Anaesth Crit Care Pain Med 42 (2023) 101223

Contents lists available at ScienceDirect

Anaesthesia Critical Care & Pain Medicine

journal homepage: www.elsevier.com

Original Article

Analgesic efficacy of selective tibial nerve block versus partial local infiltration analgesia for posterior pain after total knee arthroplasty: a randomized, controlled, triple-blinded trial

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ARTICLE INFO

Article history:
Available online 6 April 2023

Keywords:
Regional anesthesia
Peripheral nerve block
Local infiltration analgesia
Postoperative analgesia
Total knee arthroplasty
Postoperative pain

ABSTRACT

Background: The adductor canal block provides pain relief on the anterior aspect of the knee after arthroplasty. Pain on the posterior aspect may be treated either by partial local infiltration analgesia of the posterior capsule or by a tibial nerve block. This randomized, controlled, triple-blinded trial tests the hypothesis that a tibial nerve block would provide superior analgesia compared to posterior capsule infiltration in patients scheduled for total knee arthroplasty under spinal anesthesia with an adductor canal block.

Methods: Sixty patients were randomized to receive either infiltration of the posterior capsule by the surgeon with ropivacaine 0.2%, 25 mL, or a tibial nerve block with 10 mL of ropivacaine 0.5%. Sham injections were performed to guarantee proper blinding. The primary outcome was intravenous morphine consumption at 24 h. Secondary outcomes included intravenous morphine consumption, pain scores at rest and on movement, and different functional outcomes, measured at up to 48 h. When necessary, longitudinal analyses were performed with a mixed-effects linear model.

Results: The median (interquartile range) of cumulative intravenous morphine consumption at 24 h was 12 mg (4–16) and 8 mg (2–14) in patients having the infiltration or the tibial nerve block respectively (p = 0.20). Our longitudinal model showed a significant interaction between group and time in favor of the tibial nerve block (p = 0.015). No significant differences were present between groups in the other above-mentioned secondary outcomes.

Conclusion: A tibial nerve block does not provide superior analgesia when compared to infiltration. However, a tibial nerve block might be associated with a slower increase in morphine consumption over time.

Introduction

The pain after total knee arthroplasty originates mainly from an anterior component with the distal branches of the femoral nerve and a posterior component involving branches of the sciatic nerve [1]. The adductor canal block is often performed to relieve moderate to severe postoperative pain after total knee arthroplasty while attempting to preserve quadriceps muscle strength [2]. The objective is mainly to anesthetize the saphenous and infrapatellar nerves that conduct pain from the anterior aspect of the knee. However, up to two-thirds of patients are uncomfortable due to pain in the posterior aspect, which could be treated with a sciatic nerve block [3,4]. Currently, this technique is no longer recommended in the setting of fast-track surgery and early mobilization due to the secondary foot drop that delays early rehabilitation and physiotherapy.

Sinha *et al.* have reported an interesting regional anesthesia approach that could treat the pain from the posterior aspect with a selective tibial nerve block [5]. This technique provides similar analgesia on the posterior aspect of the knee as the sciatic nerve block, while crucially avoiding complete peroneal motor block,

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https://doi.org/10.1016/j.accpm.2023.101223

allowing the patient to walk and perform early rehabilitation [5]. In many institutions, the posterior knee pain is treated with local infiltration analgesia of the posterior capsule by the surgeon just after insertion of the prosthesis [6]. In our constant quest to improve pain relief and accelerate rehabilitation, we decided to directly compare these two techniques for the treatment of posterior knee pain and determine which option could provide superior analgesia for the patients.

This randomized, controlled, triple-blinded trial tested the hypothesis that a selective tibial nerve block would provide superior analgesia compared to partial local infiltration analgesia of the posterior capsule in patients scheduled for total knee arthroplasty under spinal anesthesia with an adductor canal block. Therefore, we designed this study where the primary outcome was cumulative intravenous morphine consumption at 24 postoperative hours.

Material and methods

Patients and inclusion criteria

We followed the recommended process described in the Consolidated Standards of Reporting Trials (CONSORT) statement [7].

The University Hospital of Lausanne Ethics Committee approved this trial (Commission d'Ethique Romande, protocol number 201801080) and was prospectively registered on ClinicalTrials.gov (NCT03698006). All patients aged 18 years or older, American Society of Anesthesiologists physical status I–III, who were scheduled to undergo elective total knee arthroplasty under spinal anesthesia between February 2021 and October 2021 were eligible to participate in this study. Exclusion criteria included contraindications to peripheral nerve block (*e.g.*, coagulopathy, infection in the area), known allergy to any drug used in the study protocol, pregnancy, and chronic use of opioids. After providing written informed consent, participating patients were randomly allocated on the day of surgery to either the tibial nerve block (TNB) group or the lateral infiltration analgesia (LIA) group, using a computer-generated randomization table (block size of 10). The information regarding the treatment group allocation was concealed in a sealed opaque envelope.

Regional anesthetic techniques

Patients in the TNB group received an adductor canal block, a selective tibial nerve block followed by spinal anesthesia prior to the surgical procedure. Patients in the lateral infiltration analgesia (LIA) group received an adductor canal block, followed by spinal anesthesia and local infiltration analgesia of the posterior capsule after prosthesis implantation. All ultrasound-guided blocks were conducted prior to surgery in a dedicated block procedure room by an experienced staff regional anesthetist, or a directly supervised regional anesthesia fellow. Electrocardiogram, pulse oximetry, and blood pressure monitors were routinely applied, and oxygen was provided. Peripheral intravenous (iv) access was established and iv midazolam 0.05 $mg.kg^{-1}$ was administered before the block procedures. The adductor canal block was performed following previously published descriptions [8,9]: the mid-thigh site was identified, defined as the midpoint between the anterior superior iliac spine and the base of the patella, and the skin was prepared with a solution of chlorhexidine 2% in isopropyl alcohol 70%. Under sterile conditions, a high-frequency linear array transducer (18–6 MHz, HF Linear Array 8870, BK Ultrasound, Pea-body, Massachusetts) was placed on the medial, mid-thigh to permit the visualization of the superficial femoral artery in short axis. A 21-gauge 50-mm insulated facet tip needle (SonoLong NanoLine cannula; Pajunk® GmbH, Geisingen, Germany) was then inserted in-plane of the ultrasound beam, from a lateral to medial direction. The needle tip was advanced under direct ultrasound guidance to the superolateral corner of the artery, just below the sartorius muscle. Given that the saphenous nerve may be difficult to identify, the needle was targeted to the triangular hyperechoic region lateral to the artery, defined by the sartorius muscle superficially, and the vastus medialis muscle laterally. A small amount (1–2 mL) of dextrose 5% was used for needle tip hydrolocation at the discretion of the operator. Once the needle tip was satisfactorily positioned, 20 mL of ropivacaine 0.5% was injected, in slow 5 mL increments, with an intermittent aspiration to prevent intravascular injection. Adequate spread of local anesthetics around the saphenous nerve was observed in a caudal-cephalad direction. The selective tibial nerve block was performed with the patients in a lateral position after sterilization of the lower third of the posterior thigh. The probe was placed in a transverse position proximal to the popliteal crease to identify the sciatic nerve bifurcation before scanning down and tracking the tibial nerve positioned above the popliteal artery in short axis; a 21-gauge 50-mm insulated facet tip needle (SonoLong NanoLine cannula; Pajunk® GmbH, Geisingen, Germany) was inserted in-plane of the ultrasound beam, in a medial to lateral direction, until the tip was positioned between the popliteal artery and the tibial nerve, where 10 mL of ropivacaine 0.5% were injected. Patients allocated to the LIA group had local infiltration analgesia of the posterior capsule administered by the surgeon after prosthesis implantation with 25 mL of ropivacaine 0.2%. Concentrations and volumes of local anesthetics were chosen in order that patients of both groups received an equal total mass of ropivacaine (150 mg). To maintain blinding to group allocation, we proceeded with sham injections: patients in the LIA group had a subcutaneous injection of 10 mL normal saline 0.9% under ultrasound guidance instead of a selective tibial nerve block. For patients from the TNB group, the surgeon injected 25 mL of normal saline 0.9%. The anesthetist in charge of patient management was given a sealed opaque envelope and was responsible for preparing and administering the study drug, and for communicating to the operating room nurse the solution to inject by the surgeon. Consequently, the patients, the surgeons, the research assistant, and the physiotherapist collecting the data, as well as the statistician, were all kept blinded to group allocation.

After the application of routine monitors in the operating theatre, patients in the lateral position received a spinal anesthetic. A pencil-point needle (25 gauge) was inserted via a 21-gauge introducer needle after sterile skin preparation at a level of L3-L4 or L4-L5 and 2.5 mL hyperbaric bupivacaine (5 $mg.mL^{-1}$) with 0.5 mL morphine (200 $\mu g.mL^{-1}$) and 1 mL fentanyl (20 $\mu g.mL^{-1}$) were injected. Three surgeons (JW, AA, MK) performed all surgical procedures. As per our routine institutional practice, all patients received, after the induction, iv dexamethasone 0.1 $mg.kg^{-1}$ and magnesium 40 $mg.kg^{-1}$ and, at the end of the surgery, 1 g of iv acetaminophen, 30 mg of ketorolac, and ondansetron 4 mg for the purposes of multimodal analgesia and antiemetic prophylaxis, respectively [10]. In phase I recovery, patients were provided iv patient-controlled analgesia (PCA) of morphine with boluses of 2 mg available every 10 min and received instructions on the use of the PCA device. All patients received our institutional standard multimodal analgesic regimen of acetaminophen 1 g every 6 h, and ibuprofen 400 mg every 8 h. Antiemetic medications on the ward included iv ondansetron 4 mg as requested. On the morning of postoperative day 2, the iv PCA was discontinued.

Outcomes

The primary outcome was cumulative iv morphine consumption at 24 postoperative hours. Secondary outcomes were iv morphine consumption at 6, 12, and 48 h; pain scores at rest and

on movement measured at 6, 12, 24, and 48 h (Visual Analogue Scale [VAS], 0–10); rates of postoperative nausea and vomiting, and pruritus within 48 h; satisfaction score (VAS, 0–10); and any incidence of adverse events such as peroneal motor block, hematoma, infection, neuropathic pain, persistent paraesthesia or paresis at 48 postoperative hours. We also measured the following functional outcomes: passive range of motion (°) at 24 and 48 h; quadriceps strength at 24 and 48 h (ordinal scale of 1−5, with 5 being the maximal developed strength compared with the opposite side); walking distance at 24 and 48 h (m), and length of stay (days).

Based on unpublished data, the mean consumption of iv morphine in patients with a local infiltration analgesia of the posterior capsule was expected to be 25 mg with a standard deviation of 12 mg. It was hypothesized that this consumption would decrease by 40% with a selective tibial nerve block.

Statistical analyses

To obtain a minimal power of 80% with an alpha of 5%, we calculated that 23 patients per group need to be enrolled. To correct for an anticipated drop-out and protocol violation rate of 20%, we planned to recruit a total of 60 patients (30 patients per group).

Data were analyzed on a per-protocol basis. Categorical variables are presented as frequencies and continuous variables are summarised as mean, standard deviation (SD), or median, interquartile range [IQR], when appropriate. Continuous data between groups were compared using a Student t-test or a Mann-Whitney-Wilcoxon test. Categorical and dichotomous data were compared using the Chi-square test, or Fisher's exact test when appropriate. For analysis of longitudinal outcomes (cumulative iv morphine consumption, pain score at rest, pain score on movement), mixed-effects linear models were used, including the group, the time, and an interaction between group and time as fixed effects, and the patient as a random effect. Significance was considered at $p < 0.05$ based on a two-tailed probability. Statistical analyses were performed using the Stata software (Stata version 16.1, StataCorp, College Station, TX, USA).

Results

Sixty patients were included and 52 completed the protocol for the measurement of the primary outcome; three patients in the LIA group had failed spinal anesthesia and therefore general anesthesia was induced. Fig. 1 describes the flow of patients during the trial and Table 1 presents their characteristics, which were similar between groups, except for age, where patients in the LIA group were younger.

The median [interquartile range] of cumulative iv morphine consumption at 24 postoperative hours was 12 mg [4–16] in the LIA group and 8 mg [2–14] in the TNB group (p = 0.20). This consumption did not significantly differ at all time points, but our longitudinal model showed a significant interaction between group and time (Fig. 2). Patients in the LIA group have a mean increase in morphine consumption of 0.52 [95%CI: 0.43–0.60] mg.h^{-1}, while patients in the TNB group have a mean increase of

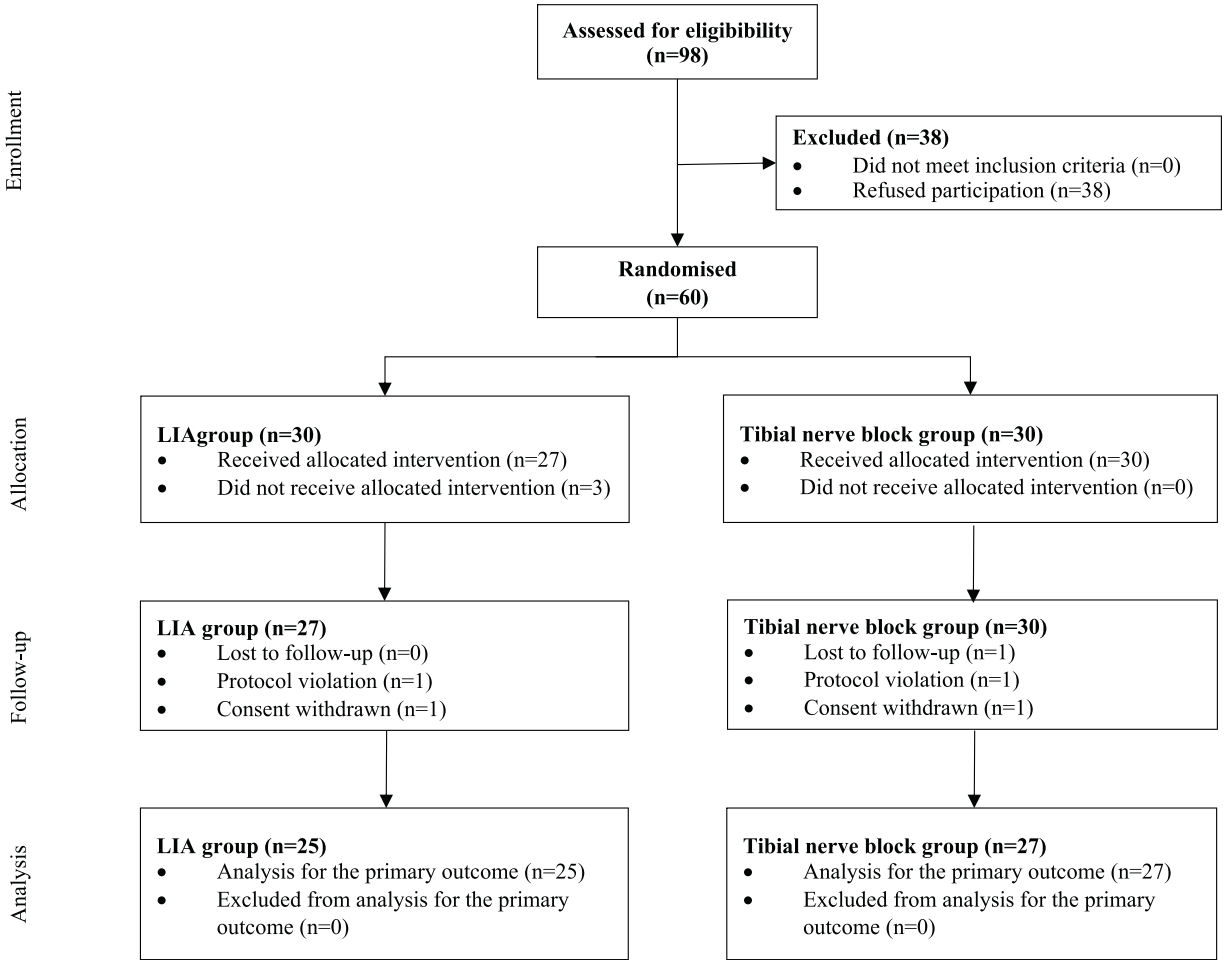

Figure 1. Flow of patients through trial (CONSORT diagram). LIA, local infiltration analgesia.

Table 1
Patient demographics and clinical characteristics. Continuous data are presented as means and standard deviations and compared by using Student's t-tests; categorial data are presented as number of patients (%) and compared using chi-squared tests.

	LIA (n = 25)	TNB (n = 27)
Gender		
Male; n (%)	11 (44)	12 (44)
Female; n (%)	14 (56)	15 (56)
Age; years	73 (9)	65 (10)
Weight; kg	83 (18)	88 (20)
Height; cm	166 (9)	168 (12)
Body mass index; $kg.m^{-2}$	30 (7)	31 (5)
ASA score; n (%)		
I	1 (4)	1 (3)
II	16 (64)	17 (63)
III	8 (32)	9 (33)
Duration of surgery; min	68 (17)	74 (22)

Table 2
Secondary outcomes. Continuous data are presented as medians and interquartile range and compared by using a Mann-Whitney-Wilcoxon test; categorial data are presented as number of patients (%) and compared by using chi-squared tests. PONV, postoperative nausea and vomiting.

	LIA (n = 25)	TNB (n = 27)	*p*-value
24 postoperative hours			
Passive range of motion (°)	90 (80–90)	90 (80–90)	0.73
Quadriceps strength (1–5)	3 (3–3)	3 (2–3)	0.27
Walking distance (m)	60 (20–60)	55 (20–60)	0.53
48 postoperative hours			
Passive range of motion (°)	85 (75–90)	90 (85–95)	0.13
Quadriceps strength (1–5)	3 (2–3)	3 (2–3)	0.61
Walking distance (m)	60 (30–60)	60 (55–60)	0.93
PONV within 48 postoperative hours, n (%)	1 (4)	5 (19)	0.19
Pruritus within 48 postoperative hours, n (%)	1 (4)	1 (4)	1.00
Length of stay (days)	6 (5–6.5)	6 (5–8)	0.35

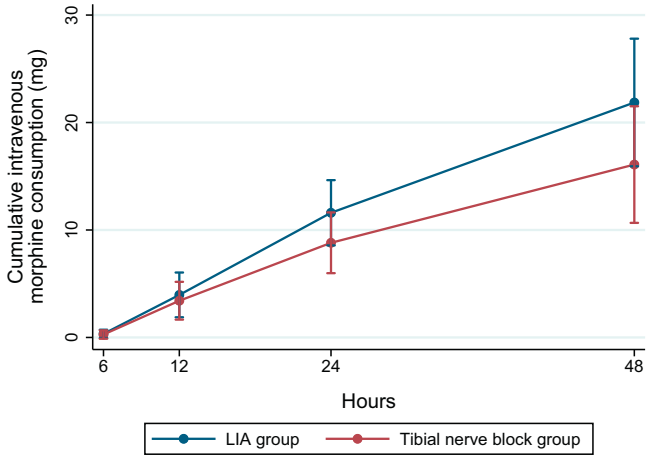

Figure 2. Cumulative intravenous morphine consumption during the course of the study. Means with 95% confidence interval are represented. The mixed-effects linear model showed that there was no group effect ($p = 0.62$), while cumulative intravenous morphine consumption significantly increased over time ($p < 0.001$), with a significant interaction between group and time ($p = 0.015$). LIA, local infiltration analgesia.

0.37 [0.29–0.45] $mg.h^{-1}$ ($p < 0.001$). These two slopes are significantly different: $\Delta = 0.15$, [0.03–0.26] ($p = 0.015$).

Fig. 3 depicts the trajectory of the pain scores at rest and on movement during the course of the study. The median [interquartile range] satisfaction score was 8 [7–9] and 9 [8–10] in the LIA and tibial nerve block groups, respectively ($p = 0.008$). There were no significant differences between groups in the other secondary outcomes (Table 2). Two patients out of 27 (7.4%) in the tibial nerve block group developed a peroneal motor block that resolved spontaneously at 24 postoperative hours. No patients developed a hematoma, infection, neuropathic pain, persistent paraesthesia, or paresis

Discussion

After including 60 patients, this randomized controlled triple-blinded trial was unable to confirm that a selective TNB would provide superior analgesia than partial LIA of the posterior capsule in patients scheduled for total knee arthroplasty under spinal anesthesia with an adductor canal block. Indeed, iv morphine consumption at 24 postoperative hours, pain scores at rest and on movement, along with functional outcomes were similar between groups. Interestingly, patients with a selective TNB had a significant reduction in the increase in opioid consumption over time, suggesting reduced resorption of the local anesthetics, when injected close to the tibial nerve as opposed to the infiltration of the posterior capsule. This reduction between the groups with increased morphine consumption may explain the superior satisfaction score from patients in the tibial nerve block group.

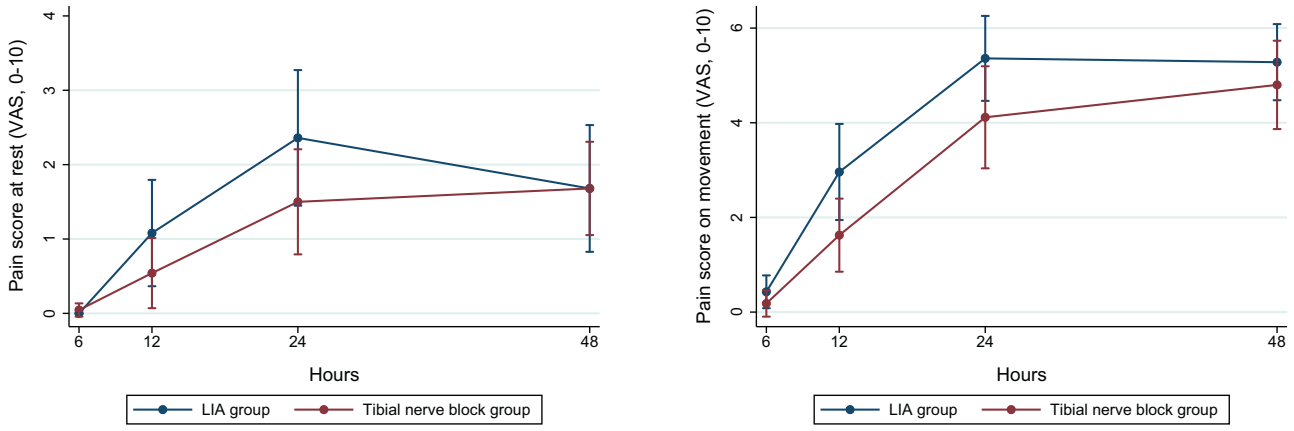

Figure 3. Pain scores at rest and on movement during the course of the study. Means with 95% confidence interval are represented. The mixed-effects linear model showed that there was no significant group effect ($p = 0.30$), interaction ($p = 0.75$), while pain score at rest significantly increased over time ($p = 0.002$). Similarly, the same model indicated for pain score on movement that there was no significant interaction ($p = 0.72$), group effect ($p = 0.09$), while a significant time effect was present ($p < 0.001$). LIA, local infiltration analgesia.

The discrepancy between these results and those used from our pilot phase for the power analysis may stem from the generalization of our multimodal analgesia protocol inclusive of intrathecal morphine, and iv dexamethasone, magnesium, ketorolac, acetaminophen, all administered during the surgery, thus decreasing baseline pain outcomes and morphine consumption [11–13]. A posthoc analysis revealed that a total of 110 patients per group would be needed to reject the null hypothesis, with alpha and beta values of 0.05 and 0.2, respectively, highlighting that this study may be underpowered. That said, the findings of this study inform physicians that both techniques similarly provide analgesia on the posterior aspect of the knee and can even be combined in case of refractory posterior knee pain. The technique choice should be dependent on surgical preference, the anesthetist's familiarity with the technique, the patient's conditions, and the postoperative hospital environment and settings.

Of note, 7.4% of the patients in the TNB group had a peroneal motor block due to the cephalad spread of the local anesthetic towards the common peroneal nerve, when injected on the medial aspect of the tibial nerve. In their trial, Sinha *et al.* reported a figure of 22.5% of peroneal motor block [5]. We speculate the difference in the percentage is the result of a reduced volume of local anesthetic injected in our trial (i.e., 10 mL vs. 20 mL).

Among the potential study weaknesses, one deserves to be addressed. Many trials investigating LIA for total knee arthroplasty use a regimen of local anesthetics combined with many different adjuncts [6]. In the absence of a clear consensus and rationale behind the solutions injected for LIA, we elected to administer a pure solution of local anesthetic and inject the different adjuncts intravenously for the sake of patient safety and to eliminate any direct local effect from the additives, that may influence our results. Secondly, the sham injections of 0.9% normal saline could have potentially diluted the concentration of ropivacaine at the effector site and consequently the block efficacy. We speculate that the smaller volume of 10 mL used for the 0.2% ropivacaine in the LIA group would therefore have less of an impact compared to the 25 mL volume used in the TNB group. Finally, we do not have any data on pain-related and functional-related outcomes after hospital discharge.

Conclusions

In conclusion, a TNB does not provide superior analgesia compared to partial LIA of the posterior capsule in patients scheduled for total knee arthroplasty under spinal anesthesia with an adductor canal block.

Details of authors' contributions

FP: study registration, patient recruitment, data collection, manuscript editing; JW: data interpretation, manuscript editing; JBR: statistical analysis; EG: patient recruitment, data collection; AA: manuscript editing; MK: manuscript editing; MW: manuscript editing; JL: manuscript editing; EA: study design, data interpretation, manuscript writing.

Funding

This work was supported by departmental funding (Department of Anaesthesia, University Hospital of Lausanne, University of Lausanne, Lausanne, Switzerland)

Availability of data and material

The data of this study are available from the corresponding author upon reasonable request.

Conflict of interest

EA received grants from the Swiss Academy for Anesthesia Research (SACAR), Lausanne, Switzerland, B. Braun Medical AG, Sempach, Switzerland and the Swiss National Science Foundation, Bern, Switzerland to support his clinical research. EA has also received an honorarium from B. Braun Medical AG Switzerland, Sintetica Ltd UK and MSD AG Switzerland. No conflict of interest declared by the other authors.

References

[1] Bendtsen TF, Moriggl B, Chan V, Børglum J. The optimal analgesic block for total knee arthroplasty. Reg Anesth Pain Med 2016;41:711–9. http://dx.doi.org/10.1097/AAP.0000000000000485.
[2] Albrecht E, Wegrzyn J, Dabetic A, El-Boghdadly K. The analgesic efficacy of iPACK after knee surgery: a systematic review and meta-analysis with trial sequential analysis. J Clin Anesth 2021;72110305. http://dx.doi.org/10.1016/j.jclinane.2021.110305.
[3] Weber A, Fournier R, Van Gessel E, Gamulin Z. Sciatic nerve block and the improvement of femoral nerve block analgesia after total knee replacement. Eur J Anaesth 2002;19:834–6. http://dx.doi.org/10.1017/S0265021502221353.
[4] Grape S, Kirkham KR, Baeriswyl M, Albrecht E. The analgesic efficacy of sciatic nerve block in addition to femoral nerve block in patients undergoing total knee arthroplasty: a systematic review and meta-analysis. Anaesthesia 2016;71:1198–209. http://dx.doi.org/10.1111/anae.13568.
[5] Sinha SK, Abrams JH, Arumugam S, et al. Femoral nerve block with selective tibial nerve block provides effective analgesia without foot drop after total knee arthroplasty: a prospective, randomized, observer-blinded study. Anesth Analg 2012;115:202–6. http://dx.doi.org/10.1213/ANE.0b013e3182536193.
[6] Albrecht E, Guyen O, Jacot-Guillarmod A, Kirkham KR. The analgesic efficacy of local infiltration analgesia vs femoral nerve block after total knee arthroplasty: a systematic review and meta-analysis. Br J Anaesth 2016;116:597–609. http://dx.doi.org/10.1093/bja/aew099.
[7] Schulz KF, Altman DG, Moher D. CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. PLoS Med 2010;7e1000251. http://dx.doi.org/10.1136/bmj.c332.
[8] Stebler K, Martin R, Kirkham KR, Lambert J, De Sede A, Albrecht E. Adductor canal block versus local infiltration analgesia for postoperative pain after anterior cruciate ligament reconstruction: a single centre randomised controlled triple-blinded trial. Br J Anaesth 2019;123:e343–9. http://dx.doi.org/10.1016/j.bja.2019.04.053.
[9] Martin R, Kirkham KR, Ngo THN, Gonvers E, Lambert J, Albrecht E. Combination of femoral triangle block and infiltration between the popliteal artery and the capsule of the posterior knee (iPACK) versus local infiltration analgesia for analgesia after anterior cruciate ligament reconstruction: a randomized controlled triple-blinded trial. Reg Anesth Pain Med 2021;46:763–8. http://dx.doi.org/10.1136/rapm-2021-102631.
[10] Al Ja'bari A, Robertson M, El-Boghdadly K, Albrecht E. A randomised controlled trial of the pectoral nerves-2 (PECS-2) block for radical mastectomy. Anaesthesia 2019;74:1277–81. http://dx.doi.org/10.1111/anae.14769.
[11] Beloeil H, Albaladejo P, Sion A, Durand M, Martinez V, Lasocki S, et al. Multicentre, prospective, double-blind, randomised controlled clinical trial comparing different non-opioid analgesic combinations with morphine for postoperative analgesia: the OCTOPUS study. Br J Anaesth 2019;122:e98–106. http://dx.doi.org/10.1016/j.bja.2018.10.058.
[12] Wick EC, Grant MC, Wu CL. Postoperative multimodal analgesia pain management with nonopioid analgesics and techniques: a review. JAMA Surg 2017;152:691–7. http://dx.doi.org/10.1001/jamasurg.2017.0898.
[13] Memtsoudis SG, Poeran J, Zubizarreta N, Cozowicz C, Mörwald EE, Mariano ER, et al. Association of multimodal pain management strategies with perioperative outcomes and resource utilization: a population-based study. Anesthesiology 2018;128:891–902. http://dx.doi.org/10.1097/ALN.0000000000002132.