

Randomized Controlled Trial



Ultrasound-Guided Oblique Sagittal Anterior Quadratus Lumborum Block in Total Hip Arthroplasty: A Randomized Controlled Trial

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Background: The anterior quadratus lumborum block (QLB) is gaining popularity in total hip arthroplasty (THA) surgeries for postoperative pain management and this technique rarely results in lower limb muscle weakness. However, no studies have described the range of its blockade.

Objectives: The aim of the study was to confirm the range of cold temperature sensory blockades, observe the opioid consumption after THA surgery, assess the pain of the patients, and assess the safety of this technique.

Study Design: Randomized controlled study.

Setting: Taizhou Hospital of Zhejiang Province.

Methods: Patients who underwent primary THAs were randomized to take an oblique sagittal anterior QLB with 30 mL of 0.375% ropivacaine (QLB+G group) or with 30 mL of 0.9% saline (G group). The main purpose of the study was to confirm the range of cold hypoesthesia. The other aim included the average blood pressure, heart rate, surgical pleth index, and bispectral index values fluctuation during the intraoperative period of expanding the medullary cavity, the sufentanil, and remifentanil consumption during the operation, the amount of time the patients stayed in the Postanesthesia Care Unit, the 8 hours, 16 hours, and 24 hours total dosage of oxycodone, the resting and exercise Visual Analog Scale (VAS) pain scores at 8 hours, 16 hours, and 24 hours after surgery, postoperative adverse events, and safety.

Results: The QLB+G group identified areas of cold hypoesthesia after the block, but there were no areas of cold hypoesthesia in the G group. The consumption of oxycodone in the 8 hours, 16 hours, and 24 hours after the surgery and the consumption of sufentanil during the surgery were significantly smaller in the QLB+G group ($P < 0.05$). The QLB+G group have lower pain scores at the resting 8 hours and exercise 8 hours, 16 hours, and 24 hours after the surgery ($P < 0.05$). The 2 groups have comparable safety in the study.

Limitations: This study only tested the areas of cold hypoesthesia after the QLB, but not tested the area of sensory loss. Using ice to test for hypoesthesia is subjective, and may not reflect the actual area of the block.

Conclusions: Ultrasound-guided oblique sagittal anterior QLB can reduce the analgesics required after and during THA and the postoperative VAS pain scores, but it rarely affects muscle strength.

Key words: Quadratus lumborum block, total hip arthroplasty, cold temperature sensory blockade, analgesia, opioid dose, randomized controlled study, VAS pain score, postoperative

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The number of hip replacement surgeries is increasing rapidly because society's average life expectancy continues to rise. These patients are always elderly and frail with multiple comorbidities. Keeping the circulation stable during the operation, having a good postoperative analgesia protocol, and reducing adverse reactions are important. In this population, analgesic treatment can have a positive influence on the trajectory of the postoperative recovery. In recent years, multimodal analgesia is becoming the main postoperative analgesia, and regional blocking is a key technique of multimodal analgesia. However, the innervation of the hip area innervation is complex with contributions from many known nerve components, so it is difficult to achieve good results by blocking a single nerve. The traditional lumbar plexus block, although effective for analgesia, may have serious complications (1-4) and can also block the motor ability of the lower limbs, which can affect early movement. The iliac fascia block (5) is also effective, but can carry a high risk of undesirable lower limb muscle weakness. The quadratus lumborum block (QLB) was originally described by Blanco (6) in 2007, and was developed from a transverse abdominis plane block (TAP) to achieve a broader nerve block. The ultrasound-guided anterior QLB is the injection of local anesthetics between the fascia of the psoas major muscle and the quadratus lumborum muscle. Cadaver studies (7,8) have shown that the diffusion of local anesthesia through the fascia can infiltrate adjacent nerves, including the iliohypogastric, subcostal, ilioinguinal, lateral femoral cutaneous, and genitofemoral nerves, and sometimes even the lumbar sympathetic trunk. It may also spread to the paraspinal space to achieve a wider block. It has been proven to have a good analgesic effect in many abdominal gynecological and lower limb surgeries (9-12). There have been case reports (13-16) that have preliminarily demonstrated the analgesic effect of the ultrasound-guided QLB in hip surgery without the associated muscle weakness. A retrospective cohort study (17) comparing the QLB with the lumbar plexus block for total hip arthroplasty (THA) showed comparable analgesic efficacies, and similar opioid demands, pain scores, and lengths of hospital stay after surgery. The diffusion of analgesic drugs after the use of the quadratus lumborum block has been reported in cadaver and imaging studies (7,8,18,20), but no studies have described the range of its blockade. Therefore, we aimed to confirm the surface area that had cold hypoesthesia after an anterior QLB, the perioperative

analgesic effects, and the postoperative adverse reactions during THA.

METHODS

Study Design and Patients

In this study, the patients who need a total hip replacement were recruited in our hospital from June 2020 to March 2021. All patients filled out the informed consent. This study was registered in the Chinese Clinical Trial Registry (www.chictr.org.cn, #ChiCTR2000038748) on September 30, 2020 and approved by the ethics committee of the Taizhou Hospital of Zhejiang Province (approval number K20191006).

The inclusion criteria were (1) American Society of Anesthesiology (ASA) I to III; (2) age 46 to 77 years; and (3) scheduled for primary THA. The exclusion criteria were (1) a history of surgery at the relevant site; (2) body mass index (BMI) ≥ 25 kg/m²; (3) allergies to the local anesthetic drug; (4) abnormal coagulation function; (5) communication difficulties with the medical staff; (6) infection near the puncture site; and (7) use of painkillers.

Randomization and Blinding

Forty strips of paper were prepared, 20 were labeled G group and another 20 were labeled G+QLB group, randomly placed into 40 envelopes and arranged in a stack by another anesthesiologist in disorder, numbered 1-40 from top to bottom. If a suitable patient was present, the patient selected an envelope in the order from smallest to largest, and the anesthesia plan was given in the envelope. An anesthesiologist who knew nothing about this study handled the drug preparations and blinding procedures. The Postanesthesia Care Unit (PACU) personnel and anesthesiologists also knew nothing about the group assignments.

Intervention

The oblique sagittal anterior QLB was performed in the preoperative preparation room. After routinely monitoring and placing an intravenous catheter, the patients were placed in the lateral position. A low-frequency probe (1-5 MHz) was placed perpendicular to the spine between the iliac ridge and the ribs, and approximately 2 to 4 cm away from the spine (Figs. 1,2). The direction was adjusted appropriately to clear the quadratus lumbar muscle, the psoas major, and the transverse process, and an intraplane injection was

given between the quadratus lumbar muscle and the psoas major muscle as close to the transverse process as possible (Figs. 3, 4). 0.375% ropivacaine (30 mL) was injected in the QLB+G group, and 0.9% saline (30 mL) was injected in the G group. After blocking for 60 minutes, each patient was measured the range of cold hypoesthesia with an ice cube and marked with a surgical marking pen. Numbness and temperature sensation decreased in the joint area determined the block was successful. If failed, we would exclude this patient, the remaining patients were rerandomized following the above scheme. And then, body surface landmarks, such as the midabdominal line, midaxillary line, ischium tuberosity, the lower margin of the 12 costal ribs, and the perineal region, were noted (Figs. 5, 7). The marked area was transferred to a sticky transparent film (Figs. 6, 8).

Anesthetic Procedure

All the patients fasted for more than 8 hours as prescribed. They were routinely monitored after entering the operating room, and were going to use a uniform anesthetic plan. The induction drugs were propofol 1.5 mg/kg to 2 mg/kg, sufentanil 0.2 µg/kg to 0.4 µg/kg, and rocuronium 0.8 mg/kg. After induction, a tracheal catheter was inserted. Rocuronium was injected as needed according to the surgical conditions. Propofol (3 mg/kg/h to 10 mg/kg/h) and remifentanyl (0.3 µg/kg/min to 0.5 µg/kg/min) were used for anesthesia maintenance and were adjusted according to the bispectral index values (BIS), and



Fig. 1. Schematic diagram of puncture point.

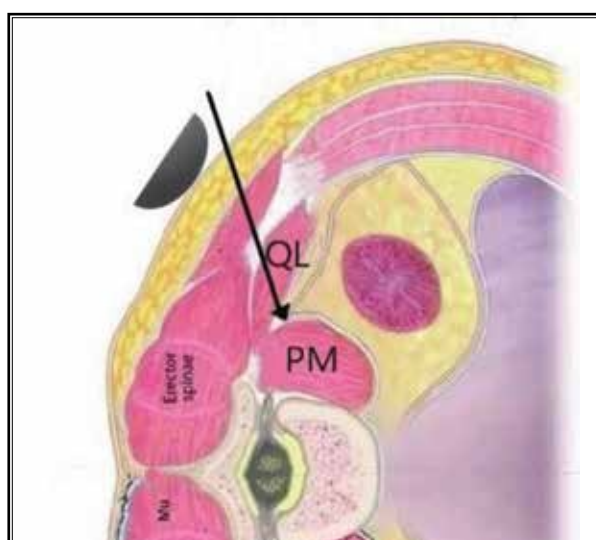


Fig. 2. Cross section of puncture route.

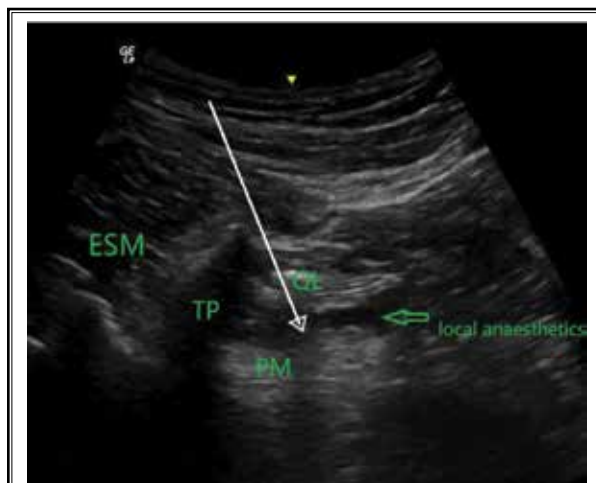


Fig. 4. After the QLB block.

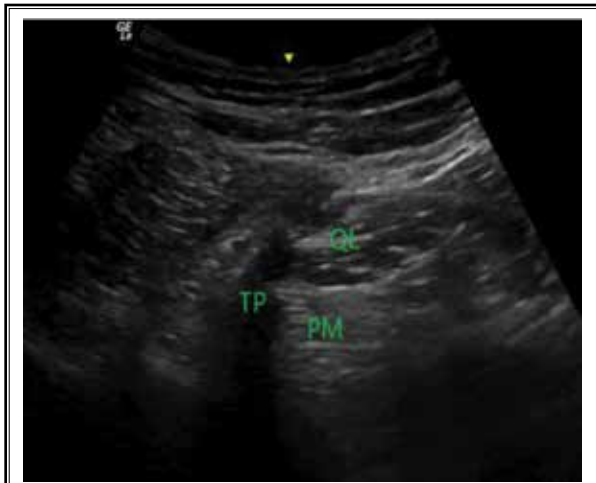


Fig. 3. Before the QLB block.



Fig. 5. Anterior hypoesthesia area after QLQ.

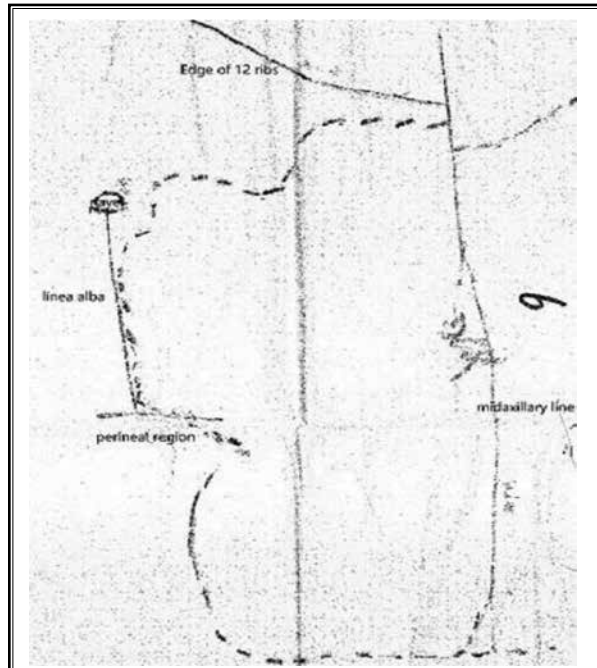


Fig. 6. Rubbing figure of anterior hypoesthesia area.



Fig. 7. Back hypoesthesia area after QLQ.

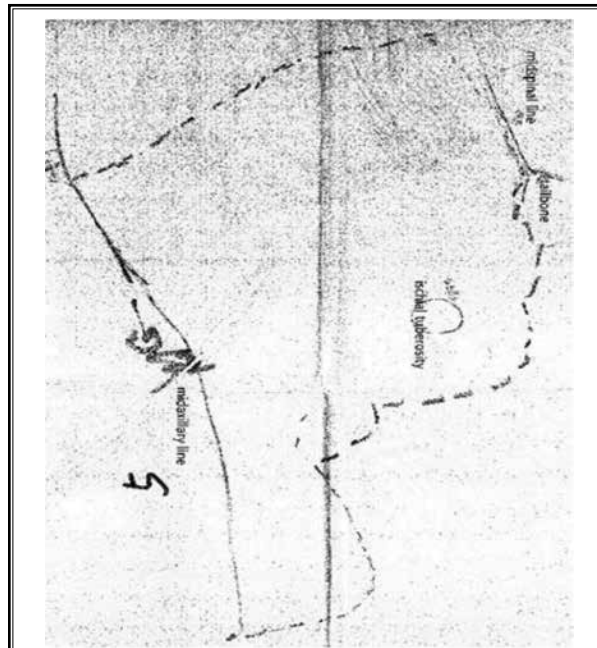


Fig. 8. Rubbing figure of back hypoesthesia area.

kept the BIS between 40 and 60. All patients were given intraarticular injections of 150 mg ropivacaine hydrochloride and tropisetron hydrochloride 2 mg intravenously. All

patients were provided patient-controlled interscalene analgesia with oxycodone after the surgical procedure and would get a blood gas analysis at the PACU.

Endpoint

The main purpose of the study was to confirm the range of cold hypoesthesia. The other aim included the average blood pressure, heart rate (HR), surgical pleth index (SPI), and BIS fluctuation in the intraoperative period during the expansion of the medullary cavity, the sufentanil, and remifentanyl consumption during operation, the time that the patient stayed in the PACU, the 8 hours, 16 hours, and 24 hours total dosage of oxycodone, the Visual Analog Scale (VAS) pain scores at 8 hours, 16 hours, and 24 hours after the surgery, the postoperative adverse events and safety, the postoperative anal exhaust time, postoperative time out of bed, and the postoperative hospital stay. We scanned] the images, which were transferred on the sticky transparent films into digital images. Used the height and weight parameters to create a standard model in MATLAB (MathWorks, Natick, MA) programming. Based on the standard model, multiple images were synthesized into renderings, and the left and right sides were separated. The adverse events, including vomiting, dizziness, and limb muscle strength, were monitored.

Statistical Analyses

Using the StatBox Online {Appsmith.com} statistical computing system to calculate the sample size. Preliminary observations showed that in the QLB+G group the mean oxycodone consumption was 9.0 ± 3.6 mg and in the G group it was 13.6 ± 2.0 mg at 24 hours after THA. With $\alpha = 0.05$ and $1 - \beta = 0.80$, and consider some dropout rate, we confirmed 20 patients each group. SPSS 25.0 (IBM Corporation, Armonk, NY) was used for the statistical analyses. Categorical data were analyzed using the χ^2 test. Continuous were shown as mean \pm standard deviation, and using the Mann-Whitney U test or the independent sample t test. P values < 0.05 were considered statistically significant.

RESULTS

Characteristics of the Patients

A total of 40 patients in the 2 groups participated in this study, including 20 patients in the control group (G) and 20 patients in the experimental group (QLB+G). No patients dropped out of the study (Fig. 9). The characteristics of the patients and the operation informa-

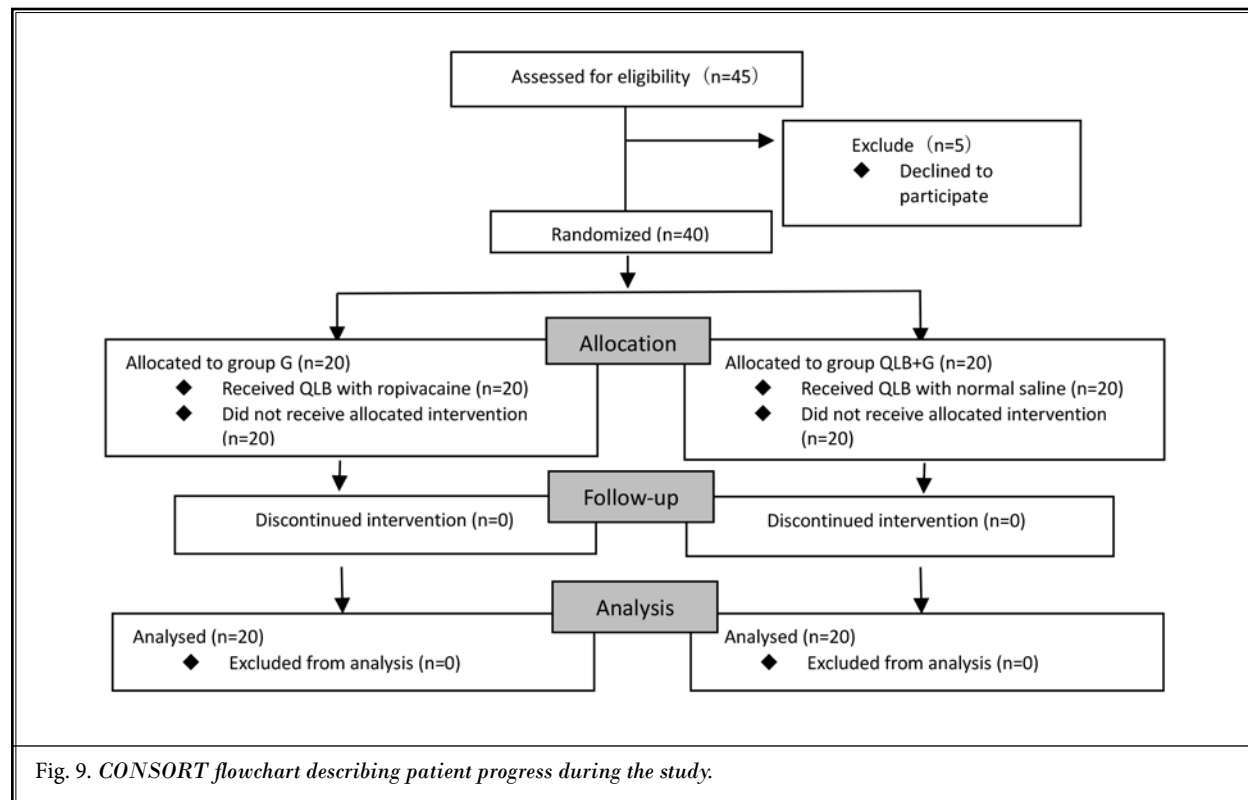


Fig. 9. CONSORT flowchart describing patient progress during the study.

tion were shown in Table 1. And it shown no significant differences between the G group and the QLB+G group in gender, ASA class, age, BMI, or duration of surgery ($P > 0.05$) (Table 1).

Table 1. Demographic and operative characteristics of the patients ($n = 20$).

Group	Gender (M/W)	ASA (II/III)	Age (y)	BMI	Duration of Surgery (min)
G	10/10	14/6	65 ± 8.4	22 ± 2.2	99 ± 11.7
QLB+G	12/8	16/4	66 ± 8.1	21 ± 3.0	95 ± 8.4
<i>P</i> value	0.525**	0.465**	0.852*	0.534*	0.276*

Values are presented as number or mean ± SD. Abbreviations: M, men; W, women; ASA, American Society of Anesthesiologists; BMI, body mass index; SD, standard deviation. * Independent sample t test. ** χ^2 test.

The Range of Cold Temperature Sensory Blockade

The cold hypoesthesia range in the QLB+G group can achieve a range from the level of T10 to the level of L3 (Figs. 10, 11), but no cold hypoesthesia range was found in the G group.

Secondary Endpoints

During the surgery, the consumption of sufentanil was significantly lower in the QLB+G group ($16 \pm 2.8 \mu\text{g}$ vs $27 \pm 5.2 \mu\text{g}$, $P < 0.05$). The changes in the mean arterial pressure (MAP), HR, BIS, and SPI during reaming were smaller in the QLB+G group than in the G group, and the difference was statistically significant ($P < 0.05$) (Table 2). Compared with the G group, the consumption of oxycodone at 8 hours, 16 hours, and 24 hours after surgery was lower in the QLB+G group ($P <$



Table 2. Intraoperative indexes during medullary reaming and dosage of general anesthesia drugs ($x \pm s$, $n=20$).

Group	Changes in MAP (mmHg)	Changes in HR	Changes in BIS	Changes in SPI	Sufentanil (ug)	Remifentanil (mg)
G	22 ± 8.9	10 ± 4.2	9 ± 4.8	14 ± 6.3	27 ± 5.2	0.4 ± 0.1
QLB+G	9 ± 4.0*	4 ± 2.4*	4 ± 2.7*	6 ± 3.5*	16 ± 2.8*	0.7 ± 0.1
P value	0.008	0.017	0.046	0.008	0.002	0.944

Abbreviations: MAP, mean arterial pressure; HR, heart rate; BIS, bispectral index values; SPI, surgical pleth index. Compared with group G, * $P < 0.05$.

0.05) (Table 3). The pain scores at resting 8 hours, and exercise 8 hours, 16 hours, and 24 hours after surgery were also lower in the QLB+G group ($P < 0.05$) (Table 4). Compared with the QLB+G group, the G group had a longer retention time in the PACU, which was statistically significant ($P < 0.05$). There was no significant difference in the time to get out of bed, the anal exhaust time, or the postoperative length of stay (Table 5). The 2 groups had comparable safety in the study.

Safety

Drowsiness was observed in 4 patients (20%) in the G group after the surgery, but was not observed in the QLB+G group ($P < 0.05$). There were no significant differences in dizziness, postoperative nausea, or lower limb muscle weakness (Table 6).

DISCUSSION

In this study, we found a clear range of hypoaesthesia following the administration of the local anesthetic ropivacaine in the oblique agnostic anterior lumbostratus block. Compared with the control group, the experimental group exhibited decreased fluctuations in MAP, HR, BIS, and SPI during the key steps of the operation, decreased motor VAS scores after hip replacement, decreased consumption of oxycodone 24 hours after the operation, and reduced the postoperative drowsiness and adverse reactions. In addition, the technique almost did not affect patients' activity of getting out of bed within 24 hours. In this study, some patients could even get out of bed after extubation in the PACU, which accelerated patients' postoperative recovery. However, we also observed one patient with lower limb muscle weakness in the experimental group, indicating that there may also be drug diffusion to the paraspinal space in the anterior quadratus luma block, which may affect the muscle strength of the lower limb, which is worthy of attention and further study.

The QLB is a new method of blocking the trunk. The main advantage of its application in hip arthroplasty is that it has little effect on lower limb muscle strength,

Table 3. Oxycodone consumption (mg) at various time after surgery.

Group	8h (mg)	16h (mg)	24h (mg)
G	5.2 ± 2.3	9.8 ± 3.7	14.5 ± 5.9
QLB+G	3.0 ± 0.8*	5.0 ± 1.4*	7.2 ± 2.1*
P value	0.000	0.006	0.008

P values less than 0.05 are considered statistically significant. Continuous data were summarized as mean ± SD.

Compared with group G, * $P < 0.05$.

Abbreviation: SD, standard deviation.

and early activity, early rehabilitation, and physical therapy are important links to enhance the postoperative functional recovery. Studies (18) have shown that the oblique sagittal quadratus lumbar block is more likely to block the lateral femoral cutaneous nerve. Moreover, this method can spread the drug posteriorly as far as possible, which may block more nerves in the hip joint area. Therefore, the oblique sagittal quadratus lumbar block (19) was selected in this study. Although increasing research is being done on the QLB, the exact mechanism of its action is not very clear, and research reports have mostly described 2 approaches: one is to directly infiltrate the nerves running between the quadratus lumbar muscle and the psoas major muscle to include the iliohypogastric nerve, ilioinguinal nerve, lateral femoral cutaneous nerve, subcostal nerve, and genitofemoral nerve; and the other is to diffuse into the paraspinal space to play a role. An imaging study (20) has previously reported that there is a 25% chance of the anterior lateral lumbar block diffusing into the paravertebral space, a 10% chance of diffusing into the lumbar nerve root, and a 15% chance of diffusing into the sympathetic nerve chain. The mechanism of the QLB needs to be further studied. There are 3 commonly used approaches for blocking the quadrant lumbar muscle, which can be divided into QLB1, QLB2, and QLB3 according to the different injection points (21-23). The liquid diffusion of each approach also has different characteristics (20), which are suitable for different surgeries. QLB1 and QLB2 mainly diffuse to the TAP plane, which is more

Table 4. VAS score at each time point after operation ($\bar{x} \pm s$, $n = 20$).

Group	8h		16h		24h	
	Resting	Exercise	Resting	Exercise	Resting	Exercise
G Group	0.6 ± 0.6	2.3 ± 0.9	1.0 ± 0.7	2.7 ± 1.1	0.5 ± 0.5	2.8 ± 1.1
QLB+G Group	0.2 ± 0.4	0.8 ± 0.6	0.3 ± 0.6	1.1 ± 0.6	0.4 ± 0.5	0.9 ± 0.6
P value	0.000*	0.049*	0.850	0.022*	0.178	0.020*

Compared with group G, * $P < 0.05$.

Table 5. Postoperative general conditions.

Group	The Stay in PACU (min)	Get Out of Bed (h)	Exhaust Time (h)	Postoperative Length of Stay (d)
G	82 ± 14.6	7 ± 8.3	5 ± 2.7	7 ± 1.4
QLB+G	50 ± 8.3*	14 ± 8.6	6 ± 2.9	7 ± 1.6
P value	0.022	0.734	0.629	0.805

Abbreviation: PACU, post anesthesia care unit.

Compared with the G group, the QLB+G group has the shorter stay in PACU, * $P < 0.05$.

suitable for abdominal operations. The anterior quadratus lumbos block (QLB3) has the potential to spread into the paraspinal space and infiltrate the nerves between the quadratus psoas and the psoas major, making it more suitable for hip and lower limb surgery. In this study, it was emphasized that local anesthetics should be injected as close to the transverse process as possible in the anterior lumbar square muscle block technique. It was also found in clinical practice that the effect would be better when local anesthetics were injected near the transverse process, which may be related to a little diffusion of the anesthetic into the paraspinal space.

Hockett et al (13) reported for the first time the use of the quadratus lumbar muscle block for analgesia in hip patients, and many other studies (24,25) have confirmed its effectiveness and safety. Compared with the G group, the fluctuation of blood pressure, HR, BIS, and SPI values in patients with quadratus lumbar muscle block was less, indicating that quadratus lumbar muscle block can effectively reduce surgical stimulation and play a role in advanced analgesia.

The quadratus lumborum muscle group can also reduce the postoperative exercise pain score, which can theoretically help patients get out of bed early and achieve rapid recovery.

However, in this study, there was no statistical significance in the time of getting out of bed between the 2 groups, which may be related to the time arrangements of the rehabilitation therapist in our hospital. Getting out of bed is based on the therapist's schedule

and not just on whether the patient is ready to get out of bed. To fully record the diffusion range of the QLB, we conducted a temperature sensing test 60 minutes after the block, which allowed the complete diffusion of the drug to reach the final blockade range. The control group had no sensory block area after 60 minutes, while the experimental group had different ranges of blockade, the best block could reach the level of T10-L3 and can basically block 100% of the skin at the incision site of the hip replacement. The study also showed that the QLB had advantages in retaining muscle strength: 14 of the 20 block patients retained grade 5 muscle strength, 5 patients retained grade 4 muscle strength, and 1 patient developed grade 1 muscle strength. Good muscle strength is necessary for early postoperative mobility. Compared with the lumbar plexus block, the quadratus lumbos block has a shallower depth, is technically easier to handle and master, has fewer peripheral blood vessels, is farther away from the vertebral body, and is less prone to complications, such as hematoma epidural puncture; however, it is necessary to pay attention to the position of the kidney during the operation and to avoid puncture of the kidney, especially on the right side.

Nevertheless, there were also several limitations. The first limitation was the sample size, it was so small that limiting the generalizability of the results. The second was we used ice to test the areas of cold hypoesthesia, which relies on the patient's judgment, and there was a certain subjectivity. The third was we only tested the areas of cold hypoesthesia, but not the area of sensory loss.

CONCLUSIONS

The ultrasound-guided anterior quadratus lumborum block at an oblique agnostic position has a definite sensory block range, which can effectively reduce the amount of analgesics, reduce intraoperative stimulation, stabilize the circulation, reduce the postoperative VAS score, and reduce the application of postoperative analgesic drugs, but it concurrently has little effect on lower limbs muscle strength, promotes rapid recovery, and leads to less adverse reactions.

Table 6. Adverse reactions.

Group	Cases	Vomiting [(%)cases]	Dizzy [(%)Cases]	Drowsiness [(%)cases]	Lower Limbs Weakness [(%)cases]
G	20	15% (3)	25%(5)	20%(4)	0(0)
QLB+G	20	5%(1)	10%(2)	0 (0)	5% (1)
χ^2 value		1.111	1.558	4.444	1.026
P value		0.292	0.212	0.035*	0.311

Values are presented as number.

Categorical data were summarized as frequency and percentages.

Compared with group G,* $P < 0.05$.

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