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Association of Ultrasound-Guided Transversus Abdominis Plane Block With Postoperative Pain and Analgesic Requirements in Pediatric Lower Abdominal Surgery: A Retrospective Cohort Study

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ABSTRACT

Ultrasound-guided transversus abdominis plane (TAP) block is increasingly incorporated into multimodal analgesic protocols for children undergoing abdominal procedures. We investigated whether adding a TAP block to general anesthesia was associated with improved postoperative pain control and reduced analgesic use in pediatric patients undergoing lower abdominal surgery.

We retrospectively reviewed pediatric lower abdominal operations performed from January 2023 through December 2025. Ninety-five patients fulfilled the predefined eligibility criteria and constituted the study cohort. Of these, 41 received an ultrasound-guided TAP block in addition to general anesthesia, whereas 54 were managed without the block. Postoperative pain intensity was the primary endpoint. Other evaluated outcomes were the need for rescue analgesia, cumulative tramadol and paracetamol use, additional fentanyl administration during surgery, and time spent in the post-anesthesia care unit (PACU).

Baseline demographic and operative characteristics did not differ significantly between the two groups. Patients receiving TAP block required less supplemental intraoperative fentanyl (p=0.008), and the proportion requiring an additional fentanyl dose was 17.1% compared with 37.0% among controls (p=0.032). Recovery in the PACU was faster in the TAP group, with a mean stay of 33.5±5.6 minutes versus 42.2±9.1 minutes in the control group (p=0.001). Across every recorded postoperative assessment through hour 12, pain scores favored the TAP group (all p=0.001). During the first 24 hours, rescue analgesia was administered to 1 of 41 patients (2.4%) who received TAP block and to 26 of 54 patients (48.1%) in the control group (p=0.001). Cumulative tramadol use, frequency of tramadol administration, and 24-hour paracetamol consumption were likewise reduced in the TAP group (all p=0.001). After adjustment for age, sex, ASA physical status, surgical duration, and procedure type, receipt of TAP block remained strongly associated with a lower probability of rescue analgesia use within 24 hours (adjusted OR 0.020, 95% CI 0.002–0.172; p=0.001).

In this retrospective pediatric cohort, incorporating a unilateral ultrasound-guided TAP block into the anesthetic regimen was associated with better early postoperative pain control, substantially less need for rescue medication, lower overall analgesic exposure, and a shorter PACU stay. These results suggest that TAP block can provide meaningful analgesic benefit as part of a multimodal strategy for pediatric lower abdominal procedures.

Keywords: Transversus abdominis plane block, pediatric anesthesia, lower abdominal surgery, postoperative analgesia, regional anesthesia, ultrasound guidance

Introduction

Adequate control of postoperative pain is an important component of perioperative care in children, as it can influence comfort, mobilization, opioid exposure, length of hospitalization, and overall recovery (1). When acute postoperative pain is insufficiently recognized or treated, children may experience greater anxiety, unfavorable behavioral responses, delayed recovery, and an increased need for analgesic medication (2). Pain management in pediatric patients nevertheless presents particular difficulties, including limitations in age-dependent communication and concerns regarding the administration of analgesic drugs (3).

Lower abdominal and inguinoscrotal operations such as inguinal hernia repair, orchiopexy, hydrocele surgery, and appendectomy are frequently performed in pediatric surgical practice (4,5). Although many of these procedures are suitable for day-case surgery or brief hospitalization, postoperative discomfort may

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interfere with mobilization, oral intake, and readiness for discharge (6,7). Analgesia has traditionally relied on systemic opioid and non-opioid medications. The undesirable effects of opioids, including nausea, vomiting, sedation, respiratory depression, and delayed recovery, have encouraged greater use of multimodal approaches designed to limit perioperative opioid exposure (2,3).

The transversus abdominis plane (TAP) block targets the abdominal wall by depositing local anesthetic in the fascial plane separating the internal oblique and transversus abdominis muscles, thereby providing somatic analgesia (8). With ultrasound guidance, the relevant muscular layers, needle trajectory, and distribution of the injected local anesthetic can be observed during block placement, allowing more precise performance of the technique (9). Evidence from adult populations, including individual studies and meta-analyses, indicates that TAP block can reduce postoperative pain intensity and opioid consumption (10,11). Beneficial analgesic effects have also been described in children, although the existing pediatric literature includes studies with relatively small cohorts as well as considerable variation in surgical procedures and perioperative analgesic protocols (12).

Against this background, we examined postoperative outcomes associated with ultrasound-guided TAP block in pediatric patients undergoing lower abdominal surgery. The analysis focused on postoperative pain intensity, rescue analgesic use, and overall analgesic consumption. We additionally evaluated whether receipt of TAP block remained associated with rescue analgesia requirements after accounting for relevant patient and surgical characteristics in a multiple logistic regression model.

Materials and Methods

Patient Selection: Potentially eligible cases were identified through the electronic medical record and anesthesia information management systems. The screening process covered patients undergoing inguinal hernia repair, open appendectomy, hydrocele surgery, or orchiopexy.

Patients were eligible when they were 4–13 years old, had an American Society of Anesthesiologists (ASA) physical status of I or II, underwent lower abdominal surgery under general anesthesia, and had complete documentation of postoperative pain assessments and administered medications. Cases were excluded when clinical information was missing, postoperative pain documentation was incomplete, chronic pain was present, neurological or developmental conditions could compromise reliable pain evaluation, another surgical procedure was performed during the same operative session, or perioperative documentation was insufficient.

For analysis, patients were grouped according to the analgesic approach recorded in their perioperative care. Those who received an ultrasound-guided transversus abdominis plane block together with general anesthesia constituted the TAP group. Patients managed with general anesthesia without a TAP block formed the control group.

Anesthetic and Surgical Management: All patients received the institution's routine perioperative monitoring. General anesthesia was initiated with propofol at 2–3 mg/kg, fentanyl at 2 μg/kg, and rocuronium at 0.6 mg/kg. Airway management was achieved by either tracheal intubation or placement of a laryngeal mask airway, after which mechanical ventilation was instituted. Maintenance anesthesia consisted of sevoflurane in an oxygen–air mixture at 0.8–1.2 minimum alveolar concentration.

Additional fentanyl could be given intraoperatively when hemodynamic changes indicated a clinical need for further analgesia. Intravenous paracetamol was administered during surgery to every patient.

To limit variability attributable to operative technique, all procedures were carried out by the same pediatric surgeon. Each operation was performed in accordance with the institution's established protocol for that specific procedure.

TAP Block Procedure: TAP block use reflected routine anesthetic practice rather than assignment according to a research protocol. No predefined patient-related or operative criteria, including demographic characteristics, procedure type, or expected surgical duration, were used to determine whether the block would be performed. Because this could introduce selection bias, demographic and surgical characteristics at baseline were compared between the two groups.

Experienced anesthesiologists performed the blocks after induction of general anesthesia and under ultrasound guidance. A high-frequency linear transducer was positioned to visualize the external oblique, internal oblique, and transversus abdominis muscles. The needle was then advanced using an in-plane technique until its tip reached the fascial plane between the internal oblique and transversus abdominis layers.

After confirming negative aspiration, the block was administered unilaterally on the side of surgery. Bupivacaine 0.25% (2.5 mg/mL) was injected at 0.5 mL/kg in all patients who received TAP block. Appropriate distribution of the local anesthetic within

the target fascial plane was verified sonographically during injection. The administered dose remained within recommended bupivacaine safety limits in every case.

The attending anesthesiologist determined whether to perform the block as part of routine clinical management; TAP block was not introduced as a study-specific intervention.

Data Collection: Clinical and perioperative variables were obtained from the electronic medical record and anesthesia information management systems. The extracted data comprised age, sex, height, weight, body mass index (BMI), ASA physical status, surgical procedure and laterality, intraoperative doses of propofol, fentanyl, rocuronium, and paracetamol, operative duration, post-anesthesia care unit (PACU) length of stay, postoperative pain measurements, rescue analgesic use, and cumulative tramadol and paracetamol consumption during the first 24 hours after surgery.

Because treatment allocation was not randomized, the possibility of selection bias inherent to the retrospective design could not be fully removed. Several features of the cohort were therefore standardized as far as possible. Only children undergoing inguinal hernia repair, open appendectomy, hydrocele surgery, or orchiopexy were included. The same general anesthesia protocol was used throughout the cohort, all operations were performed by a single pediatric surgeon, and local anesthetic infiltration of the surgical site was not used.

Comparability of the groups at baseline was examined using demographic variables, ASA physical status, surgical procedure, and operative duration. Postoperative pain scores and analgesic use were retrieved directly from routinely maintained electronic clinical records, limiting dependence on retrospective investigator assessment.

Two investigators independently extracted the study data. Whenever disagreement occurred, the corresponding original medical record was re-examined to reach a final determination.

Outcomes: Postoperative pain intensity constituted the primary outcome. Secondary outcomes were the requirement for rescue analgesia during the first 24 postoperative hours, cumulative tramadol use, number of tramadol administrations, total paracetamol consumption, need for supplemental intraoperative opioid administration, and PACU length of stay.

As this was a retrospective cohort study, the sample consisted of all patients who satisfied the eligibility criteria within the predefined study interval; an a priori sample size calculation was therefore not undertaken.

Postoperative Pain Management: Pain assessment was performed according to the child's age and ability to participate in self-reporting. In patients aged 6 years or older, pain intensity was evaluated with the Numeric Rating Scale (NRS; 0–10) (13). For children younger than 6 years, or for those unable to provide an adequate self-assessment, the revised Face, Legs, Activity, Cry, and Consolability (FLACC-R) scale was used (14).

A recorded pain score >4 triggered intravenous tramadol at a dose of 1 mg/kg as rescue analgesia. Analgesic administrations during the first 24 postoperative hours were identified from the electronic medication records. Pain-score analyses included assessments through postoperative hour 12, whereas rescue analgesia, cumulative tramadol exposure, and paracetamol consumption were evaluated over the complete first 24-hour postoperative period.

Pain evaluations in both the PACU and surgical ward formed part of routine clinical care and were performed by the responsible nursing staff. The corresponding scores had been entered into the electronic medical record for clinical monitoring rather than specifically for this research. Because the study was planned retrospectively, the personnel who originally recorded these assessments had no knowledge of the later study hypothesis.

Statistical Analysis: All statistical analyses were conducted in Python version 3.12 using the pandas, NumPy, SciPy, and statsmodels packages. Continuous variables were examined for distributional characteristics by visual inspection together with the Shapiro–Wilk test.

Data showing an approximately normal distribution are expressed as mean ± standard deviation, whereas variables with non-normal distributions are reported as median with the first and third quartiles (Q1–Q3). Comparisons between two groups were performed with the independent-samples t-test for normally distributed continuous variables and the Mann–Whitney U test when distributional assumptions were not met. Categorical data were assessed with either the chi-square test or Fisher's exact test, depending on cell frequencies. Statistical significance was defined using a two-sided p value <0.05.

Because postoperative pain scores were repeatedly measured within the same patients at PACU admission and at 1, 2, 4, 6, and 12 postoperative

hours, an additional repeated-measures analysis was performed using generalized estimating equations (GEE). A Gaussian distribution with an identity link, an exchangeable working correlation structure, and robust standard errors was used. Group, time (treated as a categorical variable), and the group × time interaction were included as model terms, with patient specified as the clustering variable. The group × time interaction was used to evaluate whether the temporal pattern of postoperative pain scores differed between the TAP block and control groups. The Mann–Whitney U comparisons at individual time points were retained to describe between-group differences at each postoperative assessment.

A multiple logistic regression model was constructed to evaluate factors associated with rescue analgesia use during the first 24 hours after surgery. The covariates entered into the model were age, sex, ASA physical status, duration of surgery, and surgical procedure (open appendectomy vs. other procedures). Associations are presented as adjusted odds ratios (ORs) together with 95% confidence intervals (CIs). Because only one rescue analgesia event occurred in the TAP block group, a sensitivity analysis using Firth's penalized logistic regression was additionally performed to reduce potential small-sample bias and instability related to quasi-separation. The sensitivity model used the same dependent variable and covariates as the primary logistic regression model. Penalized odds ratios and profile-likelihood 95% confidence intervals were estimated.

The retrospective sampling strategy included all eligible patients identified during the study period; consequently, no prospective sample size estimation was performed.

Results

Patient Characteristics: During the study period, 133 pediatric patients undergoing lower abdominal surgery were screened for eligibility. Thirty-eight were excluded: 18 because of missing data, 6 because postoperative pain assessments were incomplete, and 14 because they met other exclusion criteria. The final cohort therefore comprised 95 patients, including 41 who received a TAP block and 54 who did not (Figure 1).

The two groups showed no statistically significant differences in age, sex, height, weight, body mass index (BMI), ASA physical status, surgical procedure, or operative laterality (all $p>0.05$). Overall, baseline demographic and clinical profiles were similar between groups (Table 1).

Perioperative Characteristics: Intraoperative drug administration was generally comparable between the groups. Mean propofol dose was 80.7±22.7 mg in the TAP group and 76.4±17.4 mg in the control group ($p=0.311$). Corresponding fentanyl induction doses were 45.5±13.8 μg and 44.5±11.8 μg ($p=0.724$), while rocuronium doses were 17.9±5.2 mg and 17.2±4.1 mg, respectively ($p=0.434$). Total fentanyl exposure also did not differ significantly (43 (37–55) μg vs. 49.5 (38–64.75) μg; $p=0.241$). Intraoperative paracetamol use was 448.2±129.7 mg in the TAP group and 428.9±101.6 mg in controls ($p=0.434$). Operative duration was likewise similar (43.7±8.4 min vs. 42.6±9.0 min; $p=0.530$).

A difference emerged, however, in supplemental fentanyl use. The median additional fentanyl dose was 0 (0–0) μg among patients receiving TAP block and 0 (0–18.75) μg in the control group ($p=0.008$). Additional fentanyl was required in 7 of 41 patients (17.1%) in the TAP group compared with 20 of 54 patients (37.0%) in the control group ($p=0.032$).

Recovery-unit stay was also shorter among patients who received TAP block. Mean PACU length of stay was 33.5±5.6 minutes in the TAP group versus 42.2±9.1 minutes in the control group ($p=0.001$) (Table 2).

Postoperative Pain Assessment: At every recorded postoperative assessment, pain scores were lower in the TAP group (Table 3, Figure 2). On admission to the PACU, the median score was 2 (2–3) after TAP block and 4 (3–6) in controls ($p=0.001$). The same pattern persisted at 1 hour (2 (2–3) vs. 3 (3–4); $p=0.001$), 2 hours (1 (1–2) vs. 2 (2–3); $p=0.001$), 4 hours (1 (0–1) vs. 2 (1–3); $p=0.001$), 6 hours (0 (0–1) vs. 2 (1–2); $p=0.001$), and 12 hours (0 (0–1) vs. 1 (0–2); $p=0.001$).

In the repeated-measures GEE analysis, the group × time interaction was statistically significant (Wald $\chi^2(5)=67.13$, $p=0.001$), indicating that the temporal pattern of postoperative pain scores differed between the TAP block and control groups. The between-group differences observed at the individual postoperative assessments were consistent with this overall repeated-measures finding.

Postoperative Analgesic Requirements: During the first 24 postoperative hours, rescue analgesia was administered to 1 of 41 patients (2.4%) in the TAP group and to 26 of 54 patients (48.1%) in the control group ($p=0.001$).

Median total tramadol consumption was 0 (0–0) mg in the TAP group and 0 (0–27.5) mg in the

Table 1: Demographic, Clinical, and Surgical Characteristics of the Study Population

Variable	TAP group (n=41)	Control group (n=54)	p value
Age, years	8.0 ± 2.7	7.7 ± 2.1	0.510
Male sex, n (%)	25 (61.0)	24 (44.4)	0.165
Height, cm	133.4 ± 17.1	131.5 ± 13.5	0.545
Weight, kg	29.9 ± 8.6	28.6 ± 6.8	0.434
BMI, kg/m²	16.4 ± 0.7	16.3 ± 0.7	0.401
ASA physical status, n (%)			0.307
├─ ASA I	28 (68.3)	43 (79.6)	
└─ ASA II	13 (31.7)	11 (20.4)	
Type of surgery, n (%)			0.175
├─ Inguinal hernia	24 (58.5)	27 (50.0)	
├─ Open appendectomy	8 (19.5)	12 (22.2)	
├─ Hydrocele	7 (17.1)	5 (9.3)	
└─ Orchiopexy	2 (4.9)	10 (18.5)	
Surgical laterality, n (%)			0.860
├─ Right	25 (61.0)	30 (55.5)	
├─ Left	12 (29.3)	19 (35.2)	
├─ Bilateral	4 (9.8)	5 (9.3)	

Values are presented as mean ± standard deviation or n (%). BMI: body mass index; ASA: American Society of Anesthesiologists physical status classification. Continuous variables were compared using the independent-samples t-test, and categorical variables were compared using the chi-square test or Fisher's exact test, as appropriate

Table 2: Intraoperative Anesthetic Management and Perioperative Characteristics

Variable	TAP group (n=41)	Control group (n=54)	p value
Propofol dose, mg	80.7 ± 22.7	76.4 ± 17.4	0.311
Fentanyl induction dose, μg	45.5 ± 13.8	44.5 ± 11.8	0.724
Rocuronium dose, mg	17.9 ± 5.2	17.2 ± 4.1	0.434
Additional fentanyl consumption, μg	0 (0–0)	0 (0–18.75)	0.008
Total fentanyl dose, μg	43 (37–55)	49.5 (38–64.75)	0.241
Intraoperative paracetamol dose, mg	448.2 ± 129.7	428.9 ± 101.6	0.434
Surgery duration, min	43.7 ± 8.4	42.6 ± 9.0	0.530
PACU duration, min	33.5 ± 5.6	42.2 ± 9.1	0.001
Patients requiring additional fentanyl, n (%)	7 (17.1)	20 (37.0)	0.032

Table 3: Comparison of Postoperative Pain Scores Between the TAP Block and Control Groups

Time point	TAP group (n=41)	Control group (n=54)	p value
PACU	2 (2–3)	4 (3–6)	0.001
1 h	2 (2–3)	3 (3–4)	0.001
2 h	1 (1–2)	2 (2–3)	0.001
4 h	1 (0–1)	2 (1–3)	0.001
6 h	0 (0–1)	2 (1–2)	0.001
12 h	0 (0–1)	1 (0–2)	0.001

Values are presented as median (Q1–Q3). Postoperative pain was assessed using the 0–10 Numeric Rating Scale in cooperative children aged ≥6 years and the FLACC-R scale in children aged <6 years or those unable to cooperate. Because both scales provide scores on a 0–10 range, pain scores were analyzed as a common 0–10 postoperative pain score. Between-group comparisons were performed using the Mann–Whitney U test. PACU: post-anesthesia care unit

Table 4: Postoperative Analgesic Requirements and Rescue Analgesia Outcomes Within the First 24 Hours

Variable	TAP group (n=41)	Control group (n=54)	p value
Rescue analgesia requirement, n (%)	1 (2.4)	26 (48.1)	0.001
Total tramadol consumption, mg/24 h	0 (0–0)	0 (0–27.5)	0.001
Number of tramadol administrations, n	0 (0–0)	0 (0–1)	0.001
Total paracetamol consumption, mg/24 h	435 (345–555)	555 (442.5–825)	0.001

Values are presented as median (Q1–Q3) or n (%). Continuous variables were compared using the Mann–Whitney U test and categorical variables using Fisher's exact test. Rescue analgesia consisted of intravenous tramadol administered according to the institutional postoperative pain management protocol

Supplementary Table 1: Multiple Logistic Regression Analysis for Rescue Analgesia Requirement Within the First 24 Postoperative Hours

Variable	β	SE	Wald	Adjusted OR	95% CI	p value
TAP block	-3.903	1.092	12.78	0.020	0.002–0.172	0.001
Age (years)	-0.248	0.140	3.15	0.781	0.594–1.026	0.076
Male sex (vs. female)	0.135	0.632	0.05	1.144	0.332–3.950	0.831
ASA II (vs. ASA I)	-0.008	0.690	0.00	0.992	0.256–3.837	0.990
Surgery duration (min)	0.013	0.040	0.10	1.013	0.937–1.095	0.749
Open appendectomy (vs. other procedures)	-1.738	0.988	3.09	0.176	0.025–1.219	0.079

Abbreviations: OR, odds ratio; CI, confidence interval; SE, standard error.
Dependent variable: rescue analgesia requirement within the first 24 postoperative hours.
Reference categories: female sex, ASA I, and surgical procedures other than open appendectomy

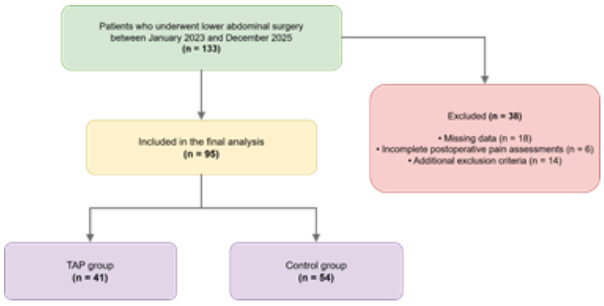

Fig. 1. Flow Diagram of Patient Selection and Inclusion Process Patients who underwent lower abdominal surgery between January 2023 and December 2025
Flowchart illustrating patient screening, exclusion, and final allocation to the TAP block and control groups. A total of 133 patients were assessed for eligibility, and 95 patients were included in the final analysis

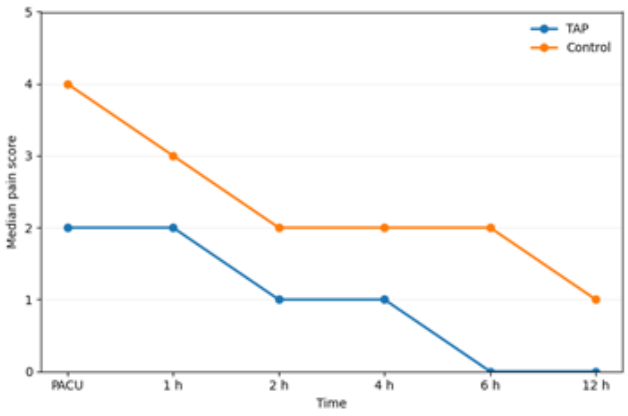

Fig. 2. Postoperative Pain Trajectory During the First 12 Hours After Surgery
Median postoperative pain scores at PACU admission and at 1, 2, 4, 6, and 12 postoperative hours. Pain was assessed using the 0–10 Numeric Rating Scale (NRS) or FLACC-R according to age and ability to cooperate. Patients receiving ultrasound-guided TAP block had lower pain scores than the control group at all individual assessment time points (all p=0.001)

control group (p=0.001). The number of tramadol administrations followed the same pattern, with medians of 0 (0–0) and 0 (0–1), respectively (p=0.001).

Paracetamol exposure over 24 hours was also lower among patients receiving TAP block, with median cumulative doses of 435 (345–555) mg versus 555 (442.5–825) mg in the control group (p=0.001) (Table 4, Figure 3).

Supplementary Table 2. Firth Penalized Logistic Regression Sensitivity Analysis for Rescue Analgesia Requirement Within the First 24 Postoperative Hours

Variable	Penalized OR	95% CI	p value
TAP block	0.037	0.004–0.163	0.001
Age (years)	0.805	0.614–1.031	0.086
Male sex (vs. female)	1.116	0.345–3.691	0.854
ASA II (vs. ASA I)	1.009	0.275–3.597	0.987
Surgery duration (min)	1.012	0.940–1.092	0.758
Open appendectomy (vs. other procedures)	0.217	0.032–1.244	0.087

Abbreviations: OR, odds ratio; CI, confidence interval.
Dependent variable: rescue analgesia requirement within the first 24 postoperative hours.
Reference categories: no TAP block, female sex, ASA I, and surgical procedures other than open appendectomy.
Firth's penalized logistic regression was performed as a sensitivity analysis using the same covariates as the primary logistic regression model. Confidence intervals were obtained using profile likelihood

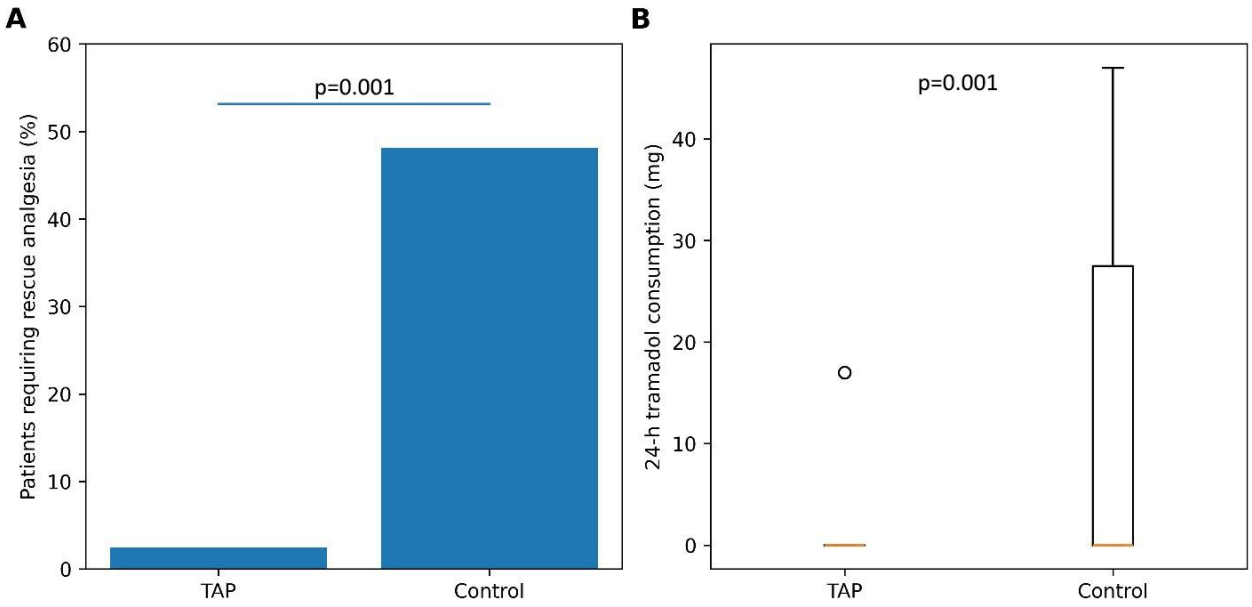

Fig. 3. Association of TAP Block With Postoperative Analgesic Requirements
(A) Proportion of patients requiring rescue analgesia during the first 24 postoperative hours. (B) Total tramadol consumption during the same period. Patients in the TAP block group had significantly lower rescue analgesia requirements and lower cumulative tramadol consumption compared with the control group (both p=0.001)

After adjustment for age, sex, ASA physical status, operative duration, and surgical procedure, the multiple logistic regression model showed that TAP block remained associated with a substantially lower likelihood of rescue analgesia use during the first 24 postoperative hours (adjusted OR: 0.020, 95% CI: 0.002–0.172; p=0.001). None of the remaining covariates demonstrated an independent association with rescue analgesia requirement (all p>0.05) (Supplementary Table 1). In the Firth penalized logistic regression sensitivity analysis, the association between TAP block and reduced rescue analgesia requirement remained evident (penalized OR: 0.037, 95% CI: 0.004–0.163; p=0.001), supporting the robustness of the primary logistic regression finding despite the low event count in the TAP block group (Supplementary Table 2).

Discussion

Principal Findings: In this retrospective cohort, the addition of an ultrasound-guided unilateral TAP block to general anesthesia was associated with better early postoperative analgesic outcomes in children undergoing lower abdominal surgery. Compared with patients managed without TAP block, those receiving the block had lower pain scores throughout the recorded postoperative period, required rescue analgesia less often, consumed smaller amounts of tramadol and

paracetamol, and spent less time in the PACU. The association between TAP block and reduced rescue analgesia use also remained evident after adjustment for relevant demographic and surgical variables in the multiple logistic regression analysis.

Association With Postoperative Pain Scores: The TAP block was administered unilaterally on the operative side. This approach was anatomically appropriate for the majority of procedures represented in the cohort, which consisted predominantly of unilateral inguinoscrotal operations such as inguinal hernia repair, hydrocele surgery, and orchiopexy. Open appendectomy was likewise performed through a unilateral lower abdominal incision. Moreover, the distribution of procedure types did not differ significantly between the study groups, reducing the likelihood that the observed analgesic differences were primarily driven by surgical heterogeneity.

Pain scores consistently favored the TAP group from PACU admission through postoperative hour 12. In addition, the repeated-measures GEE analysis demonstrated a significant group × time interaction, indicating that the temporal pattern of postoperative pain scores differed between the TAP block and control groups. This pattern is in agreement with previously reported pediatric data showing improved early postoperative pain control following TAP block in lower abdominal procedures (15,16).

The analgesic effect of TAP block is explained by interruption of somatic afferent transmission within the anterolateral abdominal wall. Local anesthetic deposited between the internal oblique and transversus abdominis muscles reaches thoracolumbar nerve branches traveling within this fascial plane (17). Such coverage is particularly relevant for operations including inguinal hernia repair, orchiopexy, and hydrocele surgery, in which a substantial proportion of postoperative pain originates from somatic structures (16).

Randomized pediatric studies have also reported reductions in early postoperative pain after TAP block (18,19). Evidence from systematic reviews and meta-analyses similarly supports the analgesic effectiveness of the technique when compared with alternatives such as caudal block or systemic analgesic regimens (16,20). The present findings are therefore consistent with the existing literature while providing additional evidence from routine clinical practice.

Analgesic Consumption and Rescue Analgesia Requirements: A particularly pronounced difference between groups was observed in the use of rescue analgesia. Only one patient in the TAP group (2.4%) required rescue medication during the first 24 postoperative hours, compared with 48.1% of patients managed without the block. Cumulative tramadol exposure, frequency of tramadol administration, and total paracetamol consumption were also lower among children who received TAP block.

This opioid-sparing pattern is consistent with findings previously reported in both pediatric and adult populations (21,22). Limiting opioid exposure is especially relevant in children because these drugs may contribute to postoperative nausea and vomiting, sedation, and respiratory depression (23). For this reason, contemporary multimodal analgesic strategies aim to achieve adequate pain relief while reducing dependence on systemic opioids (24,25).

The multiple logistic regression analysis further showed that TAP block remained associated with reduced rescue analgesia use after adjustment for age, sex, ASA physical status, surgical duration, and procedure type. Although residual confounding cannot be fully excluded in a retrospective study, persistence of the association after adjustment suggests that the observed difference was not attributable solely to measured demographic or operative characteristics. The Firth penalized logistic regression sensitivity analysis yielded a similarly strong association, supporting the robustness of this finding despite the low number of rescue analgesia events in the TAP block group.

PACU Stay and Clinical Implications: Children in the TAP group also had a shorter PACU stay. Improved early analgesia may facilitate a more stable and comfortable recovery by reducing emergence-related distress and decreasing the need for additional analgesic interventions (26). Although PACU discharge criteria were not specifically analyzed in this study, the approximately 9-minute difference in recovery-unit stay raises the possibility that improved pain control contributed to earlier readiness for discharge from the PACU.

A reduction of this magnitude may have practical relevance in high-throughput pediatric surgical settings. Even relatively small decreases in recovery-room occupancy could potentially improve patient turnover, reduce demands on PACU staff, and allow earlier reunification of children with their families. These operational outcomes were not directly measured, however, and should therefore be regarded as potential implications rather than demonstrated effects of TAP block.

TAP block is generally considered a safe component of regional anesthesia, but local anesthetic systemic toxicity (LAST) remains an important consideration in pediatric patients. Differences in body composition, distribution volume, and drug pharmacokinetics may result in more rapid increases in plasma local anesthetic concentrations in children than in adults (9). Careful use of ultrasound guidance, weight-adjusted dosing, and adherence to recommended maximum dose limits are therefore essential.

In the present cohort, the administered bupivacaine doses remained within accepted safety limits. Review of the medical records did not identify any documented episode of LAST or another serious complication attributable to the block.

Strengths of the Study: Several aspects of the study design helped improve the internal consistency of the cohort. All operations were performed by the same pediatric surgeon, which limited variation arising from differences in surgical technique and tissue handling. In addition, none of the patients received local anesthetic infiltration at the surgical site, reducing the possibility that wound infiltration influenced postoperative analgesic outcomes.

Perioperative management was also relatively uniform, with the same general anesthesia protocol and postoperative pain-management approach used throughout the study period. Finally, the multiple logistic regression model allowed the association between TAP block and rescue analgesia use to be examined while accounting for several clinically relevant patient- and procedure-related variables.

Limitations: The findings should be interpreted in light of several limitations. Most importantly, the retrospective nature of the study prevents complete elimination of treatment-selection bias. TAP block was performed according to the attending anesthesiologist's clinical judgment rather than according to predetermined allocation criteria. Although the TAP and control groups did not differ significantly in the measured baseline demographic or surgical characteristics, and adjustment for measured covariates was undertaken, propensity score methods were not used. Therefore, the possibility that unmeasured factors contributed to the observed between-group differences remains. In addition, only one patient in the TAP block group required rescue analgesia, which may have contributed to quasi-separation and instability in the conventional logistic regression estimate. To address this issue, a Firth penalized logistic regression sensitivity analysis was performed, and the resulting estimate was consistent with the primary analysis.

The single-center setting also limits the extent to which the findings can be generalized to institutions with different patient populations or perioperative practices. Furthermore, postoperative pain assessments were obtained from routine clinical records. Because data were collected retrospectively, it was not possible to confirm complete blinding of all personnel involved in pain assessment.

Pain measurement additionally relied on two different instruments according to patient age and ability to cooperate. The NRS and FLACC-R both provide scores on a 0–10 scale and are established approaches to pediatric pain assessment, but the use of more than one instrument may nevertheless have introduced some heterogeneity into pain-score comparisons.

No documented episodes of local anesthetic systemic toxicity, injection-site infection, hematoma, or peritoneal puncture were identified among patients receiving TAP block. However, adverse-event assessment was limited to events that had been entered into the medical record. Undocumented or very mild complications therefore cannot be excluded on the basis of this retrospective review.

Finally, the analysis was restricted to the early postoperative period. Outcomes extending beyond the initial postoperative follow-up were not available and were therefore not examined.

Among children undergoing lower abdominal surgery, the use of an ultrasound-guided unilateral TAP block was associated with more favorable early postoperative analgesic outcomes. Patients who received the block experienced lower pain scores, required rescue analgesia less frequently, consumed less postoperative analgesic medication, and had shorter PACU stays. These findings indicate that TAP block may be a useful addition to multimodal analgesic care for pediatric lower abdominal procedures.

Declarations

Ethics Approval and Consent to Participate: The study protocol was approved by the local ethics committee (approval number: 2025/14-39; approval date: September 4, 2025). The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Due to the retrospective nature of the study and the use of anonymized medical records, the requirement for informed consent was waived by the Ethics Committee.

Consent for Publication: Not applicable.

Availability of Data and Materials: The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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Author Contributions: OKB: Conceptualization, methodology, data curation, formal analysis, investigation, interpretation of data, and writing—original draft preparation.

SSK: Conceptualization, methodology, investigation, interpretation of data, writing—review and editing, supervision, and correspondence.

SFO: Methodology, data curation, formal analysis, investigation, interpretation of data, and writing—review and editing.

All authors read and approved the final manuscript and agree to be accountable for all aspects of the work.

Use of Artificial Intelligence Tools: Large language model–based artificial intelligence tools (ChatGPT, OpenAI) were used solely for language editing and improvement of manuscript readability. All scientific content, study design, data analysis, interpretation of results, and final approval of the manuscript were performed by the authors.

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