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ORIGINAL RESEARCH **REGIONAL ANESTHESIA**

Ultrasound-guided popliteal plexus block versus fascia iliaca block for postoperative analgesia after total knee arthroplasty: a randomized clinical trial

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ABSTRACT

Background: Regional nerve blocks have attained a popularity for total knee arthroplasty (TKA) because they can anesthetize a wider area with a prolonged postoperative analgesic effect. This clinical trial compared postoperative pain control using popliteal plexus blockade (PPB) and fascia iliaca block (FIB) in cases of TKA.

Methodology: This double-blinded randomized clinical trial enrolled 60 patients planned for unilateral, primary TKA under spinal anesthesia. Participants were randomly allocated to either the PPB group or the FIB group. The blocks were performed at the end of surgery. Postoperative pain was measured on Numeric Rating Scale (NRS) during rest, and on arrival in PACU, then at 1, 2, 4, 8, and 24 h. Time to first rescue, total morphine consumption and any complications / side-effects were noted in both groups.

Results: Numeric rating scale (NRS) scores at 8 h and 12 h during rest, and at 4 h, 8 h, and 12 h during movement were significantly lower in the FIB group than in the PPB group. Morphine consumption in the first 24 h postoperative was significantly lower in the FIB group than in the PPB group. Time to first rescue was delayed significantly in the FIB group than PPB group. Rehabilitation was comparable between the two groups. Patient satisfaction, postoperative nausea and vomiting, hypotension, and bradycardia were comparable between both groups.

Conclusions: Fascia iliaca block was superior to popliteal plexus blockade in controlling postoperative pain after total knee arthroplasty, as evidenced by lower pain scores, lesser postoperative morphine consumption, and delayed time to first analgesic request with comparable minimal adverse events.

Abbreviations: TKA - Total Knee Arthroplasty; PPB - Popliteal Plexus Blockade; FIB - Fascia Iliaca Block; PONV - Postoperative Nausea / Vomiting; IQR - Interquartile Range; NRS - Numerical Rating Scale; PACU - Post Anesthesia Care Unit; LLS - Lower Limb Surgery; PCA - Patient-Controlled Analgesia

Preregistration: The study was performed from June 2022 to March 2023 at Tanta University Hospitals, Egypt, after approval from the Tanta University Hospitals Ethical Committee (approval code: 35431/04/22) and registration of clinicaltrials.gov (ID: NCT05390450).

Key words: Popliteal Plexus Block; Fascia Iliaca Block; Total Knee Arthroplasty; Analgesia

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1. INTRODUCTION

Total knee arthroplasty (TKA) is a widely practiced surgery in managing advanced knee osteoarthritis accompanied by moderate to severe pain.[1]

Insufficient postsurgical analgesia after TKA hinders rehabilitation, lengthens hospitalization, and is accompanied by a higher likelihood of adverse events such as pulmonary dysfunction, myocardial ischemia, and thromboembolism.[2] Thus, appropriate postoperative pain management is essential for early ambulation and early postoperative rehabilitation to ensure satisfactory functional outcome.[3] Multimodal analgesia is the standard of care for TKA perioperative analgesia.[4] Different approaches, including systemic opioids, local anesthetic infiltration, regional nerve block, and spinal anesthesia, have been incorporated.[5,6] Substantial opioid consumption may result in serious side effects, including postoperative nausea and vomiting (PONV), hypotension, respiratory depression, and other systemic reactions, resulting in delayed recovery and limited quality of life.[7,8]

Regional nerve blocks have attained popularity in TKA due to their ability to reduce opioid consumption and good pain control.[9] Fascia iliaca block (FIB) is a common method for analgesia by applying local anesthetic beneath the iliacus muscle fascia to numb the peripheral nerves. By anesthetizing the femoral nerve away from the main neurovascular structures, it is possible to eliminate complications and produce sufficient analgesia.[10]

A blockade of the popliteal plexus (PP), formed in the popliteal fossa by branches of the posterior obturator nerve and the tibial nerve, could achieve correspondent analgesia, avoiding motor weakness after TKA. Theoretically, incorporating the contribution of the tibial nerve to the genicular supply from the PP may make it even more effective.[11,12]

A recent cadaver study confirmed that 10 mL of the dye injected into the adductor canal at the distal end reaches the popliteal fossa by the adductor hiatus and discoloration of the PP.[13]

The comparison of PPB and FIB in TKA is not reported in the literature. Therefore, this clinical trial aimed to compare postoperative pain control using PPB block versus FIB in cases of TKA.

2. METHODOLOGY

This double-blinded randomized study involved 60 cases aged 40 to 75 y, ASA class I-II, listed for unilateral, primary TKA under spinal anesthesia. The study was performed from June 2022 to March 2023 at Tanta University Hospitals, Egypt, after approval from the Tanta University Hospitals Ethical Committee (approval code: 35431/04/22) and registration in clinicaltrials.gov (ID: NCT05390450). The written informed consent was acquired from every participant.

Exclusion criteria were coagulopathy, obesity, diabetes, heart, liver, and kidney failure, decreased sensation in the lower extremity, daily opioid consumption, and contraindication to any of the study drugs.

Using a computer-generated sequence randomization, participants were allocated randomly in a parallel manner to either the PPB or the FIB group on a 1:1 basis. The allocation of cases was concealed with sequentially numbered and sealed envelopes stored in a research office far from the clinical care team and supplied to the operating room after anesthesia induction. A nurse uninvolved in patient care opened the envelope to assign the patient to the appropriate group. Cases and outcome assessors were blinded for group allocation.

Preoperatively, history taking, clinical examination, and routine laboratory investigations were performed. Electrocardiography, noninvasive blood pressure monitoring, and pulse oximetry were utilized to monitor the cases. Spinal anesthesia was performed in all cases with heavy bupivacaine 0.5% (3-3.5 ml).

Two orthopedic surgeons performed TKA by inserting bi- or tricompartmental prostheses via a classic medial often-to strategy. At the end of the operation, nerve blocks were performed while the patient was supine with a full sterile technique. All blocks were performed under ultrasound (US) guidance (Philips CX50 Extreme edition).

2.1. Group PPB (Popliteal plexus blockade)

The proximal end of the adductor canal was recognized. The transducer dropped distally within the femoral artery till it diverged from the sartorius muscle toward the adductor hiatus in the distal portion of the adductor canal. The nerve block needle was placed beyond the vastus medialis muscle from the anterolateral end of the transducer. The injection ended within the adductor canal's distal end, near the adductor hiatus. The injection was administered between the vastus medialis and the adductor magnus, close to the femoral artery, including 10 ml bupivacaine 0.5% after aspiration to avoid intravascular injection.

2.2. Group FIB (Fascia Iliaca block)

On the skin, the inguinal ligament was drawn from the anterior superior iliac spine to the tuberculum pubis and divided into three partitions. The injection site was one-centimeter caudal to the point where the lateral and

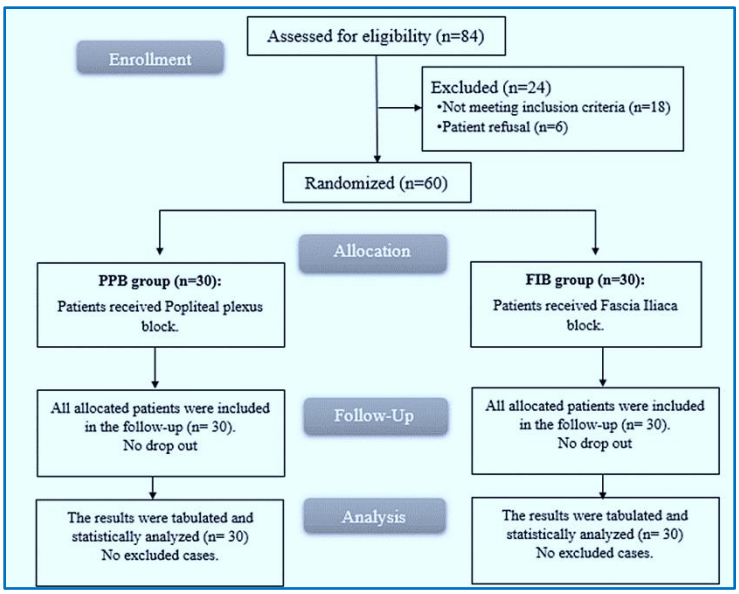


Figure 1: CONSORT diagram

middle portions of the inguinal ligament met. A perpendicular 18G nerve block needle was inserted into the skin till the first (fascia lata) and second (fascia iliaca) loss of resistance was encountered. Bupivacaine 0.25% 40 mL was subsequently injected.

Postoperative heart rate, mean blood pressure measurements, and NRS at rest and at movement (knee flexion) were recorded on arrival in PACU at 1, 2, 4, 8, and 24 h. If NRS was more than 3, the patient needed analgesia in the form of morphine 0.05 mg/kg. Routine analgesia was 1 G paracetamol every six hours IV. Time to first rescue analgesia, 24 h postoperative morphine consumption, time to ambulation, and patient satisfaction were recorded. The degree of patient satisfaction was assessed on a 5-point scale; (1 = highly satisfied, 2 = satisfied, 3 = neither satisfied nor dissatisfied, 4 = dissatisfied, 5 = highly dissatisfied). Incidence of adverse events, e.g., PONV, bradycardia, hypotension, and respiratory depression etc. were also noted.

The primary outcome was the total morphine consumed in the first 24 h. The secondary outcomes were the time to first request for analgesia, the severity of pain, rehabilitation, and the patient satisfaction.

2.3. Sample size calculation

The sample size calculation was performed by G*Power 3.1.9.2 (Universitat Kiel, Germany). We performed a pilot study (five cases in each group), and we observed that the mean ± SD of morphine consumption during the first 24 h postoperative (the primary outcome) was 8.8 ± 2.17 mg in the PPB group and 7.4 ± 1.34 mg in FIB group. The sample size was determined by the following factors: 0.80 effect size, 95% confidence limit, 80% study power, group ratio 1:1; and extra 4 cases were included in each group to compensate for the dropouts. Hence, we recruited 30 cases in each group.

2.4. Statistical analysis

SPSS v.28 (IBM, Chicago, IL, USA) was utilized for statistical analysis. The distribution normality of the data was determined using the Shapiro-Wilks test and the histograms. Quantitative parametric data are expressed as the mean and standard deviation (SD) and analyzed using the unpaired Student's t-test. Quantitative non-parametric data are presented as the median and interquartile ranges (IQR) and analyzed using the Mann-Whitney test. Qualitative variables are presented as frequencies and percentages and analyzed using the Chi-square or Fisher's exact test. A two-tailed $P \leq 0.05$ was judged statistically significant.

3. RESULTS

In this study, 84 cases were assessed for eligibility, 18 cases did not fulfill the criteria, and six cases declined to continue to the study. The remaining cases were allocated randomly into two groups (30 cases each). All allocated cases were monitored and statistically analyzed (Figure 1).

Table 1: Comparative demographic data and duration of surgery in the groups

Parameter		PPB group (n = 30)	FIB group (n = 30)	P value
Age (years)		56.63 ± 7.85	55.87 ± 6.78	0.687
Sex	Male	14 (46.67)	11 (36.67)	0.432
	Female	16 (53.33)	19 (63.33)	
Weight (kg)		70.27 ± 6.12	72.47 ± 6.12	0.169
Height (m)		1.73 ± 0.06	1.71 ± 0.08	0.472
BMI (kg/m^2)		23.67 ± 2.7	24.86 ± 3.19	0.125
ASA physical status	I	9 (30)	13 (43.33)	0.284
	II	21 (70)	17 (56.67)	
Duration of surgery (min)		153.17 ± 9.96	149.17 ± 10.01	0.126

Data are presented as mean ± SD or frequency (%). BMI: Body mass index,

Demographic data and duration of surgery were similar between both groups (Table 1).

Postoperative heart rate and mean blood pressure measurements at PACU, and at 1, 2, 4, and 24 h were comparable between both groups. These were significantly lower at 8 h and 12 h in the FIB group than in the PPB group (P < 0.05) (Figure 2)

NRS measurements at rest at PACU, then at 1, 2, 4, and 24 h were comparable between the two groups. These were significantly lower at 8 h and 12 h in group FIB group than in PPB group C (P = 0.005 and 0.018, respectively) (Table 2).

NRS measurements at movement at PACU, and at 1, 2, and 24 h were comparable between the two groups. These were significantly lower at 4, 8, and 12 h in group FIB group than in PPB group C (P = 0.035, 0.004, and 0.002, respectively) (Table 2).

Morphine consumption in the first postoperative 24 h reduced significantly in the FIB group than PPB group (6.75 ± 1.36 mg vs. 8.78 ± 2.58 mg, P <.001). Time to first rescue was delayed significantly in the FIB group than PPB group (P < 0.001). Time to ambulation and patient satisfaction were comparable between both groups (Table 3).

Regarding complications, PONV, bradycardia, and hypotension were comparable between the two groups. Respiratory depression didn't happen in any patient in the groups (Table 4).

Table 3: NRS measurements of the studied groups

Measurement time	PPB group (n = 30)	FIB group (n = 30)	P value
At rest			
PACU	0 (0-1)	1 (0-1)	0.609
1h	1 (1-2)	1 (1-1)	0.394
2h	1 (1-2)	1 (1-2)	0.595
4h	2 (1-2)	1 (1-2)	0.305
8h	2 (1-2)	1 (1-2)	0.005
12h	4 (2.25-6)	2 (1-4.75)	0.018
24h	4 (3-6)	4 (3-6)	0.858
At movement			
PACU	2 (1-2)	2 (1-2)	0.653
1h	3 (2-3)	2 (2-3)	0.182
2h	3 (2-3)	2 (2-3)	0.568
4h	3 (2-4)	2.5 (2-3)	0.035
8h	4 (3-6)	3 (2-4)	0.004
12h	5 (3.25-6)	3 (2-5)	0.002
24h	5 (3-7)	6 (4-7)	0.395

Data are presented as median (IQR), PACU: Post anesthesia care unit.

4. DISCUSSION

Adequate pain management after TKA is crucial to patient care since it expedites functional recovery.[14] Multimodal analgesia with regional procedures is currently the gold standard for TKA perioperative pain control.[15] Regional nerve blocks have attracted attention for TKA because they can anesthetize a broad region while remaining distant from the surgical site and spinal cord.[16]

We performed both blocks under US guidance. Ultrasound (US) assists clinicians in evaluating anatomic structures with accuracy and reliability and in safely administering injections due to recent technological advancements.[17]

Our results revealed that NRS measurements at rest at all points were insignificantly different between both groups; these were significantly lower at 8 and 12 h in Group FIB than Group PPB. Morphine consumption in first 24 h postoperatively was significantly less in the FIB group than PPB group. Time to first rescue was delayed significantly in the FIB group than PPB group. Rehabilitation and patient satisfaction were

Table 2: Time to first rescue analgesia, morphine consumption in 1st 24h postoperative, time to ambulation, and patient satisfaction of the studied groups

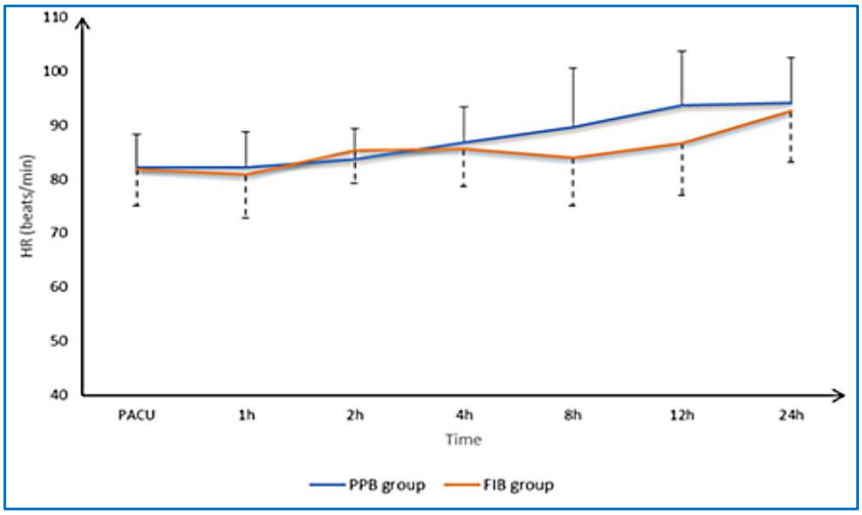
Parameter		PPB group (n = 30)	FIB group (n = 30)	P value
Time to first rescue analgesia (h)		6.87 ± 0.94	9.2 ± 2.44	<0.001
Morphine consumption in 1st 24 h postop (mg)		8.78 ± 2.58	6.75 ± 1.36	<0.001
Time to ambulation (h)		5.07 ± 0.78	4.77 ± 0.77	0.141
Patient Satisfaction	Highly satisfied	12 (40)	19 (63.33)	0.071
	Satisfied	18 (60)	11 (36.67)	

Data are presented as mean ± SD or frequency (%).

Table 4: Side effects of studied groups

Side effects	PPB group (n = 30)	FIB group (n = 30)	P
PONV	8 (26.67)	3 (10)	0.095
Bradycardia	3 (10)	1 (3.33)	0.301
Hypotension	4 (13.33)	2 (6.67)	0.389
Respiratory depression	0 (0)	0 (0)	---

Data are presented as frequency (%). PONV: Postoperative nausea and vomiting.



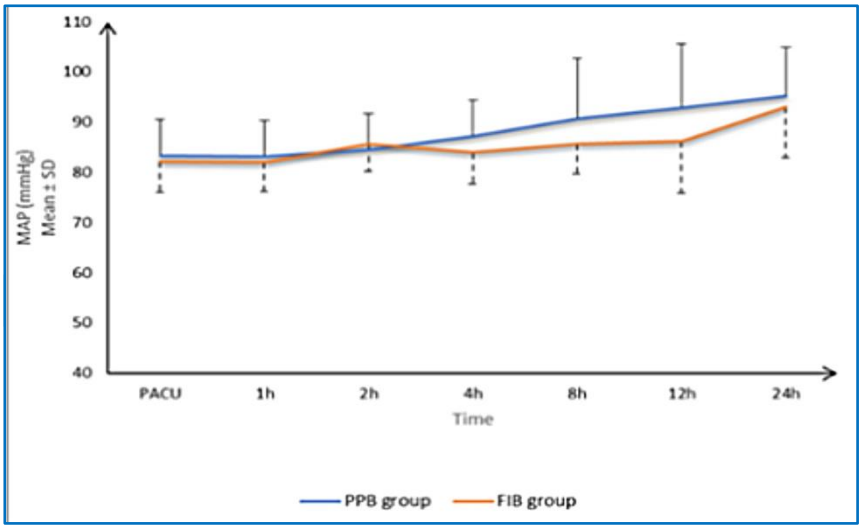


Figure 2 (A&B): Comparative postoperative heart rates and MAP in two groups

insignificantly different between the two groups. These results could be explained as FIB could block the femoral nerve, the obturator nerve, and the lateral cutaneous nerves.[18] The FIB aimed to obstruct the sensory innervation and depth of femoral nerves in the hip, thigh, and knee. Due to the substantial sensory supply of the lower limbs, this block has been introduced for use in knee arthroplasty and hip surgeries for pain management.[19]

To our knowledge, this is probably the first trial comparing the efficacy and safety of PPB and FIB after TKA. Recently, FIB has been suggested as a common pain control procedure involving local anesthesia infiltration beneath the fascia iliaca. The technique relies on the spread of the local anesthetics spread in the fascia to block the peripheral nerves.[20]

In their meta-analysis, Zhang et al. [20] documented that after total hip and knee arthroplasty, FIB could significantly decrease pain scores and morphine intake at 12 and 24 h. Foss et al.[21] demonstrated in a randomized, placebo-controlled study, that pain control by FIB in hip fracture resulted in an opioid sparing action and remarkable pain control. McMeniman et al. reported that as part of a multimodal anesthetic regimen for TKA, FIB was found to be as effective as a femoral nerve block.[22]

A meta-analysis by Yang et al. of seven clinical trials data, that involved 508 cases showed that cases that underwent FIB had lower pain scores at 4 h and 24 h post lower limb surgery (LLS). Moreover, FIB could reduce the 24 h morphine consumption. [23]

Hong et al. reported in their meta-analysis, including eleven trials on 937 cases, experiencing hip fracture, that FIB positively affected pain intensity and morphine intake following hip fracture. In addition, FIB has morphine-sparing effects relative to a control group. [24]

Studies have shown that the PPB approach can be applied safely and effectively to cases experiencing ankle and foot operation, minimizing their pain during the procedure .[25-27] Li et al. highlighted that PPB group had significant reduction in the pain scores for 4 to 16 h postoperatively;

the first analgesic requirement, the side effects, and the frequency with which the patient forced the analgesic, were all less. In group PPB, the time to initiate patient-controlled analgesia (PCA), the first rescue patient-controlled analgesia time, and the duration of use of an analgesic pump were all longer than in the control group.[26]

Due to the uniqueness of the sciatic nerve, anesthesiologists can block the sciatic nerves in various body areas, including the superior sciatic nerve, the popliteal nerve, and the ankle joint. PPB is commonly used in ankle and foot operations with limited side effects and high patient satisfaction.[26] Also, Kim et al. reported that PPB demonstrated less pain, extended sensory block duration, and fewer repeated injections compared to DB.[28]

Our results showed that both groups had comparable PONV, hypotension, and bradycardia. PONV occurred in 8 (26.67%) patients in PPB group and 3 (10%) in FIB group. Respiratory depression didn't occur in any patient in both groups. PONV is a frequent adverse effect of morphine administered intravenously or intrathecally. A meta-analysis by Yang et al. revealed that cases receiving FIB had a lower incidence of PONV (P = 0.008) compared to no block. [23]

Effective anesthetic methods can decrease morphine intake and, consequently, the risk of complications associated with opioids.[26] Comparable to our research, Zhang et al. and Gao et al. reported in meta-analyses, which included 372 and 325 cases scheduled for total hip replacement, respectively, that the incidence of adverse events brought on by opioids displayed a comparable difference between FIB group and control group. [29,30] Bang et al. reported that only 1(9.09%) patient had nausea after FIB in patients who underwent hip hemiarthroplasty.

5. LIMITATIONS

The sample size was relatively small to prove secondary outcomes. The research was conducted at a single center. The duration of cases' follow-up was restricted and relatively brief. Therefore, large-scale multicenter studies with longer follow-up duration are needed to validate our findings.

6. CONCLUSIONS

FIB was superior to PPB in controlling postoperative pain after TKA, evidenced by lower pain score, lesser postoperative morphine consumption, and delayed time for the first analgesic request with comparable minimal adverse events.

7. Data availability

The numerical data generated during this research is available with the authors.

8. Conflict of interest

The authors declare no conflict of interest. The study utilized the hospital resources only, and no external or industry funding was involved.

9. Ethical approval and protocol registration

The study was performed from June 2022 to March 2023 at Tanta University Hospitals, Egypt, after approval from the Tanta University Hospitals Ethical Committee (approval code: 35431/04/22) and registration of clinicaltrials.gov (ID: NCT05390450). The cases' written informed consent was acquired.

10. Authors' contribution

Each author took part in the idea and design of the research. Preparation of materials, gathering and analysis of data were carried out by TMA, MFA, and TMN. The initial draught of the manuscript was written by TMA and TMN and the final manuscript was reviewed and approved by all authors.

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