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Original contribution

Lumbar plexus block versus suprainguinal fascia iliaca block for total hip arthroplasty: A single-blinded, randomized trial

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ABSTRACT

Study objective: Comparison of ultrasound-guided lumbar plexus block (LPB) and suprainguinal fascia iliaca block (SIFIB) in patients undergoing total hip arthroplasty (THA).
Design: Randomized equivalence trial.
Setting: University Hospital.
Patients: Sixty patients undergoing primary THA.
Interventions: Patients were randomly allocated to receive ultrasound-guided LPB (n = 30) or SIFIB (n = 30). The local anesthetic agent (40 mL of levobupivacaine 0.25% with epinephrine 5 μg/mL) and block adjuvant (4 mg of intravenous dexamethasone) were identical in all subjects. Postoperatively, all patients received patient-controlled intravenous analgesia (morphine) as well as acetaminophen and ketoprofen during 48 h.
Measurements: A blinded investigator recorded morphine consumption at 24 and 48 h as well as time to first morphine request, pain scores at 3, 6, 12, 24 and 48 h, incidence of adverse events, time to readiness for discharge, and length of hospital stay. The blinded investigator also carried out sensorimotor block assessment at 3, 6 and 24 h using a 10-point sensorimotor composite scale.
Main results: No intergroup differences were found in terms of cumulative morphine consumption at 24 h (95% CI: −4.0 mg to 2.0 mg) and 48 h (95% CI, −5.0 mg to 2.0 mg) or time to first morphine request. Furthermore, pain scores were similar at all time intervals after 3 h. There were no intergroup differences in terms of composite sensorimotor scores at 3 and 6 h. However, SIFIB lasted longer than lumbar plexus block as evidenced by a higher composite score at 24 h. No intergroup differences were found in terms of complications. Compared with LPB, SIFIB was associated with shorter time to readiness for discharge (3 [1-4] vs. 2 [1-3] days; P = 0.042) and length of hospital stay (3 [2-5] vs. 3 [2-4] days; P = 0.048).
Conclusions: For THA, no differences were found between LPB and SIFIB in terms of breakthrough morphine requirement and pain control. However, SIFIB resulted in a longer block and was associated with shorter time to readiness for discharge as well as decreased hospital stay.

1. Introduction

First described in 2011, ultrasound (US)-guided suprainguinal fascia iliaca block (SIFIB) targets the fascia iliaca compartment cephalad to the inguinal ligament [1]. In addition to the femoral and lateral femoral cutaneous nerves, SIFIB can also anesthetize the obturator nerve [2–5].

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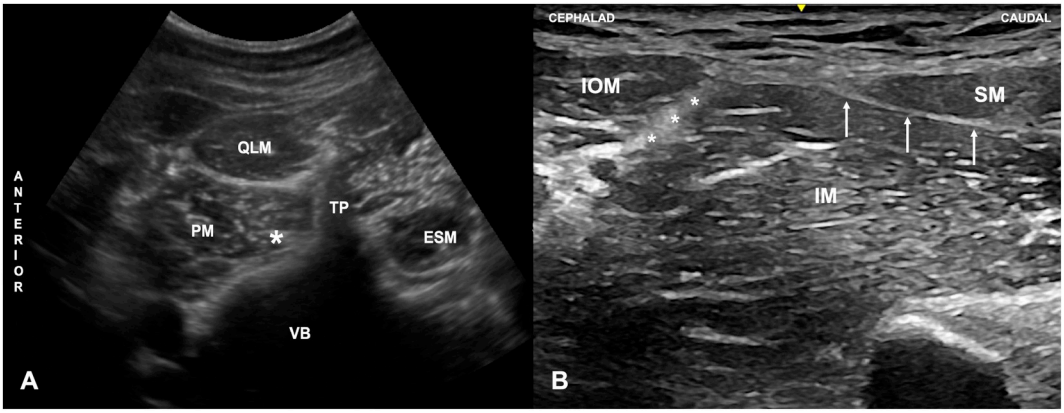

Fig. 1. A. Target for lumbar plexus block.
B. Target for suprainguinal fascia iliaca block.
ESM: erector spinae muscle; IM: iliacus muscle; IOM: internal oblique muscle; PM: psoas muscle; QLM: quadratus lumborum muscle; SM: sartorius muscle; TP: transverse process; VB: vertebral body.
The white arrows indicate the fascia iliaca.
The asterisks indicate the needle target.

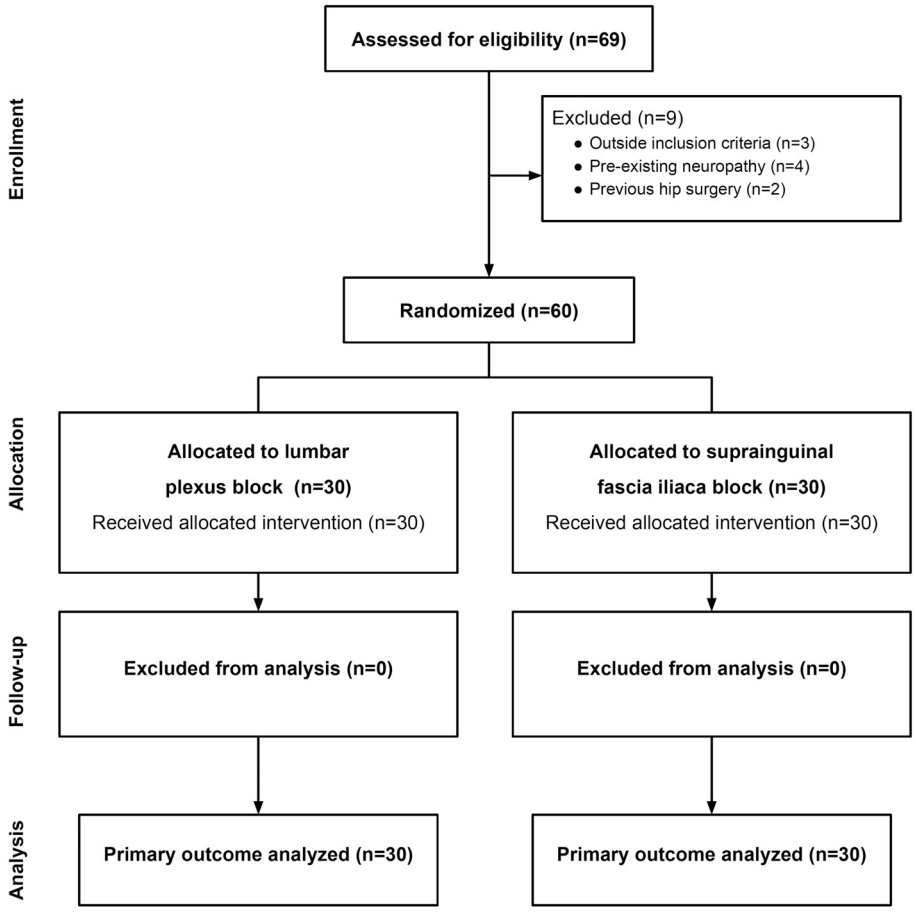

Fig. 2. CONSORT diagram of patient flow through the study.

The improved obturator blockade may explain why recent randomized trials have found superior postoperative analgesia with SIFIB compared to conventional fascia iliaca block (performed below the inguinal ligament) for total hip [6] and total knee arthroplasty [5]. In fact, Kumar et al. [6] opined that SIFIB constitutes an effective strategy to anesthetize the lumbar plexus. This hypothesis remains unproven, as SIFIB has not been directly compared to lumbar plexus block (LPB).

Thus, in this randomized trial, we compared US-guided SIFIB and LPB in patients undergoing total hip arthroplasty. We speculated that, if SIFIBs can reliably anesthetize the femoral, lateral femoral cutaneous and obturator nerves, they should provide similar analgesia to their lumbar plexus counterparts. Consequently, we selected 24-hour breakthrough intravenous morphine consumption as the primary outcome and designed the study as an equivalence trial (equivalence margin = 3.3 mg).

Table 1
Patient demographics and surgical duration.

	LPB (n = 30)	SIFIB (n = 30)
Age (years)	59.5 (13)	62.9 (10.9)
Sex (male/female)	10/20	10/20
BMI (kg/m^2)	28.2 (4.7)	27.5 (3.8)
ASA (I/II/III)	6/24/0	5/25/0
Surgical duration (minutes)	71.3 (18.6)	65.9 (21.4)

Continuous variables are presented as mean (SD), while categorical variables are presented as counts. ASA: American Society of Anesthesiologists; BMI: body mass index; LPB: lumbar plexus block; SIFIB: suprainguinal fascia iliaca block.

Table 2
Postoperative opioid consumption, sensorimotor block, block performance data, adverse events, and length of stay.

	LPB (n = 30)	SIFIB (n = 30)	P value
Cumulative morphine consumption at 24 h (mg)	5.0 (9)	6.0 (6)	0.476[a] (−4.0 to 2.0)
Cumulative morphine consumption at 48 h (mg)	6.0 (15.5)	9.0 (10.8)	0.584[a] (−5.0 to 2.0)
Time to first morphine request (hours)	5.5 (8.5)	4.9 (4.8)	0.269[a]
Composite score at 3 h (0−10)	6 [1−10]	7.5 [3−10]	0.191[a]
Composite score at 6 h (0–10)	5 [0−10]	6 [3–10]	0.082[a]
Composite score at 24 h (0–10)	1 [0–5]	3 [0–6]	< 0.001[a]
Inability to perform physiotherapy at 24 h	3 (10)	0	0.237[b]
Performance time (min)	3.8 (1.5)	4.8 (1.8)	0.020[c]
Number of passes	1.5 [1–5]	2 [1–3]	0.357[a]
Vascular puncture	0	0	Not assessed
Local anesthetic toxicity	0	0	Not assessed
Postoperative nausea/vomiting	2 (6.7)	2 (6.7)	> 0.999[b]
Pruritus	3 (10)	1 (3.3)	0.612[b]
Somnolence	0	1 (3.3)	> 0.999[b]
Respiratory depression	0	0	Not assessed
Epidural spread of local anesthetic	2 (6.7)	0	0.492[b]
Time to readiness for discharge (days)	3 [1–4]	2 [1–3]	0.042[a]
Length of stay (days)	3 [2–5]	3 [2–4]	0.048[a]

Continuous variables are presented as mean (SD); categorical variables are presented as count (percentage). Ordinal variables (i.e., number of passes, composite scores, time to readiness for discharge, length of stay) are presented as median [range]. Morphine consumption at 24 and 48 h is presented as median (interquartile range). The 95% confidence intervals are presented in parentheses under the P values for morphine consumption at 24 and 48 h. LPB: lumbar plexus block; SIFIB: suprainguinal fascia iliaca block.

[a] Mann-Whitney *U* test.
[b] Fisher's exact test.
[c] Student's *t*-test.

2. Material and methods

The current trial was registered at ClinicalTrials.gov (Study ID: NCT03744065) on 11/13/2018 prior to patient recruitment. After obtaining ethics committee approval (Hospital Clínico Universidad de Chile; 10/2/2018) and written informed consent, we enrolled 60 patients undergoing primary total hip arthroplasty. CONSORT guidelines were followed. Inclusion criteria were: age between 18 and 80 years, American Society of Anesthesiologists (ASA) physical status I to III and body mass index between 18 and 35 kg/m^2. Exclusion criteria were: inability to consent to the study, coagulopathy, sepsis, hepatic or renal failure, allergy to local anesthetic (LA), pre-existing femoral/obturator neuropathy, prior surgery in the lumbar spine or inguinal area, and opioid intake at home.

All patients received spinal anesthesia with 10 mg of isobaric bupivacaine (i.e., 2 mL of bupivacaine 0.5%) and 20 μg of fentanyl. All surgical interventions were performed by the same team of surgeons (CB, RW) using a posterior approach and a lateral decubitus position. During the case, propofol sedation through a target-controlled infusion (site effect concentration = 0.5–1 μg/mL) was provided at the discretion of the treating anesthesiologist, provided patient response to verbal stimulus was maintained. At the end of the case, all patients received intravenous ketoprofen (100 mg) and paracetamol (1 g).

Upon arrival in the Post Anesthesia Care Unit (PACU), using a computer-generated sequence of random numbers and a sealed, opaque envelope technique, patients were randomly allocated to receive US-guided LPB (n = 30) or SIFIB (n = 30). The randomization list and opaque envelopes were created by a research assistant who was not otherwise involved in patient care. All blocks were performed by trainees (Fellows or residents) and supervised by one of three co-authors (DB, SL, JA). The LA (40 mL of levobupivacaine 0.25% with epinephrine 5 μg/mL), block adjuvant (4 mg of intravenous dexamethasone) and 100-mm, 22-gauge, short-beveled block needles (Stimuplex Ultra 360, B Braun Medical, Melsungen, Germany) were identical for all subjects.

2.1. Performance of nerve blocks

In the LPB group, patients were placed in the lateral decubitus position with the surgical limb uppermost. After skin disinfection and draping, a 2–6 MHz curvilinear US probe (GE Logiq e, GE Healthcare, Wauwatosa, Wisconsin, USA) was placed between the iliac crest and costal margin in order to obtain a “shamrock” view [7]. The vertebral body, transverse process and psoas muscle were identified. The puncture site was located 4-cm lateral to the midline. Using an in-plane technique and a posterior-to-anterior direction, the block needle was advanced until its tip was positioned in the posteromedial quadrant of the psoas muscle [7] (Fig. 1A). The entire LA volume was injected in this location.

In the SIFIB group, patients were placed in the supine position. After skin disinfection and draping, a 5–10 MHz linear US probe (GE Logiq e, GE Healthcare, Wauwatosa, Wisconsin, USA) was placed in a parasagittal orientation, medial to the anterosuperior iliac spine in order to obtain the “bow-tie” sign [3]. The sartorius, iliacus and internal oblique muscles were identified. Using an in-plane technique and a caudad to cephalad direction, the block needle was advanced until its tip was positioned between the internal oblique and iliacus muscles underneath the fascia iliaca (Fig. 1B). The LA volume was injected as the needle was slowly advanced cephalad inside the fascia iliaca compartment.

2.2. Postoperative analgesic regimen

In the PACU, after the performance of LPB or SIFIB, all patients received patient-controlled analgesia (morphine bolus = 1 mg; lockout interval = 8 min). On the surgical ward, in addition to patient-controlled morphine analgesia, they also received regular acetaminophen (1 g per os every 6 h), ketoprofen (100 mg per os every 8 h) during 48 h.

2.3. Primary and secondary outcomes

Our primary outcome consisted of cumulative morphine consumption during the first 24 h (PACU and surgical ward). Secondary outcomes included block performance time (defined as the temporal interval between the start of skin disinfection and the end of LA injection through the block needle), number of needle passes during the performance of the block, time to first morphine request, cumulative morphine consumption at 48 h, static (at rest) and dynamic (with hip adduction) pain scores at 3, 6, 12, 24 and 48 h, incidence of adverse events (i.e., vascular puncture, LA toxicity, epidural spread of LA, postoperative nausea/vomiting, pruritus, somnolence, respiratory depression), ability to perform physiotherapy at 24 h, time to readiness for discharge (defined as the time required to independently navigate stairs), and length of hospital stay.

Sensorimotor assessment of the block was carried out at 3, 6 and

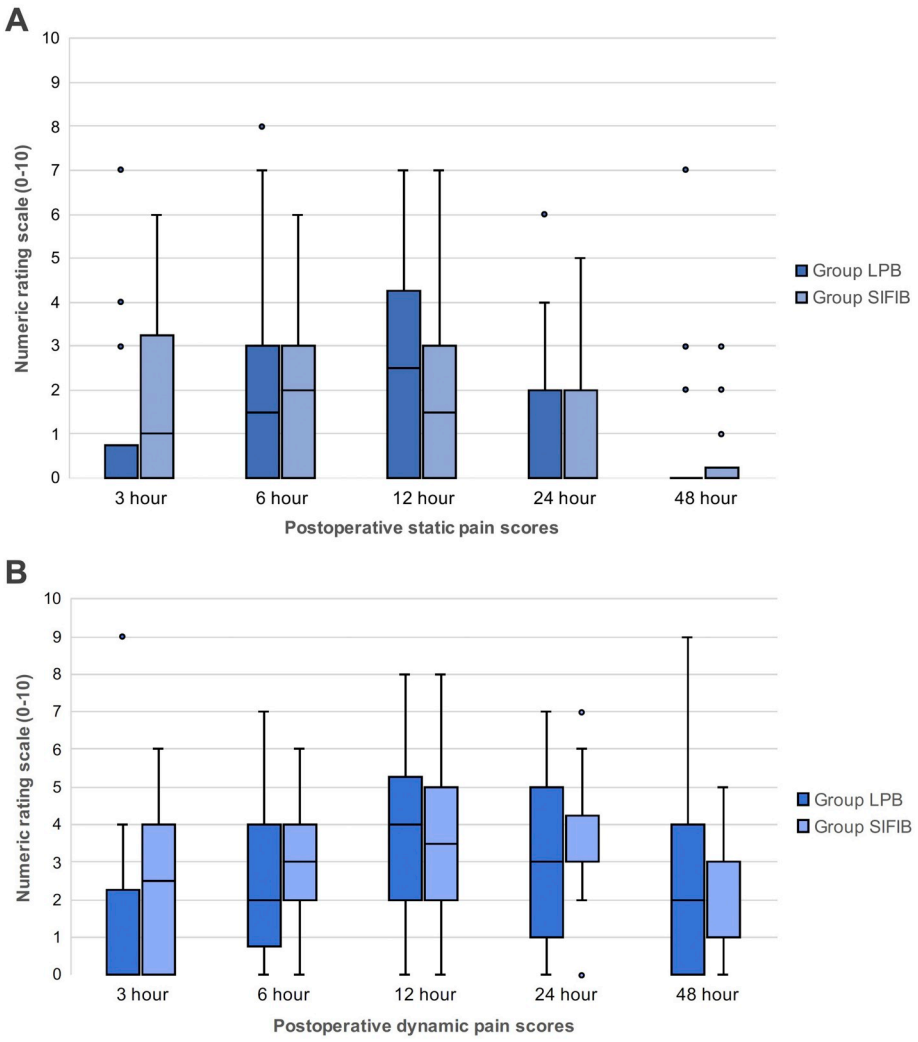

Fig. 3. Pain scores at rest (static) (3A) and with hip adduction (dynamic) (3B) using a 0–10 scale at different time intervals. Except for static pain at 3 h (P = 0.039), there were no statistical differences between the two groups at any time interval. P values were calculated with the Mann Whitney U test.

24 h using a previously described 10-point composite sensorimotor score [7]. Sensory block was assessed in the anterior, lateral and medial aspects of the mid-thigh. For each territory, blockade was evaluated using a 3-point scale: 0 = no block, 1 = analgesia (patient can feel touch, not cold), 2 = anesthesia (patient cannot feel touch). Motor block was assessed using knee extension and hip adduction. Knee extension was graded according to a 3-point scale: 0 = no block, 1 = paresis (decreased ability to extend the leg), 2 = paralysis (inability to extend the leg). Since hip adduction originates from the lumbar and sacral plexi, it was evaluated by comparing post-block to baseline strength. Before the LPB or SIFIB, a blood pressure cuff, inflated at 40 mmHg, was inserted between the knees of the patient: the latter was then instructed to squeeze the cuff as hard as possible and to sustain the effort. We defined hip adduction scores of 0, 1 and 2 points as decreases in strength of 0–20%, 21–70% and 71–90% compared to baseline measurement, respectively [7].

Except for performance time, number of needle passes, and incidence of vascular puncture (which were recorded by the coauthor supervising the block), all other outcomes were evaluated by a blinded investigator. The latter also recorded demographic data (i.e., sex, age, weight, height and ASA class) and surgical duration.

2.4. Sample size calculation and statistical analysis

Our preliminary experience with LPB revealed a mean intravenous morphine consumption of 6.6 (3.3) mg at 24 h (unpublished data). For the current trial, we speculated clinical equivalency between LPB and SIFIB and, consequently, designed the study as an equivalence trial. We selected a 50% (3.3 mg) equivalence margin because we deemed that a 24-hour morphine consumption of 10 mg constitutes a reasonable dose. Thus, a calculated sample size of 54 patients (27 subjects per group) was required to provide a statistical power of 0.90 and a type I error of 0.025. A total of 60 subjects was enrolled to account for possible patient dropout.

Statistical analysis was performed using SPSS version 21 statistical software (IBM, Armonk, New York). For continuous data, normality was first assessed and then analyzed with the Student *t*-test. Data that did not have a normal distribution, as well as ordinal data, were analyzed with the Mann-Whitney *U* test. For categorical data, the chi square test was used. The Fisher's exact test was used when any cell for the aforementioned categorical data had an expected count of less than five. All P values presented were 2-sided and values inferior to 0.05 were considered significant.

Table 3
Patterns of sensory and motor block.

	LPB (n = 30)			SIFIB (n = 30)			P value
Sensory block	No block	Analgesia	Anesthesia	No block	Analgesia	Anesthesia	
Lateral thigh at 3 h post-block	2(6%)	12(40%)	16(53%)	2(6%)	8(26%)	20(66%)	0.536
Lateral thigh at 6 h post-block	4(13%)	17(56%)	9(30%)	3(10%)	14(46%)	13(43%)	0.657
Lateral thigh at 24 h post- block	24(80%)	6(20%)	0	15(50%)	14(46%)	1(3%)	0.030
Anterior thigh at 3 h post-block	1(3%)	17(56%)	12(40%)	0	13(43%)	17(56%)	0.298
Anterior thigh at 6 h post-block	2(6%)	22(73%)	6(20%)	1(3%)	19(63%)	10(33%)	0.521
Anterior thigh at 24 h post-block	26(86%)	4(13%)	0	15(50%)	14(46%)	1(3%)	0.006
Medial thigh at 3 h post-block	5(16%)	12(40%)	13(43%)	1(3%)	11(36%)	18(60%)	0.209
Medial thigh at 6 h post-block	9(30%)	13(43%)	8(26%)	4(13%)	13(43%)	13(43%)	0.225
Medial thigh at 24 h post-block	27(90%)	3(10%)	0	16(53%)	14(46%)	0	0.003

	LPB (n = 30)			SIFIB (n = 30)			P value
Motor block	No block	Paresis	Paralysis	No block	Paresis	Paralysis	
Knee extension at 3 h post-block	5(16%)	17(56%)	8(26%)	3(10%)	13(43%)	14(46%)	0.255
Knee extension at 6 h post-block	6(20%)	21(70%)	3(10%)	7(23%)	12(40%)	11(36%)	0.025
Knee extension at 24 h post-block	22(73%)	7(23%)	13(3%)	19(63%)	11(36%)	0	0.400
Hip adduction at 3 h post-block	4(13%)	12(40%)	14(46%)	4(13%)	14(46%)	12(40%)	0.936
Hip adduction at 6 h post-block	7(23%)	13(43%)	10(33%)	5(16%)	16(53%)	9(30%)	0.788
Hip adduction at 24 h post-block	15(50%)	12(40%)	3(10%)	8(26%)	18(60%)	4(13%)	0.208

Absolute counts (percentage) are provided inside each cell. P values are calculated with the Fisher's exact test. LPB: lumbar plexus block; SIFIB: suprainguinal fascia iliaca block.

3. Results

The 60 subjects were recruited over a period of 14 months (11/19/2018 to 1/20/2020) (Fig. 2). Demographic characteristics and surgical duration are presented in Table 1.

No intergroup differences were found with regards to cumulative morphine consumption at 24 h (95% CI: −4.0 mg to 2.0 mg) and 48 h (95% CI: −5.0 mg to 2.0 mg), time to first morphine request, postoperative pain scores after 3 h, ability to undergo physiotherapy at 24 h, and adverse events (Table 2 and Fig. 3). In terms of technical performance, both groups required a similar number of needle passes. However, LPB was associated with a shorter performance time [3.8 (1.5) vs. 4.8 (1.8) minutes; P = 0.02] (Table 2).

There were no intergroup differences in terms of composite sensorimotor scores at 3 and 6 h. However, SIFIB lasted longer than LPB as evidenced by a higher composite score at 24 h (3 [0–6] vs. 1 [0–5]; P < 0.001) (Table 2) and denser sensory block of the thigh at 24 h (Table 3).

Compared with LPB, SIFIB was associated with shorter time to readiness for discharge (3 [1-4] vs. 2 [1-3] days; P = 0.042) and length of hospital stay (3 [2-5] vs. 3 [2-4] days; P = 0.048).

4. Discussion

In this randomized trial, we compared US-guided LPB and SIFIB in patients undergoing total hip arthroplasty. Although we found no significant differences in terms of pain control and breakthrough opioid requirement, our results suggest that SIFIB may result in a longer sensory block. We speculate that this increased block duration stems from the relatively avascular fascia iliaca compartment. In contrast, the psoas muscle (where LA is deposited for LPB) may be more vascularized thereby leading to swifter resorption of LA molecules.

Our primary outcome (cumulative morphine consumption at 24 h) requires discussion. In both LPB and SIFIB groups, its median value (5–6 mg) mirrors the average (6.6. mg) found in our pilot study. However, its range (6–9 mg) was unexpectedly large. We hypothesize that the wide variability in morphine consumption could be attributed to the posterior surgical approach. Although LPB and SIFIB reliably anesthetize the femoral, lateral femoral cutaneous and obturator nerves, they do not block the sciatic nerve. Therefore, a subset of patients may have experienced significant postoperative pain stemming from surgical retraction and trauma to gluteal and short external rotator muscles of the hip joint, which are supplied by the sciatic nerve [8]. Thus, in light of the variability in morphine consumption, we cannot rule out the possibility that our sample size was underpowered to detect a difference between the two study groups.

The LA volume used in the current study also deserves special mention. Although the 40 mL-injectate may appear unwarranted, it echoes the volume recommended for SIFIB by Vermeylen et al. [4]. Furthermore, in a 2015 LPB dose-finding trial, Sauter et al. [9] concluded that the minimum effective volume in 95% of patients (ED_{95}) is 36 mL for ropivacaine 0.5%. Since the ED_{95} has not been elucidated for levobupivacaine 0.25%, we elected to use 40 mL (instead of 36 mL) because we reasoned that levobupivacaine 0.25% is more dilute than ropivacaine 0.5%. More importantly, the use of 40 mL for LPB allowed us to harmonize the LA injectate for both study groups.

Our protocol contains some limitations. First, our patients were not blinded to the nerve block performed. Since LPB and SIFIB required different patient positioning, the only way to ensure blinding would have been to carry out two blocks in all subjects (one sham and one therapeutic). Since LPB can result in complications such as psoas hematoma [10], for ethical reasons, we elected to forego the performance of sham blocks. Second, our results are specific to single-injection LPB and SIFIB. Additional studies are required to confirm our findings for continuous LPB and SIFIB. Third, although shorter time to discharge and decreased hospital stay were found in the SIFIB group, one should not prematurely conclude causality. Considering the small absolute differences as well as the multifactorial nature of length of hospital stay and patient discharge, only a statistical association should be recorded for the time being. Finally, both LPB and SIFIB inherently result in motor block. Future trials are needed to investigate if quadriceps-sparing alternatives such as pericapsular nerve group (PENG) blocks [11], which selectively target articular branches of the femoral and obturator nerves, could perhaps expedite physiotherapy and patient discharge.

In conclusion, for total hip arthroplasty, no differences were found

between LPB and SIFIB in terms of breakthrough morphine requirement and pain control. However, SIFIB resulted in a longer sensory block and was associated with shorter time to readiness for discharge as well as decreased hospital stay. Future trials are required to compare SIFIB with quadriceps-sparing alternatives such as PENG blocks.

CRediT authorship contribution statement

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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