Transmuscular quadratus lumborum versus lumbar plexus block for total hip arthroplasty: A retrospective propensity score matched cohort study

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Introduction

Following total hip arthroplasty (THA), pain can be significant.¹ Lumbar plexus block (LPB) reduces pain, but has been associated with serious complications.²⁻⁵ The quadratus lumborum block (QLB) evolved from the transversus abdominis plane (TAP) block as a technique for providing analgesia following abdominal surgery. However, recent studies have shown that QLB injectate spreads to the lumbar plexus and that hip analgesia can be achieved.⁶⁻¹⁰ Based on this evidence, we have increasingly utilized transmuscular QLB to provide analgesia following elective THA. This retrospective, propensity score matched cohort study aims to compare analgesia provided by transmuscular QLB and LPB following elective THA.

Abstract

**Background and Aims:** Cadaveric studies have shown that injectate from transmuscular quadratus lumborum block (QLB) can spread to the lumbar plexus. Our aim was to compare analgesic efficacy of transmuscular QLB with lumbar plexus block (LPB) for patients undergoing total hip arthroplasty (THA).

**Material and Methods:** Thirty patients receiving transmuscular QLB were propensity score matched with 30 patients receiving LPB for age, sex, ASA score, BMI, operative time, preoperative oxycodone, and intraoperative opioid use. The primary outcome was postoperative opioid consumption during the first 24 postoperative hours. Secondary outcomes included static pain scores at 0–12, 12–24, and 24–48 h intervals, opioid consumption at 0–12, 12–24, and 24–48 h intervals and the length of hospital stay. The incidence of severe adverse events was also compared.

**Results:** Opioid consumption (median [IQR]) in the first 24 h was similar between the transmuscular QLB and LPB patient groups—33.6 mg (22.9–48.5) versus 32.8 mg (24.8–58.3) intravenous morphine equivalents. There was no difference between groups in static pain scores or opioid consumption during any time interval up to 48 h postoperatively. Length of hospital stay (median [IQR]) was similar between the transmuscular QLB and LPB groups—55.6 h (53.7–60.3) versus 57.9 h (54.3–79.1).

**Conclusions:** This study suggests that transmuscular QLB provides similar analgesia to LPB following THA. Prospective studies are needed to confirm this.

**Keywords:** Analgesia, nerve block, postoperative pain, total hip replacement, ultrasound

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Material and Methods

Study design
Institutional authorization was obtained to conduct a retrospective review of electronic medical records of patients who underwent primary unilateral THA between 1st November 2013 and 30th November 2015, and received either a LPB or transmuscular QLB as part of their anesthetic care. The initial population was identified from electronic patient record software (Cerner® North Kansas City, MO, USA) using two queries. Query 1 used the following criteria: (a) anesthesia start time within the specified date/time parameters and (b) surgical procedure equal to THA. Query 2 used the following criteria: (a) the patient set from query 1 and (b) a completed anesthesia acute pain procedure form indicating the performance of LPB or transmuscular QLB. Once the patient population had been established, other requested data elements were retrieved in a series of further queries and then compiled into a standardized Microsoft Excel 2016 (Microsoft Corp, Redmond, WA, USA) spreadsheet.

Study cohort
All blocks were performed in a dedicated block room by one of six consultants practicing regional anesthesia. In all cases, the patient was placed in the lateral position and sedation administered as required. LPB was performed preoperatively using a landmark-guided neurostimulation technique as follows: the lumbar spinous processes were palpated and the midline marked at the intercristal line. A second mark was made at the junction of the intercristal line and a line parallel with the spine though the posterior superior iliac spine (PSIS). A 100 mm Stimuplex® Ultra needle (B. Braun, Melsungen, Germany) was inserted at a point 10 mm cephalad to the junction of the lateral third and medial two thirds of a line drawn between the two marks. The needle was advanced perpendicular to all planes with an initial stimulation current of 1.5 mA. If bone was encountered, the needle was withdrawn and directed caudad underneath the transverse process with further advancement of no more than 15–20 mm. The endpoint for needle insertion was a quadriceps twitch elicited with a minimum threshold current of between 0.3 and 0.5 mA. A total of 15–30 ml of 0.5% ropivacaine was injected with intermittent aspiration confirming absence of blood or cerebrospinal fluid, to achieve the desired spread of local anesthetic between QLM and psoas muscle [Figure 1].

All patients in both groups subsequently received a general anesthetic. Induction was typically achieved with intravenous (IV) fentanyl and propofol with or without the use of the muscle relaxant rocuronium. Maintenance of anesthesia was typically achieved with sevoflurane. Intraoperative opioids were administered in the face of clinical evidence of requirement at the discretion of the attending anesthetist. Local infiltration analgesia (LIA) was not performed by surgeons during the study period. All THAs were performed by one of two consultant surgeons using the posterolateral approach. There were no significant changes to surgical practice during the study period. Postoperatively, patients were transferred to the post-anesthesia care unit where they received IV fentanyl and hydromorphone as required for pain. Postoperative oral analgesia typically including acetaminophen, a non-steroidal anti-inflammatory drug (NSAID) and a controlled release opioid were prescribed according to clinical need.

Statistical analysis
SPSS® for Mac version 23.0 (SPSS® Inc., Chicago, IL, USA) was used for statistical analysis. We performed propensity score matching of the two groups in order to reduce any potential impact of treatment selection bias or posterior to anterior direction through the quadratus lumborum muscle (QLM) until its tip reached the anterior aspect of the QLM where it borders the psoas major. A total of 15–30 ml of 0.5% ropivacaine was injected with intermittent aspiration confirming absence of blood or cerebrospinal fluid, to achieve the desired spread of local anesthetic between QLM and psoas muscle [Figure 1].

Transmuscular QLB was performed preoperatively using the ultrasound-guided anterior approach. A curvilinear ultrasound transducer was placed in a transverse orientation in the mid-to-posterior axillary line and between the costal margin and iliac crest. A 100 mm Stimuplex® Ultra needle (B. Braun, Melsungen, Germany) was advanced in plane in a posterior to anterior direction through the quadratus lumborum muscle (QLM) until its tip reached the anterior aspect of the QLM where it borders the psoas major. A total of 15–30 ml of 0.5% ropivacaine was injected with intermittent aspiration confirming absence of blood or cerebrospinal fluid, to achieve the desired spread of local anesthetic between QLM and psoas muscle [Figure 1].
covariates on study outcomes. Propensity score matching was conducted using the SPSS® custom dialogue PS Matching version 3.04. This utilizes several R package extensions through the open source software R Essentials version 3.2.4 SPSS® plugin.[14] Age, sex, American Society of Anesthesiologists (ASA) classification, body mass index (BMI), premedication with oxycodone, surgical time, and intraoperative opioid use were identified a priori as covariates based on their previous association with postoperative pain.[15] Intraoperative opioids were converted to IV morphine equivalents for analysis using previously established conversion ratios.[16]

Each patient receiving transmuscular QLB was propensity score matched to a single patient receiving LPB using a 1:1 nearest neighbor methodology with a caliper of 0.15 (the maximum allowable difference in propensity scores between two subjects).[17] As a result, a final matched cohort of discrete individuals was produced with no repetition.

The primary outcome of interest was opioid consumption (calculated as IV morphine equivalents) during the first 24 postoperative hours. Secondary outcomes included patient-reported numeric rating scale (NRS) static pain scores (minimum, mean, and maximum) at 0–12, 12–24, and 24–48 h intervals, opioid consumption at 0–12, 12–24, and 24–48 h intervals and the length of hospital stay. The incidence of severe adverse events was also compared between the two groups.

Continuous variables were tested for normality using the Shapiro Wilk Test. Variables with non-skewed distributions were reported as mean (SD) and differences evaluated using the unpaired Student’s t-test. Continuous variables with skewed distributions were reported as median (IQR) and differences were assessed using the Mann–Whitney test. Effect size and precision was reported using mean difference (95% confidence interval) for parametric data and differences were assessed using the Mann–Whitney test. Effect size and precision was reported using mean difference (95% confidence interval) for parametric data and differences were assessed using the Mann–Whitney test. Wilcoxon–Mann–Whitney odds (95% confidence interval) were used for non-parametric outcomes. Holm’s stepwise approach and the Holm step-down procedure were used for the correction of multiple comparisons.[21] Confidence intervals were adjusted by an extension of the Holm step-down procedure.[22,23]

Results

The initial search strategy identified a cohort of 175 patients (142 LPB, 33 transmuscular QLB) for chart review. Twenty-five patients had incomplete medical records where key data points were missing (24 LPB, 1 transmuscular QLB). These patients were excluded, leaving 150 patients (118 LPB, 32 transmuscular QLB) available for propensity score matching. Following propensity score matching, 30 patients who received LPB were compared with 30 patients who received transmuscular QLB.

Patient sex, age, BMI, ASA score, operative time, preoperative use of oxycodone, and intraoperative use of opioids were similar between groups [Table 1]. Patients in both groups received similar doses of acetaminophen and NSAIDs in the first 24 h [Table 2].

There was no significant difference in 24-h opioid consumption between patients in the LPB group and transmuscular QLB group, respectively—33.6 mg (22.9–48.5) versus 32.8 mg (24.8–58.3), WMW odds 1.10 (0.62–1.96), \( P = 0.75 \). In addition, there were no significant differences between patients receiving either LPB or transmuscular QLB with regard to NRS static pain scores [Table 3] or opioid consumption [Table 4] at any of the time intervals studied. The length of hospital stay was 55.6 h (53.7–60.3) in the QLB group versus 57.9 h (54.3–79.1) in the LPB group. This difference was not statistically significant (WMW odds 0.72 (0.41–1.30), \( P = 0.29 \)).

One patient in the LPB group experienced hypotension following the block and prior to induction of general anesthesia, which was documented as due to epidural spread of local anesthetic. The patient required an intraoperative phenylephrine infusion, but subsequently made a good recovery. No serious complications were recorded in the transmuscular QLB group.

| Variable | LPB group (\( n=30 \)) | QLB group (\( n=30 \)) |
|----------|------------------|------------------|
| Male; n (%) | 15 (50) | 16 (53) |
| Female; n (%) | 15 (50) | 14 (47) |
| Age (y) | 63.0 (58.8–70.0) | 63.5 (52.3–74.0) |
| BMI (kg/m\(^2\)) | 28.5 (25.8–34.8) | 29.0 (24.0–34.5) |
| ASA score | 3 (2–3) | 3 (2–3) |
| Preoperative oxycodone (mg) | 10.0 (10.0–10.0) | 10.0 (10.0–10.0) |
| Surgical time (min) | 129.6 (35.1) | 127.6 (28.3) |
| Intraoperative opioids in IV morphine equivalents (mg) | 14.8 (9.2–22.4) | 16.0 (11.8–22.1) |

LPB=Lumbar plexus block; QLB=Quadratus lumborum block; BMI=Body mass index; ASA=American Society of Anesthesiologists; IV=Intravenous

| Drug | LPB group (\( n=30 \)) | QLB group (\( n=30 \)) |
|------|------------------|------------------|
| Acetaminophen (mg) | 3,000 (2,000–3,000) | 3,000 (2,750–3,000) |
| Celecoxib (mg) | 0 (0–200) | 0 (0–0) |
| Nabumetone (mg) | 0 (0–1,000) | 250 (0–1,000) |

LPB=Lumbar plexus block; QLB=Quadratus lumborum block
Table 3: Numerical rating scale (NRS) pain scores at different time intervals

| Time interval          | LPB group (n=30) | QLB group (n=30) | Effect size (95% confidence interval) | P   |
|------------------------|------------------|------------------|---------------------------------------|-----|
| 0-12 H nrs pain scores (0-10 scale) |                  |                  |                                       |     |
| Min                    | 0.0 (0.0-1.3)    | 0.0 (0.0-1.0)    | WMW odds 0.87 (0.49, 1.56)            | 0.58|
| Mean                   | 3.0 (2.3-3.9)    | 2.8 (1.5-5.0)    | WMW odds 0.96 (0.54, 1.71)            | 0.89|
| Max                    | 5.0 (4.0-8.0)    | 6.0 (5.0-8.0)    | WMW odds 1.34 (0.75, 2.39)            | 0.33|
| 12-24 H nrs pain scores (0-10 scale) |                  |                  |                                       |     |
| Min                    | 3.0 (0.8-5.0)    | 2.5 (0.0-5.0)    | WMW odds 0.88 (0.48, 1.53)            | 0.60|
| Mean                   | 4.1 (2.66)       | 3.9 (2.22)       | Mean difference 0.23 (−1.03, 1.50)    | 0.71|
| Max                    | 5.0 (2.85)       | 5.0 (2.23)       | Mean difference 0.67 (−1.26, 1.39)    | 0.92|
| 24-48 H nrs pain scores (0-10 scale) |                  |                  |                                       |     |
| Min                    | 3.0 (0.0-4.0)    | 1.5 (0.0-4.0)    | WMW odds 0.73 (0.32, 1.71)            | 0.27|
| Mean                   | 4.0 (2.06)       | 3.7 (2.18)       | Mean difference 0.33 (−0.76, 1.43)    | 0.55|
| Max                    | 5.6 (2.43)       | 5.4 (2.24)       | Mean difference 0.17 (−1.04, 1.37)    | 0.78|

Discussion

In this retrospective propensity score matched cohort study, ultrasound guided transmuscular QLB was associated with similar postoperative analgesia to LPB following elective THA. No statistically significant differences were found in opioid consumption or static pain scores between the two groups at any time up to 48 h postoperatively. The length of hospital stay was statistically similar between the two groups.

The QLB evolved from the TAP block as a technique for providing analgesia following abdominal surgery.[24] The QLB has since gone through an evolution of its own, with at least three different variations described depending on whether local anesthetic is injected lateral, posterior, or anterior to the QLM. These were initially termed the quadratus lumborum 1, quadratus lumborum 2, and transmuscular approaches although a nomenclature based on the site of injection relative to the QLM has recently been proposed.[13,25] Abdominal wall analgesia has been described in multiple case reports[26-31] and series.[32] The mechanism of action is thought to involve cephalad spread of local anesthetic through the medial and lateral arcuate ligaments of the diaphragm to the thoracic paravertebral space.[33]

However, there is increasing evidence that QLB can also act on the branches of the lumbar plexus and provides analgesia for hip surgery. In a randomized study, Parras and Blanco compared single-shot quadratus lumborum 2 block with femoral nerve block in patients undergoing hip fracture surgery. Patients receiving quadratus lumborum 2 block had significantly less pain and required less opioids compared to those patients receiving femoral nerve block.[8] In another report, Hockett and colleagues describe the use of continuous quadratus lumborum 2 block in a 69-year-old man with chronic pain undergoing THA. The patient had diminished sensation in the T10–L1 dermatomes and mobilized on postoperative day 1. The patient had excellent dynamic pain control (NRS of between 0 and 3/10) and required no IV opioids.[10] In another report, Ueshima and colleagues describe two cases in which continuous transmuscular QLB provided effective analgesia following THA. The investigators reported reduced sensation to pinprick in the T11–L4 and T12–L2 dermatomes in the first and second cases, respectively.[9] The same authors have also described the use of combined transmuscular QLB and subgluteal sciatic nerve block to provide successful surgical anesthesia for above knee amputation.[34] The description of leg weakness following QLB provides further evidence of block of the lumbar plexus or its branches.[35] Ueshima and colleagues recently reported quadriceps muscle weakness occurring with an incidence of 1% (7/771) following quadratus lumborum 1 block, 19% (285/1485) following quadratus lumborum 2 block, 90% (65/81) following transmuscular QLB, and 0% (0/45) following intramuscular QLB.[36]
Anatomically, the lumbar plexus is formed from the roots of T12 to L4 as they emerge from their respective intervertebral foramina. As they pass through psoas major muscle (PMM), the larger branches of the lumbar plexus leave the muscle at various sites to run obliquely and caudally through the pelvis. The exception is the obturator nerve that exits through the obturator foramen. Notably, at the L4 level, the ventral rami of L2 and L3 spinal nerves lie within the PMM close to the anterior thoracolumbar fascia and the anterior border of the QL muscle. At this level, the lateral cutaneous nerve of the thigh (LCNT) lies anterior to the transversalis fascia. Thus, when local anesthetic is deposited between the quadratus lumborum and PMM in the transmuscular QLB, there is potential for medial spread to the ventral rami of L2 and L3, lateral spread to the lateral cutaneous nerve of the thigh and caudal spread under the fascia iliaca, all of which will contribute to analgesia following THA.

The spread of injectate following different variants of QLB has been described in several studies. Adhikary et al. demonstrated consistent spread to upper branches of the lumbar plexus following transmuscular QLB at L4 using 20 ml of dye injectate in fresh cadavers. In another cadaveric study, Carlone et al. compared dye spread following quadratus lumborum 1, quadratus lumborum 2, and transmuscular QLB techniques. All transmuscular QLBs resulted in spread of injectate to the L1–L3 nerve roots but this was not consistently observed with other QLB variants. In contrast to these results, Dam et al. showed no staining of the lumbar plexus, femoral nerve, or lumbar sympathetic trunk following either transmuscular QLB or a transverse oblique paramedian variant performed more medially at the L2 level, although the lateral femoral cutaneous nerves were stained to a varying degree. The authors speculated that spread to the lumbar plexus might be observed if injectate was placed more anteriorly, within the PMM itself. In a letter of response, Kumar et al. reported an absence of visible paravertebral spread on fluoroscopic images of cadavers following transverse oblique paramedian transmuscular QLB at the L3 level. Even more recently, intramuscular variants of quadratus lumborum 1 and quadratus lumborum 2 blocks have been shown to result in a very limited spread of injectate around the QLM and a limited area of flank anesthesia between T8 dermatome and proximal lateral thigh. At this time therefore, the patterns of injectate spread, mechanisms of action, and clinical anesthesia that can be consistently achieved by the QLB remain controversial, and are likely to vary with different points of injection relative to the QLM.

A recent high quality meta-analysis has supported the analgesic efficacy of LPB following THA. However, the LPB is a technically difficult deep block and multiple needle passes may be required to obtain the appropriate needle position and elicit the requisite motor response. It is not only painful but has been associated with serious complications, including visceral injury and epidural spread of local anesthetic. This has led some authors to advise against routinely employing this block for THA. In this study, epidural spread of local anesthetic was felt to account for persistent hypotension in one patient receiving LPB.

The transmuscular QLB is easier to perform as the endpoint is injection within a readily-visualized fascial plane, rather than a specific motor response. Furthermore, as entry into the psoas muscle (which is highly vascular) is not required, transmuscular QLB carries a potentially lower risk of local anesthetic systemic toxicity. Pharmacokinetic studies using ropivacaine have demonstrated that plasma concentrations following QLB are within threshold levels for local anesthetic systemic toxicity. In addition, as contact with the lumbar plexus is not sought, there is minimal risk of inadvertent dural puncture and intrathecal spread of local anesthetic. It should be noted that this study is not powered to draw definitive conclusions regarding the relative safety of transmuscular QLB compared to LPB. However, for reasons of technical simplicity and potentially a reduced incidence of serious complications, patients undergoing THA at our institution no longer receive LPB as part of their anesthetic, but instead receive either neuraxial anesthesia with intrathecal opioid, or general anesthesia with an anterior QLB or LIA.

The main limitation of this study is that historical data were used, and patients were not randomized, thus introducing the possibility of selection bias. In addition, several patients were excluded from analysis due to missing data. We compensated for this with the use of propensity score matching, which creates groups that are similar with respect to preselected covariates. This allowed us to minimize the influence of confounding variables inherent to retrospective cohort studies. An additional limitation was the lack of an explicit record of block success or failure in the database. However, a mean morphine consumption of 32 mg during the first 24 postoperative hours is consistent with studies of LPB for THA.

Considering the limitations inherent to this retrospective study, our results are more hypothesis generating than clinically conclusive. However, the results of this study offer the first clinical comparison between the transmuscular QLB and LPB and by demonstrating that both blocks result in similar analgesic outcomes following THA, support the cadaveric evidence for a significant effect of transmuscular QLB on the lumbar plexus. It remains uncertain if other QLB variants will produce similar clinical analgesia of the hip. Given the possibility of leg weakness, we would advise practitioners...

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using any QLB to remain vigilant to the risk of leg weakness and falls, especially in the context of fast track THA pathways with early mobilization. There remains the need for adequately powered randomized studies comparing the different modalities of hip analgesia. Comparison of quadratus lumborum 1, quadratus lumborum 2, transmuscular QLB, LPB, LIA, fascia iliaca block, and intrathecal morphine, both alone and in combination is required with standardized outcome measures for safety, efficacy, and functional recovery, to determine the optimal analgesic regimen for THA.

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**Conflicts of interest**
There are no conflicts of interest.

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