The Comparing of Ultrasound-guided Techniques: Sciatic Block with Continuous Lumbar Plexus Block or Continuous Femoral Nerve Block for Anesthesia and Analgesia of Total knee Replacement

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Abstract: *Background and Aims:* This double blind prospective randomized clinical trial evaluated the efficacy and safety of continuous ultrasound-guided lumbar plexus block compared to continuous ultrasound-guided femoral nerve block, in the intra-operative and postoperative periods after total knee replacement.

Methods: Forty ASA I-III patients were randomized to receive: continuous femoral block (n= 20, 30 ml of ropivacaine 5 mg/ml) or continuous lumbar plexus block (n= 20, 30 ml of ropivacaine 5 mg/ml) both in association with single injection sciatic nerve block. All patients received continuous infusion of 2 mg/ml of ropivacaine at 8 ml/h for 48 hours and intravenous morphine for patient-controlled analgesia. Primary outcomes were intra-operative sufentanil consumption and verbal analogue scale (VAS) score at rest at 24h follow up.

Results: Intra-operative sufentanil consumption was higher in the femoral block (FEM) group compared to the lumbar plexus block (PSOAS) group (FEM: 10.00 (10.00, 17.50) μg; PSOAS: 2.50 (0.00, 10.00) μg. p= 0.002).

Obturator motor blockade occurred more frequently in the PSOAS group (70%) than in the FEM group (40%) (p=0.1); however, we found no differences in sensory blockade (p=0.6).

VAS at rest was similar in the two groups at 24h postoperatively (FEM: 29.50 ± 14.74 mm; PSOAS: 25.60 ±17.42 mm. p=0.4), and throughout the follow-up period. No differences were detected in pain scores during physiotherapy.

Conclusion: Continuous femoral and lumbar plexus blocks, both in association with sciatic nerve block, provided similar VAS scores at 24h, and throughout the follow-up period; intra-operative sufentanil consumption was, however, lower in the lumbar plexus block group.

Keywords: Continuous ultrasound-guided femoral nerve block, continuous ultrasound-guided lumbar plexus block, postoperative analgesia, total knee replacement.

INTRODUCTION

It is well known that suboptimal postoperative pain management after total knee replacement (TKR) is one of the main factors for physiotherapy and rehabilitation impairment and prolongation [1]. Several authors have demonstrated that continuous peripheral techniques represent a better side effect profile alternative than PCA or epidural analgesia after TKR, improving most of the common rehabilitation goals, through finer pain relief [1-3].

The role of femoral nerve block in this clinical setting, is well established [4]. However, obturator nerve blockade has a controversial role in TKR pain management. McNamee *et al.* [5] concluded in their trial that the addition of an obturator nerve block to femoral and sciatic blockade improves post-operative analgesia after TKR [5]. This could be explained considering that the three-in-one block does not involve the posterior branch of the obturator nerve [6], resulting in a less consistent blockade of this nerve than the lumbar plexus block (PSOAS) [5, 7]. However, Kaloul *et al.* [8] and Morin *et al*. [9] found no differences in postoperative pain relief comparing continuous lumbar plexus and femoral blockades, after TKR. None of these previous studies explored intra-operative time, nor did they use ultrasound-guided techniques.

Thus, the aim of this study was to compare the efficacy and safety of continuous ultrasound-guided lumbar plexus and femoral blocks for intra-operative anesthesia and for postoperative analgesia after TKR.

METHODS

Patient Selection and Study Design

This was a randomized double blind study design. After the approval of the study design by the "Tor Vergata University Ethics Committee", and having obtained written in-

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formed consent from each patient, we enrolled 40 American Society of Anesthesiologists (ASA) physical status class I-III patients who were scheduled for unilateral elective TKR; they were randomized by a computer-generated list to be allocated to one of the two groups: the FEM group received continuous ultrasound guided femoral nerve block and single shot ultrasound-guided sciatic nerve block (n=20); the PSOAS group received continuous ultrasound-assisted lumbar plexus block and single shot ultrasound-guided sciatic nerve block (n=20). Exclusion criteria included allergy to any local anesthetic; dementia with incomplete understanding; refusal of the procedure; ASA physical status class IV; use of psychotropic drugs (all drugs used in psychiatric disorders) and abuse of alcohol and drugs (the harmful or hazardous use of psychoactive substances, including alcohol and illicit drugs), severe hematological and coagulation disorders, severe rhythm disorders, neurological disorders (peripheral neuromuscular), local or systemic infection, history of chronic pain. Patients in the FEM group received continuous ultrasound-guided femoral nerve block and single shot ultrasound-guided sciatic nerve block, patients in the PSOAS group received continuous ultrasound-guided lumbar plexus block and single shot ultrasound-guided sciatic nerve block.

Anesthetic Protocol

Before surgery, patients underwent regional anesthesia after non-invasive monitoring and intravenous premedication with midazolam 1 to 3 mg.

FEM group: the patient was placed in the supine position: the groin was prepped and draped in sterile fashion; the same was done for the ultrasound probe. The physician applied the probe to the patient's groin and the femoral nerve sheath was visualized. A small skin wheal was made over the target site with lidocaine. The injection was made using a 50mm, 17-gauge insulated needle (Polymedic; Temena SARL, Bondy, France) attached to a syringe with 30 ml of 5mg/ml of ropivacaine, which was inserted in-plane with the probe. Once the needle came into view on the monitor, the tip was positioned posterior to the femoral nerve and the catheter was then inserted under the femoral nerve. After the needle was withdrawn, the catheter tip position was verified with the probe and ropivacaine solution was then injected. Finally, the catheter was tunneled and fixed with a sterile medication.

PSOAS group: the patient was placed in the lateral decubitus position with the side to be operated uppermost, and the area was prepared and draped in a sterile fashion. A 7 MHz curved array C11 ultrasound probe, draped in a sterile manner, was applied to the patient's lumbar area in a cross-sectional fashion. The L3 spinous process and the transverse process of L3 were identified. After local anesthetic skin infiltration, a 120mm, 17-gauge insulated needle (Polymedic; Temena SARL, Bondy, France) connected to a peripheral nerve stimulator (Stimuplex; B. Braun, Melsungen, Germany) with initial current intensity of 1.0 mA (2 Hz, 0.1 millisecond) was introduced in-plane with the probe. The lumbar plexus was finally identified by eliciting quadriceps contraction at current below 0.4 mA. The catheter was then inserted in the needle and advanced 3 cm beyond the needle tip and a total of 30 mL of ropivacaine 5 mg/ml was injected in incremental doses. The needle was then withdrawn and the catheter was tunneled and fixed with a sterile medication.

Sciatic nerve block: the patient was left in the same lateral position. The ultrasound curved transducer was positioned on the line connecting the ischial tuberosity and greater trochanter, and the hyperechoic sciatic nerve was identified. After skin infiltration with 1% lidocaine, the block was performed with a short bevel 120 mm, 21-gauge insulated nerve block needle inserted in-plane with the transducer with lateral to medial direction. A local anesthetic solution of 20 mL of 5 mg/ml of ropivacaine was then injected incrementally surrounding the nerve.

The same anesthesiologist, who had experience in both techniques, performed all procedures in both groups.

The observer was unaware of patient group allocation; moreover he was not present during the block execution, returning at the end of the procedure in order to collect the data required. Each patient had two catheters with filters fixed in the same way to the skin: the real catheter of the continuous block according to randomization and a phantom catheter from the area of the block not performed in order to keep both the patient and the observer blind. Both catheters were removed at 48h of follow-up. Only the study coordinator and the anesthesiologist performing the chosen technique were informed, according to the randomization list.

Sensory and motor blockade of the FEM and PSOAS was assessed every five minutes until their appearance. Sensory and motor blockade of the obturator nerve was also recorded.

Intra-operative Management and Follow-up

In the operating room, ASA standard monitors were placed and vital signs recorded every 15 minutes.

During surgery, in event of pain expressed by the patient, sufentanil (0.2-0.4 μg/kg) was titrated until regression of pain. In the event of persistent patient discomfort, sedation could be administered with propofol in TCI (Target Controlled Infusion) mode (Orchestra® Base Primea, Fresesnius Kabi), Schneider pharmacokinetic protocol (initial target site-effect concentration of 1.5 μg ml), maintaining spontaneous breathing. No local anesthetics were administered through the perineural catheter during the intra-operative period. At the end of the procedure, an elastomeric pump with 2 mg/ ml of ropivacaine at 8 ml/h infusion rate was connected to the catheter of each patient of each group; each patient was also connected to a PCA device (I Pump, Baxter) set to deliver a 2 mg morphine bolus, with 10 min lockout and a one hour limit of 8 mg morphine. In the surgical ward, patients were able to request an additional analgesic (ketorolac 30 mg, maximum 90 mg/day).

Outcomes

The primary outcomes of this study were VAS score at rest at 24h and total intra-operative sufentanil consumption. Pain intensity was scored using a 0 to 100 verbal analogue scale (VAS). Pain scores at rest were noted before surgery, at the end of surgery, at 2h, 6h, 12h, 24h, 36h and 48h after surgery. Secondary outcomes were: pain score during physiotherapy (24h), 48h postoperative morphine consump-

tion (recorded at the end of surgery, 2h, 6h, 12h, 24h, 36h and 48h of follow-up), and the assessment of motor blockade of the femoral and obturator nerves. Motor blockade was evaluated testing the ability to straighten the operative leg against the hand of the examiner (FEM: end of surgery, 2h, 6h, 24h, 48h) or evaluating hip adduction, with knee flexed, against resistance (obturator nerve); movement was classified according to modified Bromage scale: no weakness = 0; partial weakness = 1; almost complete weakness = 2; complete weakness = 3 [10]. Sensory blockade of the obturator nerve was assessed as decreased perception to ice over the internal medial area of the thigh. Intra-operative hemodynamic parameters, total intra-operative propofol consumption, patient and surgeon overall satisfaction were also recorded, assessed by a scale from 0 (unsatisfied) to 10 (very satisfied). All data were collected by a clinical research assistant, who was blinded to the technique used.

Statistical Analysis

To calculate the sample size an α error = 0.05 (type I error probability for a 2-sided independent t test) and β error = 0.2 (power 80%) was accepted. Our first hypothesis (H_1) was to find at least a difference of 60% in the use of intra-operative sufentanil required. Our second hypothesis (H_2) was to find at least a VAS difference between groups of 20 mm, during the post-surgery follow-up.

Minimal sample sizes of 36 patients (18 in each group) and 34 patients (17 in each group) for the two clinical settings, respectively, met these criteria. Thus 20 patients for each group were recruited to allow for incomplete data collection. We based analyses on the intention to treat principle; we thus included all randomised patients who had potentially ultrasound guided regional anestesia and analgesia for TKR.The t-test was used to analyze normally distributed numeric variables. For non-parametric variables, the Mann-Whitney U test was used. Categorical differences were tested using the Yates's chi-square test or the Fisher exact method depending on the size of the observed frequencies. A p-value <0.05 was considered statistically significant. Statistical analyses were performed using the free software G*Power version 3.1.4 (Faul, Erdfelder, Lang, & Buchner, 2009) and the commercial software MATLAB version R2011a (MathWorks, Natick, Massachusetts, USA).

RESULTS

A total of 40 patients were assessed for eligibility and all were analyzed following an intention-to-treat method (FEM=20, PSOAS=20). There were 2 patients whose catheters were accidentally removed in the early period of follow-up, both in the PSOAS group. There were no significant differences between the two groups according to sex, age, ASA score, BMI and preoperative values (Table **1**).

The total amount of intra-operative sufentanil consumption was lower in the PSOAS group (p= 0.002) (Table **3**).

VAS score at rest was similar in the two groups, both at 24h postoperatively (FEM: 29.50 ± 14.74 mm; PSOAS: 25.60 ±17.42 mm; p=0.4) and throughout the postoperative follow-up period (Fig. **1a**; Fig. **1b**).

There were no differences in pain scores during physiotherapy (24h) (FEM 39.4 ± 27.5 mm; PSOAS 40.6 ± 23.7 mm; p= 0.7).

Total morphine self-administration was similar in the two groups throughout the postoperative follow up period (FEM:

Table 1. Demographic Data

	FEM (N=20)	PSOAS (N=20)	p-value
Age (years)	75.00 (68.50, 78.00)	74.00 (65.00, 78.00)	0.6
Sex (M/F)	6/14	7/13	0.7
Height (cm)	165.00 (160.00, 172.50)	164.00 (158.50, 168.00)	0.3
Weight (Kg)	81.00 (71.50, 87.50)	73.00 (68.00, 82.50)	0.08
BMI (Kg/m^2)	30.00 (27.00, 31.50)	28.00 (25.00, 31.00)	0.3
ASA I **II** **III**	1 17 2	2 13 5	0.3
SBP- pre (mmHg)	139.10 ± 23.64	137.55 ±17.42	0.8
DBP- pre (mmHg)	80.50 ± 77.50, 90.00	75.00 ± 68.50, 82.00	0.1
MBP- pre (mmHg)	99.50 ± 14.07	96.30 ± 11.85	0.4
BPM- pre (bpm)	68.30 ± 8.89	70.05 ± 6.17	0.5
Hb- pre (mg/dl)	13.35 (12.3, 14.4)	12.60 (12.3, 13.6)	0.2

FEM = continuous femoral nerve block; PSOAS = continuous posterior lumbar plexus block. Age, weight, height, BMI, ASA and Hemoglobin (Hb) are expressed as median (IQR) and range. SBP- pre, DBP-pre and MBP-pre are expressed as mean ± standard deviation. SBP: systolic blood pressure. DBP: diastolic blood pressure. MBP: mean blood pressure. –pre: preoperative values.

Table 2. Assessement of Motor Block of Femoral Nerve Throughout 48h of Follow Up

Motor block	FEM (n° 20)	PSOAS (n° 20)	p-value
End of surgery	3.00 (3.00, 3.00)	3.00 (3.00, 3.00)	0,7
2 h	3.00 (3.00, 3.00)	3.00 (3.00, 3.00)	0,2
6 h	3.00 (2.00, 3.00)	3.00 (2.00, 3.00)	0,6
12 h	2.00 (2.00, 2.00)	2.00 (2.00, 2.50)	0,9
24 h	1.00 (1.00, 2.00)	2.00 (1.00, 2.00)	0,1
36 h	1.00 (1.00, 1.50)	1.50 (1.00, 2.00)	0,06
48 h	1.00 (0.50, 1.50)	1.00 (1.00, 2.00)	0,3

Movement was classified as follows: no weakness = 0; partial weakness = 1; almost complete weakness = 2; complete weakness = 3. Data are expressed as median (IQR) and range.

5.50 (1.50, 10.00); PSOAS: 6.00 (3.00, 7.00); p=0.7) (Fig. **2a**, Fig. **2b**).

After anesthesia, the rate of obturator nerve motor blockade was higher in the PSOAS group (70%) than in the FEM group (40%); however, sensory blockade of the same nerve was similar between groups (p=0.6). Concerning motor blockade of the femoral nerve, this was similar between groups throughout the follow-up (Table **2**).

Intra-operatively, there were no differences between groups regarding the amount of propofol infused, or surgery (and tourniquet duration (Table **3**). Hemodynamic parameters were similar between groups during surgery, including the times of the most painful stimuli (incision, femoral bone resection, and tibial bone resection) (Table **3**).

There were no differences regarding postoperative hemodynamic data during the follow-up or in rescue ketorolac consumption (p=0.9) (data not shown).

Postoperative blood loss from drainages was similar in the two groups (FEM: 779.50 ± 212.99; PSOAS: 821.00 ± 295.10; p=0.6) as was hematic hemoglobin concentration before (p=0.1), and 24h (p=0.06) and 48h (p=0.6) after surgery. A total of 23 patients were transfused after surgery, with no differences between groups. Regarding complications, there were no differences regarding postoperative nausea (FEM: 30%; PSOAS: 25%; p=1.0) and vomiting (FEM: 10%; PSOAS: 20%; p=0.6) between groups. Only two patients in the FEM group reported post-operative pruritus (p=0.5). There were no adverse effects linked to perineural injection of ropivacaine. No technique-related complications were reported.

There were no significant differences between the groups in terms of surgeon satisfaction (P=0.08); patient satisfaction was greater for the PSOAS group than for the FEM group (P=0.01).

DISCUSSION

The results of this study demonstrate that both FEM and PSOAS blocks provided satisfactory surgical anesthesia and similar VAS during the first 48 hour postoperatively. However, overall intra-operative sufentanil consumption was reduced in the PSOAS group (Table **3**), probably thanks to the higher rate of obturator nerve territory involvement by lumbar plexus block compared to femoral nerve block. We evaluated obturator nerve blockade assessing the hip adduc-

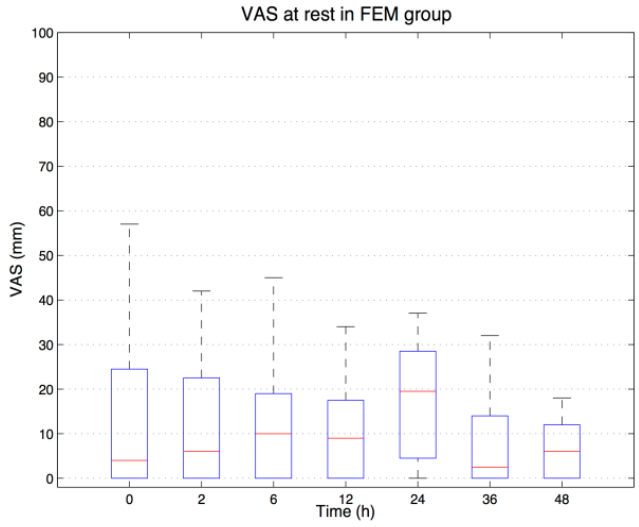

Fig. (1a). VAS at rest in FEM group throughout the follow up period. Data are shown as median (IQR) and range.

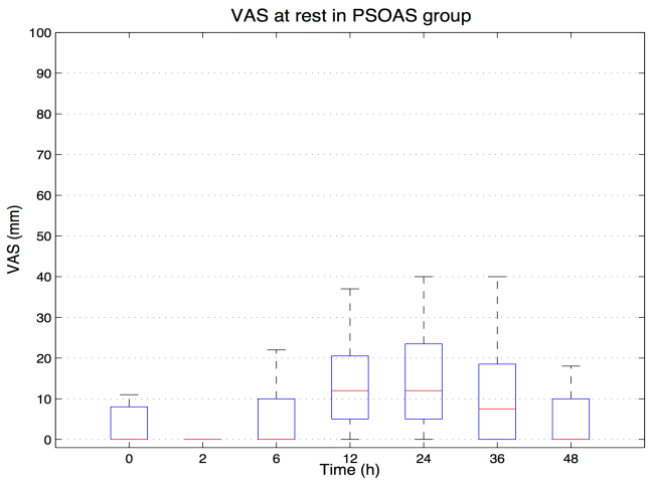

Fig. (1b). VAS at rest in PSOAS group throughout the follow up period. Data are shown as median (IQR) and range.

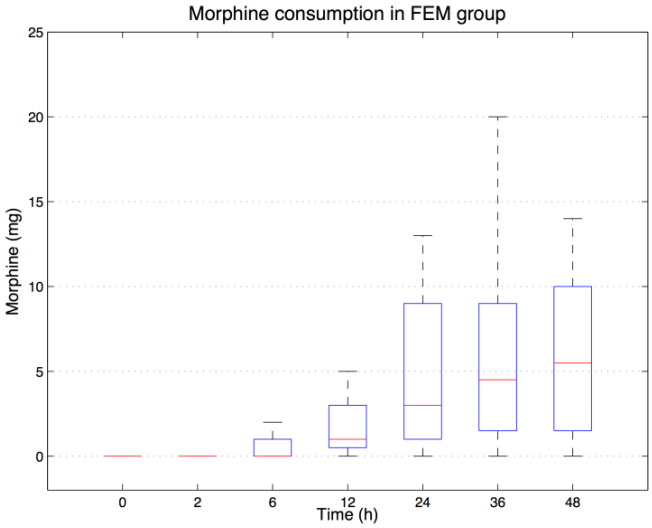

Fig. (2a). morphine consumption in FEM group throughout the follow up period. Data are expressed as median (IQR) and range.

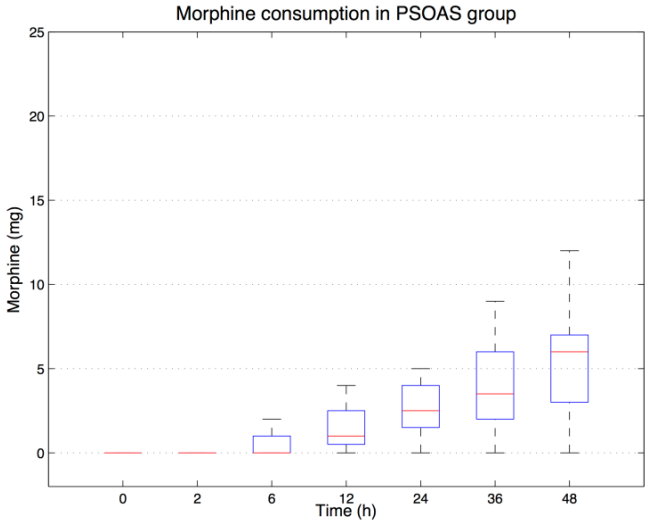

Fig. (2b). morphine consumption in PSOAS group throughout the follow up period. Data are expressed as median (IQR) and range.

tor strength, considering the finding of Bouaziz *et al*. who demonstrated that the cutaneous distribution of the obturator nerve is not only highly variable but may even be incomplete or totally absent (57% of the patients) [11]. To our knowledge, there are currently no studies that explore whether adding obturator nerve block to femoral nerve blocks results in improved intra-operative TKR management.

Table 3. Intraoperative Data

	FEM (n=20)	PSOAS (n=20)	p-value
Skin incision			
SBP (mmHg)	145.45 ± 37.92	139.30 ± 32.02	0.6
DBP (mmHg)	79.00 (69.50, 80.50)	70.00 (64.00, 82.00)	0.3
MBP (mmHg)	100.00 (87.50, 106.00)	88.50 (82.50, 109.00)	0.7
HR (bpm)	66.00 (60.00, 77.00)	61.50 (57.50, 66.00)	0.1
Femoral bone resection			
SBP (mmHg)	132.95 ± 29.49	132.95 ± 29.49	0.6
DBP (mmHg)	70.90 ± 15.01	69.50 ± 13.48	0.8
MBP (mmHg)	91.55 ± 18.41	89.30 ± 16.79	0.7
HR (bpm)	63.00 (58.50, 69.00)	59.50 (55.50, 66.00)	0.3
Tibial bone resection			
SBP (mmHg)	127.95 ± 28.85	129.00 ± 25.30	0.9
DBP (mmHg)	71.45 ± 14.25	67.15 ± 12.26	0.3
MBP (mmHg)	90.35 ± 17.58	87.75 ± 15.38	0.6
HR(bpm)	59.00 (55.00, 69.50)	59.00 (56.00, 66.50)	0.9
Propofol (mg)	500.00 (295.00, 728.00)	358.50 (42.00, 578.00)	0.1
Sufentanil (μg)	10.00 (10.00, 17.50)	2.50 (0.00, 10.00)	0.002
Tourniquet (min)	77.85 ± 22.13	83.70 ± 14.60	0.3
Surgery duration (min)	104.25 ± 19.89	104.50 ± 30.08	0.9

Data are espressed as Mean ± SD or as median (IQR) and range. SBP: systolic blood pressure. DBP: diastolic blood pressure. MBP: mean blood pressure. HR: heart rate.

We know, however, from anatomy studies that the posterior branch of the obturator nerve terminates by passing through the adductor hiatus to enter the popliteal fossa, supplying the posterior aspect of the knee joint and the popliteal artery. Considering all these data, we could argue that obturator nerve block could be important for intra-operative TKR management, but we cannot affirm this only on the basis of our trial results.

Considering the postoperative period, the question whether or not obturator nerve block improves postoperative analgesia still remains unclear. McNamee *et al.* [5] affirm that the addition of an obturator nerve block improved postoperative analgesia following total knee replacement; however, while our results show a higher rate of obturator nerve involvement in the PSOAS group, there were no differences between the two techniques in terms of VAS pain scores and total morphine consumption after TKR. In agreement with our trial, Kaloul *et al.* [8] suggest that obturator nerve involvement does not improve postoperative pain scores after TKR; Morin *et al.* [9] come to the same conclusion. Preliminary results by Lund *et al.* go in the opposite direction: continuous adductor-canal-blockade may be a valuable adjunct for post-operative analgesia after major knee surgery [12]. With this scenario we can affirm that, both for the intraoperative and postoperative period after TKR, the role of obturator nerve block remains unclear and further trials are therefore necessary to clarify this aspect. Considering our trial results, we could argue that obturator nerve block could be important for intra-operative management but is not necessary for the postoperative period.

We did not detect any differences in post operative complications between the groups. Only one patient in the PSOAS group reported post-operative pruritus. There were no adverse effects linked to perineural injection of ropivacaine; however, the power chosen for the study may have led to a false negative result. We chose a single anesthesiologist with considerable experience in peripheral nerve block, to manage all the patients, thus reducing methodological bias.

There are several reports about serious adverse complications linked to the continuous lumbar plexus technique (total spinal anesthesia, epidural spread of local anesthetic, acute local anesthetic toxicity, and renal subcapsular, psoas and retroperitoneal hematomas) [13-18], despite weak benefits observed over the femoral technique.

Ultrasound guidance, however, may increase the safety and efficacy of both techniques [19, 20]. Above all for lumbar plexus block, this could translate into higher success rates and reduced needle-related complications [21].

Continuous femoral and lumbar plexus blocks, both in association with sciatic nerve block, provided similar VAS scores at all times of the follow-up. Intra-operative sufentanil consumption was reduced in the lumbar plexus block group; however, the clinical significance of this finding is unclear.

Analyzing both technique-related complications, continuous ultrasound-guided femoral nerve block seems to be the best choice considering the risk/benefit balance. Whether to add obturator nerve block for the intra-operative period requires further evaluation.

CONFLICTS OF INTEREST

The authors confirm that this article content has no conflicts of interest.

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This was a not for profit trial.

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