EGYPTIAN JOURNAL OF ANAESTHESIA
2023, VOL. 39, NO. 1, 680–686
https://doi.org/10.1080/11101849.2023.2246732

Effect of Adding Infiltration between The Popliteal Artery and Capsule of The Knee Block (IPACK) to Continuous Adductor Canal Block after Total Knee Arthroplasty

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ABSTRACT

Background: Total knee arthroplasty (TKA) is a major surgical procedure that can be extremely upsetting. There are several methods available for postoperative pain management after knee surgery. One commonly used method is multimodal analgesia based on continuous adductor canal block.

Aim of The Work: Comparing the effect of the addition of posterior knee block, known as the infiltration between the popliteal artery and capsule of the knee (IPACK) block, to continuous adductor canal block (CACB) after total knee arthroplasty.

Patients and Methods: A total of 52 patients who underwent total knee arthroplasty were included and randomly divided into two groups receiving ultrasound-guided continuous adductor canal block or a combination of continuous ultrasound guided adductor canal block and the Infiltration between the popliteal artery and capsule of the knee block at the end of the surgery.

Results: Regarding the criteria for pain control, there was a statistically significant difference between the two groups regarding the postoperative visual analog score at 2, 4, 8, and 12 h after following up, which was not reported at 16 or 24 h postoperatively. The total nalbuphine consumption on the first day postoperative also showed a significant difference. A comparison of the basic demographic data, the onset of ambulation, the Timed Up and Go (TUG) test, and the straight leg raising test revealed no significant difference between the two groups.

Conclusion: Our study found that the use of continuous ultrasound guided adductor canal block and the Infiltration between the popliteal artery and capsule of the knee block together resulted in better postoperative pain management and reduced the need for nalbuphine. Despite this, there were no significant differences between the groups in terms of motor power or ambulation abilities. Trial registration number: PACTR202301536928551

ARTICLE HISTORY
Received 23 May 2023
Revised 25 July 2023
Accepted 7 August 2023

KEYWORDS
Adductor canal; IPACK; knee surgeries

1. Introduction

Osteoarthritis and rheumatoid arthritis are two common comorbidities among patients undergoing total knee arthroplasty (TKA), in addition to presentation in old age. For perioperative and postoperative pain management, it is required to employ a multimodal, opioid-sparing approach. This method uses a single injection, continuous nerve block, periarticular injection (PAI) of local anesthetics (LAs), non-opioid analgesics, and postoperative nausea and vomiting prophylaxis. All these factors enable early mobilization [1].

The nerves to vastus medialis, intermedius, lateralis, and medial and intermediate femoral cutaneous and saphenous nerves supply the majority of the knee joint's innervation. The sciatic nerve is partially innervating the joint by the tibial and the common peroneal nerves. Also, lateral femoral cutaneous and posterior obturator nerves provide even less [2].

Adductor canal block (ACB) is an effective peripheral nerve block that can relieve post-knee arthroplasty pain, especially in the peripatellar and intra-articular regions, with minimal or no motor affection on the quadriceps muscle's motor activity. Continuous adductor canal block (CACB), however, fails to alleviate the moderate pain felt behind the knee [3].

Blocking the interspace between the popliteal artery and the posterior capsule of the knee (IPACK) has been shown to be safe for blocking the small sensory branches of the sciatic nerve that run through this area, preserving motor functions.

Even though many institutions use this technique, its effectiveness is still completely unrevealed. Since this block is not sufficient for postoperative analgesia

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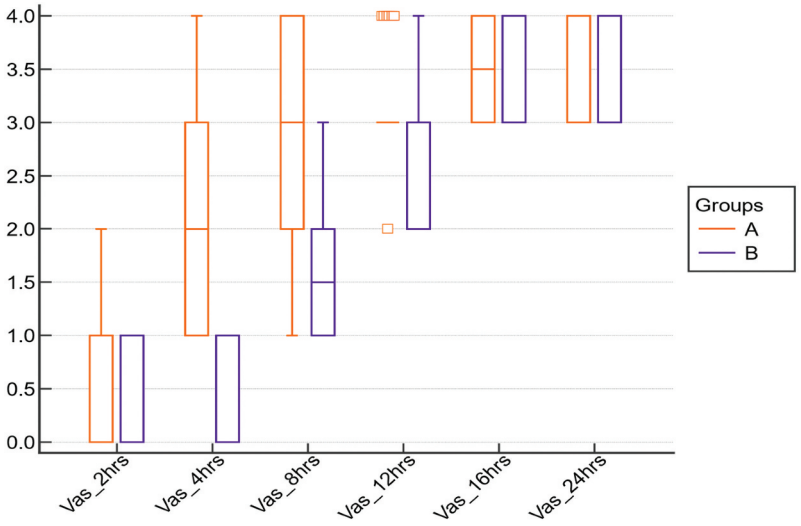

Figure 1. Box and whisker graph between groups as regard VAS score.

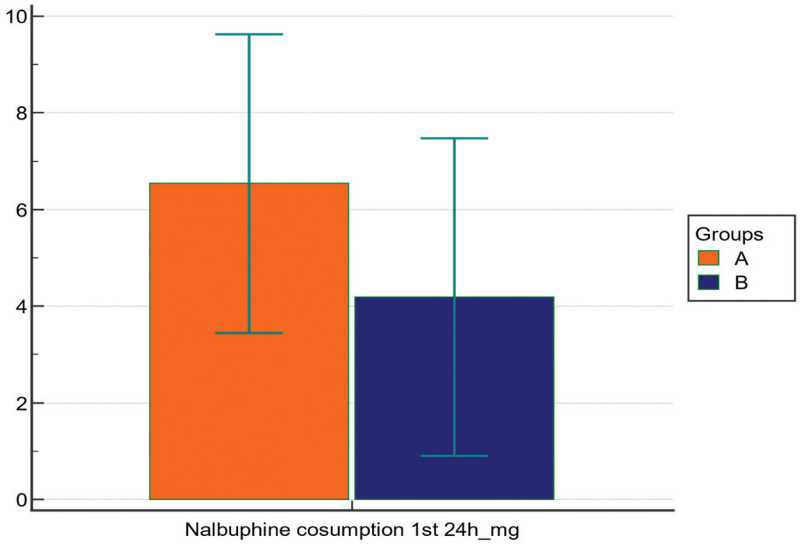

Figure 2. Bar graph between groups as regards nalbuphine consumption in 1st 24 h.

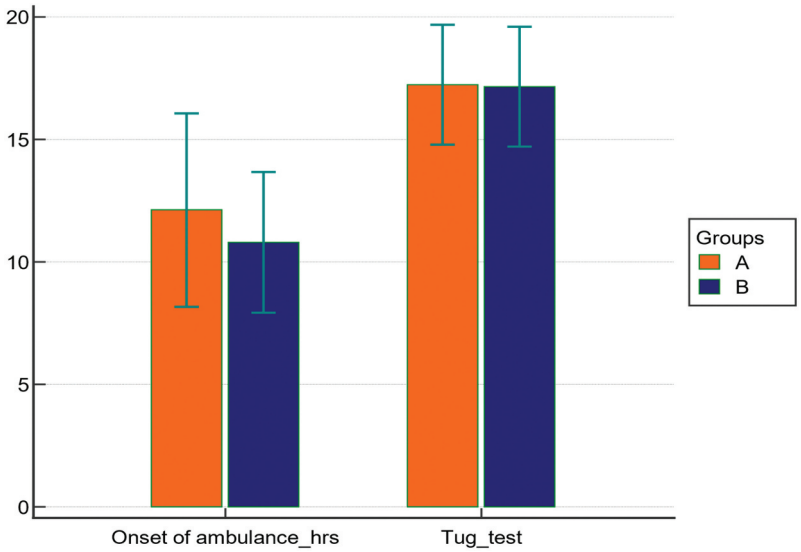

Figure 3. Bar graph between groups as regard motor power.

on its own, it is often combined with CACB in a multimodal analgesic pathway [4].

2. Aim of the study

The aim of the study is to assess the analgesic effectiveness of adding IPACK to the CACB block after TKA.

3. Patients and methods

Between September 2021 and January 2023, 52 patients were enrolled in this prospective, randomized, comparative study at Ain Shams University Hospitals, Cairo, Egypt. The trial was registered in Pan African Clinical Trials Registry (PACTR) PACTR202301536928551.

3.1. Inclusion criteria

This study included individuals of both sexes aged 21–65 years with American Society of Anesthesiologists (ASA) I or II physical status who were scheduled to undergo unilateral TKA with effective spinal anesthesia.

3.2. Exclusion criteria

An **A**bsence of informed consent, history of medication allergies, regional anesthesia contraindications (coagulopathy, local infections), myopathy, or neuropathy on the operative limb, psychological condition, obesity with a BMI of over 45 kg/m2, patients with diabetes mellitus, polytrauma patients with lower limb fractures, ASA III or IV, and complicated surgical procedures.

Patients were randomly divided into two groups. There were 26 patients in each group. Group B received an IPACK block in addition to CACB, while Group A received an ultrasound-guided CACB only.

3.3. Patients consent

A written informed consent (outlining the procedures to be followed and the overall goals of the study) was signed by each patient enrolled in the study.

3.4. Ethical consideration

The Faculty of Medicine Ain Shams University Research Ethical Committee (FMASU REC) gave their approval to the entire research project (FMASU MD 120/2021). Privacy and confidentiality were respected at every stage of the research. Patients felt completely free to discontinue the study at any time with no penalties. No other use has been made of or will be made of the collected data.

4. Methodology

Each patient had his medical history reviewed, a complete physical examination, and lab work done before surgery. All patients were admitted 8 h before surgery and given instructions to fast.

4.1. Sample size

The sample size was calculated to include 52 patients (26 per group). According to Chutikant Vichainarong et al. (2020), the adjusted pain score with movement differed significantly between groups. A two-sided two-sample equal-variance t-test with at least 26 and 26 samples will have 80% power to reject the null hypothesis of zero effect size when the population effect size is 0.80, and the significance level (alpha) is 0.050 [5].

5. Study procedure

On arrival at the operation theatre, motor and sensory assessments were done pre-operatively for baseline documentation. Temperature testing (using the ice test) was used to evaluate sensitivity in the anterior and medial thigh (testing the femoral nerve), the medial lower leg (testing the saphenous nerve), and the posterior knee and lower leg (for sciatic nerve).

Motor assessment for quadriceps muscle was done by asking the patient to sit with his knees over the side of the table. The examiner held the thigh firmly down on the table, while the patient extended the knee joint without rotation of the thigh. Grade 0 represents normal muscle power, Grade I represents motor weakness, and Grade II represents total motor paralysis.

A lactated ringer solution was infused into the patient's intravenous line at 3 mL/kg per hour, and 0.05 mg/kg of midazolam was administered intravenously to sedate them. Patients' perioperative vital signs were observed using monitors for non-invasive blood pressure (every 5 min), electrocardiogram (continuous), and pulse oximetry (continuous). Three milliliters of 0.5% hyperbaric bupivacaine and 25 µg of fentanyl were used to administer spinal anesthesia.

Patients were observed for any complications, e.g., hypotension (a drop of blood pressure ˃20% of baseline reading), bradycardia (heart rate of <60 beats/min), decrease in peripheral oxygen saturation (SpO2 < or = 85% or <90% for more than 3 min), nausea, vomiting, or any other adverse effect, and were managed.

After the end of the surgery, CACB or IPACK combined with CACB was performed according to patient group allocation.

5.1. In group A

The ultrasound probe was positioned about halfway up the patient's thigh (halfway between the anterior

superior iliac spine and the patella). A 10 cm, 18-gauge needle was used to make a plane puncture through the sartorius muscle. To ensure that the needle was inserted into the correct adductor canal, a 10 ml saline injection was administered.

A bolus injection of 30 ml of 0.25% bupivacaine was given to all patients following US protocol. The adductor canal was catheterized with a 21-gauge needle under ultrasound guidance, and 125 ml of 0.125% bupivacaine was infused at a rate of 5 ml/hour with a continuous infusion set for 24 h.

5.2. In group B

After completing the CACB, the IPACK technique with ACB can be modified to allow for supine positioning, which eliminates the need to reposition and repeat prepping/draping. The patient is placed in a supine position with the knee flexed and the hip slightly abducted (frog-leg position). The popliteal fossa is scanned using a low-frequency curvilinear probe placed in a posteromedial position to visualize the tissue plane between the popliteal vessels and the femoral shaft proximal to the femoral condyles. The 22 G spinal needle is inserted in-plane in an anteromedial to posterolateral direction between the popliteal artery and femur until the needle tip lies no more than 2 cm beyond the lateral edge of the popliteal artery. Small aliquots of local anesthetic are infiltrated evenly in the plane between the popliteal artery and the femur. A total of 20 ml of bupivacaine 0.25% were injected [6].

Postoperative pain is treated by increments of nalbuphine 5 mg as rescue analgesia.

5.3. Outcome measures

The primary outcome measure is the intensity of pain after surgery, measured using a Visual Analogue Scale (VAS) score at various time points: at 2, 4, 8, 12, 16, and 24 h after surgery.

5.4. Secondary outcome measures include

- The total dose of nalbuphine was consumed postoperatively during the first 24 h.
- Early mobilization in the first 24 h.

5.5. Statistical analysis

Statistical Package for Social Science (SPSS) version 22.0 program was used to analyze the data. Quantitative data were shown as mean ± SD or median, interquartile range (IQR) according to the normality test. Qualitative data were presented as frequency and percentage.

5.6. The following tests were used

Comparing the quantitative data within two groups was conducted using independent samples t-test or Mann–Whitney U-test in parametric and non-parametric data, respectively. Two qualitative variables were correlated using the Chi-square test of significance. The confidence interval was 95%, and the allowed error was 5%. A p-value below 0.001 was highly significant. Statistically insignificant p-values were above or equal to 0.05.

6. Results

The study included 52 participants, consisting of 23 females and 29 males between the ages of 21 and 65. The participants were divided into two groups: group A, with 26 participants (12 females and 14 males), and group B, with 26 participants (11 females and 15 males), as shown in Table 1. There were no significant differences between the two groups in terms of age, sex, Body Mass Index, BMI, and ASA physical status. All patients successfully completed the study protocol without any intraoperative incidents or exclusions from the protocol.

Age, sex, BMI, and ASA did not significantly differ between groups (p-value >0.05). VAS scores were statistically significant between groups for pain control data except at 16 and 24 h as shown in Table 2 and Figure 1. Day-one nalbuphine consumption differed significantly between groups with a high consumed dose in group A as shown in Table 3 and Figure 2. Motor power, measured by the time to first ambulate, the TUG test, and the SLR, was not statistically different between groups after 24 h, as shown in Table 4 and Figure 3.

Table 1. Demographic data in the two studied groups.

Demographic data		A ($n = 26$)	B ($n = 26$)	T/x2	p-value
Age (years)		56.35 ± 5.6	58.15 ± 4.5	1.3^{t}	0.21
BMI		26.91 ± 1.0	26.40 ± 1.2	1.7^{t}	0.1
ASA	I	14(53.8%)	16(61.5%)	0.3^{x2}	0.58
	II	12(46.2%)	10(38.5%)		
Sex	Male	14(53.8%)	15(57.7%)	0.08^{x2}	0.78
	Female	12(46.2%)	11(42.3%)		

Data expressed as mean ± SD, proportion. *t* = student t test, x2= Chi square test.

Table 2. Comparison between groups regarding VAS score data.

	A ($n = 26$)			B ($n = 26$)			
	range	Median	IQR	range	Median	IQR	P value
Vas_2hrs	0–2	1	0–1	0–1	0	0–1	0.006
Vas_4hrs	1–4	2	1–3	0–1	0	0–1	<0.001
Vas_8hrs	1–4	3	2–4	1–3	1.5	1–2	<0.001
Vas_12hrs	2–4	3	3–3	2–4	3	2–3	<0.001
Vas_16hrs	3–4	3.5	3–4	3–4	3	3–4	0.4
Vas_24hrs	3–4	4	3–4	3–4	4	3–4	0.25

Data expressed as range, median, and IQR. P = Mann–Whitney test.

Table 3. Comparison between groups regarding nalbuphine consumption in first 24 h.

	A ($n = 26$)	B ($n = 26$)	t	p-value
Nalbuphine consumption in first 24 h	6.54 ± 3.1	4.19 ± 3.3	2.7	.01

Table 4. Comparison between groups as regards motor power.

	A ($n = 26$)	B ($n = 26$)	t/X^2	p-value
Onset of ambulation	12.12 ± 3.9	10.81 ± 2.9	1.4^{t}	.18
TUG test	17.23 ± 2.5	17.15 ± 2.4	0.1^{t}	.9
SLR	19 (73%)	17 (65.4%)	0.4^{x2}	.55

7. Discussion

The rise in TKA procedures performed globally in recent years, which are extremely painful procedures with a high risk of complications, has highlighted the need for patients having these operations to have access to effective pain management techniques [7].

Opioid analgesics that are typically administered parenterally or epidurally to treat pain after TKA surgery are ineffective and may cause side effects [8].

There are many techniques that have been developed to lessen pain. In recent years, methods for blocking peripheral nerves have grown in popularity. The quadriceps muscle can be protected during knee surgery by using a powerful peripheral nerve block called a (CACB). By doing so, early mobilization after surgery and a sufficient analgesic effect are guaranteed [9].

But because the deep genicular neurons that transmit pain signals from the back of the knee are not affected by the CACB, the drug's analgesic effect is limited to the front of the knee [10].

IPACK avoids damaging the tibial and peroneal nerves that control movement by injecting LAs between the popliteal artery and the posterior capsule of the knee. This may selectively block the sensory deep genicular nerves, which supply sensory nerves to the back of the knee without affecting muscle strength [11].

Our study compared CACB and IPACK in reducing postoperative knee pain. Pain control data, including VAS score, were significantly different between the two groups, except at 16 and 24 h and total nalbuphine consumption in the first 24 h after surgery. The Visual Analogue Scale is a widely used tool for assessing pain levels in medicine. It is a visual representation of the numerical rating scale. The most common version of the VAS is a horizontal line with an 11-point numerical range. Patients are asked to rate their pain on a predefined scale using the VAS. It is a simple and commonly used tool. The scale typically ranges from 0 to 10, with 0 representing "no pain" and 10 representing "the worst pain imaginable." The advantages of using the VAS include its simplicity, reproducibility, ease of understanding and sensitivity to small changes in pain levels.

The Timed Up and Go test, also known as the TUG test, is a simple evaluative test used to measure functional mobility. The TUG test measures how long it takes to stand up, walk 10 feet, turn, walk back, and sit down again [12].

Straight leg raise (SLR) test is a common exercise prescribed after TKA. Performing SLR on the first day after TKA is associated with a shorter length of stay, time to ambulate, and time to stair climbing. Early postoperative SLR can prognosticate early recovery and discharge [13].

Accordingly, Chun-Guang Wang et al., the group that received CACB + IPACK, demonstrated better pain control (VAS) as well as encouraging the recovery of motor function than CACB alone. However, by combining distal IPACK with CACB, the consumption of opioids did not decrease [14]. These results were not consistent with our results as regards opioid consumption which could be due to using general anesthesia after the nerve block in Wang's study unlike our study in which spinal anesthesia is used and the block is done after the end of surgery.

Scimia et al. (2017) evaluated the effectiveness of the IPACK block in conjunction with CACB for postoperative analgesia and early rehabilitation in the first 72 h after a TKR. While maintaining quadriceps

strength and improving ambulation, this technique provides comparable analgesia and opioid consumption to FNB [15].

ACB + IPACK patients had lower pain, opioid consumption, and analgesic durations than ACB alone patients, according to Li et al. [16]. These results were consistent with our results.

Different research by Et et al. found that when ACB was paired with IPACK, patients had quicker discharge and mobilization days, less pain, and fewer needs for opioids than those who received only ACB [17]. Our results were consistent with these findings with regard to analgesia and opioid needs.

According to Singtana, IPACK block reduced opioid consumption 12 h after surgery more than ACB alone. The numeric pain rating scale, analgesic use, patient satisfaction, and complications were not statistically different between groups [18]. While ACB with IPACK block technique provides effective postoperative pain control for TKA patients. This technique shows significant less accumulative opioids needed. Our results were consistent with these findings.

According to Caballero-Lozada et al. (2020), a multimodal analgesia regimen, commonly involving opioids, is the most promising method for managing pain in patients undergoing elective TKA. This includes a combination of techniques (such as adductor canal combined with IPACK) [19].

Further, IPACK did reduce postoperative VAS scores in both active and resting patients, as shown by Guo et al. (2022). The IPACK supplement, when used with ACB, can reduce the cumulative postoperative morphine consumption of patients, improve their activity performance after surgery, and have no adverse effects. Our results were consistent with these findings [20].

8. Conclusion

Our study found that the use of CACB and IPACK together resulted in better postoperative pain management and reduced the need for nalbuphine. Despite this, there were no significant differences between the groups in terms of motor power or ambulation abilities.

Abbreviations

ASA	American Society of Anesthesiologists.
IPACK	Interspace between the popliteal artery and capsule of the knee
CACB	Continuous Adductor canal block
ACB	Adductor canal block
TKR	Total knee replacement
TKA	Total knee arthroplasty
VAS	Visual analog score
TUG	Timed Up and Go test
ROM	Range of movement
FNB	Femoral nerve block
SLR	straight leg raising test

Disclosure statement

No potential conflict of interest was reported by the author(s).

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