ORIGINAL ARTICLE

The effects of transmuscular quadratus lumborum blocks on postoperative pain in arthroscopic hip surgery: a cohort analysis

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Abstract

Purpose The Transmuscular Quadratus Lumborum block (TQLB) is one of the newest blocks and has been used as an effective analgesic option for various surgeries. However, it is still uncertain whether the TQLB provides beneficial analgesic outcomes for hip arthroscopic surgeries. Therefore, we aimed to investigate effects of the preoperative TQLB on postoperative pain levels and perioperative opioid consumption in patients who underwent outpatient arthroscopic hip surgery.

Methods In this retrospective cohort study, patients who underwent arthroscopic hip surgery for femoroacetabular impingement (FAI) between June 1, 2017 and December 1, 2017 were included. All patients received general anesthesia for surgery. Two groups of patients were compared: (1) patients who received a preoperative TQLB, (2) patients who did not receive a TQLB.

Results Seventy procedures (68 patients) were included in the study. Of these, 15 procedures (15 patients) received a preoperative TQLB (TQLB group) in addition to general anesthesia, whereas the other 55 procedures (54 patients) received general anesthesia only (control group). Highest pain scores in the PACU were similar in the TQLB (6.2) group versus the control group (5.6) (95% CI − 2.08 to 0.99, $p = 0.484$). Pain scores decreased over time in both groups and there were no statistical differences in mean values or absolute risk differences between study groups (95% CI − 0.19 to 0.33, $P = 0.596$). In addition, there were no significant differences in perioperative opioid consumption, length of PACU stay, or the need for a rescue block in the PACU between the two groups.

Conclusion The present study did not find the preoperative TQLB to be an effective analgesic technique for patients who underwent arthroscopic hip surgery for FAI. A randomized clinical trial may further validate these results.

Keywords Quadratus lumborum block · Postoperative pain · Hip arthroscopy · Regional anesthesia

Introduction

Arthroscopic hip surgery can be a painful procedure, often requiring opioid pain medications during the acute postoperative period. Pain control is a key component of successful outpatient arthroscopic hip surgery. As a part of multimodal analgesia, peripheral nerve blocks such as lumbar plexus [1, 2], paravertebral [3], femoral nerve [4, 5], and fascia iliaca blocks [6-8] have been studied with mixed results and these blocks have potential side effects. Our recent randomized control study [8] showed that preoperative fascia iliaca blocks did not improve postoperative analgesia, but caused quadriceps weakness which may have led to falls in some patients. Femoral nerve blocks carry the same fall risk. Lumbar plexus blocks and paravertebral blocks have an increased risk of epidural or spinal spread of local anesthetic. Hence, they are less favored in a freestanding ambulatory surgery center. Therefore, alternative approaches to improve analgesia have been sought. In recent years, the literature has suggested that Quadratus Lumborum Blocks (QLBs) provide effective analgesia for various surgeries and potentially could decrease the consumption of opioids. There are variants of QLBs depending upon the endpoint of injection in relation to the QL muscle: type 1 (lateral), type

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2 (posterior), transmuscular QLB (TQLB) (anterior) and intramuscular QLB. More recently, a case report described TQLB as an effective analgesic technique in total hip arthroplasty (THA) [9, 10] and congenital hip surgery [11]. The TQLB was first described in 2013 [12] and has been used as an effective analgesic option similar to other types of QLBs for major abdominal surgeries [13, 14]. However, it is still uncertain whether the TQLB provides beneficial outcomes for hip arthroscopic surgeries.

Therefore, we aimed to investigate the effects of a preoperative TQLB on postoperative pain levels and opioid consumption in patients who underwent outpatient arthroscopic hip surgery. In the present study, we compared early postoperative pain scores in patients receiving a preoperative TQLB in addition to general anesthesia, to patients receiving general anesthesia alone. We hypothesize that preoperative a TQLB reduces pain and opioid consumption during the acute postoperative period.

Methods

The study is a retrospective cohort analysis of patients who underwent arthroscopic hip surgery for femoroacetabular impingement (FAI) from June 1, 2017 to December 1, 2017 at an academic freestanding ambulatory surgery center. The study was approved by the Institutional Review Board (IRB) of University California San Francisco (IRB#17-24,033). The electronic medical records were reviewed and patients were divided into two groups: 1) patients who received a preoperative TQLB in addition to general anesthesia (TQLB group), 2) patients who received general anesthesia alone (control group).

Inclusion criteria were patients 18 years or older, having ASA physical status I–II, and who underwent arthroscopic femoroplasty and/or labral repair of the hip. Patients who underwent a procedure on each hip at different dates were included. Exclusion criteria were: patients taking opioids; and patients who received a preoperative nerve block other than a TQLB.

The primary predictor variable was the administration of a preoperative TQLB. Other predictor variables included patients' demographic characteristics, ASA classification, prescription medications, as well as perioperative data such as surgery duration, type of anesthesia, preoperative administration of non-opioid pain medications, and preoperative pain scores.

The primary outcome was defined as longitudinal pain scores during the recovery period in the Post-Anesthesia Care Unit (PACU). Pain scores were extracted from the medical record every 15 min, using the highest charted score from the previous 15 min. Admission to the PACU was defined as the start time, and ready for discharge as

the end time, based on standardized discharge criteria. Pain scores were evaluated using a scale of 0–10. When a verbal pain indicator was given, we used the following conversion: none = 0, mild = 2, moderate = 5, severe = 8.5.

Secondary outcome variables were defined as total Oral Morphine Equivalents (OME); OMEs for the intra and postoperative time periods separately; total non-opioid pain medications, length of the PACU stay (from PACU admission to discharge ready); and the need for a rescue block in the PACU. OMEs were calculated using the recommended conversion factors derived from international sources [15].

All patients who received a preoperative TQLB consented to the procedure. All TQLBs were performed in the preoperative area with sedation (1–2 mg of IV midazolam). The procedure was performed under ultrasound guidance in a lateral position via a posterior approach as originally described by Børglum and colleagues [12]. Local anesthetic was injected into the fascial plane between the quadratus lumborum and psoas major muscles. After the nerve block was done, the patient was taken to the operating room and received general anesthesia. Anesthesia was induced with propofol, and the airway secured using either a laryngeal mask airway or endotracheal tube. Anesthesia was maintained with either inhalational anesthetics or propofol, or combination of both. All surgeries were a combination of arthroscopic labral repair and femoroplasty of the hip joint. All patients received 10 mL of 0.2% ropivacaine intra-articularly by the surgeon at the end of surgery. All surgeries were performed by the same surgeon (ALZ). After emergence from anesthesia, the patient was taken to the PACU. After meeting the discharge criteria, the patient was discharged home.

All data were extracted from electronic medical records by a trained study staff (KD) using a standardized data extraction sheet. 10% of all extracted data were validated by a second study team member (KK).

Statistical analysis

The Student's *t* test was used to compare the mean difference of continuous predictor variables between the TQLB group and the control group. To compare proportions of categorical variables, we used the Chi-squared test or Fisher's exact test, depending on the number of events per group. The preoperative administration of a TQLB was solely dependent on the availability of an anesthesiologist (SK) who is trained and competent to perform this block. We hypothesized that this would lead to a quasi-random group assignment. Therefore, we used univariate analysis to compare the primary and secondary outcomes between study groups.

To accommodate for the longitudinal nature of our primary outcome, pain scores in the PACU, we fitted a mixed effect model with the study group as the only adjustment variable. We checked the model for normal distribution of

the residuals. Sensitivity analysis was performed by fitting a model that excluded outliers, as well as using a bootstrap procedure.

The mean difference of continuous secondary outcome variables was compared using the Student's *t* test. A Chi-squared test or Fisher's exact test was used to calculate the absolute risk difference of categorical variables.

All analyses were performed using Stata 14 (StataCorp. 2015. *Stata Statistical Software: Release 14*. College Station, TX: StataCorp LP).
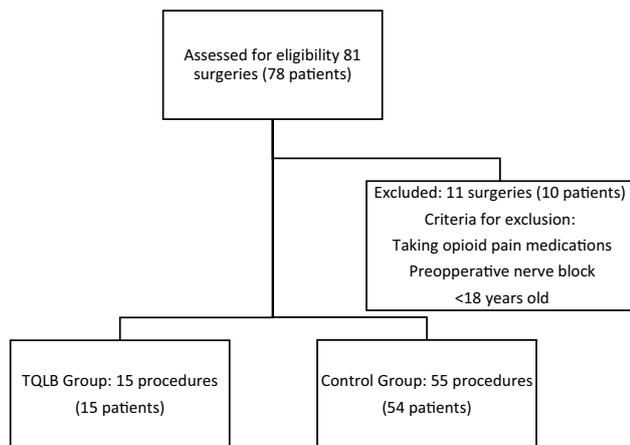

Fig. 1 Study Flowchart. Note the number of patients with TQLB and control groups do not add up to 68 patients because one patient had one procedure with TQLB and one procedure without TQLB, one patient had two procedures under general anesthesia only (control group). Total procedures included = 70, total number of patients included = 68

Results

Eighty-one arthroscopic hip surgeries were identified in 78 patients. Of those, 11 procedures in 10 patients did not meet the inclusion criteria (Fig. 1). We included 70 procedures in 68 patients in the study. Two patients underwent both right and left hip arthroscopic surgeries on different surgery days. One patient had surgery twice under general anesthesia only. The other patient received a TQLB for one procedure but not for the other. Fifteen procedures (15 patients) received a preoperative TQLB (TQLB group), and 55 procedures (54 patients) received general anesthesia only (control group).

The doses of local anesthetic used in TQLBs were 20–30 mL of 0.325–0.5% ropivacaine, with a median of 150 mg (range from 93.75 to 150 mg).

We did not find statistically significant differences in demographic data including age, sex, height, weight, BMI, ASA-physical status, surgery duration, or preoperative pain scores between the two groups ($p > 0.05$ for all) (Table 1).

Table 2 shows longitudinal pain scores in the PACU for the two groups. Pain scores were compared using a mixed effects model that included group assignment (TQLB vs. control), postoperative time from 0 to 195 min as a linear term, and the interaction term of both. Within the first 15 min in the PACU, the highest pain score was 6.2 in the control group and 5.6 in the TQLB group. The difference of 0.6 points was statistically insignificant (95% CI − 2.08 to 0.99, $p = 0.484$). Pain scores decreased statistically significantly over time in both study groups: in the control group, the pain scores decreased by 0.31 points for every 15 min in the PACU (95% CI − 0.43 to − 0.19, $p < 0.0001$);

Table 1 Demographic and perioperative characteristics of 15 patients who received a preoperative transmuscular quadratus lumborum block (TQLB) and 55 patients who did not receive a nerve block (control)

	Mean ± SD		*p* value
	TQLB (*n* = 15)	Control (*n* = 55)	
Age (years)	35 ± 9.4	35 ± 9.4	0.951
Height (cm)	174 ± 10.6	174 ± 8.4	0.95
Weight (kg)	71 ± 11.9	74 ± 14.6	0.403
BMI	23 ± 3.9	24 ± 4	0.358
Surgery duration (min)	97 ± 22.6	89 ± 20.1	0.200
Pre-operative pain score (NRS)	3.3 ± 1.8	3.6 ± 2.6	0.603
	n (%)		*p* value
	TQLB (*n* = 15)	Control (*n* = 55)	
Sex (female)	10 (67)	25 (45)	0.145
ASA status			1.0
I	12 (80)	45 (82)	
II	3 (20)	10 (18)	

NRS 11-point numeric rating scale from 0 to 10

Table 2 Mean pain scores ± SD in the PACU in 15 min intervals

		0–15	16–30	31–45	46–60	61–75	76–90	91–105	106–120	121–135	136–150	151–165	166–180	181–195
														Time in recovery (min)
TQLB	Mean ± SD	4.5 ± 3.1	5.3 ± 2.8	4.8 ± 2.1	5.1 ± 2.0	3.9 ± 1.7	3.9 ± 2.4	4.1 ± 2.4	4.3 ± 3.1	4.5 ± 3.5	1		7	
	N	11	13	14	13	12	9	8	6	2	1	0	1	0
Control	Mean ± SD	5.5 ± 2.5	5.8 ± 2.4	5.3 ± 2.0	5.1 ± 1.6	4.3 ± 1.6	4.4 ± 1.6	4.6 ± 1.4	4.1 ± 1.6	4.4 ± 1.5	3.5 ± 1.4	3.2 ± 2.1	3 ± 2.2	3.5 ± 0.7
	N	32	43	49	44	39	36	29	21	16	12	6	4	2

Over the last hour, only one or zero observations were available for the TQLB group

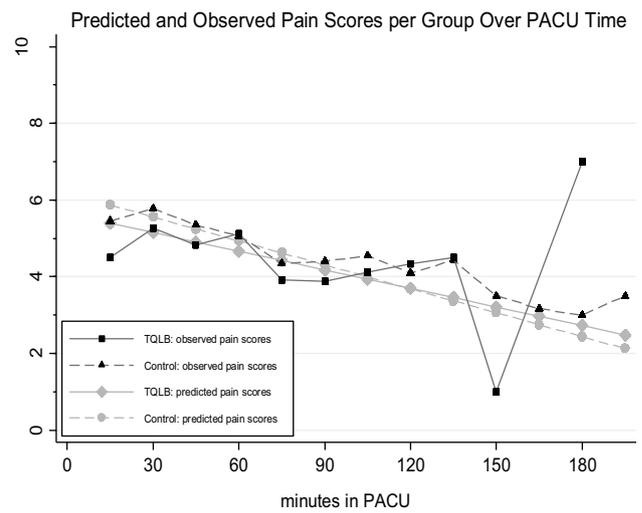*N* number of observations, *TQLB* transmuscular quadratus lumborum block

Fig. 2 Predicted and observed pain scores over recovery time for each study group. *PACU* Post-Anesthesia Care Unit, *TQLB* transmuscular quadratus lumborum block

in the TQLB group, the pain scores decreased by 0.24 points for every 15 min in the PACU (95% CI − 0.47 to − 0.02, *p* = 0.037). The difference in change of pain scores over time between the study groups was 0.07 points for every 15 min spent in the PACU (95% CI − 0.19 to 0.33) and statistically insignificant (*p* = 0.596).

Figure 2 shows the observed pain scores for each study group as well as the predicted pain scores for each study group based on our model, confirming a good model fit. The observed pain scores in the control group showed the highest pain score shortly after admission to the PACU, followed by a decline in pain scores over time. The TQLB group exhibits a similar pattern, except for the last 45 min of the PACU stay. Of note, only two pain scores were available in the TQLB group during this time period (Table 2).

With regard to pain medications, IV fentanyl and/or IV hydromorphone were used intraoperatively. Postoperatively, oral pain medications such as hydrocodone/acetaminophen, oxycodone or tramadol were used, in addition to IV fentanyl and IV hydromorphone. IV meperidine was used in case of shivering. There was no significant difference in OMEs between the study groups (Table 3). However, there were some differences in the amount of adjunct pain medications. One patient in the control group received 1000 mg acetaminophen and 800 mg gabapentin preoperatively. In 60 out of 70 procedures, oral acetaminophen (ranging from 325 to 1000 mg) was administered in the PACU. The TQLB group received higher doses of acetaminophen (522 mg ± 243 mg) and more often (14 out of 15 procedures) as compared to the control group (378 mg ± 223 mg in 46 out of 55 procedures). The mean difference of the amount of acetaminophen between study

Table 3 Comparison of secondary outcomes between the study groups

	Mean		Mean difference (95% CI)
	TQLB ($n = 15$)	Control ($n = 55$)	
OME, intraoperative (mg)	23.3	27.1	3.7 (− 1.9 to 9.3)
OME, postoperative (mg)	41.4	43.5	2.1 (− 9 to 13.2)
OME, total (mg)	64.7	70.5	5.8 (− 6.4 to 18.1)
Length of PACU stay (min)	114	120	6 (− 16 to 28)
Acetaminophen, postoperative (mg)	522	378	144 (11–276)*
	N (%)		Absolute risk difference [% (95% CI)]
	TQLB ($n = 15$)	Control ($n = 55$)	
Ketorolac, total	13 (87)	36 (65)	21 (− 0.1 to 43)

OME oral morphine equivalents; *95% CI* 95% confidence interval, *TQLB* transmuscular quadratus lumborum block, *PACU* post-anesthesia care unit

*Statistical significance ($p < 0.05$)

groups was statistically significant (143 mg, 95% CI 11–276).

In 49 out of 70 procedures, 30 mg ketorolac was administered, except for one patient in the control group who received 45 mg ketorolac. The TQLB group had a higher proportion of procedures with ketorolac administration. The absolute difference in the proportions between study groups was close to statistical significance (21%, 95% CI − 0.1 to 43).

We did not find significant differences in mean values or absolute risk differences between the study groups for other secondary outcomes: lengths of PACU stay, and the need for a rescue block (fascia iliaca block) in the PACU ($p > 0.05$, respectively) (Table 3). There were no adverse events or complications reported in either group. No patient was admitted postoperatively.

Discussion

The QLB blocks are interfascial plane blocks and are still rapidly evolving in research and clinical practice. Literatures suggest that QLB blocks provide effective postoperative analgesia for abdominal and retroperitoneal surgeries [16]. In general, it is thought that local anesthetic solution injected into the fascial plane around the QL muscle spreads into the thoracolumbar fascia and provides analgesia from the lower abdomen to the upper thoracic area, however, the true mechanisms of any analgesic effects are still unknown. The target point of injection is different in all QLBs, thus QLBs might have different characteristics with different sensory coverage. For example, it has been reported that QLB1 and QLB2 provide analgesia in the area of T7-L1, T10-L4 for

TQLB and T7-T12 for an intramuscular QLB [17]. Therefore, each QLB block needs to be viewed separately.

To the best of our knowledge, this is the first study focused on the effectiveness of a TQLB for arthroscopic hip surgery. In contrast to previous literature on the use of QLBs for hip surgeries, our cohort analysis could not replicate a beneficial effect of a TQLB on pain control after arthroscopic hip surgery. There were no differences in perioperative OMEs between the two groups. Although the amount of acetaminophen was higher in TQLB group, pain scores in the PACU were not different for the two groups.

The evidence of analgesic effect of QLBs for hip surgeries is still preliminary, and primarily supported by case reports. A few papers have described that QLB Type 1 and Type 2 provided good analgesia for hip arthroplasty [18, 19] and femoral neck fracture [20]. A few case reports showed that continuous TQLB is an effective analgesia for THA [9, 10].

For a TQLB, the injection point is the fascia plane between the QL and PM muscles. Local anesthetic spread can be different depending on subtle differences of the injection point: it may produce variable analgesia similar to thoracic paravertebral blocks or lumbar plexus blocks. The hip joint has a complex innervation and receives sensory input from the femoral, obturator and sciatic nerves that are formed via the lumbar and sacral plexus. A plausible analgesic mechanism of TQLB for hip joints is that local anesthetic spreads to the lumbar nerve roots within the psoas muscle compartment [21]. We speculate that local anesthetic does not spread to the lumbar nerve roots reliably in TQLBs, unless intentionally or inadvertently injected into the psoas muscle, which contributed to the negative analgesic effect in our study. In addition, TQLBs are not likely to cover the sacral plexus.
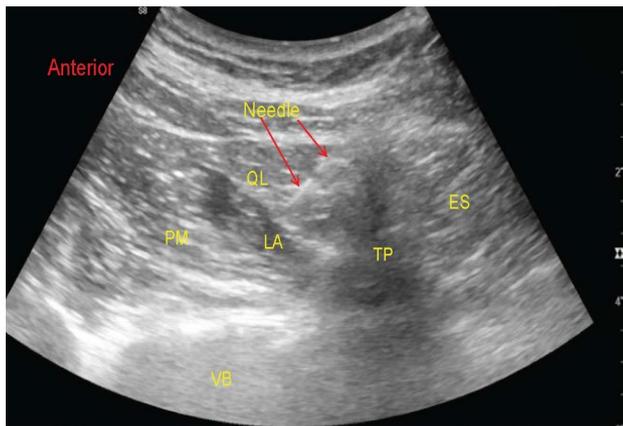
Fig. 3 Ultrasound image of transmuscular quadratus lumborum block. *ES* erector spinae muscle, *LA* local anesthetic, *PM* psoas major muscle, *QL* quadratus lumborum muscle, *TP* transverse process, *VB* vertebral body

A few cadaveric studies have investigated dye spread in a TQLB block [22, 23]. These studies showed that dye spread was seen in lumbar nerve roots, suggesting that a TQLB may be a possible alternative to a lumbar plexus block. However, another cadaveric study [24] showed that the dye spread did not reach the lumbar sympathetic trunk or lumbar nerve roots, thus contradicting these studies. In this study, the injectate was spread to the thoracic paravertebral space, posterior to the medial and lateral arcuate ligaments, and it surrounded the thoracic sympathetic trunk and segmental nerves. Caudal spread of the dye was limited at the level of the iliac crest. The authors of this cadaveric study speculated that this discrepancy was produced in part by piercing the psoas major muscles, which facilitated spread within the psoas major muscles to reach the lumbar plexus.

There are some limitations in our study. First, it was a retrospective analysis and not a prospective randomized clinical trial. Therefore, there was no standardized sensory or motor measurement. However, two investigators (SK and KK) reviewed independently available ultrasound images (10 out of 15 procedures) and the correct injection sites (between quadratus lumborum and psoas major muscles) were confirmed (Fig. 3).

Second, we assumed a quasi-random assignment of the study groups because it was solely based on the availability of an anesthesiologist competent to perform the block. The even distribution of measured potential predictors supports this assumption. This contributes to the strength of our study: there was no technical variability in performing these TQLBs. However, we cannot exclude unmeasured confounders that might have affected primary and secondary outcomes.

Third, we had a limited number of patients in our report. However, our primary outcome; the longitudinal pain scores

in the PACU showed that the difference in change of pain scores between the two group was only 0.07 points with a narrow 95% CI (− 0.19 to 0.33). The narrow confidence interval suggests that a larger sample size will unlikely change the outcome, and the difference in pain scores may not be clinically relevant. Moreover, per post-hoc power calculation, the power seems sufficient enough to show a clinically relevant difference in pain scores: if we assume a standard deviation of 2.5 pain score points in the study population, and apply our given sample size of 55 patients in the control group and 15 patients in the TQLB group, we have an 80% power to detect a difference of 2.069 pain score points (a difference of two pain score points is generally accepted as a clinically meaningful difference in pain scores).

Fourth, the available data on pain and consumption of pain medications were limited to the immediate recovery period and there are no data beyond that point. However, ropivacaine is a long-acting local anesthetic and the analgesic effect of these blocks normally endures into the duration of a PACU stay. Therefore, any significant differences in outcome data between these two groups would be evident during the recovery period.

In summary, the present study did not find the preoperative TQLB as an effective analgesic technique for patients who underwent arthroscopic hip surgery. As this report is hypothesis-generating rather than hypothesis testing, further research is warranted to investigate analgesic effect of TQLB, and a randomized clinical trial is needed to validate these results.

Compliance with ethical standards

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