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ORIGINAL INVESTIGATION

Posterior transversus abdominis plane block versus lateral quadratus lumborum block in children undergoing open orchiopexy: a randomized clinical trial☆

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Abstract
Background: Due to the complex innervation of the testicle and spermatic cord, analgesic management can be challenging in orchiopexy. We aimed to compare the effects of posterior Transversus Abdominis Plane (TAP) and lateral Quadratus Lumborum Block (QLB) on analgesic use, pain, and parent satisfaction in unilateral orchiopexy.
Methods: ASA I–III, aged 6 months –to 12 years children undergoing unilateral orchiopexy were included to this double-blinded randomized trial. Patients were randomized into two groups with the closed envelope method before the surgery. Lateral QLB or posterior TAP block was applied under ultrasonography with 0.4 $ml.kg^{-1}$ 0.25% bupivacaine for both groups. The primary outcome was the assessment of additional analgesic usage in the peri-postoperative period. Evaluation of postoperative pain until 24 hours after surgery and parental satisfaction were also assessed as secondary outcomes.
Results: A total of 90 patients were included in the analysis (45 patients in each group). The number of patients needing remifentanil was significantly higher in the TAP group ($p < 0.001$). The average FLACC (TAP: 2.74 ± 1.8, QLB: 0.7 ± 0.84) and Wong-Baker scores (TAP: 3.13 ± 2.42, QLB: 0.53 ± 1.12) were significantly higher for TAP ($p < 0.001$). Additional analgesic consumption at the 10^{th}, 20^{th} minutes, 6^{th}, 16^{th}, and 24^{th} hours, especially after the 6^{th} hour, were significantly higher for TAP. Parent satisfaction was significantly higher in the QLB group ($p < 0.001$).

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Conclusion: Lateral QLB provided more effective analgesia than posterior TAP block in children undergoing elective open unilateral orchiopexy.
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Introduction

Cryptorchidism is a common genitourinary pathology defined as the failure of the testicles to descend into the scrotum during development and seen in 30% of preterm and 3% of term infants, respectively. It should be surgically corrected to avoid significant consequences such as testicular atrophy, torsion, hernia, or malignancy. Orchiopexy is usually performed under general anesthesia, and due to the complex innervation of the testicle and spermatic cord, analgesic management can be challenging.[1]

Pain is crucial in children due to difficulty in assessment and inadequate treatment risk. Inadequate treatment may cause chronic pain and impaired mental motor development.[2] Intraoperative pain can increase morbidity and mortality by inducing risk of laryngospasm.[3] Therefore, current guidelines recommend surgical site-specific regional anesthesia techniques as an essential part of the multimodal treatment.[4] Thanks to the widespread use of ultrasonography (USG) in anesthetic practice, there has been a recently growing interest in abdominal trunk blocks; the technical difficulties and potential complications of neuraxial blocks have been avoided.[5] These methods are preferred over the conventional methods of analgesia, especially in outpatient urological interventions.[6]

The Transversus Abdominis Plane Block (TAPB) is a commonly used abdominal trunk block method in lower abdominal surgeries.[7] Previous research has shown that it is more efficacious, long-lasting, and reliable than the caudal block.[5,6,8] The TAPB method was first defined with the landmark technique through application in the Petit triangle.[7] Later, it was applied to the midaxillary line with USG guidance, giving rise to lateral and posterior concepts.[7,9] Most of the studies with US-guided TAPB were reported with the lateral approach, with US-guided TAPB were reported with the lateral approach, which was controversial due to its limited effect area.[7]

Posterior TAPB is hypothesized as closest to the landmark-guided technique regarding the analgesic spread area and effect.[9] However, the action mechanism and injection site of the posterior approach was not only reminiscent of the landmark technique but also similar to the originally described lateral (type 1) Quadratus Lumborum Block (QLB) by Blanco.[79-11] QLB is a comparatively recent technique that is proven to be effective in lower abdominal surgeries.[12] Several studies have reported that it is more effective and long-lasting than the caudal block.[13,14]

QLB and TAPB studies were usually conducted using a lateral TAPB technique, and QLB subtypes have varied.[12,15] It is still debated whether posterior TAPB and lateral QLB are fundamentally distinct techniques of regional anesthesia.[7] We hypothesized that the lateral QLB would depict better clinical efficacy by providing a wider somatic, visceral analgesic effect and more craniocaudal spread, compared to posterior TAPB.[10,11] In this study, we aimed to compare the analgesic effects of US-guided posterior TAPB and lateral QLB in pediatric patients undergoing orchiopexy. Our primary outcome was the assessment of analgesic usage in the peri-postoperative periods. Evaluation of postoperative pain until 24 hours after surgery and parental satisfaction were also assessed as secondary outcomes.

Methods

This randomized, double-blinded, prospective study was approved by Istanbul University's Institutional Review Board (IRB 71381), and written informed consent was obtained from the parents of all subjects participating in the trial. The trial was registered prior to patient enrollment at clinicaltrials.gov (NCT03969316). This manuscript adheres to the CONSORT guideline and a flow diagram was used for patient enrollment and allocation (Fig. 1).

All pediatric patients with an American Society of Anesthesiologists (ASA) physical status I–III score and aged between 6 months and 12 years undergoing elective unilateral orchiopexy were included in the study. The patients who had contraindications for regional anesthesia, those who refused to consent, laparoscopic approach, ASA physical status IV, and those who needed postoperative intensive care unit admissions were excluded from the study.

After, patients were premedicated with intravenous 0.05 $mg.kg^{-1}$ midazolam and 0.5 $mg.kg^{-1}$ ketamine. The preoperative Ramsay Sedation Scale was recorded for each patient. After standard monitorization, induction was applied with 5 $mg.kg^{-1}$ thiopental, 1 $\mu g.kg^{-1}$ fentanyl, 0.6 $mg.kg^{-1}$ rocuronium, and orotracheal intubation was performed. Sevoflurane was used for maintenance. The duration of the operations was recorded.

After intubation, patients were randomized with the closed envelope method before the surgery and separated into QLB and TAPB groups. Each patient received a random study number, and these numbers were used in the data assessment. Two experienced anesthesiologists (ACT and PK), blinded to data collecting and analysis until study completion, executed all block procedures. A third anesthesiologist and nurses, who were blinded, performed follow-ups, and handled the registration in the surgery, post anesthesia care unit, and afterward. Patients and parents were also blinded to group assignments. All analyses were performed by an independent statistician (BKE).

QLB was performed at the supine or semi-lateral position, whereas the supine position was used for the TAPB. Both techniques were executed in sterile condition and by using 18|G, 20G, 22G intravenous cannula (Bicakcilar Cooperation, Istanbul, Turkey) based on patient's age. The needle was navigated by using the linear probe of the USG (GE Logiq-E Ultrasound System with 9L Linear Transducer, Illinois, USA) and employing an "in-plane" technique. After negative blood aspiration with a 2 ml injector and confirmation of the correct position with 0.9% saline, both blocks were induced with 0.4 $ml.kg^{-1}$ 0.25% bupivacaine.

Lateral QLB

After the USG probe was positioned at the umbilicus level, the needle was advanced until visualizing the terminal part of the Transversus Abdominis Muscle (TAM) and Quadratus Lumborum Muscle (QLM). Then, the needle was directed antero-posteriorly, and the local anesthetic was applied between the posterior aponeurosis of the TAM and transversalis fascia, which is located at the anterolateral of the QLM (Fig. 2A).

Posterior TAPB

After, the USG probe was positioned at the mid-axillary line on the anterior superior iliac crest, and was advanced posteriorly until visualizing the thoracolumbar fascia, which is the conjunction of the aponeurosis of the Internal Oblique Muscle (IOM) and TAM. Local anesthetic was applied to the TAP, which is located anterior to the thoracolumbar fascia (Fig. 2B).

After the block was applied, Blood Pressure (BP) and Heart Rate (HR) were recorded before the incision, as well as 5, 10, 20, 30, 45, and 60 min after the incision. The surgery commenced at least 10 min after the application of the block. In case of a 20% increase in HR and BP from baseline, remifentanil infusion was started according to recent guideline recommendations.[4] Remifentanil dose was adjusted based on HR and BP measurements (±20% from the baseline), and the infusion was terminated as soon as possible.

In the postoperative period, patients were followed up primarily in the pediatric postanesthesia care unit for 2 hours, and then in the pediatric surgery in-patient service. Pain at 10^{th}, 20^{th}, 30^{th} minutes, 1^{st}, 2^{nd}, 6^{th} hours were evaluated with the FLACC (Face, Legs, Activity, Cry, Consolability) score. If the FLACC score $\geq$ 4 and additional analgesia was thought to be required clinically, 1 $mg.kg^{-1}$ tramadol and when the need continued, 15 $mg.kg^{-1}$ paracetamol were administered. Parents were informed and given a copy of the Wong-Baker Pain Scale before discharge of the patients. Moreover, when the patients defined pain with a score of 4 or above, parents were told that they should give 10 $mg.kg^{-1}$ ibuprofen. Pain scores and additional analgesic requirements were asked by phone call at the postoperative 16^{th} and 24^{th} hours. Parent satisfaction was noted as not satisfied (1), partially satisfied (2), and very satisfied (3), depending on the patient's painlessness status.

Sample size

The sample size was calculated using the G*Power program, version 3.1 (Heinrich-Heine University, Duesseldorf, Germany) for Chi-Squared test α = 0.05, power (1-β) = 0.80, df = 1 and effect size of 0.319. The effect size was calculated based on previous data in the literature according to patient requirements for postoperative analgesics.[16] It was determined that at least 78 patients were required to test the hypothesis.

Statistical analysis

SPSS v.21 (IBM, Illinois, USA) was used for statistical analysis. Continuous variables were presented as mean ± SD, median

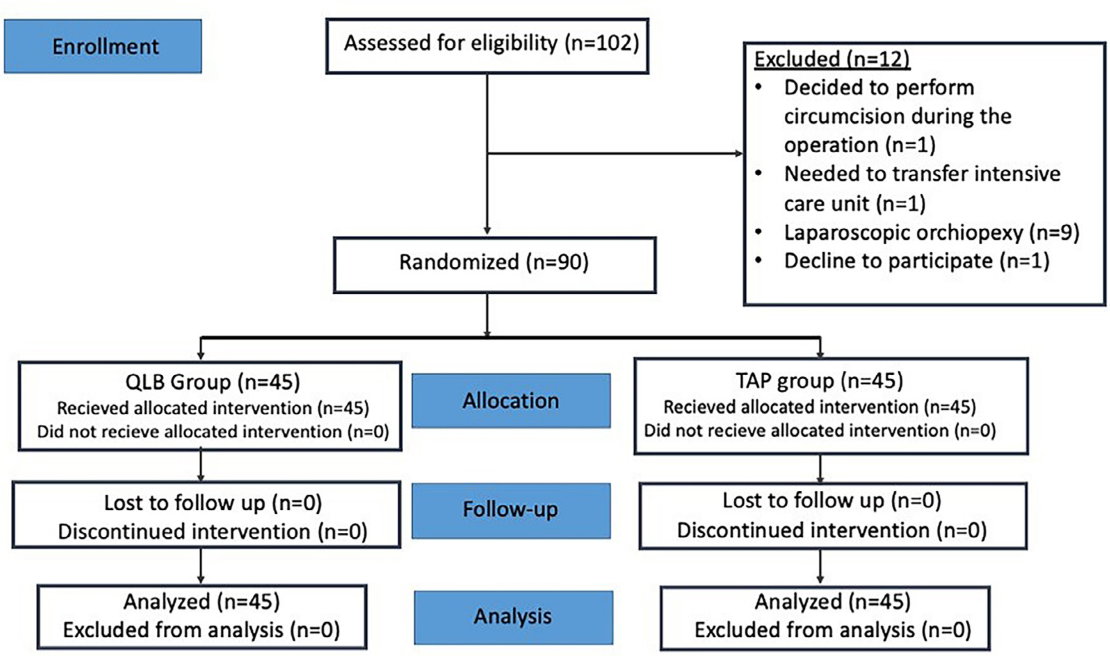

Figure 1 CONSORT diagram.

(25th–75th percentiles), and categorical variables were presented with frequency and percentage. The variables were investigated using visual (histograms, Q-Q plots) and analytical methods (Shapiro-Wilk test) to determine if they were normally distributed. Comparisons of the groups for continuous variables were carried out by Independent Sample's *t*-test or Mann-Whitney U test for two groups according to the data's normality. Chi-Squared or Fisher's Exact test was used to analyze categorical variables when appropriate. Odds ratios were given according to contingency tables run by SPSS. The Wilcoxon test was used to compare the change in two continuous variables. The Friedman test was used to compare the change in two or more continuous variables. The Cohran Q test was used to determine the percentage of patients requiring perioperative remifentanil during each regional anesthesia procedure. Following the Friedman or Cohran Q test, the post-hoc Dunn test was employed to make multiple comparisons and evaluate the significant groups. Differences in groups were determined based on their adjusted *p*-values, provided automatically by SPSS. The time spent without additional analgesia was evaluated between the two groups with Kaplan-Meier analysis and log-rank test. All tests are two-sided, and the significance level was accepted as $p < 0.05$.

Results

Fig. 1 illustrates the CONSORT diagram of study enrollment. Analyses were performed with 90 patients (45 patients in each group). There was no difference between their demographic data, pre-operative Ramsay Sedation Scores, and duration of surgery (Table 1).

Regarding intraoperative hemodynamic parameters, there was no difference between the two groups before and after the incision (Supplementary Table 1, Supplementary Figs. 1–3). Intraoperative remifentanil was used in 28 patients in the TAPB group (62.2%) and 11 patients in the QLB group (24.4%) ($p < 0.001$) (Supplementary Table 2).

The number of patients requiring postoperative analgesics was higher at the 10th and 20th minutes, and 6th, 16th, 24th hours in the TAP group, more prominently after the 6th postoperative hour ($p < 0.001$) (Table 2, Supplementary Fig. 4). Clinically adequate analgesia (FLACC score < 4, Wong-Baker score < 4) could be achieved in both groups, but pain scores were significantly lower for QLB (Total FLACC score: TAP [mean ± SD: 2.74 ± 1.8] vs. QLB [mean ± SD: 0.7 ± 0.84], Total Wong-Baker score: TAP [mean ± SD: 3.13 ± 2.42] vs. QLB [mean ± SD: 0.53 ± 1.12], $p < 0.001$) (Fig. 3 A and B; Supplementary Table 3). The mean time spent without analgesics in the QLB was statistically significantly longer than in the TAPB group ($p = 0.000002$) (Fig. 4, Supplementary Table 4). Patients in the TAPB group had higher pain scores compared with QLB except for the postoperative first hour time point FLACC score (Fig. 3 A and B; Supplementary Table 3). A comparison of parental postoperative satisfaction showed a statistically significant difference between the groups and parent satisfaction was higher in the QLB group ($p < 0.001$). (Fig. 3C, Supplementary Table 5).

There were no hemodynamic abnormalities in either group, and no complications were noted except for postoperative nausea in two patients, and nausea and vomiting in one patient in the first hour in the QLB group.

Discussion

Our findings have shown that lateral QLB significantly reduced analgesic consumption, postoperative pain, and it improved parental satisfaction compared to the posterior TAPB in unilateral elective orchiopexy.

The TAPB was first described by Rafi in 2001.[17] It was applied to the Petit triangle, delineated anteriorly by the external oblique, posteriorly by the latissimus dorsi, and inferiorly by the crista iliaca.[17] It was intended to reach the plane between the IOM and the TAM with a single pop sensation.[17] Subsequently, a double-pop approach was developed with a modification, and it was demonstrated that local anesthetics could reach the intercostal nerves of T7 to T11, subcostal nerves, and ilioinguinal-iliohypogastric nerves,

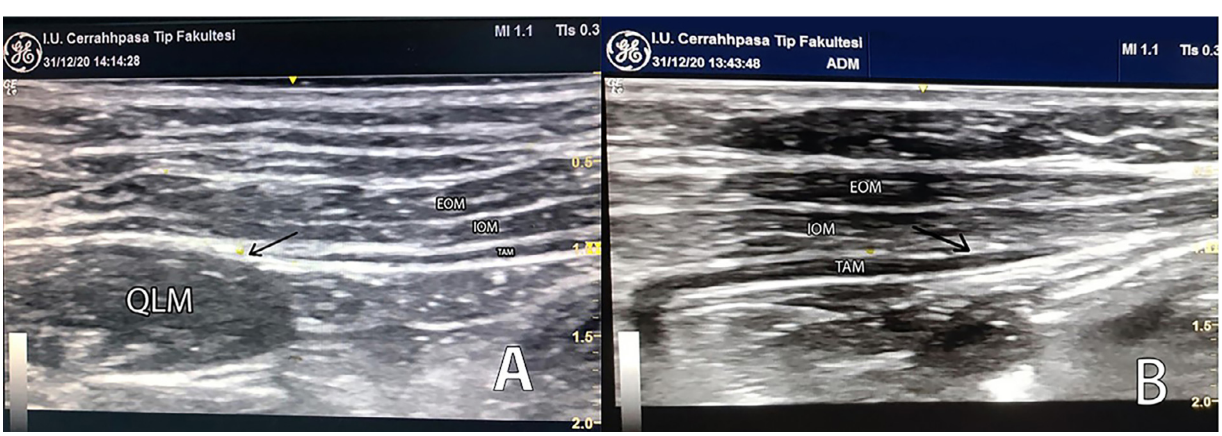

Figure 2 (A) QLM and anterolateral abdominal muscles, sonographic view of the lateral QLB application site. Arrow: The target site of the lateral QLB. (B) Sonographic view of the anterolateral abdominal muscles. Arrow: The target site of the posterior TAP block. QLM, Quadratus Lumborum Muscle; TAM, Transversus Abdominis Muscle; IOM, Internal Oblique Muscle; EOM, External Oblique Muscle.

Table 1 Demographic and clinical data.

	QLB (n = 45)	TAP (n = 45)	*p*
Age (month)[*]	48 (23–84)	42 (24–84)	0.815[a]
Weight (kg)[*]	18 (12.75–25)	16 (12.25–30)	0.913[a]
Height (cm)[**]	103.27 ± 18.35	108.11 ± 21.63	0.255[b]
Surgery[***]			0.506[c]
Right orchiopexy	31 (68.9%)	28 (62.2%)	
Left orchiopexy	14 (31.1%)	17 (37.8%)	
Preoperative RAMSAY Sedation Scale[*]	2 (2–3)	2 (2–3)	0.671[a]
Surgery Duration	91.33 ± 19.09	91.07 ± 18.31	0,946[b]

Data are presented as
[*] median (25 percentile–75 percentile).
[**] mean (SD).
[***] n (%).
[a] Mann-Whitney U Test.
[b] Independent Sample's *t*-test.
[c] Chi-Square test.

providing a sensory block of the lateral and anterior abdominal walls.[7,18]

Based on the difficulty in finding the Petit triangle, and complication risks of the blind technique, US-guided TAPB was defined by Hebbard in 2007.[7] However, US-guided TAPB, unlike the landmark technique, was applied to the midaxillary line instead of the Petit triangle. It was shown that the block applied to this region was limited to T10-L1 dermatomes.[7] Therefore, a new US-guided block technique was constructed compatible with the Petit triangle, called posterior TAPB; and the first defined block, which applied to the midaxillary line, was named the lateral TAPB. Posterior TAPB is applied to TAP at the intersection of quadratus lumborum and lateral abdominal muscles.[7] Carney et al. showed that both the landmark-guided TAPB and the US-guided posterior TAPB caused spread to the paravertebral area, creating a similar effect.[9] Therefore, the posterior TAPB has been stated as the best alternative technique for landmark-guided TAPB is.[9]

QLB was first defined by Blanco in 2007.[11] Soon after, QLB variants were defined via performing injections on different sides of the QLM.[11] Although the mechanism of action has not been fully elucidated, it is hypothesized that the effect is created by local anesthetic spreading to the paravertebral area over various fascial planes in cadaver studies.[10] For the lateral QLB, the local anesthetic is injected to the QLM's anterolateral aspect, between the posterior aponeurosis of the TAM and transversalis fascia.[11] The mechanism of effect is thought to be by spreading to TAP, and through the Anterior Thoracolumbar Fascia (ATF) into the paravertebral area.[11] However, considering its similarity to the posterior TAPB in terms of the injection site and mechanism of action, further studies are needed to evaluate the effects of the two procedures, as highlighted in current reviews.[7]

Table 2 Comparison of postoperative analgesics.

	QLB Group n = 45 n (%)	TAP Group n = 45 n (%)	*p*[**]
Total Number of patients who needed postop. analgesics	17 (37.8%)	39 (86.7%)	**<0.001**[**]
Number of patients who needed postop. analgesics			
10th min.	6 (13.3%)	15 (33.3%)[a,d]	**0.025**[**]
20th min.	2 (4.4%)	10 (22.2%)[a,c]	**0.013**[**]
30th min.	1 (2.2%)	6 (13.3%)[a,b]	0.110[f]
1st hour	0 (0%)	2 (4.4%)[a]	0.494[f]
2nd hour	2 (4.4%)	5 (11.1%)[a,b]	0.434[f]
6th hour	2 (4.4%)	21 (46.7%)[c,d]	**<0.001**[**]
16th hour	6 (13.3%)	28 (62.2%)[d]	**<0.001**[**]
24th hour	0 (0%)	18 (40%)[b,c,d]	**<0.001**[**]
p[*](In-group)	**0.016**[a]	**<0.001**	

[*] Cohran Q Test.
[**] Chi-square Test.
[f] Fisher's Exact Test.
[a] No difference in pairwise comparisons.
In group analysis; Each superscript letter denotes a subset of time categories whose row value do not differ significantly form each other at the 0.05 level.
min, minute; QLB, Quadratus Lumborum Block; TAP, Transversus abdominis plane.

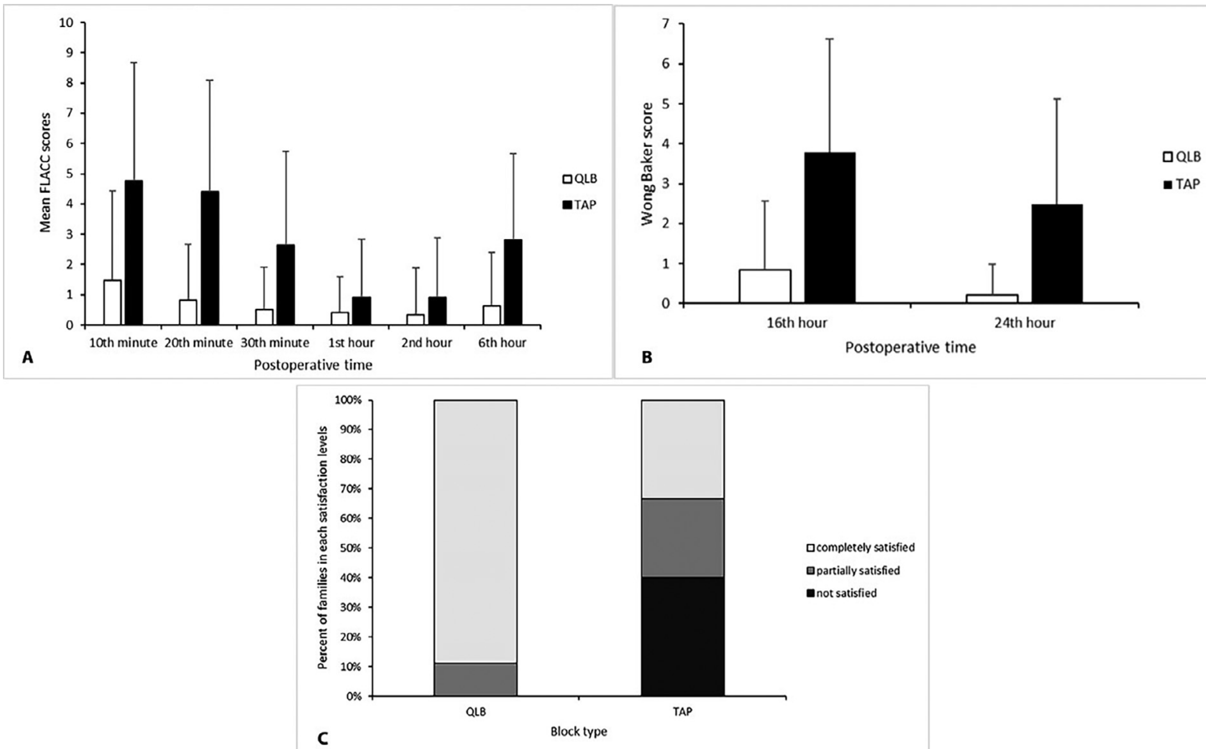

Figure 3 (A) Postoperative FLACC scores of patients. Data were expressed as mean±SD. (B) Postoperative Wong-Baker scores of patients. Data were expressed as mean±SD. (C) Percent of parents in each satisfaction level according to block types. FLACC, Face, Legs, Activity, Cry, Consolability.

Despite the advancements and guidelines emphasizing the significance of pain in children, most children continue to receive insufficient pain treatment.[2] Orchiopexy is a commonly performed surgery in children, and analgesia management is difficult due to the complex innervation of the testis and spermatic cord.[19] In addition, unlike herniorrhaphy, peritoneal dissection is performed to free the testicular vessels and the spermatic cord.[1] Peritoneal stretching and dissection cause severe visceral pain in addition to somatic pain.[1,20] The current study investigated this controversial topic in children who underwent orchiopexy and compared the clinical efficacy of posterior TAPB and lateral QLB.

Our primary outcome was the assessment of additional analgesic usage determined according to pain evaluation. We thought that analgesic administration, the clinical result of pain assessment, was a more accurate option for evaluating block effectiveness. In this respect, the number of patients who required remifentanil during the intraoperative period, and postoperative analgesics in 24 hours were significantly higher in the posterior TAPB than in the lateral

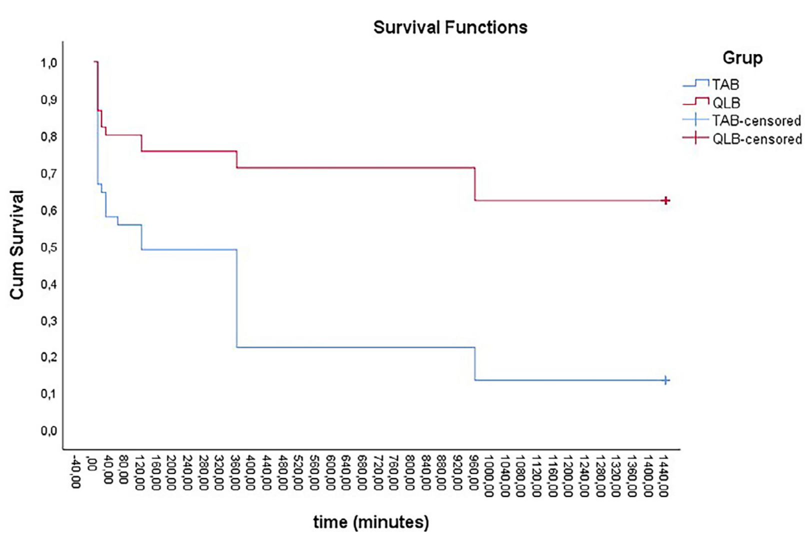

Figure 4 Mean postoperative time without analgesics according to Kaplan-Meier analysis.

QLB group, particularly after the sixth postoperative hour. The mean time spent without analgesics was statistically significantly longer in QLB. Our results were in line with previously conducted studies, which compared the posterior TAPB to QLB. Unlike our study, these studies were conducted in adults and compared posterior TAPB to posterior QLB but not lateral QLB.[21–25] The mechanism of action of the posterior QLB differs from the lateral QLB.[11] Local anesthetic is applied to the Lateral Interfascial Triangle (LIFT), formed by the junction of the middle thoracolumbar fascia and the paraspinal reticular sheath.[11] Although no difference in efficacy can be demonstrated in an RCT comparing posterior QLB with lateral QLB, discrepancies in propagation have been documented in cadaver investigations.[10,26]

To date, several studies comparing TAP with QLB in children have been performed with a lateral TAPB approach, and only somatic analgesia could be achieved with the limited spread.[7,9,12,14,16,27] Öksüz et al. also compared lateral TAPB and posterior QLB in the first study ever reported in children.[16] To our knowledge, there is no RCT with posterior TAPB in children, and data on this subject are limited to case reports and observational studies only.[28]

Both posterior TAPB and lateral QLB can create an effect by spreading to the TAP and the paravertebral area.[9,11,29] However, according to our hypothesis, since the lateral QLB is applied directly to the ATF, with accumulation in the area, it can provide a wider sensory area by spreading to the endothoracic and iliac fascia, the continuation of ATF and thoracolumbar sympathetic nerves.[11] The supposition mentioned above could be the fundamental difference between the two strategies. Furthermore, the thoracolumbar fascia contains two distinct pain mechanoreceptors known as the Ruffini and Vater-Paccini bodies, both of which have autonomic roles.[30] Stimulating these receptors has also been linked to chronic pain, and blockade of these receptors may explain the long duration of action.[11,30]

We postulate that the main rationale for the low analgesic demand in QLB is anatomical variation in local anesthetic dispersion in the thoracolumbar fascia. As a result, an effective visceral block may not be achieved despite the adequate somatic block. Differences in surgical stimuli were assumed to be the secondary reason. The participants in our study had a variety of testicular locations, including inguinal canal, suprascrotal, and high scrotal. This discrepancy may have contributed to the heterogeneity in peri-operative and postoperative analgesic demands.

Limitations to our study include, firstly, the level of sensory block could not be detected in the intraoperative and postoperative periods after applying both techniques. Secondly, patients' parents determined both pain assessment and analgesic administration after the 6^{th} hour due to the outpatient nature of the orchiopexy procedure. Since the FLACC score was unsuitable for parental assessment, the Wong-Baker score was used for post-discharge pain evaluation. Finally, although the FLACC score is more appropriate for children < 7 years of age, it was used in all age groups aimed at uniform pain assessment. However, the mean age of the patients included in our study was 45 months, so we believe it did not affect the results.

In conclusion, this study showed that preoperative lateral QLB reduced analgesic usage and postoperative pain more than the posterior TAPB method. Parent satisfaction was also higher with QLB in pediatric patients undergoing orchiopexy. The clinical efficacy difference of these blocks with analogous mechanisms was presented. Further studies comparing these two blocks are required and need to be supported by cadaver and imaging studies.

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Conflicts of interest

The authors declare no conflicts of interest.

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Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.bjane.2023.06.004.

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