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The Analgesic Efficacy of Ultrasound-Guided Quadratus Lumborum Block Versus Ultrasound-Guided Caudal Block for Hip Surgery in Pediatrics: A Prospective Randomized Study

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: Ultrasound-guided quadratus lumborum (QL) block, is local anesthetic technique providing perioperative somatic, perhaps even visceral, analgesia for patients of all ages. The aim of this study is to evaluate the analgesic efficacy of ultrasound-guided anterior QL block versus ultrasound-guided caudal block in pediatric patients undergoing hip surgery.
Patients and Methods: This prospective, randomized study was carried out on seventy patients aged 1-7 years, of both with ASA physical status I or II scheduled for elective surgical correction of developmental dysplasia of hip (DDH).
Anterior QL Block Group: Patients received ipsilateral ultrasound-guided anterior QL block after induction of general anesthesia using of bupivacaine 0.25% (0.5 mL/kg).
Caudal Block Group: Patients received ultrasound-guided caudal block after induction of general anesthesia using of bupivacaine 0.25% (0.75 mL/kg). Postoperative pain scores were assessed on admission to PACU and at 1, 2, 4, 6, 8, 12, 18 and 24 h postoperative. Total intraoperative fentanyl (μg) consumption, total postoperative rescue analgesic (morphine) consumption, time to the first

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rescue analgesic administration and Parent satisfaction were assessed. Heart rate and mean arterial blood pressure had been recorded pre–operative, every 15 min intra-operative , and postoperative on admission to PACU and at 1, 2, 4, 6, 8, 12, 18 and 24 h postoperative. Any undesirable side effects during the first 24 hours such as, bradycardia, hypotension, local hematoma at the side of injection, nausea and vomiting had been recorded.

Results: The median FLACC score was significantly lower in anterior QL block group than caudal block group at 4,6,8 and 12h postoperative (P<0.001). Total intraoperative fentanyl (μg) consumption was insignificant different between both groups (P=0.862). Post-operative morphine consumption was significantly lower in anterior QL group compared to caudal group (P<0.001). Time to first postoperative analgesic requirement was significantly prolonged in anterior QL block group compared to caudal block group (P < 0.001). The incidence of nausea and vomiting was insignificantly different between both groups (P > 0.999).

Conclusions: Ultrasound-guided anterior QL block provided effective and long lasting postoperative analgesia than ultrasound-guided caudal block with lesser postoperative analgesic consumption in pediatric patients undergoing surgical correction of DDH.

Keywords: Quadratus lumborum; caudal; hip surgery.

1. INTRODUCTION

Surgical procedure including hip joint surgery is extremely painful and associated with considerable postoperative pain in children despite the use of systemic opioids [1]. These patients may benefit from neuraxial analgesia in adjunction with general anesthesia [2].

Multimodal analgesia can improve perioperative pain control and reduces complications that arise from using a single mode of analgesia. For example, reliance on opioids analgesia increases the incidence of adverse effects of opioids including pruritus, nausea vomiting, as well as respiratory depression [3].

Caudal block is a common method used for intra-operative and postoperative pain relief in pediatric abdominal and lower limb surgeries [4]. Also, ultrasound-guided Quadratus lumborum (QL) block, a local anesthetic technique providing perioperative somatic and perhaps even visceral analgesia, can be used for pediatric patients undergoing abdominal or hip surgery [5,6].

We hypothesized that anterior QL block is an effective anesthetic technique for pediatric patients undergoing hip surgery. The aim of this study is to evaluate the analgesic efficacy of ultrasound-guided anterior QL block versus ultrasound-guided caudal block in pediatric patients undergoing hip surgery.

2. PATIENTS AND METHODS

This prospective randomized study was carried out in Tanta University Hospitals for from August 2019 till February 2020. All data of patients were confidential with secret codes and private file for each patient. All given data had been used for the explanation of the purpose of the study to parents. Seventy children aged 1-7 years of both gender with American Society of Anesthesiologists (ASA) physical status I or II scheduled for elective surgical correction of developmental dysplasia of hip (DDH) were included.

The patients with the following criteria were excluded from the study: patients with local infection at the site of injection, coagulation abnormalities, severe spinal deformity e.g. scoliosis and neurological deficit in lower limb. Patients were randomly allocated into two equal groups by computer generated sequence through sealed opaque envelopes. Each group included 35 patients.

2.1 Group I (Anterior QL block)

Patients received ipsilateral ultrasound-guided anterior QL block after induction of general anesthesia using of bupivacaine 0.25% (0.5 mL/kg).

2.2 Group II (Caudal Block)

Patients received ultrasound-guided caudal block after induction of general anesthesia using of bupivacaine 0.25% (0.75 mL/kg).

2.3 Ultrasound-Guided Anterior Quadratus Lumborum Block Technique

The patients were placed in the lateral

decubitus position. After local sterilization with povidone iodine, a high-frequency linear array ultrasound probe (5-13 MHz) covered with a sterile sheath was placed above the iliac crest. The Petit's triangle was identified. The margins of Petit's triangle are formed of the iliac crest inferiorly and the borders of external abdominal oblique anteriorly and latissimus dorsi (LD) posteriorly. The internal abdominal oblique muscle forms the floor of the Petit's triangle. The three abdominal muscles (i.e., the external oblique, internal oblique and transversus abdominus muscles) were detected. Both the external oblique and internal oblique muscles were followed posteriorly until the layers of the TLF appear as a bright hyperechogenic line. The QL muscle appears below to the LD muscle.

While performing the QL block, "Shamrock sign" is identified; the transverse process of L4 appears as a stem whereas the three muscles psoas major (PM) muscle, QL muscle and erector spinae appear as the leaves. A 22G (50 mm) needle was inserted using an in-plane technique along the posterior edge of the ultrasound probe in the anteromedial direction [7]. The needle tip was placed between the QL muscle and thePM muscle. After confirming the correct position of the needle by injecting 2 mL of normal saline with hydroids section image, bupivacaine 0.25% (0.5 mL/kg) was injected. Total dose of bupivacaine would not exceed 2 mg/kg and the maximum volume of local anesthetic solution would not be more than 20 Ml [7]. Fig. 1.

2.4 Ultrasound-Guided Caudal Block Technique

Patients were placed in the lateral decubitus position. After local sterilization with povidone iodine, the sacral hiatus was visualized at the level of the sacral cornus by employing a high-frequency linear array ultrasound probe (5-13 MHz), and the depth and gain were adjusted for optimal visual quality.

The high-frequency ultrasound probe was placed transversely at the midline to obtain a transverse view of the two cornua, sacrococcygeal ligament, sacral bone, and sacral hiatus. At this level, the ultrasound transducer was rotated to 90 degree to obtain longitudinal views of the sacrococcygeal ligament and sacral hiatus and subsequently placed between the two cornua. A 22G (50 mm) needle was advanced toward the upper third of the sacrococcygeal ligament. The needle advancement was terminated immediately after penetrating the sacrococcygeal ligament [8]. At this level, after confirming absence of blood or cerebrospinal fluid on aspiration, bupivacaine 0.25% (0.75 mL/kg) was injected over 1 minute while observing an ultrasound longitudinal image. Total dose of bupivacaine would not exceed 2 mg/kg and the maximum volume of local anesthetic solution would not be more than 20 mL. Fig. 2.

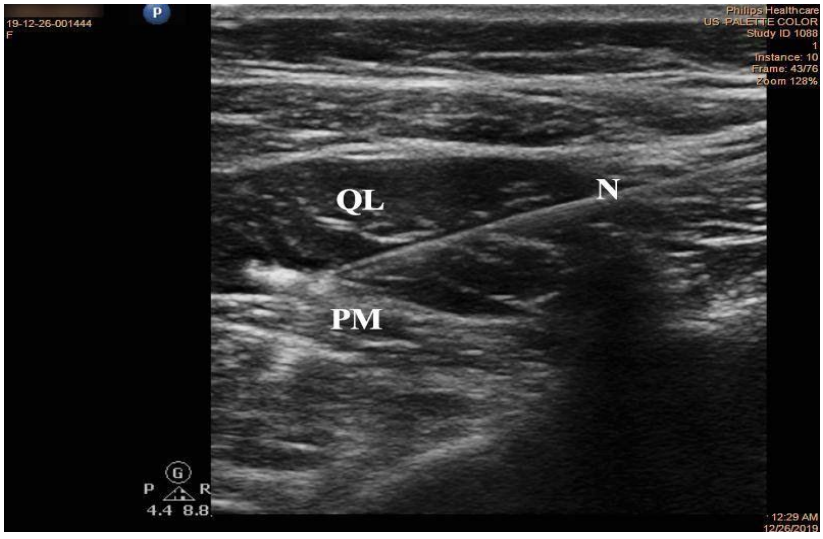


Fig. 1. US image of Quadratus Lumborum block. N: needle, QL: Quadratus Lumborum muscle, PM: Psoas major

2.5 Anesthetic Management

All the patients were under the following procedures; evaluation of medical and surgical histories of the patient, clinical examination, assessment of the laboratory investigations including complete blood picture, bleeding time and clotting time, liver functions and renal functions.

On entering operating room, routine monitoring including ECG, noninvasive blood pressure (NIBP), pulse oximetry, capnogram and temperature probe were used. Anesthesia was induced using a face mask with 8% sevoflurane in oxygen. A peripheral intravenous (IV) cannula was inserted after loss of consciousness, then fentanyl 1 µg/kg was given. Endotracheal intubation with proper sized endotracheal tube, was facilitated with cis-atracurium 0.15 mg/kg. General anesthesia was maintained using isoflurane 1.5% in 50% oxygen-50% air and incremental cis-atracurium 0.03 mg/kg.

In all patients, the assigned block was performed after induction of general anesthesia by the same investigator who had no further role in the study. Surgery was started about 15 min after performing the block. Fentanyl 1µg/ kg was administrated in the case of inadequate analgesia that defined as an increase of heart rate (HR) and/or mean arterial blood pressure (MAP) more than 20% above the pre-operative values. Total intraoperative fentanyl (µg) consumption was measured. The HR and MAP had been recorded pre–operative and every 15 min intra-operative till the end of surgery. At the end of surgery, isoflurane was switched off and extubation was done after reversal of muscle relaxant with neostigmine 0.05 mg/kg and atropine 0.02 mg/kg.

The patients were transferred to Post-Anesthesia Care Unit (PACU). Paracetamol (15 mg/kg) was administered IV every 6 hours. Postoperative pain was assessed by FLACC score (Face, leg, activity, cry, consolability) [9] on admission to PACU and at 1,2,4,6,8,12,18 and 24 h postoperative. Morphine 0.1 mg /kg IV was given as rescue analgesia if FLACC score was > 3. Total dose of morphine in the 1st 24 h postoperative was calculated. Time to the 1st dose required of morphine was recorded. Postoperative HR and MAP were recorded on admission to PACU ,at 1 h, 2 h, 4,6,8,12,18, 24 h. Parent satisfaction using a 5- point score (0 = very dissatisfied, 1=dissatisfied, 2 = neither satisfied nor dissatisfied, 3 = satisfied and 4 = very satisfied). Any undesirable side effects during the first 24 hours such as, bradycardia, hypotension, and local hematoma at the side of injection, nausea and vomiting had been recorded.

2.6 Outcomes

Primary outcome was the postoperative pain intensity in the 1st 24 hours.

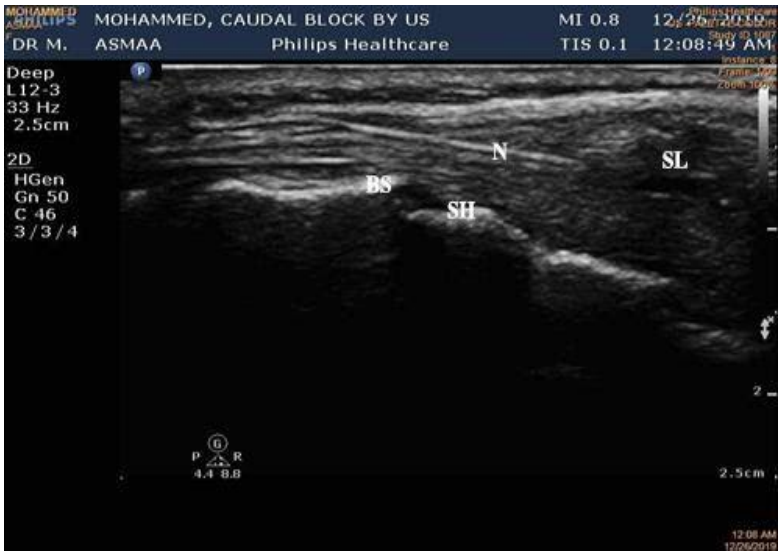


Fig. 2. Ultrasound longitudinal view of the caudal block. N: needle, BS, base of sacrum, SH: sacral hiatus, SL: sacrococcygeal ligament

Secondary outcomes were parent's satisfaction about postoperative analgesia and postoperative analgesic requirement

2.7 Statistical Analysis

Sample size was calculated using Epi-Info software statistical package created by World Health organization and center for Disease Control and Prevention, Atlanta, Georgia, USA version 2002. The criteria used for sample size calculation were as follows: 95% confidence limit, 80% power of the study, expected difference in the postoperative pain intensity between both groups was 30%. The sample size based on the previously mentioned criteria was found at 32 children for each study group.35 patients were recruited in each group to avoid drop out cases.

Organization and analysis of data were performed using SPSS version 26. (IBM®, Chicago, IL, USA). Normality of data distribution was checked by the Shapiro-Wilks test and the histogram visualization. Parametric variables with normal distribution (age, BMI, mean arterial pressure, heart rate) were expressed as mean ± standard deviation and analyzed using unpaired T-test for comparison between the two groups. FLACC score and the parameters didn't follow the normal distributions (total morphine consumption and time of first analgesic requirement) were expressed as median and inter quartile rang (IQR) and analyzed using Mann-Whitney (U) test for comparison between the two groups. Categorical data values were expressed as number and percent and analyzed using Chi-square test or Fisher exact test as appropriate. P value<0.05 was considered significant.

3. RESULTS

Seventy-seven patients were assessed for enrolment in the study; seven of them were excluded, as two patients did not meet the inclusion criteria and five patient's guardians refused to participate in the study. The remaining 70 children were randomly allocated in two equal groups. Fig. 3.

The demographic data and patients' characteristics including age, weight, sex and ASA physical status, the duration of surgery and the block performing duration were insignificantly different between both groups (P = 0.434, 0.573, 0.63, 0.582,0.149, 0.334). Table 1.

The median FLACC score was significantly lower in anterior QL block group than caudal block group at 4, 6, 8 and 12 h postoperative (P <0.001) and were insignificantly different between both groups at PACU admission, 1, 2, 18 and 24 h postoperative (P=0.413, 0.164, 0.552, 0.165 and 0.558 respectively). Fig. 4.

Two patients (5.71%) in anterior QL block group and three patients (8.57%) in caudal group required intraoperative fentanyl with significant difference between both groups (P>0.999). Total intraoperative fentanyl (µg) consumption showed an insignificant difference between both groups (P=0.862). Table 1.

The median (IQR) postoperative morphine consumption in the first 24 h was significantly lower in anterior QL group (2.6 (1.6-3.8) mg) compared to caudal group (4.4 (3.2-5.4) mg) (P <0.001). Table 1.

The median (IQR) time to first postoperative analgesic requirement was significantly prolonged in anterior QL block group 11 (8-13) hours compared to caudal block group 6 (4-6) h (P< 0.001). Table 1.

Intraoperative HR and MAP were insignificantly different between both groups (P> 0.05). Postoperative HR and MAP were significantly increased in caudal block group than anterior QL block group at 6 and 8h(P<0.05) while they were insignificant different between the both groups at remaining assessment times (P>0.05). Figs. 5,6.

Parent satisfaction score, nausea and vomiting were insignificantly different between both groups (P > 0.999, 0.571 respectively). Table 2.

4. DISCUSSION

The results of our study revealed that, anterior QL block provided lower postoperative pain scores at 4,6,8,12 hours than the caudal block, in pediatric patients undergoing DDH. The postoperative rescue analgesic consumption in the 1st 24 h was lesser in the anterior QL block group with prolonged time to the first postoperative analgesic administration than the caudal block group.

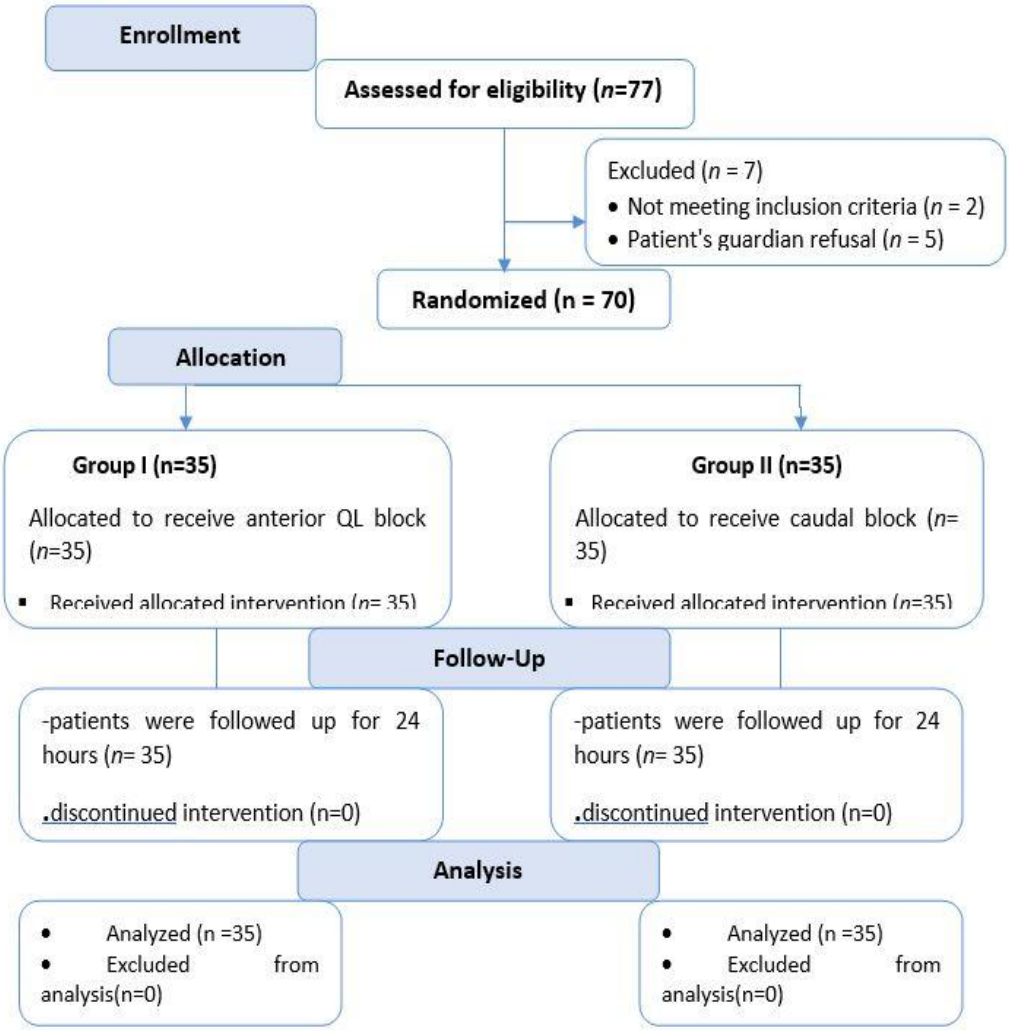


Fig. 3. Consort flow diagram of the participants through each stage of the randomized trial

Table 1. Demographic data and patient characteristic's

	Anterior QL block group	Caudal block group	P-value
	(n=35)	(n=35)	
Age (years)	4.06 ± 1.88	4.43 ± 2.06	0.434
Weight (kg)	16.3 ± 3.84	16.8 ± 4.18	0.573
Sex M/F	14/21	17/18	0.63
ASA I/II	22/13	25/10	0.582
Duration of surgery (min)	98.6 ± 11.0	94.3 ± 13.6	0.149
Block performing duration (min)	10.54 ± 3.04	9.83 ± 3.1	0.334

Data presented as mean ± SD or patients number (%)

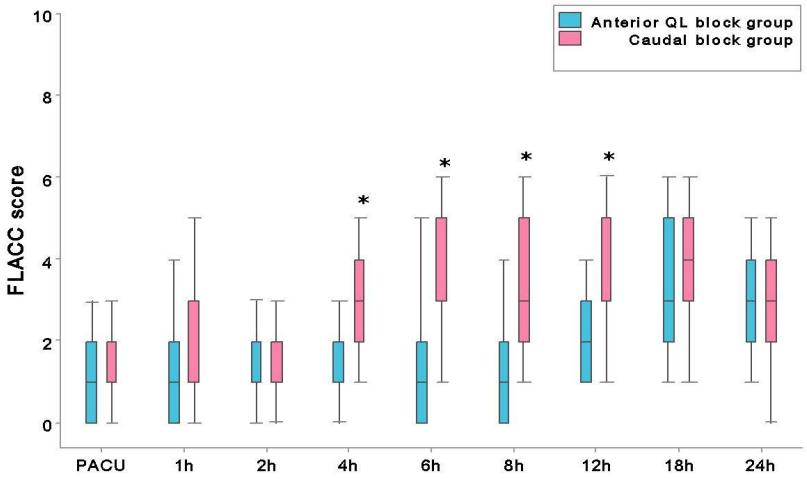


Fig. 4. FIACC score in both groups

Anterior QL block involves the process of injecting a local anesthetic into the fascial plane between the QL muscle and PM muscle. The assumption is that a local anesthetic injected adjacently into the QL muscle will spread in a medial and cranial direction under the crura and arcuate ligaments of the diaphragm, then into the thoracic paravertebral space [10]. An additional mechanism of action of local anesthetics can be explained by the anatomical–histological characteristics of the TLF. Namely, in the superficial layer of the TLF, there is a thick network of sympathetic neurons. In the fascia, there are the high-threshold and low-threshold mechanoreceptors and pain receptors sensitive to the effects of the local anesthetics. These receptors play a role in the development of both acute and chronic pain. The QL block analgesia could be, at least partially, explained by local anesthetic blockade of these receptors [11]. These data indicate that the QL block provides somatic and visceral analgesia [12].

Up to date, there is no available randomized trial comparing the analgesic efficacy of QL block and caudal block in children undergoing surgical correction of DDH. The analgesic efficacy of anterior QL block in patients undergoing hip surgery had been proved by Ahiskalioglu et al. [13] who evaluated the effects of anterior QL block in 2 pediatric cases, 2-years-old and 18-months-old girls, with DDH. Both cases received ultrasound-guided anterior QL block after general anesthesia using 0.5 mL/kg, 0.25% bupivacaine. They found that the postoperative 30-min and 1, 2, 4, 6, and 12-h FLACC scores were 0/10 and 2/10 at 24-h and none of the patients needed any rescue analgesic during postoperative 24 h follow up.

Moreover, Kukreja et al. [14] compared anterior QL block with control (no block) in adult patients undergoing primary total hip arthroplasty. Their study was carried out on 80 patients who undergoing primary total hip arthroplasty under spinal anesthesia and randomized into two groups; one with anterior QL block (using 30 ml of 0.25% bupivacaine with 1:400000 epinephrine) and one without block. They clarified that both VAS pain score at 24 hours and cumulative opioid consumption were significantly lower in the QL group as compared with the control group.

Furthermore, Yuan et al. [15] investigated postoperative analgesic effect of ultrasound-guided QL block in 40 adult patients undergoing hip arthroscopy under general anesthesia. Patients were randomly assigned to the QL block group using 0.4% ropivacaine at a dose of 0.4 mL/kg, and the control group. They showed that the postoperative resting and movement VAS scores and opioid consumption via PCA at each time point were significantly lower in the QL block group compared with the control group.

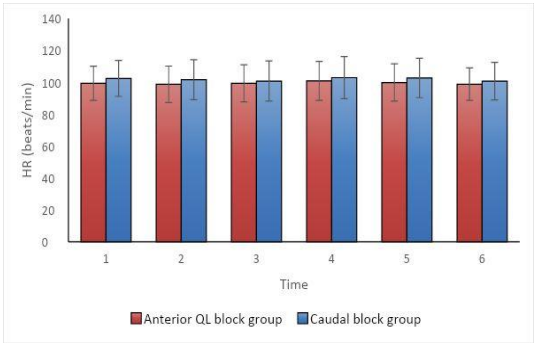
On the other hand, Kinjo et al. [16] investigated effects of the preoperative anterior QL block on postoperative pain levels and perioperative opioid consumption in 68 patients underwent outpatient arthroscopic hip surgery in

retrospective cohort study. All patients received general anesthesia for surgery. Two groups of patients were compared: (1) patients who received a preoperative anterior QL block, (2) patients who did not receive an anterior QL block. Their study did not find the preoperative TQL block to be an effective analgesic technique for patients who underwent arthroscopic hip surgery for femoroacetabular impingement. The inconsistency between their results and ours may be related to the different nature of the study (retrospective cohort), type of surgery and the different age group.

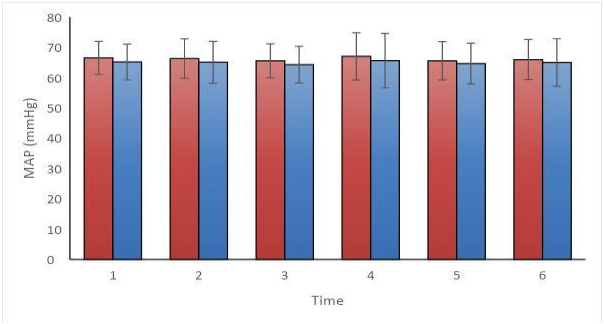
The analgesic efficacy of the QL block and caudal block had been compared by Öksüz et al. [17] in pediatric patients undergoing inguinal hernia repair and orchiopexy. Surgeries under general anesthesia. They found that postoperative pain (FLACC) scores were lower in the QL block group at the 4, 6, and 12 hours, while FLACC scores were not significantly different between both groups at the 30 min, 1,2, and 24 hours. The number of patients who required analgesics in the first 24 hours was significantly lower in QL block group. Moreover; Ipek et al. [18] studied the efficacy of ultrasound-guided TAP block, QL block, and caudal epidural block on perioperative analgesia in pediatric undergoing elective unilateral lower abdominal wall surgery under general anesthesia. They revealed that The Pediatric Objective Pain Scale (POAS) scores in the QL block group were significantly lower after 2 and 4 h than those in the other groups. However, total postoperative analgesics consumption was insignificantly different among the three groups.

The analgesic efficacy of caudal epidural block in pediatric patients undergoing hip surgery had been documented by Villalobos et al. [19], Dadure et al. [20] and Omar et al. [21].

Unfortunately, our study has some limitations. First our study is not double-blinded. Second, we did not check sensory dermatomal levels after local anesthetic injection to confirm the anterior QL block or caudal block. Third, duration of our study was not extended beyond the 1st 24h postoperative. Fourth, we did not assess quadriceps muscle strength, thus could not address the potential spread of local anesthetic to the lumbar plexus after the anterior QL block approach.



(a)



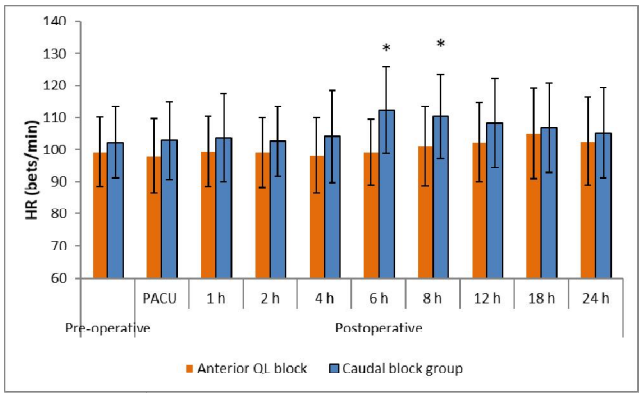
(b)

Fig. 5. Intraoperative heart rate (a) and mean arterial blood pressure (b) in both groups

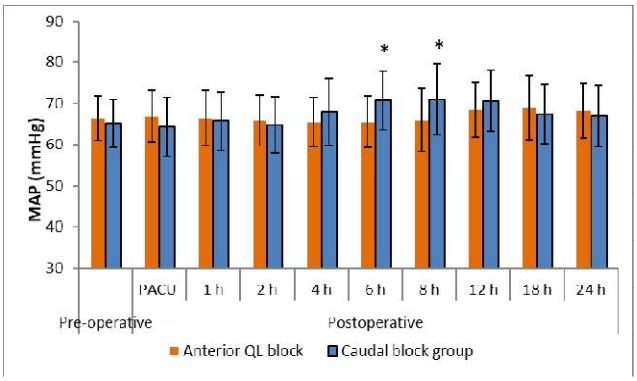
Table 2. Analgesic character, parent satisfaction score and adverse effects in both groups

		Anterior QL block group (n=30)	Caudal block group (n=30)	P-value
Patients required intraoperative fentanyl (µg)		2 (5.71%)	3 (8.57%)	> 0.999
Postoperative morphine consumption in the first 24 h (mg)		2.6 (1.6-3.8)	4.4 (3.2-5.4)	<0.001*
Time to first postoperative analgesic requirement(h)		11 (8-13)	6 (4-6)	<0.001*
Patients	0	0 (0%)	0 (0%)	
Satisfaction score	1	0 (0%)	0 (0%)	0.571
	2	2 (5.71%)	3 (8.57%)	
	3	6 (17.14%)	9 (25.71%)	
	4	27 (77.14%)	23 (65.71%)	
Side effects	Nausea	3 (8.57%)	4 (11.42%)	> 0.999
	Vomiting	2 (5.71%)	3 (8.57%)	> 0.999

Data presented as mean ± SD or patients number (%). Significant as p value <0.05*



(a)



(b)

Fig. 6. Postoperative heart rate (a) and mean arterial blood pressure (b) in both groups

4. CONCLUSION

Ultrasound-guided anterior QL block provides effective and long lasting postoperative analgesia than ultrasound-guided caudal block with lower postoperative pain scores at 4,6,8 and 12 h postoperative and lesser postoperative analgesic consumption in pediatric patients undergoing surgical correction of DDH. These beneficial effects of ultrasound-guided anterior QL block were not associated with hemodynamic or serious side effects.

CONSENT AND ETHICAL APPROVAL

This study was approved by Institutional Ethical Committee (33179/06/19), written informed consent was obtained from each patient's guardian.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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