Meta-Analysis

Quadratus Lumborum Block is an Effective Postoperative Analgesic Technique in Pediatric Patients Undergoing Lower Abdominal Surgery: A Meta-Analysis

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Background: Quadratus lumborum (QL) block has shown promising analgesic efficacy in the adult population in previous meta-analyses. However, the response of the pediatric group to pain stimulation is stronger than that in the adult population, and the management of pediatric pain is constrained by limited available analgesia agents. All data analyzed during this study are collected from published articles.

Objective: The purpose of our systematic review was to evaluate whether QL block is also an effective postoperative analgesic technique, compared to other analgesic skills in pediatric patients undergoing lower abdominal surgery.

Study Design: A meta-analysis.

Methods: We identified randomized controlled trials (RCTs) from PubMed, Embase, the Cochrane Library, Web of Science, and Science Direct to compare QL block with other analgesic methods for relief of postoperative pain in pediatric patients undergoing lower abdominal surgeries under general anesthesia. The primary outcome was the rate of postoperative rescue analgesia; secondary outcomes include: pain scores at 30 minutes and 1, 2, 4, 6, 12, and 24 hours postoperatively, patient satisfaction, and block related complications.

Results: A total of 7 studies with 346 patients were included. QL block showed a significant reduction in the rate of postoperative rescue analgesia in the first 24 hours (RR = 0.41; 95% CI = 0.28 to 0.59; $P < 0.001$) compared to other analgesic techniques, without significant heterogeneity among the articles ($I^2 = 49\%$, $P = 0.08$). Compared with other analgesic methods, QL block significantly reduced the pain scores at 2 hours (Std.MD = -0.76; 95% CI = -1.16 to -0.35; $P < 0.001$) ($I^2 < 0.001\%$, $P = 0.41$), 4 hours (Std.MD = -0.34; 95% CI = -0.67 to -0.01; $P = 0.04$) ($I^2 < 0.001\%$, $P = 0.53$) and 12 hours postoperatively (Std.MD = -0.95; 95% CI = -1.44 to -0.47; $P < 0.001$) ($I^2 = 27\%$, $P = 0.24$). No significant differences were found between techniques at 30 minutes and 1, 6, or 24 hours postoperatively ($P > 0.05$). There was no statistically significant change in patient satisfaction (Std.MD = 0.49; 95% CI = -0.32 to 1.29; $P = 0.24$) or side effects (RD = -0.02; 95% CI = -0.06 to 0.02; $P = 0.31$) with QL block.

Limitations: The major limitation of this meta-analysis is the relatively few RCTs and limited results included. Similarly, the differences in block approaches among the control groups (TAP, ESP, caudal block, opioid-based analgesia), drug types and concentrations, and multimodal analgesia programs led to considerable heterogeneity. Furthermore, some relevant outcomes were not investigated.

Conclusion: Our systematic review and meta-analysis suggests QL block use for the pediatric population undergoing lower abdominal surgery, based on the current limited research evidence, as this method was an effective postoperative analgesic technique.

Key words: Pediatric surgery, postoperative pain, quadratus lumborum block, side effects

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Lower abdominal surgeries, including inguinal hernia repair, hydrocelectomy, and orchiopexy, are common in pediatric patients (1). Complications, delayed recovery from diseases, reduced patient satisfaction, and chronic pain are all associated with postoperative pain in lower abdominal surgeries (2,3). Maintaining adequate analgesia is an important component of perioperative care, especially for the pediatric population.

Various techniques, including quadratus lumborum (QL) block, transversus abdominis plane (TAP) block, caudal block, ilioinguinal block, and wound infiltration, are all methods for adequate postoperative pain management (4-6). Effective pain relief can accelerate patient recovery, alleviate psychological distress, and improve parental satisfaction.

Blanco (7) first described QL block in 2007 and also applied this method to perioperative analgesia of lower abdominal surgery. There are currently 4 approaches described for QL block: lateral, posterior, anterior, and intramuscular (QL block 1-4 respectively) (8). QL block is presently performed for a wide variety of patient populations, including pediatric patients, adult patients, and pregnant women.

In previous meta-analyses, QL block has shown promising analgesic efficacy in the adult population as a part of multimodal analgesia (3,9,10). However, the response of the pediatric age group to pain stimulation is stronger than that in the adult population (11) and the management of pediatric pain is constrained by limited available analgesia agents. No meta-analysis has systematically evaluated the analgesic efficacy of QL block in the pediatric population. Therefore, the purpose of our systematic review was to evaluate whether QL block is also an effective postoperative analgesic technique, compared to other analgesic skills, in pediatric patients undergoing lower abdominal surgery.

Methods

We attempted to report this meta-analysis according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The protocol for this meta-analysis was registered with PROSPERO (CRD42020176758; the international prospective register of systematic reviews).

Search Strategy

We performed a systematic search in the Cochrane Library, PubMed, Embase, Web of Science, and Science Direct from inception to February 2020, for publications in the English language. We investigated and identified randomized controlled trials (RCTs) that compare the use of QL block with other analgesic methods only for pediatric patients undergoing lower abdominal surgeries under general anesthesia. The reference lists of all selected articles were also reviewed to identify other studies that fulfilled the inclusion criteria.

The databases were explored using a search algorithm with Boolean operators: "(QL OR quadratus lumborum OR quadratus OR QLB) AND (block OR anesthesia OR neurolysis OR analgesia) AND (pediatric OR children OR infant OR adolescent OR schoolchild OR preschool OR teens OR youth) AND abdominal surgery." A detailed list of search terms is available in Appendix 1.

Study Selection

We only selected RCTs if they assessed QL block in pediatric patients undergoing lower abdominal surgeries with general anesthesia. For the purpose of this review, all forms (approaches, anesthetic concentrations, and doses) of QL block are included. Studies with adult patients (above 18 years old), non-RCTs, case reports, conference abstracts, studies with no control group, and ongoing studies were excluded.

Two independent reviewers (WZ and BW) reviewed and identified studies on the basis of the previously mentioned strategy. Any discrepancies were discussed and resolved with a third author (SL).

Data Extraction

Two investigators extracted the data from eligible studies, including bibliographical information (author name, published year), study design (number, gender, and age of patients; type of surgery; analgesic methods for the experimental and control group), primary outcomes (rate of postoperative rescue analgesia), and secondary outcomes (pain scores, patient satisfaction, and block-related complications). For the quantitative analyses, pain scores reported as Face, Legs, Activity, Cry, Consolability (FLACC), Pediatric Objective Pain Scale (POAS), or Children's Hospital of Eastern Ontario Pain Scale (CHEOPS) were transformed to an analog scale from 0 to 10.

Primary Outcome

The rate of postoperative rescue analgesia is defined as the proportion of patients who received additional analgesia, including acetaminophen, ibuprofen, and the like, when pain scores were more than a value preset in the protocol in the first 24 hours after operation.

Assessment of Study Quality

The methodological quality and the risk of bias in each study are evaluated by the Cochrane Collaboration's tool (12). Studies are scored as "low risk", "high risk", or "unclear risk" based on the following categories: randomization, allocation concealment, blinding of patients and personnel, outcome assessment blinding, incomplete data, and selective reporting.

Statistical Analysis

For dichotomous variables, the outcomes are presented as relative risk (RR) with the 95% confidence interval (CI); risk difference (RD) with CI is used for complications and side effects. For continuous variables the mean difference (MD) with 95% CI is calculated. If we were unable to transform the scales to a standard unit of measurement we used the standardized mean difference (SMD). Cochrane I^2 statistics were chosen as the criteria for evaluating heterogeneity. A value > 50% is considered substantial heterogeneity and a random effects model is applied. When I^2 was < 50% a fixed-effects model is applied.

We tried to contact the authors for original data, when the data are shown as graphs or text. Treatment effects are assessed by forest plots. To perform quantitative analyses, skewed data described as median and interquartile range have been converted to the mean and estimated standard deviation (13,14). Publication bias was evaluated by Egger's and Begg's test. $P < 0.05$ is considered statistically significant and effect sizes are presented with 95% CI. RevMan 5.3 has been applied (RevMan; Copenhagen: The Nordic Cochrane Center, The Cochrane Collaboration, 2014), and the GRADE approach was used to assess the quality of evidence (GRADEpro GDT: GRADEpro guideline development tool [software]. McMaster University; 2015) (Appendix 2).

Subgroup analyses and meta-regression have been used to identify the source of heterogeneity. Some variables, including the approach of QL block, the analgesia method of control group, year of publication, dose, and concentration of local anesthetics, have been considered as factors that would have influence on the analgesic effect of QL block. We also have preformed sensitivity analyses to evaluate the robustness of the results.

Sample Size Calculation and Power Analysis

In this meta-analysis, the complication rates were 0.57% and 2.37% in the QL block group and other analgesia group, respectively. The results show that this study sample of 346 patients had only 16% power to detect whether QL block could reduce complications or side effects, when an α of 0.05 was applied. Therefore, the study is underpowered for identifying an effect of QL block on complications and the analysis was performed with PS3.0 (Version 3.0, Power and Sample size calculation) software.

Results

Literature Search and Study Characteristics

This meta-analysis identified 164 relevant studies, of which 7 studies including 346 patients (15-21) are included. All references of the included studies have also been reviewed and no additional studies were identified. The study flowchart and selection processes are shown in Fig. 1. The basic clinical features of the 7

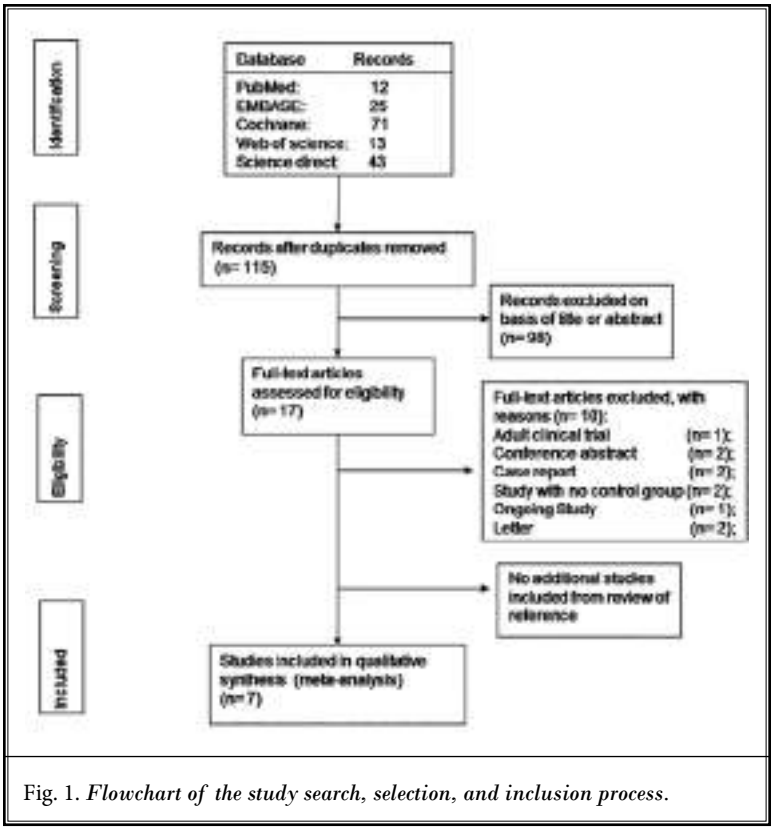

Fig. 1. *Flowchart of the study search, selection, and inclusion process.*

included RCTs are summarized in Table 1. Three RCTs compare QL block to the caudal block procedure, and 1 study each compares QL block to TAP, erector spinae plane (ESP), ilioinguinal/iliohypogastric (II/IH) block and systemic intravenous analgesia. QL block was applied for a variety of surgeries, including inguinal hernia repair, orchiopexy, hydrocelectomy, and ureteral reimplantation.

Risk of Bias in Included Studies

The assessment of the risk of bias is shown in Fig. 2 (Fig. 2A: risk of bias summary and Fig. 2B: risk of bias graph). All of the trials have been randomized and most (5 out of 7, 71.43%) reported the methods of randomization. All trials have reported assessment blinding and complete outcome data. Most of the trials also reported outcomes unselectively (6 out of 7, 85.71%); however, only 28.57% (2 out of 7) reported allocation concealment and only 14.29% (1 out of 7) reported double-blinding methods.

Meta-analysis Results

The pooled results of postoperative outcomes are presented in Table 2.

Primary Outcome

The Rate of Postoperative Rescue Analgesia

The rate of postoperative rescue analgesia is evaluated as the number of patients who required rescue analgesia in the first postoperative 24 hours. Six trials, with 302 patients total, reported the 24 hour rescue analgesia requirement (15-17,19-21). QL block shows a significant reduction in the rate of postoperative rescue analgesia in the first 24 hours (RR = 0.41; 95% CI = 0.28 to 0.59; $P < 0.001$; Fig. 3) compared to other analgesic techniques, without significant heterogeneity among the articles ($I^2 = 49\%$, $P = 0.08$).

Sensitivity Analysis and Publication Bias

The results are consistent in the sensitivity analyses when eliminating a single study per replication (Table S1). Begg's ($P = 0.452$, Fig. S1) and Egger's test ($P = 0.677$) did not identify significant publication bias.

Secondary Outcomes

Postoperative Pain Scores

The postoperative pain scores at 30 minutes and

Table 1. *Main characteristics of the included trials.*

Author and year	Numbers (E/C)	Mean age (E/C)	QLB type	Types and doses of local anesthetics	Comparator	Types and doses of anesthetics	Surgery type
Aksu 2019 (16)	29/28	3.6/3.1	QLB3	0.5 ml/kg 0.25% bupivacaine	ESPB	0.5 ml/kg 0.25% bupivacaine	Inguinal hernia repair, orchiopexy, or hydrocelectomy
Genc 2020 (19)	20/20	6.10/6.60	QLB1	0.5 ml/kg 0.2% bupivacaine	IV opioid	1 mg/kg tramadol HCl in every 30 minutes	Unilateral inguinal hernia, undescended testis, and hydrocele
Ipek 2019 (17)	35/30	3.89/2.99	QLB1	0.5 ml/kg 0.25% bupivacaine	Caudal block	0.5 ml/kg 0.25% bupivacaine	Unilateral inguinal hernia repair, orchiopexy, or hydrocelectomy
Oksuz 2017 (15)	25/25	3.13/3.02	QLB2	0.5 mL/kg 0.2% bupivacaine	TAP	0.5 mL/kg 0.2% bupivacaine	Unilateral inguinal hernia repair or orchiopexy
Oksuz 2020 (20)	27/25	3.92/3.7	QLB2	0.7 ml/kg 0.25% bupivacaine	Caudal block	0.7 mL/kg 0.25% bupivacaine	Unilateral inguinal hernia repair and orchiopexy
Samerchua 2020 (21)	19/19	2.33/3.43	QLB2	0.5 ml/kg 0.25% bupivacaine	II/IH block	0.2 ml/kg 0.25% bupivacaine	Unilateral open inguinal herniotomy
Sato 2019 (18)	22/22	3.4/3.4	QLB2	0.5 mL/kg 0.2% ropivacaine*2	Caudal block	1.0 mL/kg 0.2% ropivacaine+0.03 mg/kg morphine	Bilateral ureteral reimplantation

1, 2, 4, 6, 12, and 24 hours were investigated and included 4 studies at 30 minutes (15,16,18,20), 3 at 1 hour (15,16,20), 2 at 2 hours (15,20), 3 at 4 hours (15,18,20), 3 at 6 hours (15,16,20), 2 at 12 hours (15,20), and 3 at 24 hours (15,18,20). Data from the trial by Ipek (17) are not analyzed in the forest plot, as the data were presented as graphs rather than specific values. Compared with other analgesic methods, QL block significantly reduces the pain scores at 2 hours (Std.MD = -0.76; 95% CI = -1.16 to -0.35; $P < 0.001$, [$I^2 < 0.001\%$, $P = 0.41$]), 4 hours (Std.MD = -0.34; 95% CI = -0.67 to -0.01; $P = 0.04$, [$I^2 < 0.001\%$, $P = 0.53$]), and 12 hours postoperatively (Std. MD = -0.95; 95% CI = -1.44 to -0.47; $P < 0.001$, [$I^2 = 27\%$, $P = 0.24$]). No significant differences have been found between techniques at 30 minutes and 1, 6, or 24 hours postoperatively ($P > 0.05$; Fig. 4); however, QL block also significantly reduced the pain scores at 1 hour and 6 hours postoperatively, after eliminating the study by Aksu (16) from the sensitivity analyses (Table S2).

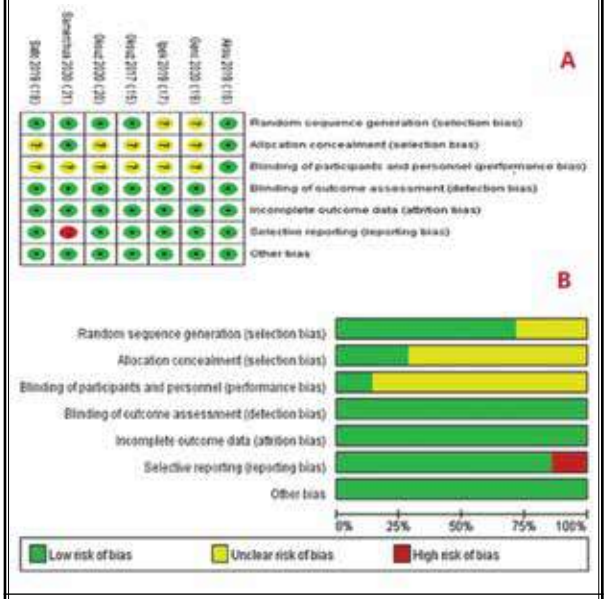

Fig. 2. *The risk of bias in the included studies.* A: *risk of bias summary and B: risk of bias graph.*

Patient Satisfaction

Three trials (15,16,20) with 159 patients investi-

Table 2. *Postoperative outcomes.*

Outcomes	Studies	QL block		Other method		Overall event rates (%)	M-H pooled RR/ SMD		Heterogeneity	
		N+ (%)	Total	N+ (%)	Total		RR/SMD (95% CI)	*P*	I^2 (%)	*P*
Rate of postoperative rescue analgesia	(15-17, 18-21)	28 (18.1%)	155	66 (44.9%)	147	31.1%	0.41 (0.28, 0.59)	< 0.001	49	0.08
Postoperative pain scores										
30 min	(15, 16,18, 20)	-	103	-	100	-	-0.18 (-0.50, 0.14)	0.27	25	0.26
1 h	(15, 16, 20)	-	81	-	78	-	-0.39 (-0.83, 0.05)	0.09	49	0.14
2 h	(15, 20)	-	52	-	50	-	-0.76 (-1.16, -0.35)	< 0.001	0	0.41
4 h	(15, 18, 20)	-	74	-	72	-	-0.34 (-0.67, -0.01)	0.04	0	0.53
6 h	(15, 16, 20)	-	81	-	78	-	-0.44 (-1.49, 0.62)	0.42	90	< 0.001
12 h	(15, 20)	-	52	-	50	-	-0.95 (-1.44, -0.47)	< 0.001	27	0.24
24 h	(15, 18, 20)	-	74	-	72	-	-0.34 (-0.92, 0.23)	0.24	67	0.05
Patient satisfaction	(15, 16, 20)	-	81	-	78		0.49 (-0.32, 1.29)	0.24	84	0.002

N+ = the number of patients needing rescue analgesia or with adverse event;
Total = the number of the total patients; RR = relative risk; SMD = standardized mean difference; QL block = quadratus lumborum block.

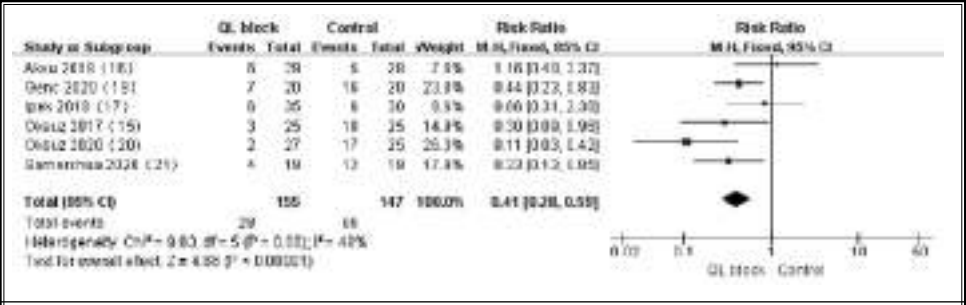

Fig. 3. *Forest plot of the risk of rate of postoperative rescue analgesia in QL block group versus other modalities of analgesia technique group. QL block = quadratus lumborum block; RR = relative risk; CI = confidence interval.*

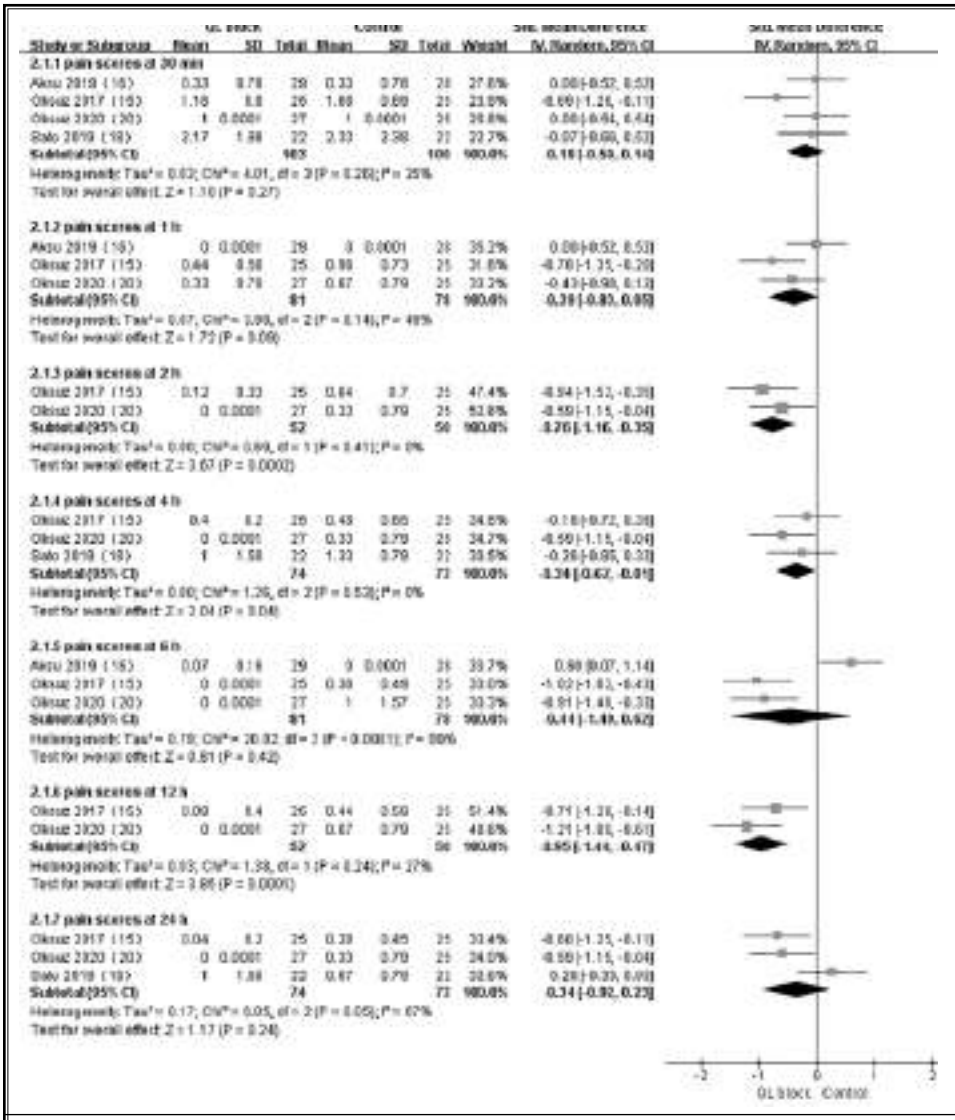

Fig. 4. *Forest plot of the risk of postoperative pain scores in QL block group versus other modalities of analgesia technique group. QL block = quadratus lumborum block; SMD = standardized mean difference; CI = confidence interval.*

gated patient satisfaction. Two studies (15,20) reported better patient satisfaction with the QL block and 1 trial (16) reported no significant difference between QL block and other analgesic methods. There was significant heterogeneity (I^2 = 84%, P = 0.002) and the pooled data shows no statistically significant improvement in patient satisfaction with QL block (Std.MD = 0.49; 95% CI = -0.32 to 1.29; P = 0.24; Fig. S2). Sensitivity analyses show that patient satisfaction was mainly influenced by the study by Aksu (16) (Table S3).

Subgroup Analysis and Meta-regression

The results of the subgroup analyses reveal that the block approaches might cause heterogeneity in patient satisfaction (Table S4).

The meta-regression analysis has been unable to further identify the sources of the heterogeneity (Table S5).

Complications or Side Effects

All trials investigated the incidence of complications or side effects, such as hypotension, arrhythmia, bradycardia, allergic reaction, nausea or

vomiting. Only 2 trials (17,20) observed block-related complications postoperatively. Ipek, et al (17), reported that 2 patients suffered an average of 2.5 hours of motor weakness; 3 cases suffered urinary retention in the caudal block group, while a patient in the QL block group also had side effects that were not described in detail. Oksuz, et al (20), demonstrated 1 case of nausea in the caudal block group. The meta-analysis results demonstrate no differences between analgesic methods (RD = -0.02; 95% CI = -0.06 to 0.02; $P = 0.31$; Fig. S3). In addition, there is no significant heterogeneity among articles ($I^2 < 0.001\%$, $P = 0.92$).

Discussion

Summary of Main Results

To the best of our knowledge, this was the first meta-analysis to evaluate the postoperative analgesic effect of QL block in pediatric patients undergoing lower abdominal surgeries. The results of the current meta-analysis of randomized trials showed that the rate of postoperative rescue analgesia was significantly lower in the QL block group, than in the other analgesia group. QL block might also reduce pain scores after surgery without increasing adverse events, compared to other analgesic techniques.

Agreements and Disagreements

Our meta-analysis further supported previous meta-analyses including adult patients that QL block was an effective analgesic option (3,9,10). However, the pediatric age group has a stronger response to pain stimulation than the adult population (11) and the management of pediatric pain is constrained by limited available analgesia agents. Caudal anesthesia is the standard anesthesia technique for relieving postoperative pain in children, since it is easy to perform and has a low complication rate (22-24). In our meta-analysis, 3 trials compared QL block with caudal anesthesia and all suggest that QL block provided more effective postoperative pain relief in children after lower abdominal surgeries. The less effective pain relief of the caudal block was probably due to the high vascularity in the epidural space; thus, a large number of local anesthetics were absorbed quickly and the duration of epidural analgesia was shortened (25). Another meta-analysis also shows that as analgesia for hypospadias repair, caudal blocks (compared with peripheral nerve blocks) showed higher pain scores 24 hours after surgery, a significantly shorter duration of analgesia, and higher analgesia consumption (26). It was concluded that peripheral nerve blocks provided better analgesic quality than caudal blocks, which is similar to our results. It has been demonstrated that QL and ESP block provide similar postoperative analgesia in pediatric patients undergoing lower abdominal surgery in Aksu (16) study; however, for pediatric surgeries performed under general anesthesia, the prone patient positioning for the ESP block might constitute a limitation for the use of this block. While TAP block, the mechanism of which involves Petit triangle, could only alleviate pain in the anterolateral abdominal wall (9).

Compared with other analgesic methods, QL block significantly reduced the rate of postoperative rescue analgesia for pain scores at 2, 4, and 12 hours postoperatively, but not at 30 minutes, or at 1, 6, or 24 hours postoperatively. There are reasons for the difference. Firstly, the non-uniform measured postoperative pain scores points. For the 2- and 12-hour pain scores, only 2 studies are included in our meta-analysis and for the other time points we included 3 or 4 studies. Secondly, QL block is compared with different control groups. Two studies compared QL block with caudal block, one compared QL block with TAP and ESP block respectively. We also found that QL block significantly reduces pain scores at 1 and 6 hours postoperatively, when eliminating the study by Aksu (16), which compared QL block with ESP block. Previous studies have demonstrated that ESP block could also spread local analgesia to the paravertebral region and achieve the relief of visceral pain (27,28). We also noticed that the median postoperative pain scores are less than one at 1 and 6 hours postoperatively by QL block in the Aksu (16) study and QL block is still an effective analgesia technique. It seems that single QL block works at 1 hour postoperatively and then loses efficacy at 24 hours postoperatively.

The QL block approaches applied could modify the analgesic efficacy, which is also confirmed in our subgroup analyses. The mechanisms and analgesic efficacy of different approaches are still controversial. A trial that was excluded, due to the lack of a control group, comparing 2 QL block approaches, anterior and intramuscular, shows that anterior QL blocks are superior to intramuscular blocks, in terms of analgesic effect after pediatric lower laparotomy (29). For adults, the anterior QL block approach also produces more postoperative pain relief and less opioid consumption than the posterior (30) and lateral approaches (31). Consequently, anterior QL block may be the most effective approach for analgesia; however, this method is also associated with

more side effects (32). A retrospective study reported that the rates of quadriceps muscle weakness after lateral, posterior, anterior, and intramuscular QL blocks were 1%, 19%, 65%, and 0%, respectively. A pediatric trial also showed that 8 children (29.6%) with anterior QL block developed quadriceps weakness, while only 1 (3.7%) with intramuscular QL block developed quadriceps weakness. Thus, the posterior approach seems to provide better analgesic efficacy with fewer complications for pediatric patients and was mostly selected for inclusion in our studies.

QL block potentially spreads local anesthetics into the paravertebral space, causing this method to have a good analgesic effect on visceral pain, but also a large impact on hemodynamics (33). Complications related to QL block, such as lower limb weakness, sympathetic block, and hematoma, have gradually been reported. Among the studies included, only 2 trials observed complications: 1 patient in the QL block group and 4 patients in the caudal block group (17,20). Sa et al (34), reported 2 patients, who underwent total gastrectomy and right hemicolectomy, with severe hypotension and tachycardia 30 to 40 minutes after the implementation of a posterior QL block, which may be related to the sympathetic block caused by local anesthetic spreading to the paravertebral and epidural space. A 6-year-old boy, undergoing right inguinal hernia repair, was incidentally found to have hepatomegaly when a regional anesthesiologist performed transmuscular QL block (35). Accordingly, we should pay attention to avoiding solid organ damage (liver, kidney, intestine, etc). A recent study (36) comparing the postoperative pain control between QL block and intravenous lidocaine showed that more patients in the QL block group showed subjective symptoms of local anesthetic systemic toxicity, a metallic taste. In the trial, 30 ml (in patients weighing > 55 kg) or 20 mL (in patients weighing < 55 kg) of ropivacaine 0.25% and clonidine 0.5 mg/kg were injected at each side. Therefore, when QL block is applied in children, the dosage of local anesthetics should be more accurate and administered strictly according to the weight of the child. Ultrasound can better help us implement the technology. Our findings did not show significant differences between QL block and other analgesia techniques in complications and side effects; however, this may stem from the lack of statistical power. More consistent clinical trials with larger sample sizes are still needed.

Limitations

The major limitation of this meta-analysis is the relatively few RCTs on this subject and the limited results included. Similarly, we should also notice the differences in block approaches among control groups (TAP, ESP, caudal block, opioid-based analgesia), drug types and concentrations, and multimodal analgesia programs. Even though the management of pediatric pain is constrained by limited available analgesia agents, we still suggest QL block for the pediatric population undergoing lower abdominal surgery based on the current limited research evidence. Furthermore, some relevant outcomes were not investigated in the included studies, for instance, the dermatomal levels of QL block and pain scores during movement, which are more clinically meaningful. All of these imbalances could introduce bias to our results; therefore, more random and larger sample studies are needed to provide more evidence regarding the postoperative analgesic effect of QL block for pediatric lower abdominal surgeries.

Conclusion

In conclusion, our systematic review and meta-analysis suggests use of QL block for the pediatric population undergoing lower abdominal surgery, based on the current limited research evidence, as this method was an effective postoperative analgesic technique. However, we identified relatively few RCTs and observed significant heterogeneity, so large, multicenter, methodologically rigorous, controlled trials are required to confirm these results.

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Table S1. *Sensitivity analysis for the rate of postoperative rescue analgesia*

Study omitted	Estimate	95% CI		*P* value	Heterogeneity	*P* value
	RR	Lower	Upper		I^2 (%)	
Aksu (2019) (16)	0.35	0.23	0.52	< 0.001	37%	0.17
Genc (2020) (19)	0.40	0.25	0.63	< 0.001	59%	0.04
Ipek (2019) (17)	0.36	0.24	0.54	< 0.001	50%	0.09
Oksuz (2017) (15)	0.43	0.29	1.63	< 0.001	57%	0.05
Oksuz (2020) (20)	0.51	0.34	0.76	0.001	21%	0.28
Samerchua (2020) (21)	0.42	0.28	0.64	< 0.001	58%	0.05
Combined	0.41	0.28	0.59	< 0.001	49%	0.08

RR = risk difference; CI = Confidence interval.

Table S2. *Sensitivity analysis for the postoperative pain scores*.

Study omitted	Estimate	95% CI		*P* value	Heterogeneity	*P* value
	SMD	Lower	Upper		I^2 (%)	
postoperative pain scores at 30 min						
Aksu (2019) (16)	-0.25	-0.68	0.18	0.25	41%	0.18
Oksuz (2017) (15)	-0.02	-0.34	0.30	0.90	0%	0.98
Oksuz (2020) (20)	-0.25	-0.67	0.18	0.26	42%	0.18
Sato (2019) (18)	-0.22	-0.65	0.22	0.33	48%	0.15
Combined	-0.18	-0.50	0.14	0.27	25%	0.26
postoperative pain scores at 1 h						
Aksu (2019) (16)	-0.59	-0.99	-0.20	0.003	0%	0.39
Oksuz (2017) (15)	-0.20	-0.62	0.21	0.34	18%	0.27
Oksuz (2020) (20)	-0.38	-1.14	0.38	0.33	74%	0.05
Combined	-0.39	-0.83	0.05	0.09	49%	0.14
postoperative pain scores at 2 h						
Oksuz (2017) (15)	-0.59	-1.15	-0.04	0.04	/	/
Oksuz (2020) (20)	-0.94	-1.52	-0.35	0.002	/	/
Combined	-0.76	-1.16	-0.35	< 0.001	0%	0.41
postoperative pain scores at 4 h						
Oksuz (2017) (15)	-0.44	-0.84	-0.03	0.03	0%	0.42
Oksuz (2020) (20)	-0.21	-0.61	0.20	0.31	0%	0.82
Sato (2019) (18)	-0.38	-0.80	0.04	0.08	13%	0.28
Combined	-0.34	-0.67	-0.01	0.04	0%	0.53
postoperative pain scores at 6 h						
Aksu (2019) (16)	-0.96	-1.37	-0.55	< 0.001	0%	0.78
Oksuz (2017) (15)	-0.15	-1.63	1.33	0.85	93%	<0.001
Oksuz (2020) (20)	-0.20	-1.80	1.39	0.80	94%	<0.001
Combined	-0.44	-1.49	0.62	0.42	90%	<0.001
postoperative pain scores at 12 h						
Oksuz (2017) (15)	-1.21	-1.80	-0.61	< 0.001	/	/
Oksuz (2020) (20)	-0.71	-1.28	-0.14	0.01	/	/
Combined	-0.95	-1.44	-0.47	0.001	27%	0.24
postoperative pain scores at 24 h						
Oksuz (2017) (15)	-0.17	-1.01	0.66	0.68	76%	0.04
Oksuz (2020) (20)	-0.21	-1.13	0.71	0.65	80%	0.03
Sato (2019) (18)	-0.64	-1.03	-0.24	0.002	0%	0.84
Combined	-0.34	-0.92	0.23	0.24	67%	0.05

SMD = standardized mean difference; CI = confidence interval.

Table S3. *Sensitivity analysis for the patient satisfaction.*

Study omitted	Estimate	95% CI		*P* value	Heterogeneity	*P* value
	SMD	Lower	Upper		I2 (%)	
Aksu (2019) (16)	0.88	0.47	1.28	< 0.001	0%	0.41
Oksuz (2017) (15)	0.21	-0.77	1.19	0.68	85%	0.01
Oksuz (2020) (20)	0.38	-0.94	1.70	0.57	91%	< 0.001
Combined	0.49	-0.32	1.29	0.24	84%	0.002

SMD = standardized mean difference; CI = confidence interval.

Table S4. *Subgroup analysis for the patient satisfaction.*

Group	Number of studies	QL block	Other analgesia technique	M-H pooled SMD	*P*	Heterogeneity I^2 (%)	*P*
		Total	Total	SMD (95%CI)			
Total	3	81	78	0.49 [-0.32, 1.29]	0.24	84%	0.002
Approach of QL block							
QLB2	2	52	50	0.88 [0.47, 1.28]	< 0.001	0%	0.41
QLB3	1	29	28	-0.29 [-0.81, 0.24]	0.28	-	-
Analgesic methods of control group							
Caudal block	1	27	25	0.71 [0.15, 1.27]	0.01	-	-
PNB block	2	54	53	0.38 [-0.94, 1.70]	0.57	91%	< 0.001

SMD = standardized mean difference; CI = confidence interval; QL block = quadratus lumborum block.
Test for subgroup differences: $Chi^2 = 11.78$, df = 1 (P = 0.0006), $I^2 = 91.5\%$ - Approach of QL block
Test for subgroup differences: $Chi^2 = 0.21$, df = 1 (P = 0.65), $I^2 = 0\%$ - Analgesic methods of control group

Table S5. *Meta-regression for the outcome of patient satisfaction.*

Sources	Coefficient (95%CI)	t	*P*	τ2	I^2 Res (%)	Adjusted R^2 (%)
Approach of QL block	-1.17 (-5.48, 3.12)	-3.49	0.18	0.00	0.00	100.00
Analgesic methods of control group	-0.34 (-15.37, 14.70)	-0.28	0.82	0.85	91.26	-99.12
Dose of local anesthetics	0.34 (-14.70, 15.37)	0.28	0.82	0.85	91.26	-99.12
Concentration of local anesthetics	-0.87 (-12.11, 10.38)	-0.98	0.51	0.44	85.04	-1.88
Year of publication	-0.17 (-8.95, 8.60)	-0.25	0.84	0.87	91.90	-102.58

CI = confidence interval

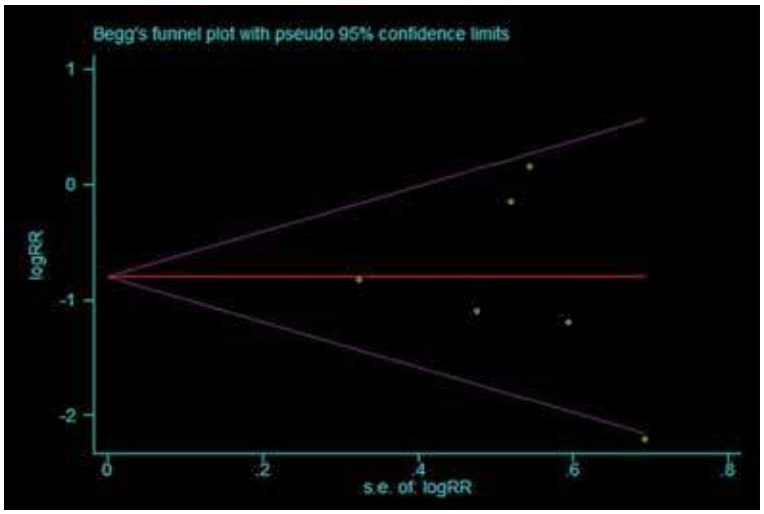

Fig. S1. *Begg's test for the rate of postoperative rescue analgesia.*

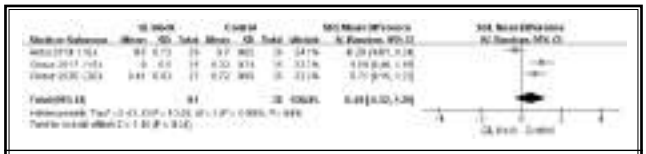

Fig. S2. *Forest plot of the risk of patient satisfaction in QL block group versus other modalities of analgesia technique group. QL block = quadratus lumborum block; SMD = standardized mean difference; CI = confidence interval.*

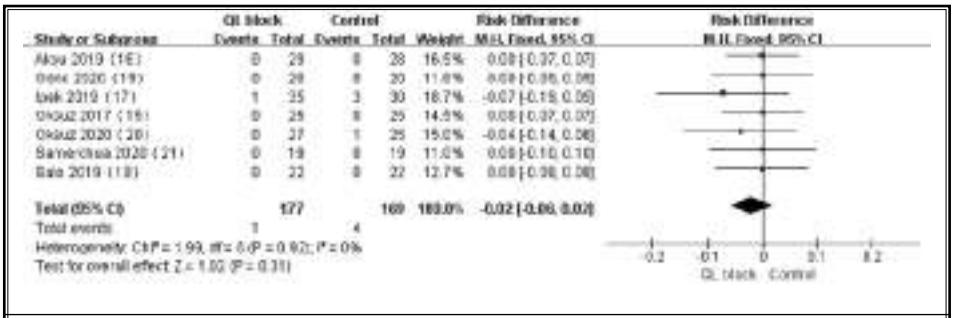

Fig. S3. *Forest plot of the risk of complications in QL block group versus other modalities of analgesia technique group. QL block = quadratus lumborum block; RD = risk difference; CI = confidence interval.*

Appendix 1. ***Search strategies for this study.***

Database: Medline (Pubmed)
Search filter
(QL [tiab]OR quadratus lumborum[tiab] OR quadratus[tiab] OR QLB[tiab]) AND (block[tiab] OR anesthesia[tiab] OR neurolysis [tiab]OR analgesia[tiab]) AND(randomized controlled trial[pt] OR controlled clinical trial[pt] OR randomized[tiab] OR controlled[tiab] OR trial[tiab]OR placebo[tiab] OR random[tiab] OR groups[tiab])AND(pediatric[tiab]OR children[tiab]OR infant[tiab]OR adolescent[tiab]OR schoolchild[tiab] OR preschool[tiab]OR teens[tiab]OR youth)

Database: EMBASE (Ovid SP)
Search filter
#1 'quadratus lumborum block'/exp
#2 'QL':ab,ti OR 'quadratus lumborum':ab,ti OR 'quadratus':ab,ti OR 'QLB':ab,ti
#3 'block':ab,ti OR 'anesthesia':ab,ti OR 'neurolysis':ab,ti OR 'analgesia':ab,ti
#4 #2 AND #3
#5 #1 OR #4
#6 'pediatric patient'/exp
#7 'pediatric surgery'/exp
#8 'child surgery':ab,ti OR 'paediatric surgery':ab,ti OR 'child':ab,ti
#9 #6 OR #7 OR #8
#10 'randomized controlled trial'/exp OR 'controlled clinical trial'/exp OR 'randomized':ab,ti OR 'controlled':ab,ti OR 'trial':ab,ti OR 'placebo':ab,ti OR 'randomly':ab,ti OR 'groups':ab,ti
#11 #5 AND #9 AND #10

Database: Cochrane Central Register of Controlled Trials (CENTRAL) in the Cochrane Library
Search filter
#1 pediatrics[mh]
#2children[mh]
#3 infant
#4 adolescent
#5 schoolchild
#6 preschool
#7 teens
#8 youth
#9 quadratus lumborum block
#10 QL
#11 quadratus lumborum
#12 Quadratus
#13 QLB
#14 Block
#15 Anesthesia
#16 Neurolysis
#17 analgesia
#18 #1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8
#19 #10 OR #11 OR #12 OR #13
#20 #14 OR #15 OR #16 OR #17
#21 #19 AND #20
#22 #9 OR #21
#23#18 AND #22

Database: Web of Science
Search filter
#1 TI=(QL OR quadratus lumborum OR quadratus OR QLB)
#2 TI=(block OR anesthesia OR neurolysis OR analgesia)
#3 #2 AND #1
#4 AB=(block OR anesthesia OR neurolysis OR analgesia)
#5 AB=(QL OR quadratus lumborum OR quadratus OR QLB)
#6 #5 AND #4
#7 #6 OR #3
#8 TI=(pediatric OR children OR infant OR adolescent OR schoolchild OR preschool OR teens OR youth)
#9 AB=(pediatric OR children OR infant OR adolescent OR schoolchild OR preschool OR teens OR youth)
#10 #9 OR #8
#11 #10 AND #7
Language: (English) AND Document type: (Article)

Database: Science Direct
Search filter
Title, abstract, keywords:(pediatric OR children OR adolescent OR school OR teens OR infant) AND (QL OR quadratus lumborum OR quadratus lumborum block)

Appendix 2. *The GRADE evidence quality for outcomes.*

Outcomes	**Design**	**Number of studies**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other considerations**	**Quality of evidence (GRADE)**
Rate of postoperative rescue analgesia	RCT	6	Not serious	Not serious	Not serious	Serious	None	Moderate
Pain scores – 30min	RCT	4	Not serious	Not serious	Not serious	Serious	None	Moderate
Pain scores – 1h	RCT	3	Not serious	Not serious	Not serious	Serious	None	Moderate
Pain scores – 2h	RCT	2	Not serious	Not serious	Not serious	Serious	None	Moderate
Pain scores – 4h	RCT	3	Not serious	Not serious	Not serious	Serious	None	Moderate
Pain scores – 6h	RCT	3	Not serious	Serious	Not serious	Serious	None	Low
Pain scores – 12h	RCT	2	Not serious	Not serious	Not serious	Serious	None	Moderate
Pain scores – 24h	RCT	3	Not serious	Serious	Not serious	Serious	None	Low
Patient satisfaction	RCT	3	Not serious	Serious	Not serious	Serious	None	Low
Complications	RCT	7	Not serious	Serious	Not serious	Serious	None	Low