Review

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Effectiveness of ultrasound-guided ilioinguinal and iliohypogastric nerve block in pediatric inguinal hernia surgery: a systematic review and meta-analysis of randomized controlled trials

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Abstract

Aim: To evaluate the efficacy of ultrasound-guided ilioinguinal and iliohypogastric nerve block (IIHB) in children undergoing surgery for inguinal hernias. **Material and methods:** PubMed, Embase, Cochrane Library, and Web of Science databases were searched to January 4, 2024. For continuous data, the effect sizes were presented as weighted mean differences (WMDs), and for categorical data, they were reported as relative ratios (RR), each accompanied by 95% confidence intervals (CIs). **Results:** IIHB demonstrated a longer duration before the need for the first analgesic compared to transverse abdominis plane (TAP), caudal epidural block (CEB), and pre-incisional wound infiltration (PWI), but a shorter duration than quadratus lumborum block (QLB). The IIHB group had a higher probability of requiring rescue analgesics compared to other blocks or PWI (RR: 1.69, 95% CI: 1.25 to 2.28, p=0.001). Higher FLACC scores were noted at 12 hours for the IIHB group (WMD: 0.50, 95% CI: 0.13 to 0.86, p=0.008). IIHB required more intraoperative fentanyl compared to controls (RR: 2.14, 95% CI: 1.17 to 3.92, p=0.014). **Conclusion:** While IIHB may have some benefits, it does not appear to be more effective overall in managing postoperative pain in pediatric inguinal hernia surgery patients compared to other blocks or PWI.

Keywords: ilioinguinal and iliohypogastric nerve block; ultrasound-guided; managing postoperative pain

Introduction

Pediatric inguinal hernia is a frequently occurring congenital condition with an incidence rate of 0.8-5% in infants and young children, marked by the protrusion of abdominal contents into the inguinal canal [1]. Pediatric inguinal hernia surgery, which can be performed through open or laparoscopic techniques, is a routine surgical procedure for children worldwide [2,3]. Nevertheless, surgery for pediatric inguinal hernia is typically linked to considerable postoperative pain and discomfort [4]. Hence, effective pain management is potentially paramount in elevating patient and family satisfaction, as well as facilitating postoperative functional recovery in the context of pediatric inguinal hernia surgery [5].

The ilioinguinal/iliohypogastric nerve block (IIHB) is widely used as a regional anesthetic method for managing pain during pediatric inguinal hernia surgery, providing effective pain relief and enhancing patient recovery outcomes [6,7]. Ultrasound-guided IIHB offers the advantages of real-time visualization and minimal invasiveness, significantly strengthening the procedure's success rate while reducing the risk of complications associated with nerve blocks [7]. Research indicates that ultrasound-guided IIHB provides superior postoperative pain control in pediatric patients, warranting its consideration as a preferred approach over postoperative perifocal wound infiltration (PWI) [6]. A meta-analysis has demonstrated that the IIHB is effective in providing analgesia at the 6-hour and 8-hour marks following in-

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guinal hernia repair, demonstrating its efficacy in comparison to the transversus abdominis plane (TAP) block [8]. However, there is no significant difference in postoperative opioid consumption, complications, or patient satisfaction between the IIHB and the TAP [8]. A prospective randomized study has indicated that both quadratus lumborum block (QLB) and IIHB provide effective postoperative analgesia for children undergoing hernia repair [9]. However, the QLB group has demonstrated lower pain scores and decreased analgesic consumption during the perioperative period when compared to the IIHB group [9]. In the context of unilateral inguinal hernia surgery, a study has indicated that ultrasound-guided QLB offers more sustained and potent postoperative pain relief than the combination of IIHB with wound infiltration [10]. Given the contradictory findings, it remains unclear whether the efficacy of ultrasound-guided IIHB in pediatric inguinal hernia surgery is superior compared to other types of blocks.

Therefore, this meta-analysis analyzes the effectiveness of ultrasound-guided IIHB in pediatric patients undergoing inguinal hernia surgery, compared to QLB, TAP, erector spine plane (ESP) block, retrolaminar block (RLB), caudal epidural block (CEB), and PWI.

Materials and methods

Search methods

The search method was meticulously designed and executed with a search period culminating on January 4th, 2024, encompassing a comprehensive sweep across multiple esteemed medical databases, including PubMed, Embase, the Cochrane Library, and Web of Science. The search terms employed for the English literature search encompass Neuralgia, Neuropathic Pain, Neurodynia, Ilioinguinal, Ilioinguinal, Iliohypogastric, IIN/IHN, Local Anesthesia, Infiltration Anesthesia, Conduction Blocking Anesthetics, Nerve Block, Chemical Neurolysis, Inguinal Hernia. The PubMed search strategy is detailed in Supplementary file 1.

Selection criteria

The inclusion criteria for this meta-analysis have been rigorously defined by adhering to the PICOS principle: (1) Population (P): pediatric patients undergoing inguinal hernia surgery; (2) Intervention (I): IIHB; (3) Comparator (C): QLB, TAP, ESP, RLB, CEB, and PWI; (4) Outcomes (O): the time to first analgesic requirement, time to first voluntary voiding of urine, the requirement for rescue analgesia, Face, Legs, Activity, Cry, and Consolability (FLACC) score, heart rate, postoperative nausea and vomiting, mean postoperative tramadol consumption, intraoperative fentanyl consumption, and total amount of acetaminophen consumption (mg); (5) Study design (S): randomized controlled trials (RCTs).

The exclusion criteria for this meta-analysis were as follows: (1) animal studies; (2) non-English literature; (3) case reports, conference abstracts, letters, protocols, and editorial material; (4) studies with topics unrelated to the research focus.

Data extraction and studies quality assessment

The extracted data encompassed key elements from each study, including the author's name, year of publication, country of origin, study design, characteristics of the population under investigation, the type of anesthesia administered, group assignments within the study, specific treatments applied, the sample size, participants' age expressed in years, and gender distribution categorized as Male/Female, average weight, duration of surgery in minutes, duration of the nerve block effect, duration of anesthesia, American Society of Anesthesiologists (ASA) physical status classification indicating the health status (I/II), side of surgery (Right/Left), and the outcomes measured.

The quality assessment of RCTs within this study was conducted utilizing the Cochrane Risk of Bias tool, a standardized approach that thoroughly examines the presence of bias within six essential domains: selection bias, performance bias, detection bias, attrition bias, reporting bias, and other potential sources of bias [11].

Statistical analysis

For continuous data, the effect measure used was the weighted mean difference (WMD). For categorical data, the statistical measure was the relative ratio (RR). Both effect sizes were reported with 95% confidence intervals (CIs). Heterogeneity among the studies was assessed for each outcome to determine the consistency of the results. In instances where the I^2 statistic exceeded 50%, signifying considerable heterogeneity, a random-effects model was engaged to conduct the meta-analysis, accounting for variability between studies. Conversely, in the absence of significant heterogeneity, a fixed-effects model was utilized, which assumes that all studies are estimating the same effect size. To further scrutinize the robustness of the results, sensitivity analyses were conducted across all outcomes, examining how the conclusions might vary under different assumptions or when excluding individual studies. The threshold for determining statistical significance in this study was set at $p<0.05$, meaning that any result with a P-value less than this threshold was considered to indicate a statistically significant effect or difference. All studies were subjected to statistical analysis utilizing Stata 15.1 software. The corresponding risk assessment figures were generated using RevMan 5.4 software.

Results

Selection process and basic characteristics of included studies

Initially, the search across multiple databases yielded a comprehensive total of 3,533 records: Pubmed (856), Embase (1,191), Web of Science (1,477), and Cochrane (9). After removing duplicates, 2,217 records remained. These records were then screened, resulting in the exclusion of 2,036 records due to various reasons. Subsequently, 181 titles and abstracts were screened for eligibility, with 172 records excluded because the subjects did not meet the necessary requirements. Finally, nine [9,12-19] articles were included in the quantitative synthesis. Figure 1 is the flowchart depicting the process of identifying, screening, and selecting studies. Figure 2a is the graph visually represents the proportion of studies with low, unclear, and high risk of bias across different domains. Figure 2b is the summary chart that provides an overview of the risk of bias judgments for each included study across the same domains. The total number of participants across the included studies is 549. The study was published from 2019 to 2023 and covered several countries, including Egypt, Turkey, India, and Thailand. The weight of the children in the included studies varied. Supplementary Table I (on the journal site) provides the baseline characteristics of the nine included studies.

Meta-analysis of the effectiveness of ultrasound-guided IIHB in pediatric inguinal hernia surgery

The first analgesic requirement time (min)

Six studies were included in the analysis of the time to the first analgesic requirement. The results indicated no significant difference between the IIHB group and other blocks concerning the time to the first analgesic requirement (WMD: -6.67, 95% CI: -357.94 to 344.59, p=0.97, I^2=98.5%) (Fig 3, Supplementary Table II on the journal site). In subgroup analyses, the IIHB group had a significantly longer time to first analgesic requirement compared to the PWI group (WMD: 522.00, 95% CI: 470.90 to 573.10, p<0.001), TAP group (WMD: 120.00, 95% CI: 2.40 to 237.60, p=0.046), and CEB group (WMD: 150.60, 95% CI: 9.20 to 291.90, p=0.037). In contrast, the IIHB group had a shorter time compared to the QLB group (WMD: -322.30, 95% CI: -514.60 to -129.90, p=0.001).

Time for first voluntary voiding of urine (minutes)

The time for the first voluntary voiding of urine was analyzed in two studies. A fixed-effect model analysis (I^2=48.20%) showed no significant difference between the IIHB and control groups regarding the time for the first voluntary voiding of urine (WMD: 2.10, 95% CI: -32.08 to 36.28, p=0.904) (Supplementary Table II).

Rescue analgesia

Eight studies were included in this analysis of the rescue analgesic. The fixed-effects model was applied due to moderate heterogeneity (I^2=45.70%). The result showed

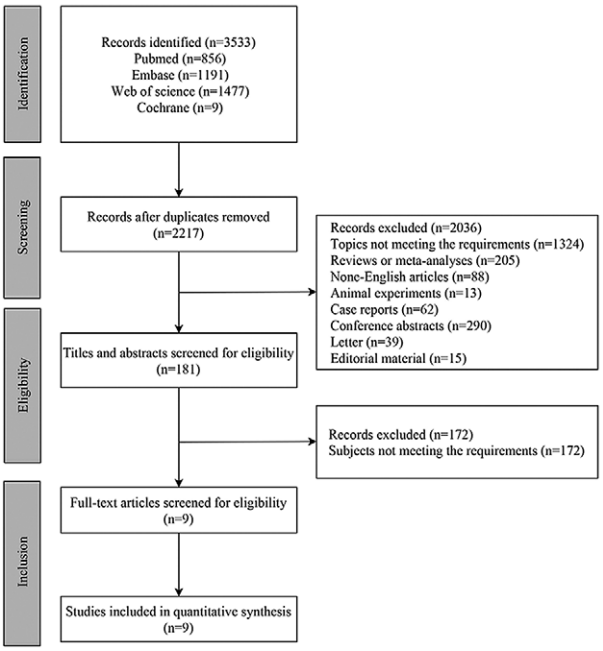

Fig 1. The flowchart depicting the process of identifying, screening, and selecting studies.

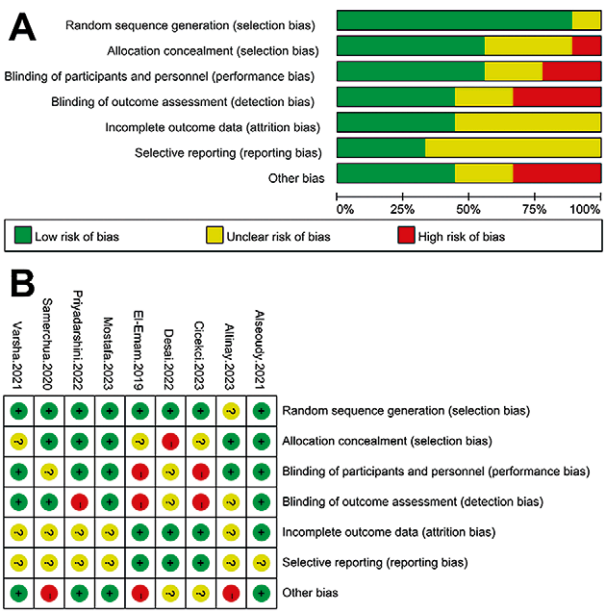

Fig 2. The risk of bias judgments. A: the graph visually represents the proportion of studies with low, unclear, and high risk of bias across different domains; B: the summary chart provides an overview of the risk of bias judgments for each included study across the same domains.

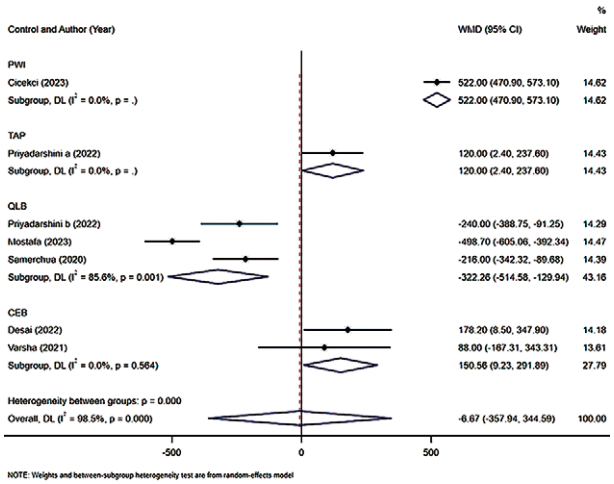

Fig 3. Meta-analysis of ultrasound-guided IIHB on the first analgesic requirement time in pediatric inguinal hernia surgery. Notes: IIHB, ilioinguinal and iliohypogastric nerve block; WMD, weighted mean difference; PWI, pre-incisional wound infiltration; TAP, transverse abdominis plane; QLB, quadratus lumborum block; CEB, caudal epidural block.

a higher probability of requiring rescue analgesia in the IIHB group compared to other blocks (RR: 1.69, 95% CI: 1.25 to 2.28, p=0.001) (fig 4a, Supplementary Table II). Subgroup analyses revealed that the IIHB group had a higher probability of requiring rescue analgesia compared to the QLB group (OR: 2.69, 95% CI: 1.55 to 4.67, p<0.001), RLB group (RR: 2.60, 95% CI: 1.06 to 6.39, p=0.037), and the ESP group (RR: 2.14, 95% CI: 1.02 to 4.49, p=0.044) (fig 4b, Supplementary Table II).

FLACC score

The FLACC scores at 30 minutes, 1 hour, 2 hours, 4 hours, 6 hours, 12 hours, and 24 hours post-surgery were compared between the IIHB group and control groups. The results showed no significant differences at 30 minutes (WMD: 0.12, 95% CI: -0.28 to 0.51, p=0.564), 1 hour (WMD: 0.16, 95% CI: -0.27 to 0.59, p=0.470), 2 hours (WMD: -0.13, 95% CI: -0.74 to 0.49, p=0.69), 4 hours (WMD: 0.24, 95% CI: -0.50 to 0.99, p=0.52), 6 hours (WMD: 0.51, 95% CI: -0.02 to 1.04, p=0.061), and 24 hours (WMD: 0.65, 95% CI: -0.08 to 1.39, p=0.083) between the IIHB group and control groups. However, the IIHB group had significantly higher FLACC scores at 12 hours (WMD: 0.50, 95% CI: 0.13 to 0.86, p=0.008) (fig 5, Supplementary Table II).

Intraoperative fentanyl requirement

Three studies assessed intraoperative fentanyl requirements. The fixed-effects model showed moderate heterogeneity (I^2=47.3%). The results suggested a higher probability of intraoperative fentanyl use in the IIHB group compared to controls (RR: 2.14, 95% CI: 1.17 to 3.92, p=0.014) (fig 6a, Supplementary Table II). Subgroup

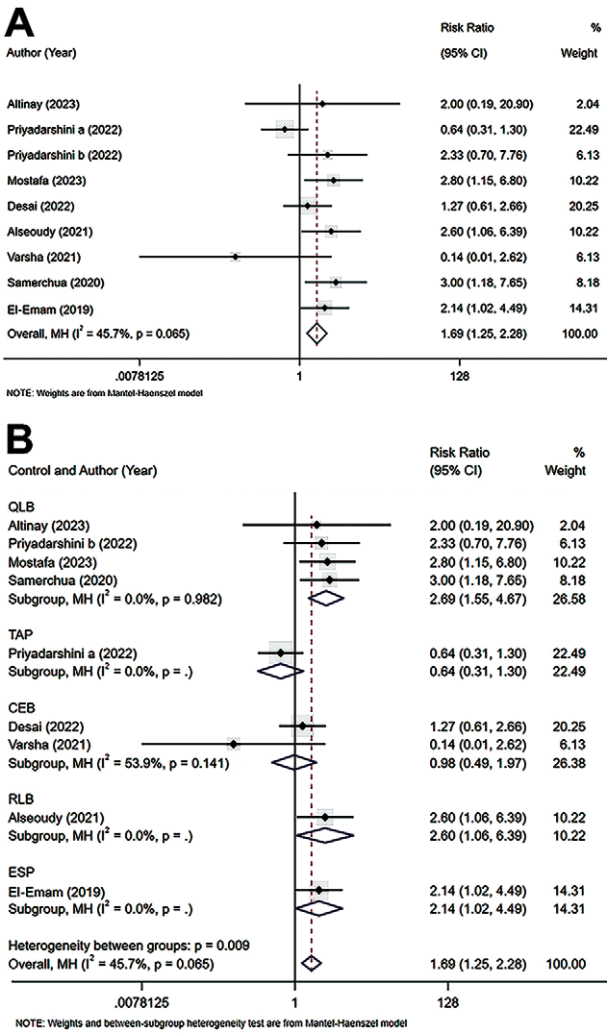

Fig 4. Meta-analysis of ultrasound-guided IIHB on the rescue analgesic in pediatric inguinal hernia surgery. A: overall; B: subgroup analyses. Notes: CI, confidence intervals; QLB, quadratus lumborum block; TAP, transverse abdominis plane; CEB, caudal epidural block; RLB, retrolaminar block; ESP, erector spine plane.

analysis also indicated a higher probability in the IIHB group compared to the QLB group (RR: 5.00, 95% CI: 1.55 to 16.17, p=0.007) (fig 6b, Supplementary Table II).

One study assessed intraoperative fentanyl consumption (μg). There was no significant difference between the IIHB group and controls in intraoperative fentanyl consumption (WMD: -3.89, 95% CI: -10.15 to 2.37, *P*= 0.223) (Supplementary Table II).

Heart rate post-block

Comparisons of heart rates at 15 minutes, 30 minutes, and 1 hour post-block were evaluated in 3, 3, and 2 studies, respectively. Comparisons of heart rates at 15 minutes (WMD: 1.93, 95% CI: -7.44 to 11.29, p=0.686), 30 minutes (WMD: -1.50, 95% CI: -5.67 to 2.67, p=0.484),

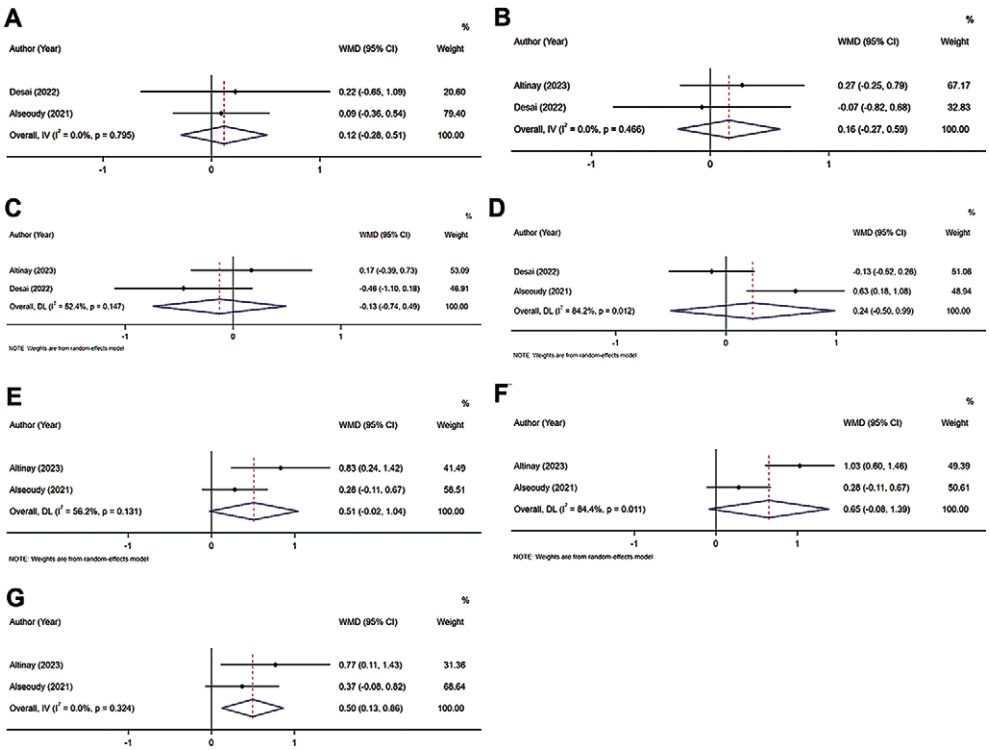

Fig 5. Meta-analysis of ultrasound-guided IIHB on the FLACC score in pediatric inguinal hernia surgery. A: at 30 minutes; B: at 1 hour; C: at 2 hours; D: at 4 hours; E: at 6 hours; F: at 24 hours; G: at 12 hours. Notes: WMD, weighted mean difference.

and 1 hour (WMD: -1.81, 95% CI: -5.22 to 1.61, p=0.300) post-block showed no significant differences between the IIHB group and control groups (Supplementary Table II).

Postoperative nausea and vomiting

Two studies were included with no heterogeneity (I^2=0.0%). The fixed-effects model was used. No significant difference between the IIHB and control groups regarding postoperative nausea and vomiting (RR: 0.79, 95% CI: 0.41 to 1.52, p=0.474) (Supplementary Table II).

The mean postoperative tramadol consumption (mg)

One study was included in this analysis of the mean postoperative tramadol consumption. The weighted mean difference (WMD: -2.67, 95% CI: -10.49 to 5.14, p=0.503) showed no significant difference in mean postoperative tramadol consumption between the II/IH group and control groups (Supplementary Table II).

Total amount of acetaminophen consumption (mg)

One study was included. No significant difference in total acetaminophen consumption between the II/IH group and control groups was observed (WMD: -24.17, 95% CI: -84.93 to 36.60, p=0.436) (Supplementary Table II).

Sensitivity analyses

The results of the sensitivity analyses suggested the robustness of our results as the results were consistent before and after sensitivity analyses (Supplementary Table II).

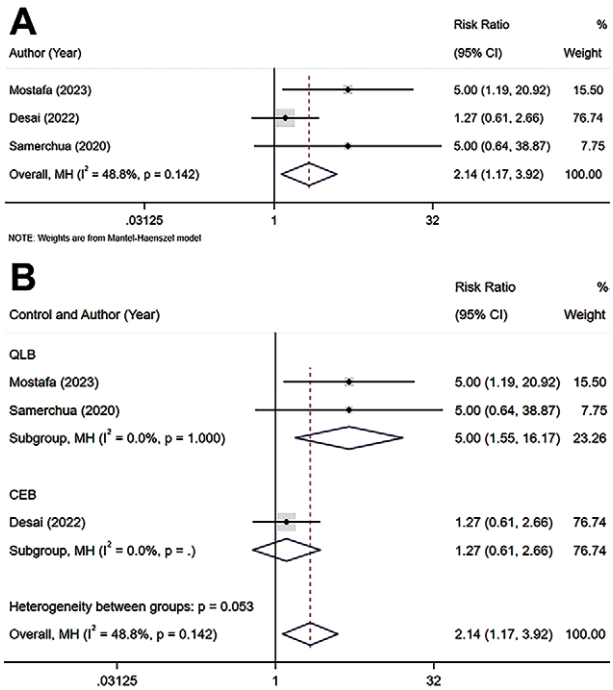

Fig 6. Meta-analysis of ultrasound-guided IIHB on the intraoperative fentanyl requirement. A: overall; B: subgroup analyses. Notes: IIHB, ilioinguinal and iliohypogastric nerve block; CI, confidence intervals; QLB, quadratus lumborum block; CEB, caudal epidural block.

Discussion

By comparing QLB, TAP, ESP, RLB, CEB, and PWI, we assessed the effectiveness of ultrasound-guided IIHB in pediatric inguinal hernia surgery. Our results demonstrated no significant differences in the time to first analgesic requirement when comparing the IIHB group with other nerve block techniques. However, the IIHB group showed a notably longer duration until the need for initial analgesic administration as opposed to the groups receiving PWI, TAP block, and CEB. Conversely, the IIHB group had a shorter time to first analgesic requirement compared to the QLB group. Additionally, the IIHB group demonstrated a higher probability of requiring rescue analgesia and intraoperative fentanyl use compared to the other blocks/PWI. At 12 hours postoperatively, the IIHB group had significantly higher FLACC scores. Furthermore, there were no significant differences between the IIHB group and control groups in terms of the time for first voluntary voiding of urine, FLACC scores at 30 minutes, 1 hour, 2 hours, 4 hours, 6 hours, and 24 hours, heart rate post-block, postoperative nausea and vomiting, mean postoperative tramadol consumption, and total acetaminophen consumption.

In this study, there was no significant difference in the time to the first analgesia between the IIHB group and the other block groups. However, it took significantly longer for the IIHB group to reach first analgesia than the PWI, TAP, and CEB groups. Previous studies have reported the advantages of IIHB versus PWI, TAP, and CEB. For children undergoing open inguinal hernia repair, compared to PWI, the administration of ultrasound-guided IIHB has been shown to extend the average time from pain-free intervals to the first use of opioid analgesics by approximately 21 minutes [6]. In a pilot study of a prospective randomized comparison of analgesic quality in pediatric patients 6 months to 4 years of age, the authors found that ultrasound-guided IIHB ensured better postoperative analgesia in children and should be prioritized over postoperative PWI [20]. In a comprehensive review and quantitative analysis, it has been demonstrated that IIHB offers superior pain relief compared to the TAP block [21]. Fredrickson et al [22] conducted a study on pediatric patients undergoing inguinal operations, where they evaluated the efficacy of ultrasound-guided TAP blocks against IIHB. The study concluded that IIHB delivers more effective pain relief than TAP blocks. In 45 children aged 1 to 6 years, ultrasound-guided IIHB was more effective than ultrasound-guided CEB in children aged 1 to 6 years for unilateral groin surgery, with the advantages of faster onset, longer duration of postoperative analgesia, and less local anesthetic [23]. In contrast, our findings demonstrated that the IIHB group had a shorter time to first analgesia than the QLB group. In an RCT, involving children who underwent open repair of inguinal hernias, it was observed that the QLB technique offered a more prolonged analgesic effect in comparison to both the TAP block and the IIHB [24]. In the study by Altınay et al, QLB has been shown to offer superior postoperative analgesic effects in pediatric patients undergoing inguinal hernia surgery, with longer pain-free intervals, lower pain scores, and reduced consumption of analgesic medication compared to the IIHB [13]. Samerchua et al showed that QLB had a better analgesic effect on children with inguinal hernia repair than IIHB and QLB is safe and has a simplicity of technique comparable to that of ultrasound-guided IIHB [25]. Our finding underscores the need for further research to explore and compare the efficacy of IIHB with various other regional blocks in pediatric inguinal hernia surgery.

In this study, the IIHB group had a higher probability of needing rescue analgesics and had a higher 12-hour FLACC score compared to other blocks or PWI. In addition, compared to the control groups, patients with IIHB required more daphanil during surgery. A prospective RCT showed that the QLB group had lower pain scores and less postoperative and intraoperative analgesic consumption than the IIHB group [9]. Ohashi et al observed that ultrasound-guided IIHB can reduce the amount of sevoflurane required intraoperatively, but it does not alleviate postoperative pain [26]. In an RCT, it was observed that children who underwent open inguinal hernia repair and received IIHB had a higher intake of opioids compared to those who received QLB [24]. In a study by Fredrickson et al, the comparison between ultrasound-guided TAP blocks and IIHB in children undergoing inguinal surgery revealed that while TAP blocks were associated with a higher frequency of pain, the level of opioid consumption remained comparable between both treatment groups [22]. However, a comparative study found that ultrasound-guided IIHB delayed the need for rescue analgesia and reduced the need for postoperative analgesia compared with ultrasound-guided TAP block [27]. Our study shows that the IIHB group even has disadvantages compared to other blocks.

Our study elucidates the clinical implications of comparing the effectiveness of ultrasound-guided IIHB with other blocking techniques such as QLB, TAP block, ESP block, RLB, CEB, and PWI for postoperative pain relief in pediatric inguinal hernia surgery. The direct comparison of these pain management techniques provided by this research aids clinicians in making informed decisions, as the results indicate that while IIHB may offer some advantages, it is not universally more effective

than other blocks. Importantly, no significant differences in side effects were observed between IIHB and other techniques, facilitating an assessment of the safety of IIHB use. Given that IIHB does not outperform other techniques in all respects, it underscores the necessity for physicians to tailor pain management strategies based on the specific circumstances of patients and the pros and cons of each technique. In addition, the study suggests that future research should focus on identifying the optimal pain management protocols to enhance recovery outcomes for children undergoing inguinal hernia surgery, offering a direction for subsequent clinical investigations.

This study has several limitations. Firstly, the meta-analysis faced limitations due to the limited number of studies available for inclusion, which could impact the strength and broad applicability of the findings. The limited data set restricts the ability to perform extensive subgroup analyses that might clarify the specific contexts or patient conditions under which IIHB is most effective compared to other blocking techniques. Secondly, the study encountered significant heterogeneity in the outcomes among the studies included, which might be due to differences in the dosages of general anesthesia administered. This variability complicates the interpretation of the effectiveness of IIHB, as differing anesthesia protocols can influence postoperative pain outcomes and the need for rescue analgesia. The limited scope of the literature included in this review restricted our ability to fully explore and account for all sources of heterogeneity, potentially obscuring important distinctions between different anesthesia approaches or surgical contexts. Thirdly, the exclusion of studies published in languages other than English introduces a language bias, potentially overlooking significant research conducted in non-English speaking regions. This limitation may skew the meta-analysis towards findings more reflective of practices prevalent in English-speaking countries, thus limiting the applicability of the conclusions to global surgical practices and diverse patient populations.

Conclusion

Although IIHB provides effective initial postoperative pain control in pediatric inguinal hernia repair, its performance is not superior in all respects. The need for more frequent rescue analgesia and higher pain scores at certain points post-operation suggests alternative blocks. This study underscores the importance of tailoring pain management strategies to individual patient needs and highlights the necessity for ongoing research to optimize analgesic approaches in pediatric surgery.

Conflict of interest: none

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