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Postoperative analgesia and opioid use following hip arthroscopy with ultrasound-guided quadratus lumborum block: a randomized controlled double-blind trial

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Abstract

Objective: To investigate the postoperative analgesic effect of ultrasound-guided quadratus lumborum block (QLB) in patients undergoing arthroscopic hip surgery.

Methods: Patients who were scheduled to undergo elective arthroscopic hip surgery were randomly assigned to the QLB (Q) or control (C) group (n = 40 each). After general anesthesia induction, unilateral QLB was performed under ultrasound guidance in the Q group. The amount of opioid use via patient-controlled analgesia (PCA) and the resting and movement pain visual analog scale (VAS) scores when the patient left the postanesthesia care unit (PACU) and 4, 8, 12, and 24 hours after surgery were recorded. Postoperative complications were recorded for both groups.

Results: At 24 hours post-surgery, opioid consumption amounts via PCA (48.4 [48.1–48.6] mL) in the Q group were significantly lower compared with the C group (52.0 [51.0–53.8] mL). A significant reduction in opioid consumption was observed between the two groups at each time point. Resting and movement VAS scores at each time point were significantly lower in the Q compared with the C group.

Conclusions: Hip arthroscopy patients who received QLB and general anesthesia in combination had less pain and a lower opioid requirement within 24 hours postoperatively.

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Introduction

Hip arthroscopy is a comprehensive treatment process, and postoperative rehabilitation has a strong influence upon the treatment outcome; however, postoperative pain is a potential limiting factor for its effectiveness.[1] Patients often require a considerable dose of opioids during their stay in the postanesthesia care unit (PACU),[2,3] and the use of narcotic drugs increases side effects such as postoperative nausea and vomiting.[4] However, application of peripheral nerve block (PNB) significantly reduces opioid use.[5] This method was shown to be successful in other areas of arthroscopy, including shoulder arthroscopy, which resulted in a faster recovery rate and reduced opioid consumption.[6,7]

Quadratus lumborum block (QLB) was first proposed by Blanco[8] in 2007. QLB has three access points, including QL1, QL2, and QL3, and the block plane varies based on the access point, with a range of T7–L2. When QLB3 (also known as transmuscular or anterior QLB) is used, anesthetics can diffuse into the L1–L3 nerve root distribution area and to the psoas major muscle and quadratus lumborum, indicating that QLB3 has the widest the block plane. Several studies[9–11] have reported using a continuous QLB3 method to provide long-term postoperative analgesia for patients who underwent total hip arthroplasty without weakening muscle strength, which has potential broad applications in clinical practice. Because L1 and L2 can move between the thoracolumbar fascia and intra-abdominal fascia before leaving the intervertebral foramina to form the plexus lumbalis, injection at this point can partially block the lateral femoral cutaneous nerves and femoral and obturator nerves from L2. Therefore, as a type of torso block, QLB can also be used for multi-modal analgesia after hip joint surgery.[10,12] However, few randomized controlled trials have evaluated the effects of QLB in hip joint surgery.[13] Thus, this randomized, controlled, double-blind study was conducted to evaluate the analgesic effect of QLB after hip arthroscopy.

Methods

This randomized controlled trial was approved by the research ethics committee at Beijing Jishuitan Hospital in May 2018 (Reference Number 201805-19). The study was registered in the Clinical Trial Registry (Chinese clinical trial registry http://www.chictr.org.cn/edit.aspx?pid=34668&htm=4 identifier: ChiCTR1900020927).

Trial participants

Patients admitted to the Sports Medicine Department at Jishuitan Hospital for arthroscopic hip surgery because of a labrum injury from January 2019 to April 2019 who volunteered to participate in the trial and signed the informed consent form were enrolled. The inclusion criteria were as follows: planned unilateral hip arthroscopic surgery; American Society of Anesthesiologists Classification physical status (ASA PS) I to III; age 15 to 60 years; and body mass index (BMI) $\leq$35 kg/m^2. The exclusion criteria were as follows: puncture site infection; anatomical

variation; use of anticoagulants or coagulation abnormalities; incompatibility of body position; abnormal neurological function in the affected limb; BMI $>35\,kg/m^2$; and refusal to undergo surgery and use postoperative continuous intravenous patient-controlled analgesia (PCA).

Surgical procedure

The network software (Research Randomizer, Version 4.0, from GC Urbaniak and S. Plous, http://www.randomizer.org/) was used to randomly assign the patients into the quadratus lumborum (Q) and negative control (C) groups digitally using a random number table. The patients were randomized at a ratio of 1:1. The random number was placed in an opaque envelope, which was opened and dispensed by the anesthesia nurse before surgery. The anesthesia nurse did not participate in any other procedures during surgery. The number was then given to the anesthesiologist, who did not know the patient group. Postoperative follow-up was performed by a dedicated postoperative follow-up team that was blinded to the patient's group.

To ensure that there was no nerve damage to the limb and that nerve innervation felt normal before surgery, alcohol swabs were used to measure the temperature in the frontal area of the lower 1/3 of the thigh, the upper 2/3 of the inner thigh above the knee joint, and the lateral area of the thigh of both lower extremities, to ensure that there was consistent temperature recording. Additionally, the patient was instructed to bend their hip and knee and to stretch the knee so that the quadriceps femoris muscle strength could be measured to ensure that there was normal muscle strength in the affected limb. Standard total intravenous anesthetic procedures and measurements were performed for all patients, as follows: induction with propofol at a rate of 4.0 to 4.5 μg/mL (by target controlled infusion [TCI]), sufentanil (0.2 μg/kg), and cisatracurium bromide (0.2 mg/kg). The propofol TCI aimed to maintain the bispectral index (BIS) at 40 to 50. The pharmacokinetic model and target concentration used in TCI propofol were the Marsh model and the effect-site concentration, respectively. After general anesthesia, an anesthesiologist performed ultrasound-guided QLB using the QLB3 method, as described by Blanco.[8] The patient was placed in the knee-chest lateral position with the surgical side up. The M-Turbo ultrasound system (SonoSite Inc., Bothell, WA, USA) was used in the neuroimaging mode. The transducer was connected to the C60x/5-2MHz convex array probe (SonoSite Inc., Bothell, WA, USA) and placed vertically above the iliac crest. The tip of a 22G 120-mm nerve-stimulating needle Stimuplex® D Plus (B. Braun, Melsungen, Germany) was guided from the back of the probe in the anteromedial direction to pass through the quadratus lumborum using an in-plane method until the tip of the needle was between the quadratus lumborum and the psoas major. Then, the anesthetics were locally injected into the fascia (Figure 1). After injection, ultrasound showed that the psoas major was pressed down by the locally injected anesthetics (Figure 2). The needle tip was guided around the nerve plexus using the in-plane method. After proper administration of the first dose of the injected drugs, patients in the Q group were administered 0.4% ropivacaine (batch number: NANT, AstraZeneca, Sweden) at a dose of 0.4 mL/kg, and patients in the C group were administered 0.9% normal saline at a dose of 0.4 mL/kg. Surgery was performed and the infusion of propofol was stopped immediately after surgery.

Postoperative continuous intravenous PCA was used for pain relief in both groups. Immediately after surgery, an electronic analgesia pump (Auto Med 2000,

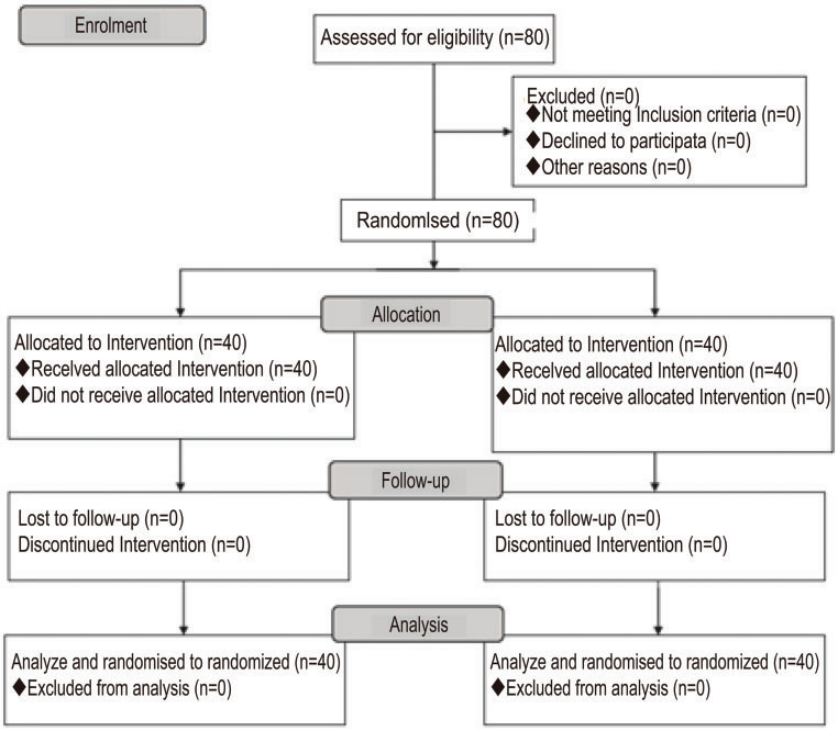

Figure 1. Image showing quadratus lumborum block under ultrasound guidance.

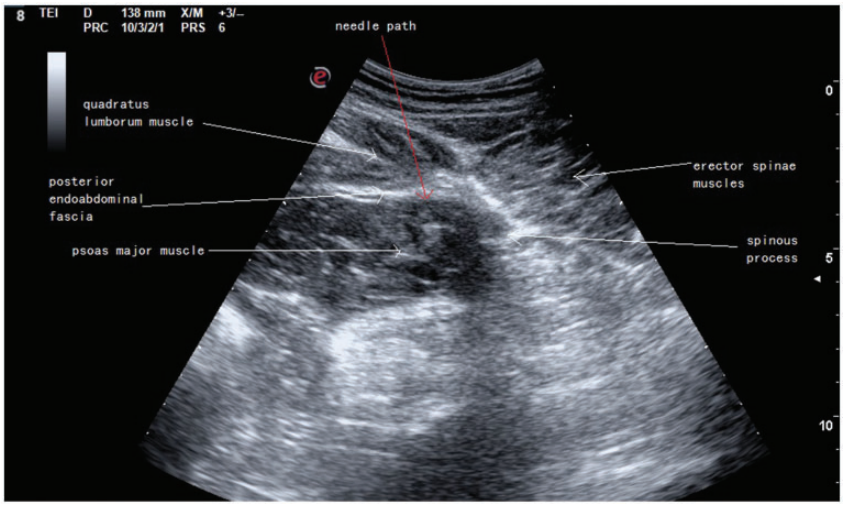

Figure 2. Image showing the local anesthesia spread during quadratus lumborum block application.

Ace Medical Co, Ltd., Seoul, Korea) was connected to administer 2 μg/kg of sufentanil, 10 mg of ondansetron in 100 mL saline at a background flow rate of 2 mL/hour, and PCA single dose (0.5 L) with a locked time of 15 minutes. The patient was then transferred to the PACU for recovery. Once the patient opened their eyes, they were checked for regular breathing, with a tidal volume of >6 mL/kg, frequency of <20/minute, and maintained pulse oximetry (SpO_2) above 95% under an oxygen mask. After cough and swallowing reflexes were restored, the laryngeal mask was removed. The patient returned to the ward with a modified Aldrete score of ≥9 points. A visual analog scale (VAS) for pain was marked based on the patient's pain, i.e., between 0 (no pain) and 10 (intense pain).

All patients took 1 g of paracetamol orally every 6 hours and 50 mg of diclofenac every 8 hours. The patients also received 4 mg of ondansetron intravenously for nausea and vomiting. Data collection lasted for 24 hours, and the patients and investigators involved in postoperative data collection were not aware of the specific anesthesia that the patients had received.

Study outcomes

The primary outcome measure was total sufentanil consumption via PCA at 24 hours after surgery. In addition, sufentanil consumption on leaving the PACU and at 4, 8, and 12 hours after surgery was collected, as well as resting and movement (buckling, internal rotation, or external rotation) VAS scores when the patient left the PACU and at 4, 8, 12, and 24 hours after surgery. Other secondary outcome measures included heart rate, respiratory rate, SpO_2, and non-invasive blood pressure, and complications such as postoperative nausea and vomiting, respiratory depression, pruritus, uroschesis, bilateral block, renal damage, and bleeding and hematoma at puncture sites.

Sample size calculation

The sample size calculation (PS: Power and Sample Size Calculation, version 3.1.2, Vanderbilt University, Nashville, TN, USA) indicated that 40 patients were required for each group based on a difference of 15% in sufentanil consumption between the two groups. The probability (power) was set to 0.8, and the Type I error associated with null hypothesis test was 0.05.

Statistical analysis

All data analyses were performed in accordance with a pre-defined statistical analysis plan. Data analysis was performed using SPSS version 21.0 software (IBM Corp., Armonk, NY, USA). Normally distributed measurement data were expressed as the mean ± standard deviation (SD), and inter-group comparison of two independent samples was performed using a *t*-test. For repeated measures data, the intragroup comparison of different time points was performed using a repeated measures analysis of variance (ANOVA). Intergroup comparison at the same time point was performed using a multivariate ANOVA. Measurement data with skewed distribution were expressed as the median (interquartile range, IQR), and intergroup comparisons were performed using the rank-sum test. Enumeration data were compared using the Chi-squared test, while level data were compared using the rank-sum test. $P < 0.05$ was considered to indicate a statistically significant difference.

Results

Eighty patients participated in this trial and were randomly assigned to one of the two groups, with 40 patients in each

group (Figure 3). All patients completed the trial. The patients' mean age was 36.5 ± 10.8 years in the C group and 36.7 ± 10.0 years in the Q group. Demographic characteristics, surgical time, and other baseline characteristics were similar between the two groups of patients (Table 1).

Opioid consumption amounts via PCA were lower (1.1 [1.0–1.2] mL, 8.4 [8.0–8.5] mL, 16.3 [16.0–16.5] mL, 24.3 [24.0–24.5] mL, and 48.4 [48.1–48.6] mL, respectively) in the Q group compared with the C group (2.1 [1.9–3.0] mL, 10.0 [10.0–11.3] mL, 19.0 [18.6–20.3] mL, 27.6 [27.9–29.3] mL, and 52.0 [51.0–53.8] mL, respectively) upon leaving PACU and at 4, 8, 12, and 24 hours after surgery after hip arthroscopy (all $P < 0.001$; Table 2).

Resting VAS scores in the Q group were 4.0 (3.0–6.0) upon leaving the PACU, and 3.0 (2.0–4.0) at 4 hours, 2.0 (1.0–3.0) at 8 hours, 1.0 (0–2.0) at 12 hours, and 1.0 (0–1.0) at 24 hours post-surgery, which were all lower compared with the C group (7.0 [3.5–8.0], 4.0 [3.0–5.0], 3.5 [3.0–5.0], 3.0 [1.0–5.0], and 3.0 [1.0–5.0], respectively) at each time point after hip arthroscopy (all $P < 0.001$; Table 3).

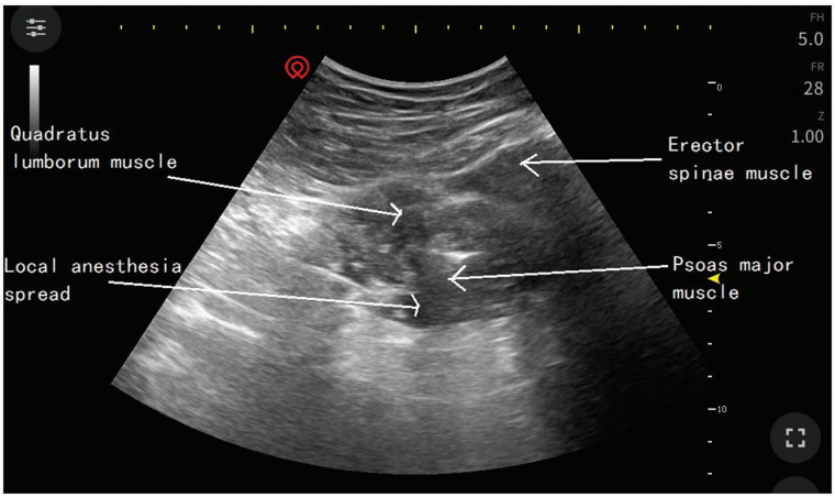

Figure 3. Study flow chart.

Table 1. Patient demographic information.

	C group	Q group	Statistics
Age (years)	36.5 ± 10.8	36.7 ± 10.0	t = −0.108 P = 0.611
Gender male/female	20/20	19/21	χ^2=0.050 P = 0.823
Body mass index	23.4 ± 2.5	22.5 ± 2.9	t = −0.933 P = 0.417
Surgery time (minutes)	82.5 ± 9.3	80.8 ± 8.1	t = 0.898 P = 0.362

n = 40 in each group.

Table 2. Opioid consumption (mL) in PCA at different time points after surgery in the two groups.

	C group	Q group	P-value
Leave PACU	2.1 (1.9–3.0)	1.1 (1.0–1.2)	<0.001
4 hours after surgery	10.0 (10.0–11.3)	8.4 (8.0–8.5)	<0.001
8 hours after surgery	19.0 (18.6–20.3)	16.3 (16.0–16.5)	<0.001
12 hours after surgery	27.6 (27.9–29.3)	24.3 (24.0–24.5)	<0.001
24 hours after surgery*	52.0 (51.0–53.8)	48.4 (48.1–48.6)	<0.001

Data are presented as the median and IQR.
*primary outcome measure
n = 40 in each group.
PCA, patient-controlled analgesia; PACU, postanesthesia care unit; IQR, interquartile range.

Table 3. Resting VAS scores at different time points after surgery in the two groups.

	C group	Q group	P-value
Leave PACU	7.0 (3.5–8.0)	4.0 (3.0–6.0)	<0.001
4 hours after surgery	4.0 (3.0–5.0)	3.0 (2.0–4.0)	<0.001
8 hours after surgery	3.5 (3.0–5.0)	2.0 (1.0–3.0)	<0.001
12 hours after surgery	3.0 (1.0–5.0)	1.0 (0–2.0)	<0.001
24 hours after surgery	3.0 (1.0–5.0)	1.0 (0–1.0)	<0.001

Data are presented as the median and IQR.
n = 40 in each group.
PACU, postanesthesia care unit; VAS, visual analog scale.

Table 4. Movement VAS scores at different time points after surgery in the two groups.

	C group	Q group	P-value
4 hours after surgery			
Flexion	5.0 (4.0–7.0)	3.0 (3.0–4.0)	<0.001
Internal rotation	5.0 (4.0–6.0)	2.5 (2.0–4.0)	<0.001
External rotation	5.0 (4.0–7.0)	3.0 (1.3–4.0)	<0.001
24 hours after surgery			
Flexion	4.0 (2.3–5.0)	2.0 (1.0–2.0)	<0.001
Internal rotation	3.0 (2.0–5.0)	1.0 (0–1.0)	<0.001
External rotation	3.0 (2.0–5.0)	1.0 (0–1.0)	<0.001

Data are presented as the median and IQR.
n = 40 in each group.
VAS, visual analog scale.

Movement (flexion, internal rotation, and external rotation) VAS scores (0 to 10 points) were lower in the Q group at 4 hours (3.0 [3.0–4.0], 2.5 [2.0–4.0], and 3.0 [1.3–4.0], respectively) and 24 hours (2.0 [1.0–2.0], 1.0 [0–1.0], and 1.0 [0–1.0], respectively) compared with the C group at 4 hours (5.0 [4.0–7.0], 5.0 [4.0–6.0], and 5.0 [4.0–7.0], respectively) and 24 hours (4.0 [2.3–5.0], 3.0 [2.0–5.0], and 3.0 [2.0–5.0], respectively) after hip arthroscopy (all $P < 0.001$; Table 4).

For postoperative complications, five patients (12.5%) had nausea and vomiting

and two patients (0.2%) had pruritus in the C group. There were no complications observed in the Q group.

Discussion

In this study, the effects of QLB on using sufentanil for pain relief after hip arthroscopic surgery were investigated. We found that sufentanil consumption in patients who were treated with QLB was significantly lower compared with the control group at each postoperative time point, and the VAS scores were also significantly improved compared with control values.

The results of this study are consistent with previous studies on the use of QLB to reduce the pain experienced by patients after hip surgery, including one previous randomized trial that was published in Chinese.[10,12,13] QLB was initially performed using posterior transverse abdominis plane (TAP) block. However, Blanco[8] first showed a potential gap between the posterior wall muscle and the quadratus lumborum. Injection of local anesthetics into the middle layer of the thoracolumbar fascia can block the subcostal, iliohypogastric, and ilioinguinal nerves. Spence et al.[15] determined that the block plane is T7–L1 using this access. Local anesthetics were injected between the quadratus lumborum and the psoas major, deep into the anterior layer of the thoracolumbar fascia using this method; therefore, the access was named muscular QLB, QLB3, or anterior QLB. Case reports by Ueshima et al.[10] and La Colla et al.[16] suggested that QLB combined with nonsteroidal anti-inflammatory drugs can be used for postoperative analgesia in patients who undergo hip arthroplasty. A study of dye diffusion in corpses conducted by Carline et al.[17] demonstrated that QLB with QLB1 and QLB2 access points sometimes resulted in dye that was diffused only into the back muscles and subcutaneous fat tissues, while for QLB3 access, the dyes were able to fully diffuse to the T12–L3 nerve roots.[17] Innervation in this segment covers the surgical area of hip arthroplasty patients, and thus, we selected QLB3 access.

Hip arthroscopy is a minimally invasive procedure that is used for the diagnosis and treatment of various intra-articular and extra-articular hip joint lesions.[18] Burman[19] first described hip arthroscopy in a cadaveric study in 1931, and since then, its popularity has increased.[18] Cvetanovich et al.[20] reported that between 2006 and 2013, the incidence of this procedure has increased 25-fold. Although hip arthroscopy is becoming increasingly popular and it is considered to be a minimally invasive alternative to open hip surgery, it still results in severe postoperative pain, and there is often a patient-reported pain score on the Ng digital rating scale (RNS) between 8/10 and 10/10.[21] This surgery is usually performed in an outpatient setting, where analgesic management is more complicated, while more serious postoperative pain can increase the risk of accidental admission. PNB effectively relieves these high pain levels and reduces the overall use of opioids. Our results suggest that preoperative ultrasound-guided QLB reduced opioid consumption 24 hours after surgery, and it was also associated with lower pain scores. Pain scores and opioid consumption are metrics for analgesic effects and they are also inversely related to overall patient satisfaction. By reducing the pain level and opioid use, PNBs have the potential to improve overall patient satisfaction after hip arthroscopy.[22] In addition, when considering the time and personnel required for regional anesthesia, PNB also reduces the overall cost of hip arthroscopic surgery. The cost-effectiveness of using PNB in hip arthroscopic surgery was investigated, and the results showed that this analgesic intervention decreases surgical costs by reducing intraoperative drug administration and complications associated with anesthesia.[23]

Haskins et al.[24] used ultrasound to identify intra-abdominal fluid exudation (IAFE) after hip arthroscopy, and they found that the incidence of IAFE after hip surgery was up to 16%, which is associated with postoperative pain and an increased demand for opioids. This suggested that for hip pain problems after hip arthroscopic surgery, loss of hip capsule integrity and/or peritoneal irritation resulting from exudation of irrigation fluid in the abdominal cavity may increase postoperative pain. However, this IAFE score of 16% might be only a small part of the problem. Branney et al.[25] found that only about 10% of ultrasound examinations showed an intra-abdominal fluid volume of less than 400 mL, with an average volume of 619 mL. Therefore, it is likely that a significant proportion of patients with hip arthroscopy have some degree of IAFE. The association of IAFE with postoperative pain suggests that this may be an important and common component of pain after arthroscopic hip surgery that has not yet been recognized. To date, studies on corpses[17,26–29] have shown that the injected contrast agents could spread towards the head into the thoracic paravertebral and intercostal spaces, covering somatic nerves and thoracic sympathetic trunks to the T4 level, although inconsistent findings have been reported.[18] The block to subcostal, iliohypogastric, and ilioinguinal nerves was consistent. The genitofemoral and lateral femoral cutaneous nerves may sometimes be blocked. Although contrast agents could reach lumbar nerve roots, the results varied. However, new research is warranted to clarify the association of the QLB type with the analgesic effect achieved. All these data indicate that QLB has a somatic and visceral analgesic effect, which subsequently can reduce the visceral neuralgia that is caused, to some extent, by intra-abdominal exudate.

Complications associated with abdominal wall block are rare and have not been described in previous QLB procedures.[30] Because QLB is a typical intramuscular injection, the likelihood of infection is much lower compared with nerve block. To date, there have been no infections observed during the implementation of QLB. Compared with other abdominal wall blocks, the needle channel and the site for local anesthesia application in QLB are located far from the abdominal cavity, visceral organs, and large blood vessels. Therefore, the needle is less likely to unintentionally puncture the peritoneum, intestine, liver, kidney, and large blood vessels. Blocking under ultrasound guidance also improves the safety and efficiency of this technology. Local anesthetics are not directly injected near large nerves, but, rather, into the surrounding areas that have a high density of small nerve endings. There have been no reports of nerve damage.

The duration of ropivacaine nerve block is generally less than 24 hours;[31] however, in our study sufentanil consumption in the QLB group 24 hours after surgery was somewhat lower compared with the control group. This was attributable to injection of local anesthetics near the thoracolumbar fascia in QLB where there are few blood vessels and slow drug absorption, thereby prolonging the drug's action time. Previous data showed that the peak blood concentration of local anesthetics in patients with QLB occurs later and is lower compared with TAP block.[32] A study by Blanco et al.[33] also demonstrated that QLB provides longer analgesic time of up to 48 hours compared with TAP block. However, the follow-up time in this study was limited to 24 hours because some patients were discharged from hospital the day after surgery. A longer follow-up would provide more information on the pain that was experienced in the two groups. Thus,

further clinical research is warranted to resolve concerns such as whether its effects could be extended to 48 hours or longer after surgery, and whether it can replace the catheterization technology that is currently more frequently used in clinical applications. Moreover, the action mechanism of QLB remains unclear. It is mainly believed that drugs may spread through the thoracolumbar fascia to the paravertebral space or directly to the plane of transverse abdominis.[32] The exact mechanism of action requires further exploration.

There are many types of hip joint operations, including hip replacement, hip arthroscopy, reduction and internal fixation for femoral neck fracture, and reduction and internal fixation for intertrochanteric fractures. The innervation in hip arthroscopy is relatively simple compared with other types of hip surgery, and postoperative pain after hip arthroscopy is moderate. This trial only investigated the clinical effect of QLB in hip arthroscopy. Whether QLB can provide a good postoperative analgesic effect for other types of hip surgery requires further study. Although this was a randomized prospective trial, all patients were enrolled from the same hospital. The analysis of outcomes secondary to the primary endpoint involved multiple comparisons. However, considering that this was an exploratory study with a small sample size, we did not correct for multiple comparisons of the secondary endpoints. Thus, the use of a P-value of 0.01 to detect significance using the Bonferroni adjustment for multiple comparisons was incorrect. Multi-center, randomized, prospective trials should be conducted to further clarify our results.

In conclusion, this study showed that ultrasound-guided QLB is a good postoperative analgesic method in patients after arthroscopic hip surgery that reduces postoperative opioid use. It is easy to operate and associated with fewer complications compared with other studies, and thus, it can be used effectively in clinical practice. However, its specific mechanism remains to be clarified, and further research is required.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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