Original Article

Comparison of continuous transmuscular quadratus lumborum block and continuous psoas compartment block for posterior total hip arthroplasty: A randomised controlled trial

Arjun Balakrishnan, Anjolie Chhabra, Ajeet Kumar[1], Praveen Talawar[2], Debesh Bhoi, Heena Garg

Department of Anaesthesiology, Pain Medicine and Critical Care, New Delhi, [1]Department of Anaesthesiology, All India Institute of Medical Sciences, Patna, Bihar, [2]Department of Anaesthesiology, All India Institute of Medical Sciences, Rishikesh, Uttarakhand, India

Address for correspondence:
Prof. Anjolie Chhabra, Room No. 5014-A, 5th-Floor Teaching Block, All India Institute of Medical Sciences, Ansari Nagar, New Delhi - 110 029, India.
E-mail: anjolie5@hotmail.com

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ABSTRACT

Background and Aims: Analgesia for hip surgery involves cutaneous anaesthesia at the site of the skin incision and the anterior hip capsule. This study aimed to compare continuous ultrasound (US)-guided transmuscular quadratus lumborum block (TQLB) with psoas compartment block (PCB) for analgesia in patients undergoing total hip arthroplasty (THA) under general anaesthesia (GA). **Methods:** This randomised, observer-blinded trial included 18–70-year-old American Society of Anesthesiologists physical status I–III patients undergoing THA under GA with either US-guided continuous TQLB or PCB. Primary objectives included a visual analogue scale (VAS; 0–100 mm) at rest and mobilisation at 6 h postoperatively (analysed by intention to treat and per protocol) using a non-inferiority margin of 20 mm. Secondary objectives included VAS at other time points, 24-h fentanyl consumption (analysed using the Wilcoxon rank-sum test), sensory dermatomes anaesthetised, motor weakness 30 min after block, and haemodynamic response to skin incision (analysed using the Chi-squared or Fisher's exact test). A *P* value less than 0.05 was considered statistically significant. **Results:** VAS (0-100 mm) score at 6 h on rest was 25.34 ± 14.25 and 27.3 ± 9.6, mean difference (MD) was 1.9 [–3.3, 7.1] and at movement was 35.1 ± 23.0 and 38.6 ± 17.0, MD was 3.5 [–5.2, 12.2], in the PCB ($n = 29$) and QLB ($n = 30$) groups, respectively (i.e. less than the non-inferiority margin). However, VAS (rest) at 1, 12, and 24 h postoperatively and median (IQR) 24-h fentanyl consumption was significantly higher in the QLB group (1212.5 [300–2345] µg] when compared to the PCB group (635 [100–1645] µg; $P = 0.0004$). **Conclusion:** Though statistically, continuous QLB was non-inferior to continuous PCB for pain at rest and mobilisation at 6-hours postoperatively, a higher 24-hour perioperative fentanyl consumption and VAS show that QLB was clinically inferior to PCB.

Key words: Arthroplasty, nerve block, pain, postoperative analgesia, psoas compartment block, transmuscular quadratus lumborum block, ultrasonography

INTRODUCTION

Analgesia for hip surgery involves cutaneous anaesthesia at the site of the skin incision and the anterior hip capsule, which is densely innervated by nociceptors.[1] The psoas compartment block (PCB) or the lumbar plexus block, especially a continuous infusion, is an effective technique for providing analgesia following posterior total hip arthroplasty

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(THA).[2] However, PCB has been associated with serious complications, namely retroperitoneal haematoma, total spinal anaesthesia, and cardiac arrest.[3]

The transmuscular quadratus lumborum block (TQLB) involves depositing local anaesthetic (LA) anterior to the quadratus lumborum muscle (QL) in the plane between the QL and psoas major muscles (PMM) at the 4th lumbar vertebra (L4) level.[4] Studies have described effective pain relief and reduction in opioid requirement with TQLB in patients undergoing THA.[5]

This study compares ultrasound (US)-guided continuous TQLB and PCB for providing perioperative analgesia in patients undergoing posterior THA under general anaesthesia (GA). The primary objectives were pain assessment at rest and mobilisation 6 h after surgery. Secondary objectives included assessing the sensory dermatomes anaesthetised, motor weakness 30 min after block, haemodynamic response to skin incision, 24-hour fentanyl consumption, pain during first two postoperative hours, and at 4, 12, and 24 h at rest and on ankle movement. Additionally, side effects, such as bruising, haematoma, hypotension, and the quality of recovery (QoR-40 score), at 24 h were also assessed.

METHODS

This randomised, observer-blinded controlled trial was conducted at a tertiary care institute. Ethics committee approval was obtained from the Institute Ethics Committee for Postgraduate Research, AIIMS, New Delhi (vide approval number IECPG-612/08.12.2016, RT-07 dated 19 January 2017), and registration at the Clinical Trials Registry - India (vide registration number CTRI/2017/03/008134 dated 17 March 2017, https://ctri.nic.in). The study was carried out by the principles of the Declaration of Helsinki, 2013. Written and informed consent for participation, research, and publication was obtained from eligible patients after explaining to them the study protocol. Inclusion criteria included 18–70-year-old American Society of Anesthesiologists (ASA) physical status I–III patients undergoing primary or revision posterior THA under GA. Exclusion criteria included patient refusal, coagulopathy, infection at the block site, bilateral THA, or body mass index (BMI) >30 kg/m^2. All patients were assessed and enrolled by investigator AB.

All patients received oral alprazolam (0.25 mg) the night before and on the morning of surgery.

The computer generated, variable block size randomisation numbers were concealed in serially numbered sealed, opaque envelopes. The patients were randomly allocated to the QLB or PCB group on opening of the envelope by a person not involved in the study. After standard fasting of 8 hours for solids and 2 hours for clear fluids, the patients were transferred to the block room 1.5 h before surgery. Monitoring (heart rate [HR], mean arterial pressure (MAP) using non-invasive blood pressure and oxygen saturation) was started, and baseline parameters were noted. All patients received intravenous (IV) midazolam (1–1.5 mg) and fentanyl (0.5 μg/kg), and oxygen (5 L/min) with a face mask. Patients were positioned lateral (operative side non-dependent) with a roll under the flank.

The blocks were performed using ultrasound (S-Nerve, Fujifilm SonoSite, Inc.; Bothell, Washington, USA) and a low-frequency curvilinear probe (3–5 MHz). After prepping-draping and skin infiltration with 5 ml of 1% lignocaine, a catheter over needle system (E-Cath according to Tsui [18-G and 83-mm] indwelling catheter and SonoPlex needle [21 G, 101 mm]; Pajunk, Germany) was used in-plane. All blocks were performed by anaesthesiologists who had administered ≥30 of these blocks before the study.

To perform continuous TQLB, the tip of the needle was advanced through the QL under US guidance until the ventral fascia of the QL was penetrated to reach the plane between the QL and PMM.[4] After confirming the needle-tip position via hydro-dissection, 0.4 ml/kg bolus of 0.25% ropivacaine was injected into the space. The catheter was threaded through the sheath, the tip re-confirmed, and the catheter fixed [Figure 1].

To perform continuous PCB, the needle was inserted under US guidance into the PMM with the peripheral

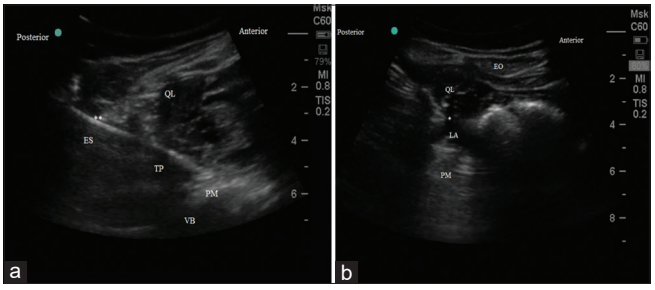

Figure 1: (a) Psoas compartment block (PCB) with needle shaft and tip (white arrow) in the psoas major muscle (TP = transverse process, VB = vertebral body, QL = quadratus lumborum). (b) LA* spread after quadratus lumborum block (QLB) (EO = external oblique, IO = internal oblique)

nerve stimulator (MultiStim SENSOR, Pajunk, Geisingen, Germany) connected till quadriceps twitch was observed with 0.5–0.7 mA current at 2 Hz.[6] After confirming the needle-tip position via hydro-dissection, 0.4 ml/kg bolus of 0.25% ropivacaine was injected. After that, the catheter was inserted and fixed [Figure 1].

Time from skin infiltration to bolus ropivacaine administration was taken as the time to perform the block. Thirty minutes later, sensory dermatomes from T10-L4 were assessed for loss of sensation to cold and pin-prick by a blinded observer and graded as 0 to indicate the total absence of sensation; 1 to indicate partial loss (can feel wet but not cold, touch but not pain); and 2 to indicate full sensation (can feel cold and pain). Both partial and total loss of sensation was considered successful blocks. Motor block was checked using the straight leg-raising (SLR) test and graded as full motor power (5); decreased power, lifting leg against resistance (4); decreased power, not lifting leg against resistance (3); not lifting leg against gravity (2); only flickering movements (1); no movements (0); Medical Research Council (MRC) Scale for Muscle strength Testing.[7]

After that, patients were transferred to the operating theatre, and routine monitoring was started. An anaesthesiologist not involved in the study provided anaesthesia to the patients. Patients received 2 μg/kg of fentanyl, 1.5–2.5 mg/kg of propofol and 0.5 mg/kg of atracurium IV, followed by tracheal intubation and ventilation with oxygen and nitrous oxide in a ratio of 50:50, isoflurane (minimum alveolar concentration [MAC] 1–1.3), ensuring normocapnia. Ropivacaine (0.25%) infusion at 0.1 ml/kg/h was started through the catheter before incision and continued for 24 h postoperatively.

Haemodynamic parameters, including response to skin incision, were noted. Any increase in HR or MAP 20% above the baseline was treated with boluses of 0.5 μg/kg IV fentanyl. In addition, all patients received 1 g of IV paracetamol 30 min before the end of the surgery, which was repeated six-hourly for 24 h.

At the end of the surgery, the residual neuromuscular block was reversed using 50 μg/kg of neostigmine and 10 μg/kg of glycopyrrolate IV. The patient's trachea was extubated after recovery of spontaneous respiration, reflexes, and consciousness. Patients were then transferred to the post-anaesthesia care unit where the pain was assessed by a blinded nurse-observer using a 0–100-mm, colour-coded Visual Analogue Scale (VAS) at rest (RVAS) on arrival (0 h), then every 15 min for the first 2 h and at 4, 6, 12, and 24 hours. VAS on movement (MVAS) at 6 h postoperatively was assessed on walking in patients in whom weight bearing was permitted. In others, it was evaluated on ankle dorsal and plantar flexion. At other time points (0–2, 4, 12, and 24 h), MVAS was assessed on ankle movement.

For RVAS or MVAS greater than 30 mm, clinical boluses of 0.5 μg/kg IV fentanyl were administered every 5–10 min till the VAS decreased to less than 30 mm. If VAS was persistently more than 30 mm after cumulative administration of 2 μg/kg of fentanyl, bolus doses of 0.1 mg/kg IV morphine were administered. Subsequently, patients were connected to a PCA device (Rythmic Evolution Blue, Micrel Medical Devices, Athens, Greece) to self-administer 25 μg boluses of IV fentanyl with a lockout interval of 5 min and a maximum of 150 μg in 1 hour. Total perioperative fentanyl and morphine consumption were noted. At 24 h after surgery, catheters were removed, any bruising or haematoma at the injection site was noted, and the QoR-40 score was assessed.[8]

The sample size was calculated based on the pilot study on 20 patients (10 per group). At 6 h postoperatively, RVAS was found to be 21 ± 15 and 23 ± 10, and MVAS was 24.5 ± 22.7 and 30 ± 17 (mean ± standard deviation [SD]) in groups PCB and QL, respectively. With an observed difference of 2 ± 13, the estimated sample size for RVAS was six per group with a non-inferiority margin of 20 mm. With an observed difference of 9 ± 19, the estimated sample size for MVAS was 20 per group. We included 30 patients per group to make allowances for attrition, with 80% power and 5% α error.

Statistical analysis was done using Microsoft Excel 2010 and Stata 14.0 (StataCorp, College Station, Texas, USA). Data are presented as numbers, mean ± SD or median (interquartile range) as appropriate. The primary outcomes (RVAS and MVAS at 6 h postoperatively) were analysed by both intention to treat (all patients) and per-protocol method (patients who walked after 6 h). Non-inferiority was announced if the upper limit of the 95% confidence interval (CI, two-sided) of the difference of means was less than 20 mm for

RVAS and MVAS at 6 h. The alpha error considered for both the outcomes was 0.025. Secondary outcomes RVAS and MVAS at 0, 1, 2, 4, 12, and 24 h and QoR scores were compared using the student *t*-test for independent samples. Haemodynamic parameters were analysed using repeated measures analysis of variance. Intraoperative, postoperative, and total perioperative fentanyl and time taken for block placement were analysed using the Wilcoxon rank-sum test. Motor block, dermatomes blocked, and morphine used were compared using Chi-squared or Fisher's exact test. A *P* value less than 0.05 was considered statistically significant.

RESULTS

Of the 63 patients, two from each group were excluded because of rescheduling. The final analysis included 29 patients in the PCB group and 30 in the QLB group [Figure 2]. Demographic and surgical parameters were comparable between the groups [Table 1]

The RVAS at 0–30 min and 12 and 24 h postoperatively were significantly lower in the PCB group [Figure 3]. MVAS was also significantly lower in the PCB group at 0–60 min postoperatively. The MVAS at 12 and 24 h postoperatively, though

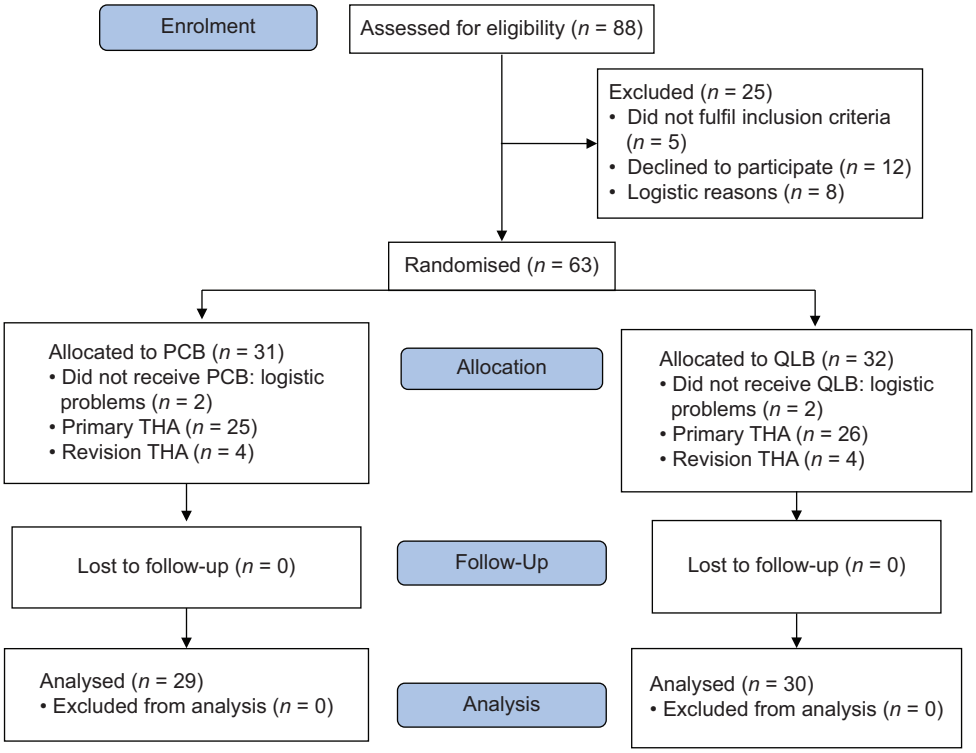

Figure 2: CONSORT (CONsolidated Standards Of Reporting Trials) flow diagram

Table 1: Demographic and surgical data

Parameter	PCB group (*n*=29)	QLB group (*n*=30)	*P*
Age (year; mean±SD)	42.2±15.9	39.3±16.3	0.70
Males-to-female ratio (*n*)	17:12	24:6	0.095
ASA classification (*n*)			
I	21	23	0.87
II	7	6	
III	1	1	
Weight (kg; mean±SD)	60.1±12.07	62.4±11.7	0.73
Primary THA (*n*)	25	26	
Revision THA (*n*)	4	4	1.0
Time taken for block placement (min), (median [range])	30 (15–150)	20 (10–40)	0.0001
Duration of surgery (min) (mean±SD)	70.51±28.51	82.66±44.40	0.21
Anaesthesia time (min) (mean±SD)	105.51±31.88	113.16±44.34	0.45

PCB=psoas compartment block, QLB=quadratus lumborum block, ASA=American Society of Anesthesiologists, THA=total hip arthroplasty. *P*<0.05 is statistically significant

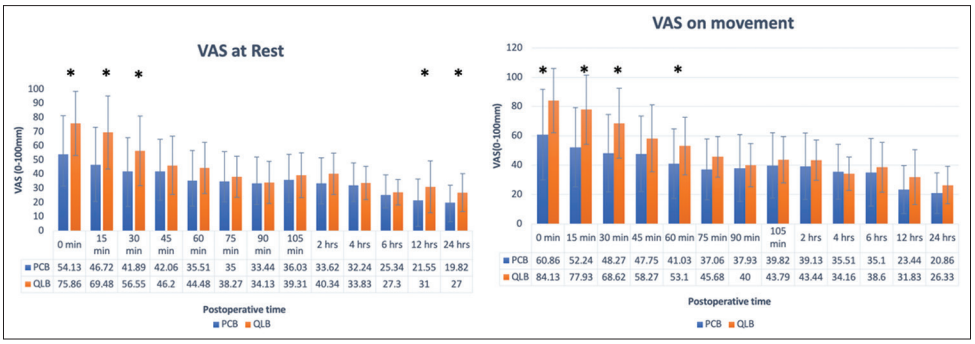

Figure 3: Visual analogue scale (VAS) (0-100mm) showing pain at rest and movement in the psoas compartment block (PCB) group and quadratus lumborum block (QLB) group from 0 to 24 h, postoperatively. Values in mean (SD). *$P < 0.05$

lower in the PCB group, was not statistically significant [Figure 3].

The primary outcome, RVAS at 6 h, was 25.34 ± 14.25 in the PCB group compared to 27.3 ± 9.6 in the QLB group. The mean difference (95% CI) was 1.9 [−3.3, to 7.1]. The MVAS was 35.1 ± 23.0 in the PCB group and 38.6 ± 17.0 in the QLB group, with a mean difference of 3.5 [−5.2, 12.2]. The upper limit of the 95% CI was less than the non-inferiority margin of 20 mm in both.

MVAS at 6 h could not be assessed on walking in five patients of the QLB group and four patients of the PCB group because the surgeon was concerned about bone fragility ($P = 0.505$). Therefore, MVAS at 6 h was assessed on ankle movement alone for these nine patients. After excluding these nine patients, the upper limit of 95% CI for both outcomes was less than the non-inferiority margin of 20 mm (per protocol) [Figure 4].

Assessment done 30 min after block showed that L1-3 dermatomes were mainly blocked in the PCB group (96.6%, 100%, and 89.7% patients, respectively) versus thoracic (T) 12 and L1 dermatomes were blocked primarily in 86.7% and 63.3% patients, respectively, in the QLB group. Eleven PCB patients experienced motor weakness 30 min after the block (mainly grades 3 and 4). No patient in the QLB group developed motor weakness.

At the time of skin incision, a significant increase in HR and MAP compared to baseline was observed in the QLB group ($P = 0.001$ and 0.002, respectively) and between the groups ($P = 0.002$ and 0.050, respectively). At all other periods, the HR and MAP between groups were comparable.

Total perioperative fentanyl consumed was more in the QLB group compared to the PCB group ($P = 0.0004$).

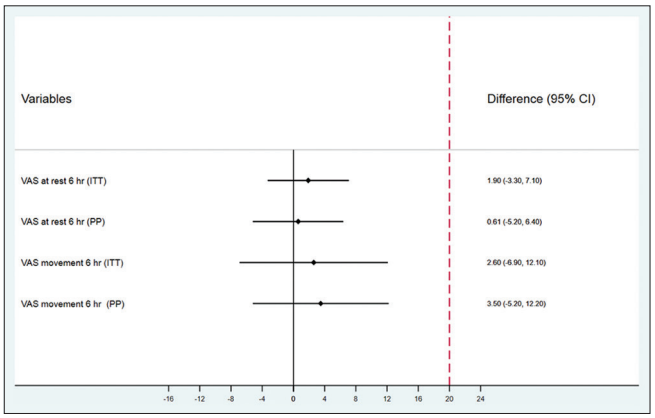

Figure 4: Visual Analogue Scale (VAS) at rest and movement after 6 h between the psoas compartment block (PCB) group and quadratus lumborum block (QLB) group. Data represented as the upper limit of the 95% confidence interval (CI) of the difference of means of VAS and analysed by intention to treat (ITT) and per protocol (PP) analysis

In addition, more patients in the QLB group (seven patients) required rescue analgesia with IV morphine when compared to the PCB group (one patient) ($P = 0.052$) [Table 2].

No patient in either group had bruising or haematoma. The QoR score at 24 h was 15.72 ± 1.96 in the PCB group and 13.83 ± 2.82 in the QLB group ($P = 0.002$).

DISCUSSION

In the present study, postoperative RVAS and MVAS on walking 6 h after posterior THA were found to be statistically non-inferior in the QLB group compared to the PCB group. However, the intraoperative statistically significant haemodynamic response to surgical incision, need for additional intraoperative fentanyl, and lower RVAS and MVAS in the initial 30–60 min after surgery combined with the significantly higher postoperative fentanyl consumption in the QLB group indicate that continuous TQLB was associated with more perioperative pain and higher fentanyl

Table 2: Fentanyl and morphine requirements between the two groups in the perioperative period

Parameter	PCB group (*n*=29)	QLB group (*n*=30)	*P*
Intraoperative rescue fentanyl (μg)	0 (0–100 [0, 0])	45 (0–140 [20, 75])	<0.0001
Postoperative rescue fentanyl (μg)	50 (0–110 [30, 90])	95 (0–205 [70, 140])	0.001
PCA fentanyl consumption (μg)	550 (100–1525 [400, 925])	1012.5 (200–2175 [850, 1275])	0.001
Total 24-h perioperative fentanyl[#] (μg)	635 (100–1645 [450, 985])	1212.5 (300–2345 [910, 1425])	0.0004
Rescue with morphine bolus (*n*)	1	7	0.052

PCB=psoas compartment block group, QLB=quadratus lumborum block group, PCA=patient-controlled analgesia. *P*<0.05 is statistically significant. [#]Total 24-h perioperative fentanyl=intraoperative fentanyl + immediately postoperative rescue analgesia + PCA fentanyl. Data reported as median (range [interquartile range]) or number (n)

requirement than continuous PCB in patients undergoing THA.

In the present study, loss of sensation after the block was mainly observed in the T12–L1 dermatomes in the QLB group, with only a blockade of T11–L2 in 9 of 30 (30%) patients. The skin incision for posterior THA is on the posterolateral part of the upper thigh, supplied by the subcostal, iliohypogastric (IH), and ilioinguinal (IIL) nerves, formed from the T12–L1 nerve roots. These are the first nerves of the lumbar plexus to emerge from the lateral border of the PMM and lie in the plane between QL; therefore, these nerves get blocked first in TQLB.[3] The genitofemoral (L1-2 roots) and the lateral femoral cutaneous nerve of the thigh (LFCN, L2-3 roots) emerge more distally from the PMM and may get blocked in 20%–30% of cases, as was observed in our study.[3,9,10] Three studies observed consistent staining of IIL, IH, subcostal, and LFC nerves in 90%–100%, 80%–90%, 50%–60%, and 22%–30% of cadaveric specimens, respectively, with TQLB.[9–11] Only one other study observed dye spread to the L1-3 nerve roots within the PMM with TQLB, which may have been due to inadvertent intramuscular injection into the PMM.[12]

The primary nerve supply to the anterior capsule of the hip joint is through the femoral and obturator nerves (L2-4 roots).[1] As these nerves emerge further distally from PMM at L4-5 and L5-S1,[3,11] these are inconsistently blocked with TQLB. Lumbar nerve roots are consistently anaesthetised (L1-3 dermatomes in 89.7%–100%) in the PCB group, providing better analgesia for posterior THA.

Prospective studies that assessed analgesia provided with TQLB in patients undergoing THA compared it to no block or local infiltration analgesia.[13–16] In these studies, T12–L1 dermatomes anaesthetised by TQLB may have provided cutaneous anaesthesia and seemed efficacious.[13–16] Only one study compared PCB to TQLB, but they used single injection PCB or TQLB combined with a subarachnoid block in THA.[17] Though central neuraxial blocks are considered standard of care for hip surgery, we compared GA combined with continuous TQLB or PCB because several patients scheduled for THA usually have chronic progressive inflammatory diseases or scoliosis due to hip deformity, which makes central neuraxial blocks, especially epidural catheter insertion difficult. Similar to our study, Polania Gutierrez *et al*.[17] found that opioid consumption in the first 6 h after surgery in the QLB group was double that in the PCB group ($P = 0.01$); however, the pain scores on movement and morphine consumption at 24 h were comparable. This was because patients received paracetamol, celecoxib, ketorolac, gabapentin, and ketamine as a multimodal analgesic regime. In our study, patients only received IV paracetamol as an adjunct to the continuous blocks, making the significantly higher PCA IV fentanyl consumption in the QLB group more apparent.

The limitations of our study included an inability to assess pain on SLR at all time points studied, as flexion of more than 90° at the hip joint is not recommended in the initial 6 h following posterior THA. Pain on mobilisation at 6 h was the primary outcome because the rapid arthroplasty mobilisation protocols encourage the mobilisation of patients after 6 h. Where this was impossible, we assessed MVAS by asking patients to move their ankles alone.[18]

While serious complications have been reported with PCB, TQLB is also a deep block with the potential to cause visceral injury (kidney or bowel). Inadvertent lower limb weakness, hypotension, and haematoma have been reported with other approaches of the QLB block.[19,20] In this study, bruising, haematoma, or hypotension was not observed in any patient. Motor block (mainly the inability to lift against resistance) 30 min after the block was observed in 11 of 29 patients in the PCB group but none in the QLB group. During mobilisation at 6 h, no patient experienced motor

weakness or drowsiness that prevented them from mobilisation.

CONCLUSION

Though statistically, QLB was non-inferior to PCB. This was probably due to significantly greater total 24-h fentanyl consumption in the QLB group. The significant response to skin incision and higher VAS at 30–60 min and 12 and 24 h postoperatively indicate that continuous QLB is clinically inferior to continuous PCB for providing analgesia in patients undergoing THA under GA. Further large, multi-centric trials are needed to validate the results of the present study.

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Conflicts of interest

There are no conflicts of interest.

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