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Research article

Effect of ultrasound-guided transversus abdominis plane block in reducing atelectasis after laparoscopic surgery in children: A randomized clinical trial

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ABSTRACT

Background: Atelectasis is a commonly observed postoperative complication of general anesthesia in children. Pulmonary protective ventilation strategies have been reported to have a beneficial effect on postoperative atelectasis in children. Therefore, the present study aimed to evaluate the efficacy of the ultrasound-guided transversus abdominis plane (TAP) block technique in preventing the incidence of postoperative atelectasis in children.

Materials and methods: This study enrolled 100 consecutive children undergoing elective laparoscopic bilateral hernia repair and randomly divided them into the control and TAP groups. Conventional lung-protective ventilation was initiated in both groups after the induction of general anesthesia. The children in the TAP group received an ultrasound-guided TAP block with 0.3 mL/kg of 0.5% ropivacaine after the induction of anesthesia.

Results: Anesthesia-induced atelectasis was observed in 24% and 84% of patients in the TAP ($n = 50$) and control ($n = 50$) groups, respectively, before discharge from the post-anesthetic care unit (T3; PACU) (odds ratio [OR], 0.062; 95% confidence interval [CI], 0.019–0.179; $P < 0.001$). No significant difference was observed between the control and TAP groups in terms of the lung ultrasonography (LUS) scores 5 min after endotracheal intubation (T1). However, the LUS scores were lower in the TAP group than those in the control group at the end of surgery (T2, $P < 0.01$) and before discharge from the PACU (T3, $P < 0.001$). Moreover, the ace, legs, activity, cry and consolability (FLACC) pain scores in the TAP group were lower than those in the control group at each postoperative time point.

Conclusion: Ultrasound-guided TAP block effectively reduced the incidence of postoperative atelectasis and alleviated pain in children undergoing laparoscopic surgery.

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Glossary

ASA	American Society of Anesthesiologists
CONSORT	Consolidated Standards of Reporting Trials
ERAS	enhanced recovery after surgery
FLACC	face, legs, activity, cry and consolability
HR	heart rate; LUS, Lung ultrasonography
MAP	mean arterial blood pressure
PACU	post-anesthetic care unit
PPCs	postoperative pulmonary complications
TAP	transversus abdominis plane
SpO2	pulse oximetry or pulse oxygen saturation

1. Introduction

Inguinal hernia is a common disease observed in the pediatric population. The advances in the field of enhanced postoperative recovery in recent years have led to laparoscopic surgery becoming the treatment of choice for pediatric inguinal hernias. Laparoscopic surgery is associated with several advantages, such as rapid postoperative recovery, minimal bleeding, and light systemic stress response. However, owing to the elevation of the diaphragm [1], the establishment of laparoscopic pneumoperitoneum results in a decrease in the compliance of the respiratory system [2], an increase in the airway resistance, and a decrease in the functional residual capacity. Therefore, anesthesiologists should carefully consider the incidence of perioperative atelectasis in children undergoing laparoscopic surgery.

Atelectasis is a respiratory complication that is commonly observed following general anesthesia. Children are more susceptible to developing respiratory complications, such as atelectasis, after the induction of general anesthesia than adults. This may be attributed to the higher chest wall compliance, higher airway resistance, poorer lung compliance, and lower functional residual capacity observed in children. The formation of atelectasis leads to a gas exchange disorder, which leads to hypoxemia and other postoperative pulmonary complications (PPCs) [3,4]. The incidence of perioperative atelectasis in children has been reported to be as high as 68–100% [5–7].

Rapid and accurate diagnosis of atelectasis is essential for improving respiratory function in children and reducing the incidence of perioperative pulmonary complications. Lung ultrasonography (LUS), a convenient and noninvasive imaging modality that does not involve radiation, has become an ideal bedside tool for monitoring the changes in lung ventilation during the perioperative period [8–10].

Several factors influencing the incidence of pulmonary complications, such as atelectasis caused by laparoscopic surgery, are related to general anesthesia [11], CO_2 pneumoperitoneum [12], and postoperative analgesia [13]. The transversus abdominis plane (TAP) block inhibits the afferent nerve fibers between the transversus abdominis and internal oblique muscles, thereby achieving an analgesic effect via the blockade of nerve conduction of the sensory nerves in the anterior abdominal wall. Thus, TAP can be used to achieve postoperative analgesia after abdominal surgery in children [14,15]. Friedrich et al. [16]. reported that the administration of low-dose fentanyl significantly reduced the incidence of postoperative respiratory complications. Based on the findings of the abovementioned studies, it was hypothesized that ultrasound-guided TAP block may provide effective postoperative analgesia and reduce the use of opioids, thereby decreasing the incidence of atelectasis in children. Therefore, this randomized controlled trial aimed to verify the effect of ultrasound-guided TAP block on atelectasis and other outcomes in children undergoing laparoscopic surgery.

2. Methods

2.1. Study population

This study was conducted at the Xinhua Hospital affiliated with Shanghai Jiaotong University School of Medicine. The study was approved by the local ethics committee (XHEC-SHDC-2021-102) and registered with the Chinese Clinical Trial Registry (ChiCTR-2100053928, principal investigator: S.L.; date of registration: December 2, 2021) before commencing patient enrollment. Written informed consent was obtained from the parents or guardians of the participants prior to commencing the trial. The study was conducted in accordance with the Consolidated Standards of Reporting Trials (CONSORT) guidelines.

Children aged 1–6 years with an American Society of Anesthesiologists (ASA) physical status of I or II who underwent laparoscopic bilateral hernia repair were eligible for inclusion in this study. The exclusion criteria were as follows: a history of chronic or acute pulmonary pathology, contraindication for receiving TAP block, uncorrected congenital heart disease, known allergy to amide local anesthetic drugs, and liver and kidney dysfunction. The exit criterion was the surgical method changing from laparoscopy to laparotomy.

2.2. Randomization and blinding

The children were randomly allocated to the TAP block and control groups at a 1:1 ratio using a simple randomization procedure (computerized random number; https://www.randomizer.org) by a researcher who was blinded to the study. The randomization sequence was placed in sealed opaque envelopes, which were opened by an experienced anesthetist who performed the block and anesthesia induction. The anesthetist did not participate in other aspects of the trial. A resident anesthetist blinded to the randomization collected the intraoperative data. An opaque patch was placed on the block site after the surgery such that the physician who performed the ultrasound examination and collected the postoperative data in the PACU was blinded to the group allocation.

2.3. Anesthesia and ventilation protocol

Monitoring of the electrocardiogram, blood pressure, and oxygen saturation was initiated when the children entered the operating room. All children underwent standard general anesthesia induction and endotracheal intubation as per the protocol, including 100% pre-oxygenation, intravenous injection of 3 mg/kg of propofol and 1 μg/kg of fentanyl, and neuromuscular blockade with 0.6 mg/kg of rocuronium. The children were intubated using an endotracheal tube with an appropriately sized cuff after the induction of anesthesia. Ventilation was performed in the volume control mode (GE, Carestation 620, USA). Anesthesia was maintained via the administration of sevoflurane in a mixture of oxygen and air. The tidal volume, positive end-expiratory pressure, and inspired oxygen concentration were set at 8 ml/kg, 5 cm H_2O, and 40%, respectively. The respiratory rate was adjusted such that end-tidal carbon dioxide was maintained at 35–45 mmHg. Patients who spontaneously breathed room air after extubation were transferred to the PACU in the supine position for 1 h of observation. Pneumoperitoneum was maintained using CO2 at an intraperitoneal pressure of 9 mmHg, and insertion position of the exhaust pipe were the same for all patients.

2.4. Lung ultrasonography

LUS was performed at three time points: 5 min after endotracheal intubation (T1), at the end of surgery (T2), and before discharge from the PACU (T3). All LUS evaluations were performed by two anesthesiologists who had performed >50 pulmonary ultrasonographic examinations in the pediatric population using a portable ultrasound device (GE, Versana Active, USA) with an 8–13 MHz linear transducer. The chest was divided into 12 regions by dividing each hemithorax into six regions using three longitudinal (parasternal, anterior axillary, and posterior axillary) and two axial (one above the diaphragm and the other 1 cm above the nipples) lines. These 12 regions were scanned sequentially from right to left, cranial to caudal, and anterior to posterior [10,16]. Monastesse's modified LUS score was used to evaluate the severity of atelectasis [17]. B-lines and juxtapleural consolidation were the most common signs of atelectasis. All cases were assigned a score of 0–3, with each score indicating the following: 0, 0–2 B lines; 1 score, ≥3 B lines or ≥1 small subpleural consolidation separated by normal pleural lines; 2, multiple coalescent B lines or multiple small subpleural consolidation separated by irregular or thickened pleural lines; and 3, white lung or subpleural consolidation >1 × 2 cm). Anesthesia-induced atelectasis with a score of ≥2 in any area was considered significant [5].

2.5. Technique of ultrasound-guided TAP block

An anesthesiologist with experience in pediatric ultrasound-guided nerve blocks performed TAP blocks under general anesthesia using a portable ultrasound device (GE, Versana Active, USA). An 8–13 Hz linear transducer was placed obliquely between the 12th rib and iliac crest and vertically scanned along the midaxillary line to the contralateral abdominal wall to locate the three layers of muscles (external oblique, internal oblique, and transversus abdominis muscles). After disinfection, the needle was inserted into the block site using the in-plane technique under sterile conditions. The needle tip was inserted into the space between the internal oblique and transversus abdominis muscles, and 0.3 ml/kg of 0.5% ropivacaine was injected after ensuring negative aspiration. Fig. 1 depicts an ultrasonographic image showing a hypo-echoic area owing to the diffusion and penetration of the liquid drug. Placebo drugs were not

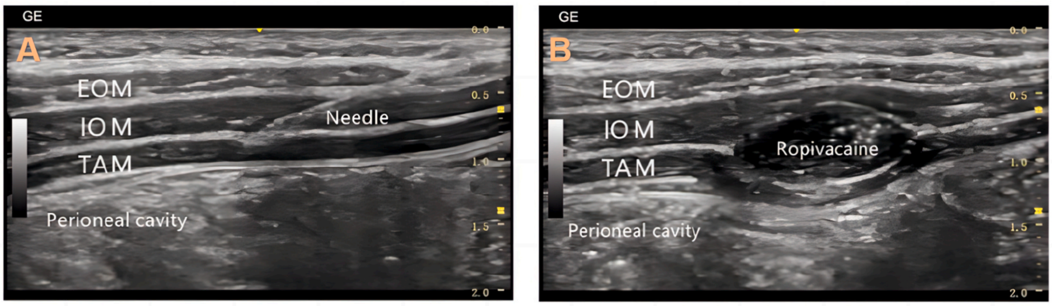

Fig. 1. Ultrasonography of transversus abdominis plane block. (A) pre-injection; **(B)** post-injection. EOM, external oblique muscle; IOM, internal oblique muscle; TAM, transversus abdominis muscle.

administered to the control group.

A surgical skin incision was made 15 min after the completion of the TAP block. Fentanyl (0.5 μg/kg) was administered every 2 min if the heart rate (HR) or mean arterial blood pressure (MAP) increased to >20% of the baseline value after skin incision until these parameters returned to within 20% of the baseline value. The number of additional doses and frequency of fentanyl administration were recorded for both groups. The face, legs, activity, cry and consolability (FLACC) scale [18] was used to evaluate pain in both groups at the end of the surgery, 1 h postoperatively, and 4 h postoperatively. Fentanyl (0.5 μg/kg) was administered as the rescue analgesic if the FLACC score was ≥5. Vital signs, such as HR and oxygen saturation. were closely monitored and recorded.

2.6. Outcome variables and statistical analyses

The primary outcome measure was the incidence of significant atelectasis at T3. The secondary outcomes included the incidence of significant atelectasis at other predefined time points; pulmonary ultrasound scores at T1, T2, and T3; the FLACC scores at each postoperative time point; intraoperative and postoperative fentanyl supplemental doses; incidence of airway adverse events; and length of hospital stay. The incidence of adverse reactions to the TAP block, including bleeding and bruising at the puncture site and the incidence of postoperative nausea and vomiting, were also recorded.

2.7. Sample size

The sample size was calculated based on the data from previous studies. The incidence of atelectasis was reported to be as high as 94% in children undergoing magnetic resonance examination under tracheal intubation under general anesthesia in a previous study [6]. The sensitivity of LUS in the diagnosis of atelectasis is 88% compared with that of magnetic resonance imaging [10]. Children undergoing laparoscopic surgery were included in this study. An increase in the intra-abdominal pressure during pneumoperitoneum aggravates alveolar collapse, thereby increasing the incidence of atelectasis. Therefore, it was assumed that the incidence of atelectasis would be 90% and 60% in the control and TAP groups, respectively. The sample size was calculated to be 40 participants per group using PASS 2008 (version 8.0.16; NCSS Statistical Software, Keysville, Utah, USA), with an α error of 0.05 and power of 90%. The required sample size was set to 50 individuals per group, considering a 20% attrition rate.

2.8. Statistical analysis

Data were analyzed using SPSS Statistics software (version 23.0, IBM, Armonk, NY, USA). The Kolmogorov–Smirnov test was used to evaluate the normality of the data. Continuous data are presented as mean and SD or median and interquartile range. Standard hypothesis tests (two-sided *t*-test or Mann–Whitney *U* test) were used to analyze the baseline characteristics and outcome parameters. Categorical data are presented as n (%) and were analyzed using the chi-squared test or Fisher's exact test. Repeated measures analysis of variance was used to perform intergroup comparisons of repeated measurement data. A P-value of <0.05 was considered statistically significant.

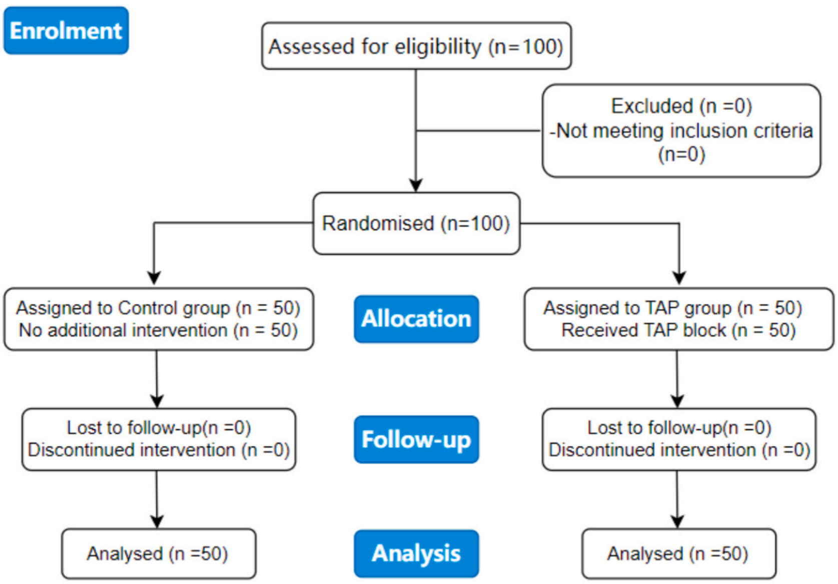

Fig. 2. Study flow diagram.

3. Results

A total of 100 children were enrolled in this study and randomly allocated to the control (n = 50) and TAP (n = 50) groups (Fig. 2). Table 1 presents the demographic characteristics of the patients. No significant differences were observed between the baseline characteristics of the two groups. The pneumoperitoneum time and ventilation time were similar in both groups.

The incidence of significant anesthesia-induced atelectasis at T3 in the TAP group was lower than that in the control group (24% *vs.* 84%; $P < 0.001$; odds ratio (OR) 0.062; 95% confidence interval (CI): 0.019–0.179). Atelectasis was observed in 16 and 44 children in the TAP (32%) and control (88%) groups, respectively (OR, 0.066; 95% CI, 0.019–0.198; $P < 0.001$) at T2 (Table 2). However, no significant differences were observed at T1 (84% *vs.* 76%; $P = 0.454$; OR, 0.606; 95% CI, 0.192–1.816).

The LUS scores of the TAP group were compared with those of the control group at the three time points. The results are summarized in Fig. 3A. The LUS scores of the control group and TAP groups were similar at T1 (4.78 ± 1.68 *vs.* 4.84 ± 1.7, $P = 0.86$). However, the mean LUS score of the control group (8.64) was higher than that of the TAP group (8.48 ± 2.45 *vs.* 7.12 ± 1.65, $P < 0.01$) at T2. The difference between the LUS scores of the two groups became more evident at T3, and the LUS score of the control group was much higher than that of the TAP group (6.38 ± 1.44 *vs.* 3.4 ± 1.07, $P < 0.001$).

The FLACC pain scores of the two groups were measured at three time points: at the end of surgery (t1), 1 h postoperatively (t2), and 4 h postoperatively (t3) (Fig. 3B). The FLACC scores in the control group was significantly higher than those in the TAP groups at all time points (6 [6,7] *vs.* 3 [3,4], $P < 0.001$ at t1; 4.5 [4,5] *vs.* 3 [2,3], $P < 0.001$ at t2; 4 [3,4] *vs.* 2 [2,3], $P < 0.001$ at t3). The intraoperative dose of fentanyl in the TAP group was significantly lower than that in the control group ($P < 0.001$; Table 2). The difference between the dose of fentanyl administered as an analgesic drug in the control and TAP groups gradually decreased over time. No significant differences were observed between the two groups at t3 (0.45 ± 0.15 μg/kg *vs.* 0.08 ± 0.18 μg/kg, $P < 0.001$ at t1; 0.08 ± 0.19 μg/kg *vs.* 0, $P < 0.01$ at t2; 0.03 ± 0.12 μg/kg *vs.* 0, $P = 0.08$ at t3). No statistically significant differences were observed between the two groups in terms of the length of hospital stay ($P = 0.51$; Table 2); however, the minimum SpO_2 in the TAP group during the stay in the PACU was higher than that in the control group (98.76 ± 1.3 vs. 95.26 ± 2.33, $P < 0.001$) when air was inhaled in the recovery room. No complications related to the nerve block were observed in either group.

4. Discussion

This prospective, randomized controlled study revealed that ultrasound-guided TAP block effectively reduced the incidence of atelectasis and LUS scores in children after laparoscopic surgery. This finding indicates that better postoperative analgesia was achieved with a reduced dose of analgesics.

The risk factors for atelectasis in children can be categorized as patient-, anesthesia-, and surgery-related. Anesthesia-related factors mainly include postoperative analgesia and anesthetic drug residue [19]. Previous studies have shown that combined epidural analgesia improves lung function and prevents atelectasis more effectively than opioid analgesia [20,21]. The dose of fentanyl, a commonly used opioid, is associated with the incidence of postoperative atelectasis in a dose-dependent manner [16]. TAP block and epidural analgesia exert comparable analgesic effects after abdominal surgery [22]. Moreover, TAP block also reduces the dosage of fentanyl [23] and the incidence of opioid-related adverse effects on the respiratory system. Thus, it was speculated that the TAP block may reduce the incidence of postoperative atelectasis in children.

TAP block exerts analgesic effects over the skin, muscle, and parietal peritoneum of the anterior abdominal wall by inhibiting the anterior branches of T7–L1 spinal nerves [24]. Fredrickson et al. first reported the use of pediatric TAP block in 2008 and described the successful implementation of this technique in eight children undergoing inguinal hernia repair [25]. Ultrasonography has enabled the visualization of the anatomical structure of the abdominal wall using a high-frequency ultrasound probe. This has aided in improving the success rate and safety of puncture [26]. Ultrasound-guided TAP block has been applied increasingly in the field of pediatrics. Most pediatric studies on the TAP block have reported a reduction in opioid use and the postoperative pain scores, indicating its effectiveness. Sola et al. reported that ultrasound-guided TAP block provided effective postoperative analgesia in >95% of children undergoing hernia repair based on the FLACC score [14]. Carney et al. conducted a randomized, double-blind, placebo-controlled study of 40 children undergoing appendectomy and considered postoperative morphine consumption as the main experimental result. Ultrasound-guided TAP block, performed on the surgical side of the children using 0.3 ml/kg normal saline or 0.75% ropivacaine in

Table 1
Personal characteristics.

	Control group (n = 50)	TAP group (n = 50)	P-value
Age,mean(SD),y	3.05 (1.14)	3.29 (1.36)	0.342
Sex (female/male)	14/36	20/30	0.146
Height, mean(SD), cm	100.08 (9.28)	99.42 (13.33)	0.775
Weight, mean(SD),kg	14.65(3.13)	14.33 (3.26)	0.616
BMI, mean(SD),kg/m^2	14.57(2.12)	14.50(2.13)	0.875
ASA physical status, I/II	42/8	40/10	0.572
Capnoperitoneum duration, mean(SD), min	31.04 (3.45)	30.30 (3.32)	0.274
Mechanical ventilation duration, mean(SD), min	45.24 (4.03)	46.32 (4.75)	0.221

Data are presented as mean ± SD or number of patients (%). Chi-square or Fisher' exact tests: Sex; ASA physical status; *U* test: Age, and Capnoperitoneum duration; *t*-test: Height, Weight and Mechanical ventilation duration.

Table 2
Comparison of intra and postoperative variables between groups.

	Control group (n = 50)	TAP group (n = 50)	P-value
Length of hospitalization, mean(SD), days	2.42 (0.65)	2.34 (0.57)	0.507
Minimum SpO_2 in PACU, mean(SD), %	95.26 (2.33)	98.76 (1.30)	< 0.001**
Intraoperative consumption of fentanyl, mean(SD), μg/kg	1.33 (0.24)	1.13 (0.22)	< 0.001**
Consumption of rescue analgesia at t1, mean(SD), μg/kg	0.45 (0.15)	0.08 (0.18)	< 0.001**
Consumption of rescue analgesia at t2, mean(SD), μg/kg	0.08 (0.19)	0	< 0.01*
Consumption of rescue analgesia at t3, mean(SD), μg/kg	0.03 (0.12)	0	0.08
The incidence of atelectasis at T1, n(%)	38 (76)	42 (84)	0.227
The incidence of atelectasis at T2, n(%)	44 (88)	16 (32)	< 0.001**
The incidence of atelectasis at T3, n(%)	42 (84)	12 (24)	< 0.001**

All data are presented as mean ± SD or number of patients (%). P value was analyzed by Student-t test, Pearson chi-square test or Fisher's exact test. t 1: at the end of the operation; t 2: 1 h after the operation; t 3: 4 h after the operation. T 1: After endotracheal intubation; T 2: At the end of surgery; T 3: Before discharge from PACU. SpO_2, pulse oximetry. PACU, postanesthesia care unit. *P < 0.01 *vs* Control group. **P < 0.001 *vs* Control group.

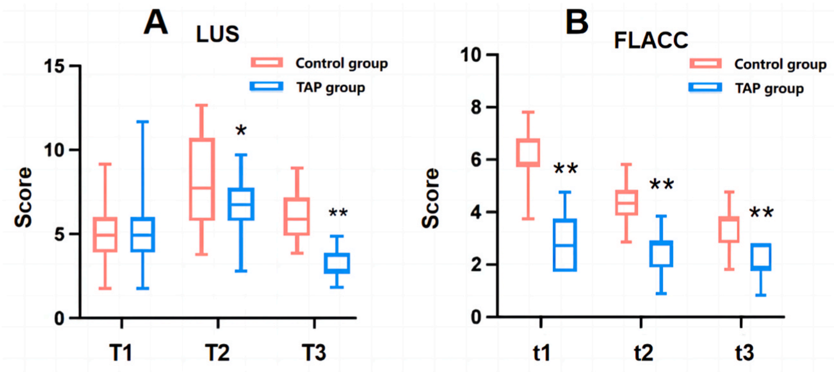

Fig. 3. Box plot for the LUS and FLACC scores during the study. **(A)** A box plot of the LUS scores in each group. Three predefined time points: 5 min after endotracheal intubation (T1); at the end of surgery (T2); before discharge from PACU (T3). **(B)** The FLACC scores are shown as box plots. t1: at the end of the surgery; t2: 1 h after the surgery; t3: 4 h after the surgery. The thick line across the box represents the median, the ends of box represent the 25th and 75th percentiles, and the whiskers represent the range. *P < 0.01 *vs* Control group. **P < 0.001 *vs* Control group.

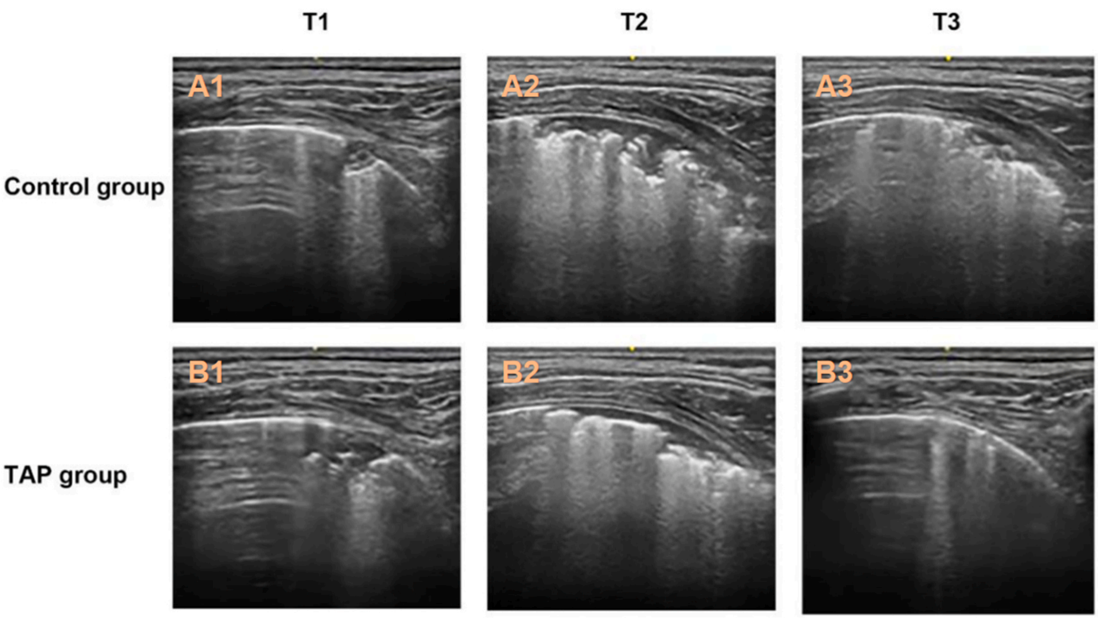

Fig. 4. Lung ultrasound images of one representative patient per group. **(A1-A3)** Control group; **(B1–B3)** TAP group. T1: 5 min after endotracheal intubation; T2: At the end of surgery; T3: Before discharge from PACU.

their study [27], was found to reduce postoperative opioid consumption in pediatric patients. The FLACC score of the TAP group was lower than that of the control group at t1, t2, and t3 in the present study ($P < 0.001$). Furthermore, the fentanyl dose was found to be significantly lower in the TAP group than in the control group 1 h postoperatively ($P < 0.01$). These findings confirm the effectiveness of the TAP block in multimodal analgesia in children.

Computed tomography remains the gold standard for the clinical diagnosis of atelectasis; however, its use is limited owing to radiation exposure, difficulty in transporting the device, and other factors [28]. LUS has gradually become one of the most commonly used methods for the bedside diagnosis of atelectasis in recent years owing to its advantages of accuracy, safety, and simplicity [10]. LUS can also be used to measure the severity of atelectasis, which could facilitate the formulation of personalized lung recruitment strategies [5,17,29] and the prediction of the incidence of PPCs [30]. The dorsal lung is the most frequent location of atelectasis in children in the supine position, which may be attributed to the influence of gravity [7]. Fig. 4 presents an LUS image depicting the changes in the dorsal lung of children in the two groups at three time points. Atelectasis was observed in >75% of patients after anesthesia-induced endotracheal intubation (76% and 84% in the control and TAP groups, respectively), and no significant difference was observed between the LUS scores of the two groups. This finding is consistent with those of previous studies, which reported that atelectasis caused by general anesthesia occurs within minutes of anesthesia induction [6,7,10]. The incidence of atelectasis increased further in both groups at the end of the surgery, which may be attributed to the establishment of a laparoscopic pneumoperitoneum. Elevation of the diaphragm, increased airway resistance, and decreased lung compliance increase the incidence of atelectasis.[1] However, the LUS score of the control group was higher than that of the TAP group ($P < 0.01$). The LUS score of the TAP group was significantly lower than that of the control group before discharge from the PACU and the third LUS examination ($P < 0.001$). The FLACC pain scores of the TAP group were significantly lower than those of the control group at the end of the surgery and 1 h postoperatively ($P < 0.001$). Moreover, the cumulative consumption of fentanyl in the TAP group was markedly lower than that in the control group 1 h postoperatively ($P < 0.01$). These results suggest that effective postoperative analgesia was achieved and that the administration of low-dose fentanyl may reduce the severity of postoperative atelectasis.

Laparoscopic hernia repair is a simple, fast, less invasive procedure. Moreover, it is associated with fast recovery. Thus, this approach is being used increasingly in the pediatric day surgery room, necessitating better postoperative analgesia and pulmonary function protection strategies. TAP block did not increase the length of hospital stay in the present study ($P = 0.507$). Moreover, the minimum SpO_2 in the TAP group during the stay in the PACU was higher than that in the control group (98.76 ± 1.3 vs. 95.26 ± 2.33, $P < 0.001$) when entering PACU without oxygen inhalation after surgery. Furthermore, no TAP block–related adverse reactions or complications were observed in the TAP group.

Nevertheless, the present study has some limitations. First, follow-up LUS assessments were not performed after discharge from the PACU room. Consequently, the duration of postoperative atelectasis and its impact on lung function could not be determined. Moreover, the long-term LUS scores of the two groups of children could not be compared. Second, pain assessments were performed only at three time points: at the end of the surgery, 1 h postoperatively, and 4 h postoperatively. No additional pain remedies were administered, and the duration of TAP block analgesia and the presence of rebound pain were not evaluated. Lastly, this study included healthy children aged between 1 and 6 years. Thus, the results cannot be generalized to an older pediatric patient population or children with cardiac or pulmonary conditions. Therefore, further studies with large sample sizes with different baseline comorbidities must be conducted to validate these findings.

In conclusion, the present study demonstrated that ultrasound-guided TAP block was effective in reducing the incidence of anesthesia-induced atelectasis. Moreover, it facilitated adequate pain control and decreased opioid consumption. Thus, TAP block could be administered as a part of multimodal analgesia after laparoscopic hernia repair to enhance postoperative recovery.

Ethics statement

This study was reviewed and approved by [Ethics Committee of Xinhua Hospital Affiliated to Shanghai Jiaotong University School of Medicine], with the approval number: [XHEC-SHDC-2021-102].

All participants/patients (or their proxies/legal guardians) provided informed consent to participate in the study.

Data availability statement

The original contributions presented in the study are included in the article; further inquiries can be directed to the corresponding author/s.

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CRediT authorship contribution statement

Siyuan Li: Writing – original draft, Methodology, Formal analysis, Data curation. **Yan Wang:** Formal analysis, Data curation. **Yunqian Zhang:** Data curation. **Hui Zhang:** Formal analysis, Data curation. **Shenghua Wang:** Writing – original draft, Formal analysis, Data curation. **Ke Ma:** Formal analysis, Data curation. **Lai Jiang:** Supervision, Methodology, Conceptualization. **Yanfei Mao:** Writing – original draft, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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