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Clinical Research Article

# Postoperative analgesic effects of the quadratus lumborum block in pediatric patients: a systematic review and meta-analysis

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ABSTRACT

**Background:** This study assessed the postoperative analgesic efficacy and safety of the quadratus lumborum block (QLB) in pediatric patients.

**Methods:** Electronic databases were searched for studies comparing the QLB to conventional analgesic techniques in pediatric patients. The primary outcome was the need for rescue analgesia 12 and 24 hours after surgery. Secondary outcomes covered the Face-Legs-Activity-Cry-Consolability Scale (FLACC) scores at various time points; parental satisfaction; time to the first rescue analgesia; hospitalization time; block execution time; block failure rates, and adverse events.

**Results:** Sixteen randomized controlled trials were analyzed involving 1,061 patients. The QLB significantly reduced the need for rescue analgesia both at 12 and 24 hours after surgery (12 hours, relative risk [RR]: 0.45; 95% confidence interval [CI]: 0.01, 0.88; 24 hours, RR: 0.51; 95% CI: 0.31, 0.70). In case of 24 hours after surgery, type 1 QLB significantly reduced the need for rescue analgesia (RR: 0.56; 95% CI: 0.36, 0.76). The QLB also exhibited lower FLACC scores at 1 hour (standardized mean difference [SMD]: –0.87; 95% CI: –1.56, –0.18) and 6 hours (SMD: –1.27; 95% CI: –2.33, –0.21) following surgery when compared to non-QLB. Among QLBs, type 2 QLB significantly extended the time until the first rescue analgesia (SMD: 1.25; 95% CI: 0.84, 1.67). No significant differences were observed in terms of parental satisfaction, hospitalization time, block execution time, block failure, or adverse events between QLB and non-QLB groups.

**Conclusions:** The QLB provides non-inferior analgesic efficacy and safety to conventional methods in pediatric patients.

**Keywords:** Analgesia; Meta-Analysis; Nerve Block; Pain; Pain Measurement; Pain, Postoperative; Pediatrics; Systematic Review.

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# INTRODUCTION

Postoperative pain control in pediatric patients is complex and challenging. The prevalence of moderate and severe postoperative pain in children has been reported to be as high as 44% and 60% in two pediatric centers in the United States [1]. In addition to the use of nonopioid analgesics, the enhanced recovery after surgery (ERAS) protocol currently encourages the use of regional analgesic techniques to provide optimal pain relief and hasten overall patient recovery [2]. Thus, prophylactic regional analgesia techniques, such as caudal blocks (CB), peripheral nerve blocks, and infiltrations, are commonly performed in pediatric surgeries [3].

Since Hebbard et al. [4] first described the ultrasound-guided transversus abdominis plane (TAP) block, new regional anesthesia techniques performed on the trunk, called truncal blocks, have emerged. The unique feature of truncal blocks is that, in contrast to peripheral nerve blocks, they do not require identification of nerves or plexuses and involve injection of a local anesthetic in a particular muscle plane until it spreads and reaches the intended nerves. This method makes the nerve block delivery easy and versatile.

Among the various types of truncal blocks, the ultrasound-guided quadratus lumborum block (QLB) is a newly described fascial plane block used for somatic and visceral analgesia during abdominal surgeries [5]. This technique was first described by Blanco in 2007 [5] and involves injecting the local anesthetic adjacent to the quadratus lumborum (QL) muscle to anesthetize the thoracolumbar nerves [6].

Although several meta-analyses have demonstrated promising analgesic effects of the QLB in adult patients [7–9], evidence from a systematic approach that supports the use of the QLB over other analgesic techniques in pediatric patients remains lacking. Although one meta-analysis [10] investigated the analgesic effects of the QLB in pediatric patients, subgroup analyses based on the type of QLB and analgesic control were not performed because of the paucity of available studies. Moreover, important study outcomes, including the rate of block failure, time to first rescue analgesia, and hospitalization time, were not analyzed. Among the increasing number of studies that have explored the use of the QLB in pediatric patients, some studies have also explored the use of the QLB outside the context of lower abdominal surgeries, including surgery for hip dysplasia [11,12] and open renal surgery [13] in pediatric patients.

Therefore, the purpose of this meta-analysis was to thoroughly evaluate and compare the postoperative analgesic efficacy of the QLB with that of other analgesic techniques by analyzing the need for rescue analgesia during the postoperative period as a primary endpoint. In addition, a number of other secondary outcomes, including the time to first rescue analgesia, pain intensity at various time points during the postoperative period, parental satisfaction score, total hospitalization time, time to perform the block, adverse events, and incidence of block failures, were also analyzed for comprehensiveness.

# MATERIALS AND METHODS

This systematic review and meta-analysis adhered to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement. The predefined protocol for the present study was registered in the International Prospective Register of Systematic Reviews (CRD42023433383).

## 1. Search strategy

We searched PubMed, Embase, CENTRAL, Scopus, and Web of Science databases using the Population, Intervention, Comparison, Outcome, Study design (PICOS) method from inception to May 31, 2023. The search scope was “title and abstract,” and details on the search terms used for each database are summarized in **Supplementary Table 1**. All randomized controlled trials (RCTs) involving QLB were investigated and the search was not restricted to studies with specific control groups or those published in specific languages.

## 2. Study selection

Two independent reviewers screened the titles, abstracts, and full texts of the articles. The inclusion criteria were as follows: (1) RCTs, (2) studies that included pediatric patients undergoing general anesthesia, and (3) studies that compared the postoperative analgesic effect of QLB with no intervention or other interventions. The exclusion criteria were as follows: (1) duplicate articles, (2) trial registry records or clinical trial protocols, (3) animal studies, (4) reviews, (5) abstract-only papers, (6) case reports, (7) letters and editorials, and (8) observational studies.

## 3. Outcome measures

The primary endpoint was the number of patients requiring rescue analgesia 12 and 24 hours after surgery. The secondary endpoints were the Face-Legs-Activity-Cry-Consolability Scale (FLACC) scores at 30 minutes, 1 hour, 2 hours, 4 hours, 6 hours, 12 hours, and 24 hours after surgery; parental satisfaction score; time to first rescue analgesia; total hospitalization time; time to perform the block; and incidence of block failure and adverse events, including postoperative nausea and vomiting (PONV), hypotension, bradycardia, urine retention, motor weakness, and procedure-related hematoma. Parental satisfaction scores, recorded on a numerical scale from 1 to 10, with 1 representing the lowest possible level of satisfaction and 10 representing the highest, were used in the pooled analysis.

### 4. Data extraction

One reviewer extracted the following information: (1) author, (2) publication year, (3) number of patients in each study and group, (4) country of publication, (5) age range of the study patients, (6) sex composition, (7) QLB type performed, (8) type of analgesic technique received by the patients in the control group, (9) type and doses of local anesthesia in each group, and (10) type of surgery performed on the patients. Another reviewer validated the extracted data.

### 5. Quality assessment of the included studies

Two independent reviewers assessed the risk of bias using the revised Cochrane risk of bias tool for randomized trials (RoB-2). This tool includes five categories: bias arising from the randomization process, bias due to deviations from intended interventions, bias caused by missing outcome data, bias in the measurement of the outcome, and bias in the selection of the reported result. Risk of bias was categorized as "low risk," "some concerns," or "high risk" [14]. In cases of disagreements between the two reviewers, resolution was achieved through discussion with the corresponding author.

### 6. Certainty of evidence

The level of certainty of the evidence for each outcome was determined based on the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) [15]. This assessment comprised of five domains: risk of bias, inconsistency, indirectness, imprecision and publication bias. If the two reviewers disagreed in their assessments, any discrepancies were resolved by the corresponding author to eliminate bias.

### 7. Statistical analysis

All statistical analyses were conducted using R software, version 4.3.0 with the assistance of the “META” package within the Rstudio platform. Effect measures for dichotomous and continuous outcomes were reported as relative risk (RR) and standardized mean difference (SMD), respectively, along with their corresponding 95% confidence intervals (CIs). For continuous outcomes, when the standard deviation (SD) was not provided in an article and the authors could not be contacted, an estimated SD was calculated using information from either the interquartile range, standard errors, or CIs, or the pooled SD from all other available RCTs within the same meta-analysis was used [16]. Inter-study heterogeneity was assessed using $I^2$ and the Mantel-Haenszel chi-square test, with the $P$ value for heterogeneity ($P_h$ value). Specifically, $I^2$ values were interpreted as follows: $I^2 < 40\%$, $40\% \leq I^2 < 60\%$, and $I^2 \geq 60\%$ indicating low, moderate, and high heterogeneity, respectively. The choice of a random-effects model was made for meta-analysis when significant heterogeneity was present ($I^2 \geq 50\%$ or a $P_h$ value $< 0.1$). For meta-analyses involving studies with small sample size ($\leq$ 5), the Hartung-Knapp-Sidik-Jonkman method was used [17]. Conversely, a fixed-effect model was employed for analysis when heterogeneity was not significant. To evaluate the presence of publication bias in pooled analyses that included ≥ 10 studies, Egger’s linear regression test was applied. All statistical tests were two-sided, and a $P$ value $< 0.05$ was considered statistically significant for the overall effect.

## RESULTS

### 1. Study selection

The literature search identified 302 potentially eligible documents. First, 124 duplicate documents were removed, and 156 and six documents were excluded on the basis of the aforementioned exclusion criteria at the title-and-abstract and full-text review stages, respectively. The average weighted kappa for study selection was 0.82. As illustrated in the PRISMA flow diagram, 16 studies involving 1,061 patients were finally analyzed (**Fig. 1**).

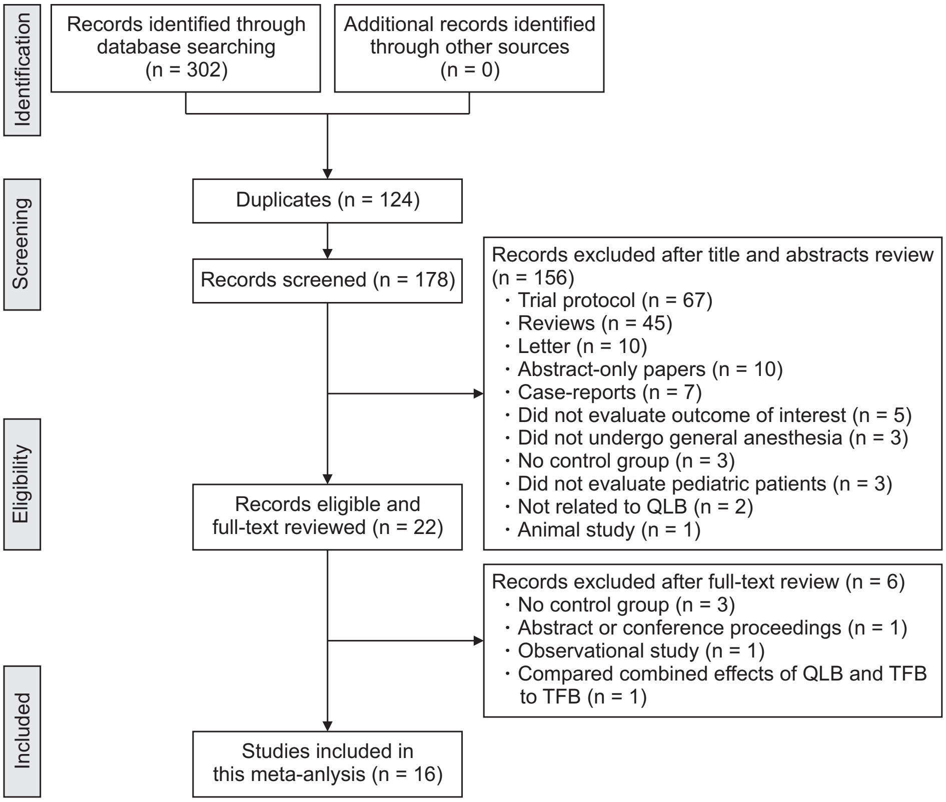

**Fig. 1.** Preferred Reporting Items for Systematic Reviews and Meta-analyses flow diagram of study selection. A total of 302 articles were identified through searches of the electronic databases. After excluding 124 duplicate studies, 156 articles were removed from the article pool based on the fitness of the title and abstract. The full texts of 22 eligible studies were then reviewed, and six studies were excluded. Finally, 16 RCTs were included in the final analysis. RCT: randomized controlled trial, QLB: quadratus lumborum block, TFB: transversalis fascia block.

## 2. Study and patient characteristics

The characteristics of the included studies are summarized in **Table 1**. Except in one study [11], all study patients were from a single center. All patients had American Society of Anesthesiologists (ASA) physical status scores of 1 or 2. In 10 [18–27] and two studies [28,29], patients underwent lower abdominal surgery, such as inguinal hernia repair or orchiopexy, and non-specified laparoscopic abdominal surgery; in two studies, patients underwent surgery for hip dysplasia [11,12], and in one study each, patients underwent open renal surgery [13] and bilateral ureteral reimplantation surgery [30]. Of the 16 studies, nine [18,20,22–25,28–30], three [21,26,27], and four studies [11–13,19] involved type 1, 2, and 3 QLB, respectively. A wide range of control procedures were used: seven studies [13,21–23,26,29,30] used CB; four [22,24,25,29] used TAP; two each used transversalis fascia block (TFB) [11,18], erector spinae plane block (ESPB) [19,28], and ilioinguinal/iliohypogastric nerve block (II/IH) [25,27]; and one each used intravenous opioids [20] and incision-line injection [12]. With regard to the type of local anesthetic, except for four studies [11,25,29,30] that used ropivacaine for QLB, all other studies used bupivacaine.

## 3. Number of patients requiring rescue analgesia after surgery

Data regarding the number of patients requiring rescue analgesia at 12 and 24 hours post-surgery are summarized in **Table 2**. Four studies [18,20,24,25] and 12 studies [12,13,19–24,27–30] analyzed the necessity for rescue analgesia at 12 and 24 hours, respectively. QLB reduced the need for rescue analgesia at 12 hours (RR: 0.45; 95% CI: 0.01, 0.88; $I^2 = 46.6\%$; $P < 0.001$; $P_h = 0.132$; **Fig. 2A**) and at 24 hours (RR: 0.51; 95% CI: 0.31, 0.70; $I^2 = 44.8\%$; $P < 0.001$; $P_h = 0.046$; Egger's $P$ value: 0.506; **Fig. 2B**) compared to non-QLB. In case of the latter, the association between QLB and a reduced need for rescue analgesia at 24 hours

**Table 1.** Characteristics of included randomized controlled trials (RCTs)

| References | Year | Study design | Country/center(s) | No. of patients analyzed | No. of patients analyzed in each group | | Age (yr) | Sex (M/F) | QLB type | Types and doses of local anesthetics | | Surgery |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | QLB | Control | | | | QLB | Control | |
| Abdelbaser et al. [18] | 2023 | Prospective/RCT | Egypt/single-center | 68 | 34 | TFB: 34 | 1–5 | 57/11 | Type 1 | 0.4 mL/kg bupivacaine 0.25% | TFB: 0.4 mL/kg bupivacaine 0.25% | Open surgical repair of unilateral inguinal hernia |
| Aksu et al. [19] | 2019 | Prospective/RCT | Turkey/single-center | 57 | 29 | ESPB: 28 | 1–7 | 44/13 | Type 3 | 0.5 mL/kg bupivacaine 0.25% | ESPB: 0.5 mL/kg bupivacaine 0.25% | Lower abdominal surgery (inguinal hernia repair, orchiopexy and hydrocelectomy) |
| Alansary et al. [13] | 2023 | Prospective/RCT | Egypt/single-center | 40 | 20 | CB: 20 | 2–11 | 35/5 | Type 3 | 0.5 mL/kg bupivacaine 0.20% | CB: 1.25 mL/kg bupivacaine 0.20% | Open renal surgery (pyeloplasty, nephrectomy, nephrolithotomy) |
| Ashoor et al. [21] | 2023 | Prospective/RCT | Egypt/single-center | 71 | 32 | CB: 39 | 1–5 | 58/13 | Type 2 | 1.0 mL/kg bupivacaine 0.25% | CB: 2 μg/kg neostigmine + 1.0 mL/kg bupivacaine 0.25% | Inguinal hernia repair or orchiopexy |
| Genç Moralar et al. [20] | 2020 | Prospective/RCT | Turkey/single-center | 40 | 20 | IO: 20 | 3–16 | 34/6 | Type 1 | 0.5 mL/kg bupivacaine 0.20% | IO: 1.0 mg/kg tramadol HCl | Lower abdominal surgery (inguinal hernia repair, orchiopexy and hydrocelectomy) |
| Huang et al. [11] | 2021 | Prospective/RCT | China/multi-center | 90 | 30 | TFB: 30<br>NNB: 30 | 2–10 | 25/65 | Type 3 | 0.8 mL/kg ropivacaine 0.3% | TFB: 0.8 mL/kg ropivacaine 0.3% | Salter acetabular osteotomy, proximal femoral rotation osteotomy, ASIS osteotomy |
| İpek et al. [22] | 2019 | Prospective/RCT | Turkey/single-center | 94 | 35 | TAP: 29<br>CB: 30 | 0.5–14 | 74/20 | Type 1 | 0.5 mL/kg bupivacaine 0.25% | TAP, CB: 0.5 mL/kg bupivacaine 0.25% | Lower abdominal surgery (inguinal hernia repair, orchiopexy and hydrocelectomy) |
| Öksüz et al. [24] | 2017 | Prospective/RCT | Turkey/single-center | 50 | 25 | TAP: 25 | 1–7 | 42/8 | Type 1 | 0.5 mL/kg bupivacaine 0.20% | TAP: 0.5 mL/kg bupivacaine 0.20% | Inguinal hernia repair or orchiopexy |
| Öksüz et al. [23][a] | 2020 | Prospective/RCT | Turkey/single-center | 52 | 27 | CB: 25 | 1–9 | 41/11 | Type 1 | 0.7 mL/kg bupivacaine 0.25% | CB: 0.7 mL/kg bupivacaine 0.25% | Inguinal hernia repair or orchiopexy |
| Oral Ahiskalioglu et al. [12] | 2021 | Prospective/RCT | Turkey/single-center | 40 | 20 | II: 20 | 1–5 | 4/36 | Type 3 | 0.5 mL/kg bupivacaine 0.25% | II: 0.2 mL/kg bupivacaine 0.25% | Unilateral hip dislocation surgery |
| Priyadarshini et al. [25] | 2022 | Prospective/RCT | India/single-center | 60 | 20 | II/IH: 20<br>TAP: 20 | 2–12 | 56/4 | Type 1 | 0.4 mL/kg ropivacaine 0.25% | II/IH: 0.2 mL/kg ropivacaine 0.25%<br>TAP: 0.4 mL/kg ropivacaine 0.25% | Inguinal hernia repair |
| Ragab et al. [26] | 2022 | Prospective/RCT | Egypt/single-center | 52 | 26 | CB: 26 | 1–7 | 37/15 | Type 2 | 0.5 mL/kg bupivacaine 0.25% | CB: 1.0 mL/kg bupivacaine 0.25% | Lower abdominal surgery (inguinal hernia repair, orchiopexy and hydrocelectomy) |
| Samerchua et al. [27] | 2020 | Prospective/RCT | Thailand/single-center | 38 | 19 | II/IH: 19 | 1–7 | 32/6 | Type 2 | 0.5 mL/kg bupivacaine 0.25% | II/IH: 0.2 mL/kg bupivacaine 0.25% | Inguinal hernia repair |
| Sato [30] | 2019 | Prospective/RCT | Japan/single-center | 44 | 22 | CB: 22 | 1–17 | 24/20 | Type 1 | 1.0 mL/kg ropivacaine 0.20% | CB: 1.0 mL/kg ropivacaine 0.20% + 0.03 mg/kg morphine | Bilateral ureteral reimplantation |
| Taman et al. [28] | 2022 | Prospective/RCT | Egypt/single-center | 85 | 42 | ESPB: 43 | 2–7 | 38/47 | Type 1 | 0.5 mL/kg bupivacaine 0.25% | ESPB: 0.5 mL/kg bupivacaine 0.25% | Laparoscopic abdominal surgery |
| Zhang et al. [29] | 2022 | Prospective/RCT | China/single-center | 180 | 60 | TAP: 60<br>CB: 60 | 1–12 | 132/48 | Type 1 | 1.0 mL/kg ropivacaine 0.20% | TAP, CB: 1.0 mL/kg ropivacaine 0.20% | Laparoscopic abdominal surgery |

QLB: quadratus lumborum block, TFB: transversalis fascia block, ESPB: erector spinae plane block, CB: caudal block, IO: intravenous opioid, NNB: no nerve block, TAP: transversus abdominis plane block, II: incision line injection, II/IH: ilioinguinal/iliohypogastric nerve block, ASIS: anterior superior iliac spine, NA: not available.

[a] Different study by the same author published at a different year (patient enrollment periods do not overlap).

**Table 2.** Number of patients needing rescue analgesia at 12 hr and 24 hr after surgery

| References | Year | No. of patients analyzed in each group | | No. patients in need of rescue analgesia (12 hr) | | No. patients in need of rescue analgesia (24 hr) | | Criterion | Rescue analgesia |
|---|---|---|---|---|---|---|---|---|---|
| | | QLB | Control | QLB | Control | QLB | Control | | |
| Abdelbaser et al. [18] | 2023 | 34 | TFB: 34 | 6 | 7 | NA | NA | FLACC ≥ 4 | Intravenous paracetamol, 10 mg/kg |
| Aksu et al. [19] | 2019 | 29 | ESPB: 28 | NA | NA | 6 | 5 | FLACC 2–3;<br>FLACC ≥ 4 | Oral acetaminophen, 15 mg/kg;<br>Oral ibuprofen, 7 mg/kg |
| Alansary et al. [13] | 2023 | 20 | CB: 20 | NA | NA | 4 | 20 | FLACC ≥ 4 | Ketorolac, 0.5 mg/kg |
| Ashoor et al. [21] | 2023 | 32 | CB: 39 | NA | NA | 12 | 34 | FLACC ≥ 4 | Intravenous acetaminophen, 15 mg/kg |
| Genç Moralar et al. [20] | 2020 | 20 | IO: 20 | 6 | 19 | 7 | 19 | Wong-Baker facial pain ≥ 3 | Intravenous tramadol hydrochloride, 1 mg/kg |
| Huang et al. [11] | 2021 | 30 | TFB: 30<br>NNB: 30 | NA | NA | NA | NA | FLACC ≥ 4 | Intravenous fentanyl, 1 μg/kg |
| İpek et al. [22] | 2019 | 35 | TAP: 29<br>CB: 30 | NA | NA | 6 | TAP: 4<br>CB: 6 | POPS > 5 | Intravenous paracetamol, 10 mg/kg |
| Öksüz et al. [24] | 2017 | 25 | TAP: 25 | 0 | 3 | 3 | 10 | FLACC ≥ 4 | Intravenous tramadol, 1 mg/kg |
| Öksüz et al. [23][a] | 2020 | 27 | CB: 25 | NA | NA | 2 | 17 | FLACC > 4 | Intravenous fentanyl, 1 μg/kg |
| Oral Ahiskalioglu et al. [12] | 2021 | 20 | II: 20 | NA | NA | 3 | 15 | rFLACC > 4 | Intravenous fentanyl, 1 μg/kg |
| Priyadarshini et al. [25] | 2022 | 20 | II/IH: 20<br>TAP: 20 | 3 | II/IH: 7<br>TAP: 11 | NA | NA | FLACC > 4 | Intravenous paracetamol, 15 mg/kg |
| Ragab et al. [26] | 2022 | 26 | CB: 26 | NA | NA | NA | NA | FLACC > 4 | Intravenous diclofenac sodium, 1 mg/kg |
| Samerchua et al. [27] | 2020 | 19 | II/IH: 19 | NA | NA | 3 | 10 | CHEOPS > 9 | Intravenous fentanyl, 0.5 μg/kg |
| Sato [30] | 2019 | 22 | CB: 22 | NA | NA | 0 | 3 | CHEOPS > 7 | PNCA (fentanyl bolus 0.2 μg/kg, lock-out time: 15 min) |
| Taman et al. [28] | 2022 | 42 | ESPB: 43 | NA | NA | 8 | 10 | FLACC > 4 | Intravenous fentanyl, 1 μg/kg |
| Zhang et al. [29] | 2022 | 60 | TAP: 60<br>CB: 60 | NA | NA | 7 | TAP: 12<br>CB: 10 | FLACC > 4 | Intravenous tramadol hydrochloride, 1 mg/kg |

QLB: quadratus lumborum block, TFB: transversalis fascia block, ESPB: erector spinae plane block, CB: caudal block, IO: intravenous opioid, NNB: no nerve block, TAP: transversus abdominis plane block, II: incision line injection, II/IH: ilioinguinal/iliohypogastric nerve block, NA: not available, FLACC: Face-Legs-Activity-Cry-Consolability Scale, POPS: Pediatric Objective Pain Scale, rFLACC: revised Face-Legs-Activity-Cry-Consolability Scale, CHEOPS: Children's Hospital of Eastern Ontario Pain Scale.

[a] Different study by the same author published at a different year (patient enrollment periods do not overlap).

post-surgery (RR: 0.46; 95% CI: 0.31, 0.67; $I^2 = 47.8\%$; $P < 0.001$; $P_h = 0.024$) was confirmed even after applying the trim-and-fill method (**Supplementary Fig. 1**). The tendency for the QLB to reduce the need for rescue analgesia at 24 hours post-surgery was also evident in subgroup analysis when compared directly to the CB (RR: 0.46; 95% CI: 0.16, 0.76; $I^2 = 25.8\%$; $P = 0.011$; $P_h = 0.240$) and non-CB, non-QLB (RR: 0.51; 95% CI: 0.10, 0.92; $I^2 = 61.6\%$; $P = 0.025$; $P_h = 0.023$) (**Supplementary Fig. 2**). The QLB was compared to the CB and non-CB, non-QLB, as the CB is the most commonly administered form of regional anesthesia in pediatric patients [31]. Subgroup analysis based on the type of QLB showed that type the 1 QLB reduced the need for rescue analgesia at 24 hours post-surgery (RR: 0.56; 95% CI: 0.36, 0.76; $I^2 = 46.4\%$; $P < 0.001$; $P_h = 0.083$) (**Fig. 3**). However, type 2 and type 3 QLB did not reduce the need for rescue analgesia at 24 hours post-surgery (type 2, RR: 0.41; 95% CI: –0.17, 0.99; $I^2 = 0\%$; $P = 0.071$; $P_h = 0.647$; type 3, RR: 0.51; 95% CI: –0.83, 1.86; $I^2 = 89.7\%$; $P = 0.243$; $P_h < 0.001$).

## 4. FLACC scores during the immediate postoperative period

Data regarding FLACC scores for the QLB and non-QLB at 30 min, 1, 2, 4, 6, 12, and 24 hours after surgery are presented in **Supplementary Table 2**. The summarized results based on these data are outlined in **Table 3**. The QLB demonstrated lower FLACC scores at 1 hour (SMD: –0.87; 95% CI: –1.56, –0.18; $I^2 = 88.3\%$; $P = 0.014$; $P_h < 0.001$) and 6 hours (SMD: –1.27; 95% CI: –2.33, –0.21; $I^2 = 91.0\%$; $P = 0.019$; $P_h < 0.001$) post-surgery compared to non-QLB. In comparison to CB, QLB showed reduced FLACC scores only at 6 hours (SMD: –1.93; 95% CI: –3.79, –0.09; $I^2 = 94.7\%$; $P = 0.040$; $P_h < 0.001$) following surgery. However, when compared to non-CB, non-QLB, QLB again demonstrated lower FLACC scores at 1 hour (SMD: –0.81; 95% CI: –1.48, –0.13; $I^2 = 82.2\%$; $P = 0.019$; $P_h < 0.001$) and at 6 hours (SMD: –0.51; 95% CI: –1.02, –0.01; $I^2 = 70.5\%$; $P = 0.047$; $P_h = 0.017$) after surgery.

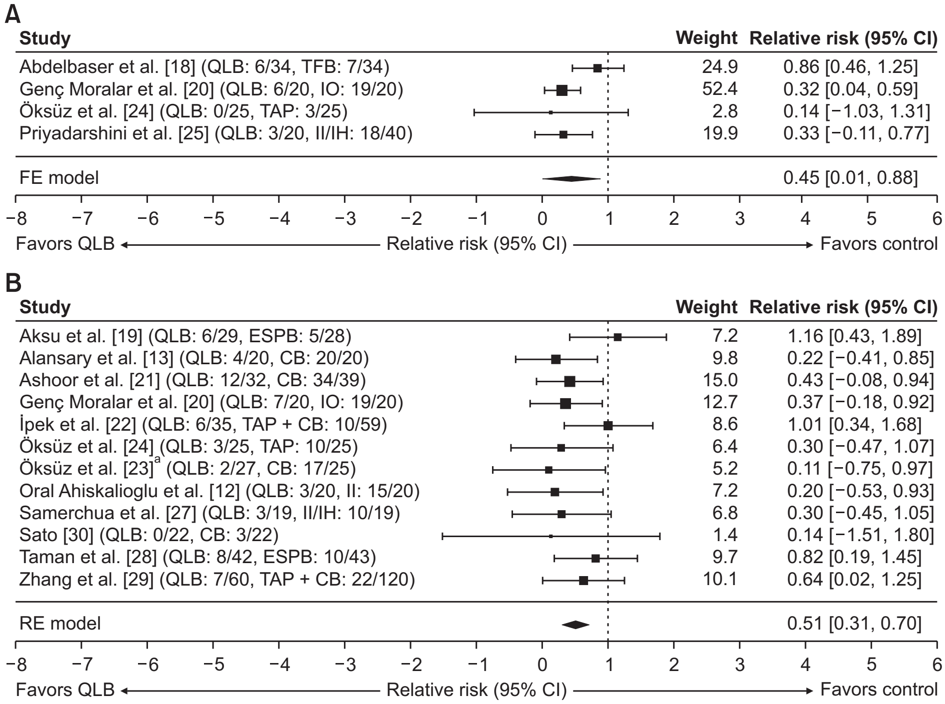

**Fig. 2.** Forest plots for the number of patients needing rescue analgesia (A) 12 hr and (B) 24 hr after surgery. QLB reduced the need for rescue analgesia at both 12 hr ($P$ value < 0.001) and 24 hr ($P$ value < 0.001, Egger's $P$ value = 0.506) after surgery. QLB: quadratus lumborum block, TFB: transversalis fascia block, IO: intravenous opioid, TAP: transversus abdominis plane block, II/IH: ilioinguinal/iliohypogastric nerve block, ESPB: erector spinae plane block, CB: caudal block, II: incision line injection, CI: confidence interval, FE: fixed effects, RE: random effects. [a]Different study by the same author published at a different year (patient enrollment periods do not overlap).

## 5. Parental satisfaction score, time to first rescue analgesia, and total hospitalization time

Data concerning parental satisfaction scores, time to first rescue analgesia, and total hospitalization time are presented in **Supplementary Table 3**. Pooled analysis indicated no difference in the parental satisfaction scores between QLB and non-QLB (SMD: 0.34; 95% CI: –0.39, 1.07; $I^2$ = 92.0%; $P$ = 0.360; $P_h$ < 0.001; **Fig. 4A**). Subgroup analysis also revealed no disparities in parental satisfaction scores when comparing QLB to CB ($P$ = 0.349) and non-CB, non-QLB ($P$ = 0.819) (**Supplementary Fig. 3**).

Pooled results also showed a weak association between the QLB and an extended time to first rescue analgesia, as the lower 95% CI for the QLB was close to zero (SMD: 0.72 hours; 95% CI: 0.004 hours, 1.44 hours; $I^2$ = 94.1%; $P$ = 0.049; $P_h$ < 0.001; Egger's $P$ value = 0.589; **Fig. 4B**). The trim-and-fit funnel plot for this pooled result is displayed in **Supplementary Fig. 4A**. After excluding outliers [13,26,29] through sensitivity analysis, this association was no longer revealed to be significant (SMD: 0.13 hours; 95% CI: –0.51 hours, 0.76 hours; $I^2$ = 90.9%; $P$ = 0.700; $P_h$ < 0.001) (**Supplementary Fig. 4B, C**). In the subgroup analysis, type 2 QLB was associated with a longer time to first rescue analgesia (SMD: 1.68 hours; 95% CI: 0.74 hours, 2.61 hours; $I^2$ = 81.3%; $P$ < 0.001; $P_h$ = 0.005), and this association remained significant after excluding an outlier study [26] through sensitivity analysis (SMD: 1.25 hours; 95% CI: 0.84 hours, 1.67 hours; $I^2$ = 0%; $P$ < 0.001; $P_h$ = 0.518) (**Supplementary Fig. 5**). No difference in total hospitalization time was observed between the QLB and non-QLB (SMD: 0.76 days; 95% CI: –1.72 days, 3.24 days; $I^2$ = 97.5%; $P$ = 0.547; $P_h$ < 0.001; **Fig. 4C**).

## 6. Time required to perform the block

Four studies [18,21,25,27] provided data on the time required to perform the blocks, and this information is summarized in **Supplementary Table 4**. With the exception of one study [21], the remaining studies found no significant difference in the time needed to perform the block when comparing the QLB and non-QLB. The pooled analysis also revealed no statistically significant difference in block performance time between the two

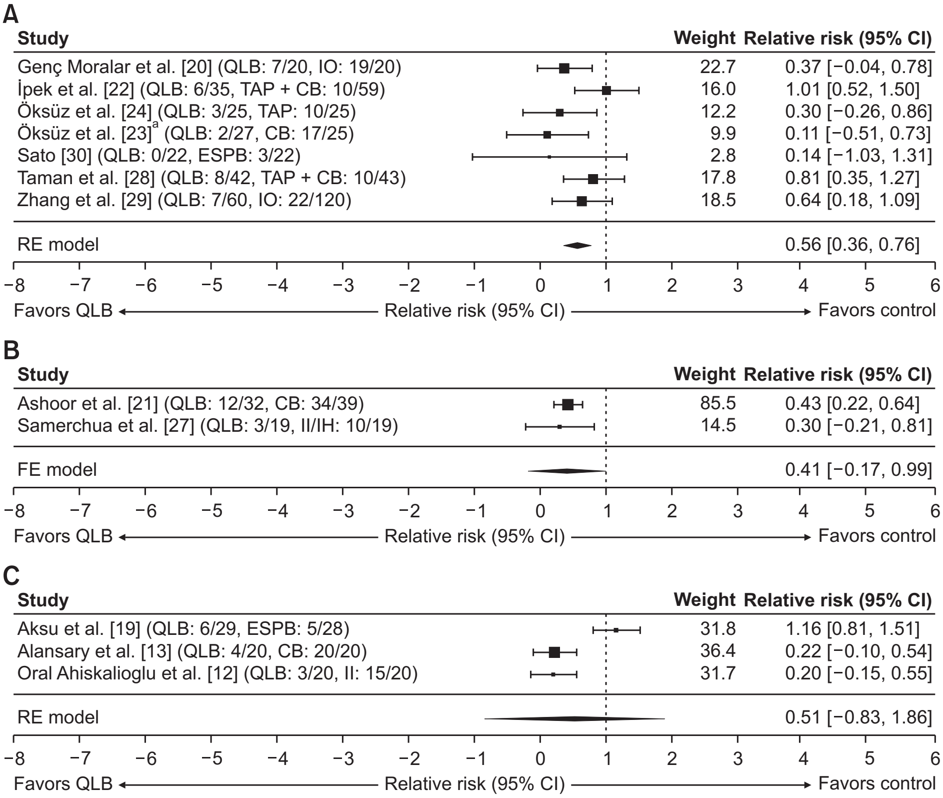

**Fig. 3.** Forest plots for the number of patients needing rescue analgesia 24 hr after surgery depending on the type of QLB: (A) type 1 QLB; (B) type 2 QLB; and (C) type 3 QLB. Type 1 QLB reduced the need for rescue analgesia at 24 hr post-surgery (*P* value < 0.001), but type 2 QLB and type 3 QLB showed no difference in the need for rescue analgesia compared on non-QLB (*P* value = 0.071 and *P* value =0.243, respectively). QLB: quadratus lumborum block, IO, intravenous opioid, TAP: transversus abdominis plane block, CB: caudal block, ESPB: erector spinae plane block, II/IH: ilioinguinal/iliohypogastric nerve block, II: incision line injection, CI: confidence interval, RE: random effects, FE: fixed effects. [a]Different study by the same author published at a different year (patient enrollment periods do not overlap).

groups (SMD: 1.58 minutes; 95% CI: –0.78 minutes, 3.95 minutes; $I^2 = 95.9\%$; $P = 0.190$; $P_h < 0.001$; **Supplementary Fig. 6**).

## 7. Incidence of block failure and postoperative adverse events

Data regarding the incidences of block failure and postoperative adverse events can be found in **Supplementary Tables 5 and 6**. Of the 16 studies included, only three [21,23,27] reported at least one instance of block failure in either the QLB or non-QLB group. In all other studies, no block failure was reported in either group. Pooled analysis showed no difference in the incidence of block failure between the QLB and non-QLB (RR: 4.39; 95% CI: –6.71, 15.50; $I^2 = 99.9\%$; $P = 0.231$; $P_h < 0.001$; **Supplementary Fig. 7**). Nine studies [11–13,19,21,23–25,29] compared the incidence of PONV between the QLB and non-QLB. However, four studies [11,19,24,25] reported no incidence of PONV in either group. Pooled results from the remaining five studies [12,13,21,23,29] demonstrated that the QLB is associated with lower incidence of PONV than non-QLB (RR: 0.61; 95% CI: 0.42, 0.81; $I^2 = 32.4\%$; $P < 0.001$; $P_h = 0.205$). Furthermore, four studies [21,22,25,29] assessed the incidence of urine retention, but two studies [25,29] reported no cases of urine retention in either group. Pooled analysis of the remaining two studies [21,22] showed no significant difference in the incidence of urine retention between the QLB and non-QLB (RR: 1.72; 95% CI: –6.93, 10.37; $I^2 = 97.8\%$; $P = 0.241$; $P_h < 0.001$).

Eleven studies [11–13,19,21,23–25,27,29,30] evaluated the incidence of postoperative hypotension and bradycardia. However, only one study [21] reported two cases of hypotension in the QLB and one case in the CB group, along with one case of bradycardia in the QLB and none in the CB group. The same study [21] also reported three cases of procedure-related hematoma in the QLB group and no cases in the CB group. None of the other studies

**Table 3.** Pooled results comparing FLACC scores between QLB and non-QLB during the first 24 hr after surgery

| | No. of studies | No. of patients | SMD (95% CI) | *P* value | $I^2$ | $P_h$ value | Egger's *P* value |
|---|---|---|---|---|---|---|---|
| QLB *vs.* non-QLB | | | | | | | |
| 30 min | 10 | 686 | 0.069 (−0.834, 0.971) | 0.882 | 94.1% | < 0.001 | 0.425 |
| 1 hr | 10 | 695 | −0.869 (−1.562, −0.175) | 0.014 | 88.3% | < 0.001 | 0.039 |
| 2 hr | 9 | 518 | −0.378 (−1.554, 0.798) | 0.528 | 93.7% | < 0.001 | - |
| 4 hr | 10 | 698 | −0.664 (−1.407, 0.079) | 0.080 | 89.8% | < 0.001 | 0.431 |
| 6 hr | 9 | 515 | −1.272 (−2.333, −0.210) | 0.019 | 91.0% | < 0.001 | - |
| 12 hr | 10 | 698 | −1.162 (−2.416, 0.091) | 0.069 | 93.4% | < 0.001 | 0.024 |
| 24 hr | 9 | 630 | −0.205 (−1.063, 0.653) | 0.639 | 94.9% | < 0.001 | - |
| QLB *vs.* CB | | | | | | | |
| 30 min | 5 | 345 | 0.321 (−0.214, 0.855) | 0.240 | 81.0% | < 0.001 | - |
| 1 hr | 5 | 335 | −0.947 (−2.376, 0.483) | 0.194 | 93.0% | < 0.001 | - |
| 2 hr | 4 | 215 | −0.201 (−0.470, 0.068) | 0.143 | 0% | 0.560 | - |
| 4 hr | 5 | 335 | −0.205 (−0.666, 0.256) | 0.384 | 75.1% | 0.003 | - |
| 6 hr | 5 | 286 | −1.927 (−3.768, −0.086) | 0.040 | 94.7% | < 0.001 | - |
| 12 hr | 5 | 335 | −1.307 (−2.997, 0.383) | 0.130 | 91.9% | < 0.001 | - |
| 24 hr | 5 | 335 | −0.333 (−1.128, 0.462) | 0.412 | 92.5% | < 0.001 | - |
| QLB *vs.* non-CB, non-QLB | | | | | | | |
| 30 min | 6 | 401 | −0.042 (−1.714, 1.629) | 0.960 | 96.4% | < 0.001 | - |
| 1 hr | 6 | 420 | −0.806 (−1.479, −0.133) | 0.019 | 82.2% | < 0.001 | - |
| 2 hr | 5 | 303 | −0.553 (−2.833, 1.726) | 0.634 | 96.8% | < 0.001 | - |
| 4 hr | 6 | 423 | −1.112 (−2.491, 0.267) | 0.114 | 93.3% | < 0.001 | - |
| 6 hr | 4 | 229 | −0.514 (−1.021, −0.007) | 0.047 | 70.5% | 0.017 | - |
| 12 hr | 6 | 423 | −1.057 (−3.043, 0.928) | 0.297 | 94.7% | < 0.001 | - |
| 24 hr | 5 | 355 | −0.089 (−1.747, 1.569) | 0.916 | 96.4% | < 0.001 | - |

$P_h$ is the *P* value of the heterogeneity test.

FLACC: Face-Legs-Activity-Cry-Consolability Scale, QLB: quadratus lumborum block, CB: caudal block, SMD: standardized mean difference, CI: confidence interval.

reported cases of procedure-related hematoma in either group. Additionally, one study [22] reported two cases of motor weakness in the CB group and none in the QLB group.

## 8. Risk of bias

The overall risk of bias was categorized as having “some concerns” in six studies [12,18,21,23,26,27] and “low” in ten studies [11,13,19,20,22,24,25,28–30], as indicated in **Supplementary Figs. 8 and 9**. Most of the included studies demonstrated a low risk of bias, with respect to several key factors, including bias stemming from the randomization process (100%), bias due to deviations from intended interventions (100%), bias due to missing outcome data (87.5%), bias in the measurement of the outcome (75.0%), bias in the selection of the reported results (100%), and an overall risk of bias (62.5%).

## 9. Level of certainty

As presented in **Supplementary Table 7**, the level of certainty of the evidence was found to be moderate for the requirement of rescue analgesia 24 hours after surgery, and low for the requirement of rescue analgesia 12 hours after surgery, FLACC scores at 30 minutes, 2 hours, and 4 hours after surgery, and time to first rescue analgesia.

# DISCUSSION

This meta-analysis and systematic review compared the need for rescue analgesia, FLACC scores, time to first rescue analgesia, hospitalization time, block execution time,

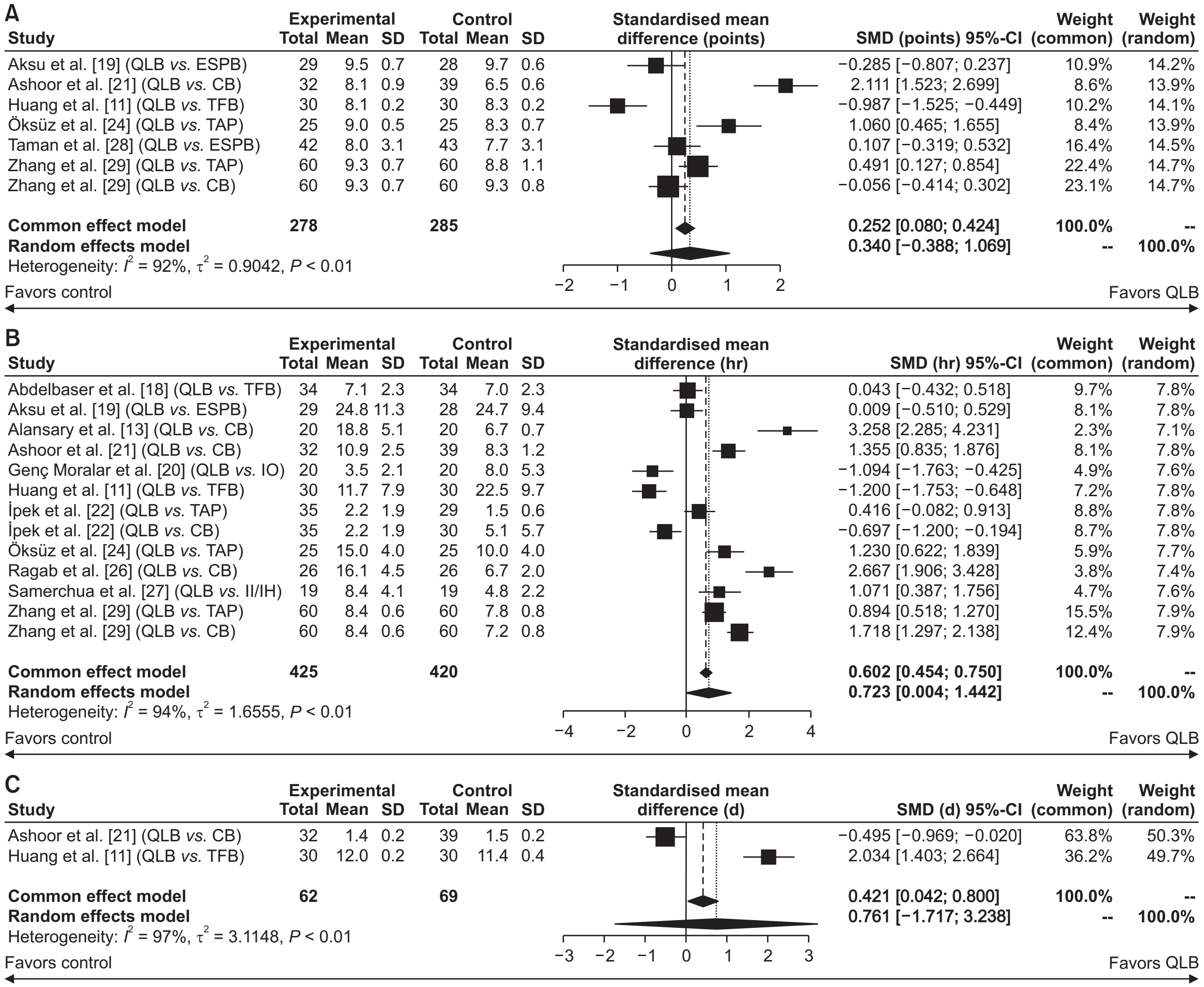

**Fig. 4.** Forest plots for (A) parental satisfaction score; (B) time to first rescue analgesia; and (C) total hospitalization time between the QLB and non-QLB groups. Parental satisfaction score did not differ between QLB and non-QLB ($P$ = 0.360). There was a weak association between QLB and extended time to first rescue analgesia ($P$ = 0.049). No difference in total hospitalization time was observed between the two groups ($P$ = 0.547). QLB: quadratus lumborum block, SD: standard deviation, SMD: standardized mean difference, CI: confidence interval, ESPB: erector spinae plane block, CB: caudal block, TFB: transversalis fascia block, TAP: transversus abdominis plane block, IO: intravenous opioid, II/IH: ilioinguinal/iliohypogastric nerve block.

incidence of block failure, and postoperative adverse events between the QLB and non-QLB. The results indicated that the QLB reduces the need for rescue analgesia at 12 hours and 24 hours after surgery. Type 1 QLB notably reduced the need for rescue analgesia at 24 hours. Moreover, QLB was associated with a longer time to first rescue analgesia, particularly for type 2 QLB. The study also found significantly lower FLACC scores at 1 hour and 6 hours post-surgery with QLB. However, there were no significant differences in block execution time, total hospitalization time, block failure rates, or the occurrence of postoperative adverse events, including PONV and urine retention when comparing the QLB to non-QLB.

In the present study, despite no difference in parental satisfaction scores, the QLB exhibited lower FLACC scores at 1 hour and 6 hours post-surgery compared to non-QLB. It's important to note that the SMD in FLACC scores were 0.87 and 1.27 at these time points. While statistically significant, these differences may not have translated into a perceivable improvement in postoperative pain, as reflected by the unaltered parental satisfaction scores. These findings contrast with an early meta-analysis [10], which analyzed seven RCTs and reported that the QLB reduced pain scores at 2 hours, 4 hours, and 12 hours after surgery. However, a previous meta-analysis [10] also did not find any difference in parental satisfaction scores.

Regarding the overall need for rescue analgesia and the time to first rescue analgesia, the QLB demonstrated noninferiority compared to conventional methods. While the QLB proved beneficial in reducing the requirement for rescue analgesia at both 12 hours and 24 hours after surgery, similar to a previous meta-analysis [10], its impact on delaying the time to first rescue analgesia was, at best, on par with conventional methods. Subgroup analysis yielded mixed results regarding the efficacy of various QLB types. The type 1 QLB significantly reduced the need for rescue analgesia at 24 hours post-surgery, whereas the type 2 QLB, and not type 1 or type 3 QLB, significantly extended the time to first rescue analgesia. It is important to note that the majority of QLB studies primarily investigated type 1, leading to fewer meta-analyzed studies for type 2 and type 3 QLB. Although the type 2 QLB exhibited a slight tendency to decrease the need for first rescue analgesia ($P = 0.071$), the statistical insignificance may have stemmed from the limited number of studies included in the analysis. Likewise, the significance of the type 2 QLB in extending the time to first rescue analgesia may need to be validated through a meta-analysis involving a larger sample size.

The analgesic effect of QLB is attributed to the local anesthetic's diffusion along the middle layer of the thoracolumbar fascia (TLF). This diffusion proceeds medially, extending toward the transverse process and into the thoracic paravertebral space (TPVS) before reaching the ventral rami [32]. This pattern of spread results in the coverage of ventral rami from T10 to L1 [6,32], aligning with findings that QLB also effectively blocks the iliohypogastric and ilioinguinal nerves [33].

In contrasts, the choice of QLB type depends on the specific injection site of the anesthetic. In cadaveric studies, for type 1 QLB, the anesthetic is injected at the anterolateral aspect of the QL muscle; for type 2 QLB, the anesthetic is injected at the posterolateral aspect of the QL muscle; and for type 3 QLB, the anesthetic is injected deep between the QL and psoas muscles by penetrating the needle tip through the QL muscle [34,35]. The TLF consists of the anterior lamina of the fused aponeuroses of the transversus abdominis and internal oblique muscles, the investing fascia of the QL muscle, and the paraspinal retinacular sheath encapsulating the paraspinal muscles. The TLF comprises the anterior lamina formed by the fused aponeuroses of the transversus abdominis and internal oblique muscles, the investing fascia of the QL muscle, and the paraspinal retinacular sheath that envelops the paraspinal muscles. Therefore, when anesthetic is administered in proximity to the lumbar interfascial triangle, a crucial anatomical landmark in QLB, it can diffuse along the TAP and the posterior fascial plane, extending towards the latissimus dorsi and subcutaneous tissue [33].

The superior analgesic efficacy of type 1 or type 2 QLB over type 3 QLB could be associated with variations in the injectate's spread. While type 3 QLB is theoretically presumed to be more effective due to its proximity to the lumbar plexus roots [36], when performed at the L3-L4 level, it has been observed that the injectate primarily affects the areas surrounding the L1-L4 transverse processes and the L1-L3 nerve roots, rather than broader coverage [33]. Even though anesthetic injected between the QL and psoas muscles may still reach the TPVS due to their shared embryonic origins and insertions in the thoracic cage [34], the amount of anesthetic that can diffuse through the inter- or intramuscular space is likely distinct from the quantity that can disperse through the middle layer of the TLF in type 1 and type 2 QLB. This variance could explain the variations in analgesic effectiveness between type 1 or type 2 and type 3 QLB. The constrained lumbar distribution noted in type 3 QLB, combined with the more extensive intrathoracic dispersion seen in type 1 or type 2 QLB, may contribute to the disparities in efficacy [32]. Previous studies have reported broader spreads for both QLB type 1 and type 2 [32,37]. Although further large-scale prospective investigations are required to validate these findings, the authors' results offer valuable insights into the selection and administration of QLB types that could optimize postoperative analgesia.

Additionally, the authors' results affirm the safety of the QLB for pediatric patients. There was no significant difference in the occurrence of PONV urine retention when comparing the QLB and non-QLB groups. Although a single study [21] documented instances of postoperative hypotension, bradycardia, and hematoma within the QLB group, the frequency of these events did not reach statistical significance when compared to the control groups such as the CB. Furthermore, while one case study described a patient experiencing motor weakness following QLB [38], none of the included RCT reported motor weakness in the QLB group.

This meta-analysis has several limitations. First, QLB is a relatively novel technique, and despite the growing evidence, the number of available studies is still limited.

Consequently, publication bias could not be assessed for meta-analyses with fewer than ten studies. Second, a significant portion of the included studies (11 out of 16) were conducted in Egypt [13,18,21,26,28] and Turkey [12,19,20,22–24], which may restrict the generalizability of the results to patients from different ethnic or geographical backgrounds. Third, variations in the choice of drugs and their dosage for the QLB were noted among the studies. Lastly, the evaluation of study endpoints involved comparing the QLB to various analgesic control procedures, including the CB, TFB, II/IH, and TAP blocks. Due to the limited number of available studies, subgroup analyses comparing QLB to each type of analgesic control could not be conducted. However, the diversity in the control groups can also be interpreted as a testament to the robustness and non-inferiority of the QLB when compared to conventional analgesic techniques.

In conclusion, this meta-analysis demonstrates that the QLB provides non-inferior postoperative analgesic effects and safety in comparison to conventional analgesic techniques in pediatric patients.

## DATA AVAILABILITY

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

## CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

## FUNDING

No funding to declare.

## AUTHOR CONTRIBUTIONS

Insun Park: Writing/manuscript preparation; Jae Hyon Park: Formal analysis; Hyun-Jung Shin: Writing/manuscript preparation; Hyo-Seok Na: Writing/manuscript preparation; Bon-Wook Koo: Writing/manuscript preparation; Jung-Hee Ryu: Writing/manuscript preparation; Ah-Young Oh: Project administrantion.

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## SUPPLEMENTARY MATERIALS

Supplementary materials can be found *via* https://doi.org/10.3344/kjp.23268.

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