (1-2)	2 (1-3)	0.251
Time to first mobilization; h	14.5 (8.8-16.5)	14 (7.8-19)	0.971
Emergence agitation	7 (21%)	6 (18%)	0.758
Postoperative nausea and vomiting	5 (19%)	6 (22%)	0.742
Chronic postoperative pain at 3 months	12 (35%)	14 (41%)	0.618
Hospital stays; days	7 (6-9)	7 (7-8)	0.698
Postoperative complications	0	1 (3%)	-

Values are number (proportion) or median (interquartile range).
ESPB, erector spinae plane; TPVB, thoracic paravertebral block

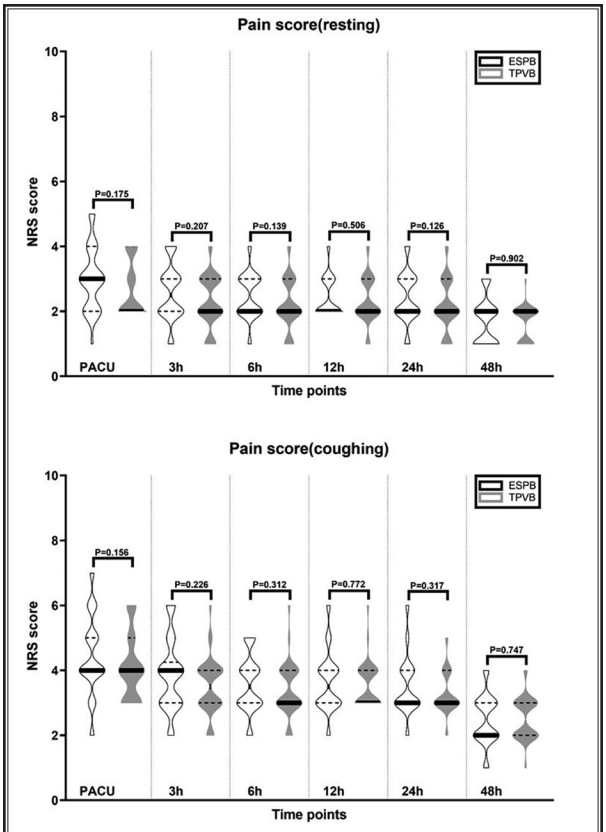

Fig. 5. *Comparison of pain scores at rest (a) or during coughing (b) between patients who received ESPB or TPVB. Scores were assigned by patients on the Numeric Rating Scale from 0 to 10. In these violin plots, thick lines indicate the median; dotted lines, the interquartile range. PACU, postanesthesia care unit.*

Pectus excavatum repair is associated with a prolonged and painful recovery, while experiences of pain during childhood might increase the pain response during subsequent procedures (6). Therefore, the quality of long-term pain management after the Nuss procedure seems to be a key issue, especially in children. The 2 treatments in our study are associated with a similarly high rate of chronic postprocedure pain of 35%–41%. This high incidence of chronic pain attests to the challenge of long-term pain management for children undergoing Nuss surgery, which can reduce quality of life and the satisfaction of patients and their parents (35). Further research is urgently needed to improve long-term postoperative analgesia.

Limitations

While this is the first report of its kind, several potential limitations of this study should be acknowledged. First, pain after the Nuss procedure was highly variable in our study patients. This was determined by several factors, such as deformity severity and patient age (36,37). Although we attempted to conduct subgroups analyses by comparing the analgesic effectiveness of young children or adolescents, these data are not comprehensive given the relatively small share of children under 10 years of age. Second, our study investigated pediatric patients after undergoing the Nuss procedure; it offers a first look at the possibilities of ESPB for this population. However, because of the low incidence of block related complications and relatively small sample size, we are aware that our study was not powered by evaluating safety endpoints, even though there were no serious block-related complications in either group. Finally, our study was aimed at optimizing postoperative pain management, so we focused primarily on pain-related measure of outcomes. Future trials would benefit from a larger sample size to evaluate the effect of analgesic protocols on patient-centric outcomes such as the resumption of functional status, as well as emotional wellbeing, quality of life, and reduced hospital stay.

Conclusion

As a preliminary study, our findings proved the safety and feasibility of ESPB after pediatric Nuss surgery. The current evidence suggests that the analgesia provided by ESPB, combined with multimodal analgesia, is noninferior to that provided by TPVB. However, the analgesic efficacy and safety of ESPB as a potential low-risk alternative to TPVB warrant a larger and more comprehensive evaluation, especially in the pediatric population.

Author Contributions

Jing Yang had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Concept and design: Min Xu, Guangchao Zhang, and Jing Yang.

Acquisition, analysis of data: Guangchao Zhang, Rui Wang, Yong Liu, Bin Du.

Drafting of the manuscript: Min Xu, Jing Yang, and Rui Wang.

Critical revision of the manuscript for important intellectual content: All authors.

Statistical analysis: Guangchao Zhang and Min Xu.

Obtained funding: Jing Yang.

Administrative, technical, or material support: Jing Yang, and Bin Du.

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Supplemental material is available at www.painphysicianjournal.com

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Supplementary Text 1.

Dear Participants,

We sincerely invite you to participate in this study entitled ‘The attitudes of anesthesiologists toward ultrasound-guided thoracic paravertebral block’. This study aimed to investigate the current operating stress, and the attitudes towards the thoracic paravertebral block among medical staff in the anesthesiology department.

The questionnaire contains about 11 questions and it takes 2 to 3 minutes to complete. This study is conducted online anonymously without obtaining any personally identifiable information. Data from this study will eventually be reported in academic journals.

You are entirely voluntary to take part in this survey and you have the right to refuse and terminate the investigation at any time for any reason. We would respect your choices if you are reluctant to participate. Please fill out the questionnaire according to your real conditions to ensure that the data are reliable.

Thank you for your assistance.

1. Your gender is
   - □ Male
   - □ Female
2. You are___years old.
3. What is your educational background?
   - □ College
   - □ Bachelor
   - □ Master
   - □ Doctor
4. What is your academic rank?
   - □ Primary title
   - □ Middle title
   - □ High title
5. Would you prefer to implement multimodal analgesia with paravertebral block as the core for patients?
   - □ Yes
   - □ No
6. What concerns prevent you from considering implementing TPVB for patients?
   - □ Inability to obtain clear positioning under ultrasound guidance
   - □ Concerns about complications
   - □ Concerns about analgesic efficacy
   - □ Worried about prolonged operation time affecting patients' turnover

7. How many times do you perform paravertebral block independently each year?
   - □ □20 times
   - □ 20-50 times
   - □ □50 times
8. Do you experience stress when performing ultrasound-guided thoracic paravertebral block independently?
   - □ Yes
   - □ No
9. If you have indeed experienced stress, what is the rating for stress? (0-10 /10 points, with 10 being the greatest pressure and 0 representing no pressure)

0	1	2	3	4	5	6	7	8	9	10

10. Have you ever experienced complications or adverse reactions associated with paravertebral block?
    - □ Yes (Jump to question 11)
    - □ No (Finished)
11. What are the complications you have experienced?
    - □ Local anesthetic toxicity
    - □ Pneumothorax
    - □ Hematoma or vascular injury
    - □ Nerve damage
    - □ Severe hypotension
    - □ Unexpected epidural anesthesia