



Original Research Article

COMPARATIVE EVALUATION OF ULTRASOUND-GUIDED iPACK COMBINED WITH ADDUCTOR CANAL BLOCK VERSUS LUMBAR ERECTOR SPINAE PLANE BLOCK FOR MULTIMODAL ANALGESIA FOLLOWING TOTAL KNEE ARTHROPLASTY: A PROSPECTIVE RANDOMIZED DOUBLE-BLIND CONTROLLED STUDY

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ABSTRACT

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Background: Total knee arthroplasty (TKA) is one of the vascularly indicated and commonly done orthopedic surgeries for osteoarthritis of the knee at terminal stages because of the surgical pain related to it. Therefore, perioperative analgesia must be provided to ensure early mobilization, reduce the patients' needs for postoperative opioids, improve functional recovery in a short period, and enhance satisfaction of the patients. Among all possible regional motor-sparing techniques of analgesia, infiltration between the knee joint capsule and popliteal artery (iPACK) block use along with adductor canal nerve block (ACB) and lumbar erector spinae plane block (L-ESPB) techniques has been shown to provide good analgesia following TKA. However, research data comparing the two techniques with respect to postoperative pain control, total quantity of opioid consumption, inflammatory biomarker levels, and early rehabilitation is limited. **Aim:** The purpose of this research study is to evaluate the difference in analgesic effectiveness, opioid-sparing effect, functional recovery, inflammatory response, and postoperative outcome variables between ultrasound-guided iPACK combined with adductor canal block compared to lumbar erector spinae plane block for elective total knee arthroplasty under spinal anesthesia.

Materials and Methods: This trial was a prospective, randomized, double-blind controlled clinical research study undertaken over a period of 18 months within the Department of Anaesthesiology in a tertiary care institution. The study consisted of ninety adult subjects (ASA Physical Status I-III) aged from 60 to 85 years who were scheduled for unilateral primary total knee arthroplasty under spinal anesthesia, which was randomly divided into three*(3) equal groups. Group IA was subjected to ultrasound-guided iPACK in conjunction with adductor canal block, Group LE was subject to ultrasound-guided erector spinae lumbar block, and Group C was administered clinical multimodal analgesia without the employment of additional regional block. The primary outcome measures included cumulative opioid usage in the first fort-eight (48) postoperative hours. The secondary outcome measures included postoperative pain scale to be measured at rest and in motion, rescue analgesia administration time measurement, quadriceps strength, early ambulation, neutrophil-lymphocyte ratio (NLR), platelet-lymphocyte ratio and postoperative complication, patient satisfaction, and hospital stay. A statistical analysis for the data obtained was carried out using appropriate nonparametric tests.

Results: The results showed that patients treated via iPACK with adductor canal block had significantly lower total opioid consumption throughout the first 48 hours as compared to both lumbar ESP block treated group and the control group. In addition, for the patients treated via iPACK with adductor canal block, pain scores were lower at rest and upon degree mobilization and those treated via iPACK with adductor canal block had much longer time before the first use of rescue analgesia was required. The patients also experienced preservation of quadriceps muscle strength and were able to ambulate independently earlier. Following the surgery, all the patients treated via both regional anesthesia techniques had lower levels of pain and utilized opioids at a lesser amount than patients who underwent multimodal analgesia. While both groups treated by the two regional anesthetic techniques showed improvement in postoperative inflammatory markers such as NLR and PLR as compared to preoperative levels, there was no statistically significant difference between both interventions provided to the patients. The incidences of postoperative nausea and vomiting and other adverse opioid effects were less for the patients in the regional nerve block group. All in all, the procedure involving co-

administration of iPACK followed by a standard adductor canal block is more advantageous in providing multimodal analgesia and accelerated recovery following total knee arthroplasty. **Conclusion:** The combination of ultrasound-guided iPACK and the adductor canal block technique is a viable and safe technique that provides motor-sparing analgesic management for patients undergoing total knee arthroplasty. It provides high-quality postoperative analgesia compared to lumbar erector spinae plane block, reduces opioid consumption significantly, prolongs the time before the use of rescue analgesia postoperatively, enhances rehabilitation, and increases patient satisfaction while providing the same level of safety as other techniques. Therefore, regional anesthesia techniques within standardized ERAS protocols can provide improved management both during the perioperative period and in recovery after primary total knee arthroplasty.

Keywords: Total knee arthroplasty; iPACK block; Adductor canal block; Lumbar erector spinae plane block; Regional anesthesia; Postoperative analgesia; Opioid consumption; Enhanced recovery after surgery; Ultrasound-guided nerve block; Multimodal analgesia.

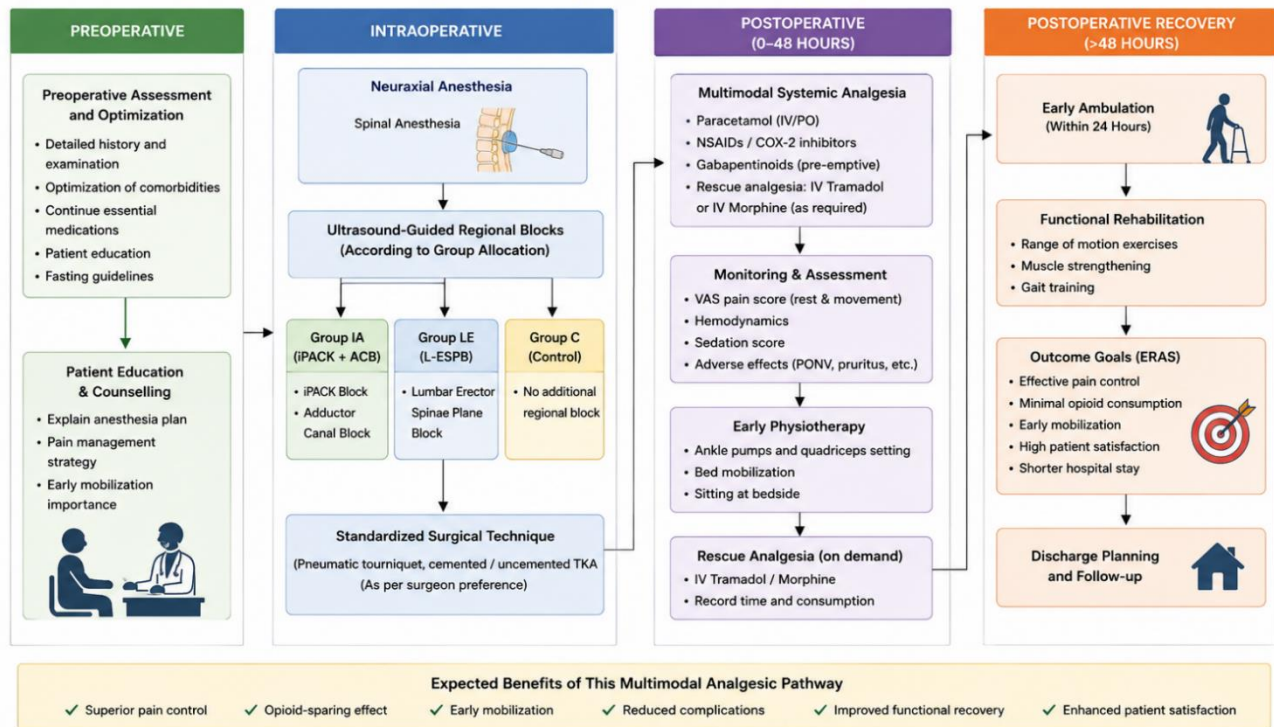
INTRODUCTION

Among all orthopedic surgical interventions, total knee arthroplasty (TKA) is currently one of the most efficacious surgical procedures to manage advanced degenerative knee disorders, especially end-stage osteoarthritis, rheumatoid arthritis, and other debilitating diseases that impede mobility and lower quality of life. As life expectancy rises and obesity rates increase, and indications for joint arthroplasty also expand, the number of primary TKA operations performed annually has been increasing worldwide.^[1] ECM techniques have been upgraded, however, postoperative pain management still remains a significant issue as it prevents early mobilization of patients, impairs functional rehabilitation, affects patient satisfaction and contributes to unsatisfactory surgical outcomes. TKA patients may suffer from unbalanced postoperative pain management that can lead to delays in gaining mobility, increased opioid consumption, prolonged period of stay in hospital, chronic postoperative pain, impaired knee function, and high healthcare costs. Systemic opioid-based analgesia despite its effectiveness is usually accompanied by unwanted effects including gastrointestinal problems, sedation, respiratory depression, urination problems, dizziness, longer rehabilitation.^[2] Therefore, currently multimodal analgesic drugs combined with regional anesthesia techniques are preferred in order to optimize pain control and decrease opioid-related complications. Femoral nerve block among all available regional anesthesia techniques is the gold standard for analgesia after TKA since it was firstly introduced. Nonetheless, weakness in the quadriceps muscle elevates the chances of falling and hinders movement soon after surgery. The use of motor-preserving regional nerve blocks has increased in prominence. The adductor canal block (ACB) provides effective pain control for the front side of the knee by covering the saphenous nerve but does not cover all of the innervations around the knee. Because of this limitation, the infiltration between the popliteal artery and the capsule of the posterior knee (iPACK) block has been utilized in order to block the articular nerves responsible for providing innervations to the

posterior capsule of the knee, while still allowing the quadriceps to function. When the iPACK block is used together with the ACB block, pain is blocked from the front and back of the knee without affecting the function of the lower extremities too much.^[3-4] Clinical data supports the effectiveness of this combination in terms of pain management after surgery, overall satisfaction of the patients receiving this method compared to other regional blocks and/or standard multimodal techniques. Recently, the lumbar erector spinae plane block (ESPB) has come to be recognized as a block technique involving the escape of local anesthetic into multiple directions. Due to its ability to achieve adequate pain control with little risk of a vascular complication, ESPB is being investigated for its potential in terms of pain relief following orthopedic surgery on the lower extremities. While there's still much to be learned, results thus far indicate that ESPB can provide adequate results in terms of pain control following surgery. Direct comparisons between iPACK used together with adductor canal block and ESPB have been limited, with most articles examining postoperative pain levels and consumption of analgesic medications, although fewer papers have examined functional recovery, quadriceps muscle strength after surgery, levels of inflammatory markers as well as patient satisfaction through the use of standardized protocols. It is imperative to study these variables to find out which technique is better suited to achieve effective pain relief, while emphasizing the time taken for rehabilitation post-surgery.^[5-6]

In addition to this, concepts such as enhanced recovery protocols have pushed for the use of regional anesthesia that allows patients to experience a good level of analgesia without reliance upon opioids, thus allowing patients to mobilize sooner. In addition to providing proper analgesia, it is also crucial that quadriceps strength be maintained in order to attain quick rehabilitation. The purpose of this study is to compare the use of ultrasound iPACK and adductor canal block against lumbar erector spinae plane block for patients undergoing TKA. This will include comparisons of postoperative pain, analgesic requirements, and functional recovery among the patients.^[7]

Figure 1. Contemporary Multimodal Analgesic Pathway for Total Knee Arthroplasty

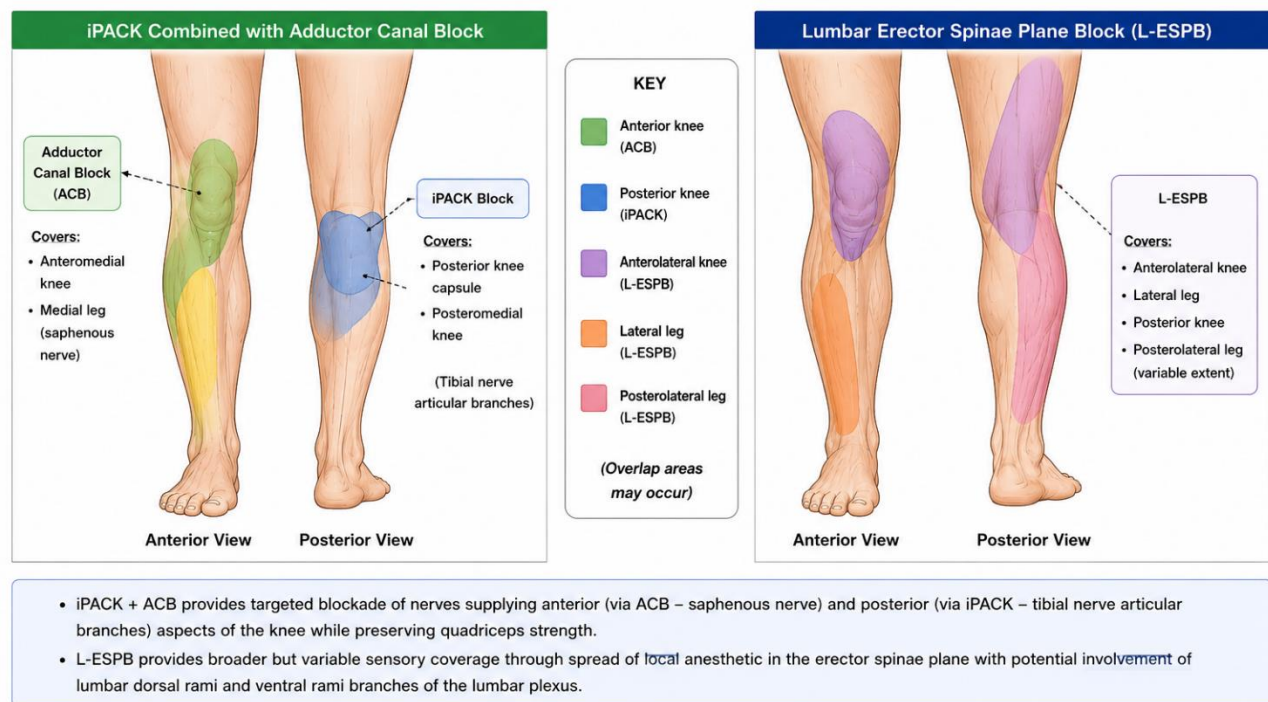


ACB – Adductor Canal Block; iPACK – Infiltration between Popliteal Artery and Capsule of the Knee; L-ESPB – Lumbar Erector Spinae Plane Block; IV – Intravenous; PO – Oral; NSAIDs – Non-steroidal anti-inflammatory drugs; PONV – Postoperative nausea and vomiting; ERAS – Enhanced Recovery After Surgery; TKA – Total Knee Arthroplasty; VAS – Visual Analogue Scale.

Figure 1. Contemporary multimodal analgesic pathway for total knee arthroplasty

The illustration shown in the first figure is a depiction of the multimodal approach of postoperative pain management, informing about the inclusion of some motor-sparing regional anesthesia techniques to the ERAS protocol following the total knee arthroplasty procedure.

Figure 2. Anatomical Sensory Coverage: iPACK Combined with Adductor Canal Block versus Lumbar Erector Spinae Plane Block



ACB – Adductor Canal Block; iPACK – Infiltration between Popliteal Artery and Capsule of the Knee; L-ESPB – Lumbar Erector Spinae Plane Block

Figure 2. Anatomical sensory coverage of iPACK combined with adductor canal block versus lumbar erector spinae plane block

Comparative anatomical representation demonstrating the sensory innervation targeted by ultrasound-guided iPACK with adductor canal block and lumbar erector spinae plane block during total knee arthroplasty.^[8]

MATERIAL AND METHODS

Study design

In this randomized, double-blinded, controlled trial, we conducted research to find out the efficiency of pain relief after surgery in patients who received ultrasonography of popliteal artery and iPACK with adductor canal technique and L-ESPB block by ultrasonography. The aim of this study was to assess the effectiveness of these procedures for postoperative pain management. In addition, we were able to monitor the effectiveness of both treatments with regards to the degree of pain relief, resulting in decreased usage of opioids, the time taken for the patient to recover, the muscle strength, perioperative inflammation markers, patients' satisfaction, and complications after surgery. The study design and methodology are in agreement with GCP guidelines of patient care.

Study setting

The research study was carried out in a collaborative manner in the anaesthesiology and orthopaedics departments of a tertiary care teaching hospital over a duration of one and a half years. Patients who had met the inclusion criteria and signed informed consent were recruited one after another for the elective unilateral total knee arthroplasty procedure.

Study duration

The total study duration was 18 months (January 2025 to June 2026).

- Patient recruitment: January 2025 to December 2025
- Clinical follow-up: Up to hospital discharge
- Data compilation, statistical analysis, and manuscript preparation: January 2026 to June 2026

Sample size calculation

Sample size estimation was done with the consideration of cumulative opioid consumption during the first 48 hours after surgery as the main outcome variable. Assuming an effect size of 0.35, a statistical power of 80%, a 95% confidence interval, and an alpha level of 0.05, the minimum sample size was calculated to be 81. To allow for protocol deviations and dropouts, an additional 10% was added to the sample size of 81. Thus, the final sample size of 90 patients was achieved.

The sample size was calculated using the formula:

$$n = [(Z\alpha/2 + Z\beta)^2 \times 2\sigma^2] / d^2$$

Where:

- n = Required sample size
- $Z\alpha/2 = 1.96$ for 95% confidence interval
- $Z\beta = 0.84$ corresponding to 80% study power
- σ = Estimated standard deviation
- d = Minimum clinically significant difference between study groups

Study population

A total of 90 adult patients undergoing elective unilateral primary total knee arthroplasty under spinal anaesthesia were enrolled.

Participants were randomly allocated into three equal groups.

- **Group IA (n = 30):** Ultrasound-guided iPACK block combined with Adductor Canal Block
- **Group LE (n = 30):** Ultrasound-guided Lumbar Erector Spinae Plane Block
- **Group C (n = 30):** Conventional multimodal analgesia (Control)

Randomization

Randomizations of eligible participants occurred in a 1:1:1 ratio by a computer-generated random allocation sequence prepared by an independent investigator. To ensure confidentiality, sequentially numbered opaque sealed envelopes were utilized and opened prior to the initiation of the intervention.

Blinding

The researchers used a double-blind design in the study. All of the patients, orthopedic surgeons, nursing personnel, physiotherapists, assessing postoperative outcomes, and the statistician were blinded to the assignment of patients to either group throughout the course of the study. The anesthesiologist who performed the regional blocks was not involved in the assessment of the postoperative patients or statistical analysis of the data.

Inclusion criteria

Patients fulfilling all of the following criteria were included in the study:

- Age between 55 and 85 years
- Either gender
- American Society of Anesthesiologists (ASA) Physical Status I–III
- Diagnosed primary osteoarthritis of the knee requiring unilateral primary total knee arthroplasty
- Body mass index (BMI) between 20 and 35 kg/m²
- Ability to understand the Visual Analogue Scale (VAS)
- Willingness to provide written informed consent

Exclusion criteria

Patients were excluded if they had:

- Revision or bilateral knee arthroplasty
- Allergy or contraindication to local anaesthetic agents
- Coagulopathy or anticoagulant therapy contraindicating regional anaesthesia
- Local infection at the proposed needle insertion site
- Peripheral neuropathy involving the lower limb
- Severe hepatic, renal, or cardiac dysfunction
- Chronic opioid dependence
- Neuromuscular disorders
- Cognitive impairment affecting pain assessment
- Pregnancy or lactation
- Refusal to participate

Preoperative assessment

Every participant had gone through a detailed preoperative assessment consisting of their medical history, clinical assessment, airway evaluation, ASA

classification, laboratory tests, ECG, chest radiographic examination (if needed), and normal biochemical tests. The baseline VAS training was provided to participants. Prior to surgery, the baseline quadriceps strength, knee joint mobility, neutrophil-lymphocyte ratio (NLR), platelet-lymphocyte ratio (PLR), and vital parameters were taken.

Anaesthetic technique

Based on standard fasting guidelines, patients were placed nil per oral and, if indicated, received standard aspiration prophylaxis during their preoperative period. Following their arrival in the operating room, ASA routine monitoring (ECG, pulse oximetry, noninvasive blood pressure) was initiated. All patients were started on intravenous fluids (Ringer's lactate 10 mL/kg) by means of an 18-G cannula placed peripherally before the initiation of neuraxial anesthesia.

Anesthesia was given under strict aseptic conditions at L3-L4 or L4-L5 using a 25-G Quincke spinal needle. Anesthesia was confirmed and surgery started once sensory level was established at T10 using 3 mL of 0.5% hyperbaric bupivacaine plus fentanyl 25 µg.

Ultrasound-guided iPACK block with Adductor Canal Block (Group IA)

After spinal anesthesia wore off, patients assigned to Group IA had an iPACK block done under ultrasound guidance followed by an adductor canal block.

The iPACK block is done using a high-frequency linear ultrasound probe placed in a transverse position over the distal femur to find the popliteal artery and posterior femoral cortex. A 22-gauge 100-mm echogenic block

needle was introduced in the in-plane position. The needle was advanced until the tip was placed between the popliteal artery and the posterior capsule of the knee and negative aspiration confirmed. Then 20 mL of 0.25% ropivacaine was injected under real time visualization of the effect.

The ultrasound transducer is now transferred to the mid thigh to locate the sartorius muscle, femoral artery, vastus medialis muscle, and saphenous nerve in the adductor canal. Then using the in-plane technique again 15 mL of 0.25% ropivacaine is injected around the saphenous nerve after negative aspiration.

Ultrasound-guided Lumbar Erector Spinae Plane Block (Group LE)

Patients in Group LE had ultrasound-guided lumbar erector spinae plane block performed at the level of L4 vertebra. To perform the procedure, a low-frequency curvilinear transducer was placed longitudinally about 3 cm laterally to the spinous process for recognition of erector spinae muscle and L4 transverse process. Subsequently, an echogenic needle having a gauge size of 22-G and a length of 100 mm was inserted either anteriorly or posteriorly into the Erector spinae muscle until the needle's end came in contact with the transverse process located posterior to erector spinae muscle. After hydrodissection using saline solution for confirmation of the proper anatomical space, 30 mL of 0.25 percent Ropivacaine was injected into the proper anatomical space observed with real-time imaging.

Figure 3. Ultrasound-guided regional block techniques.

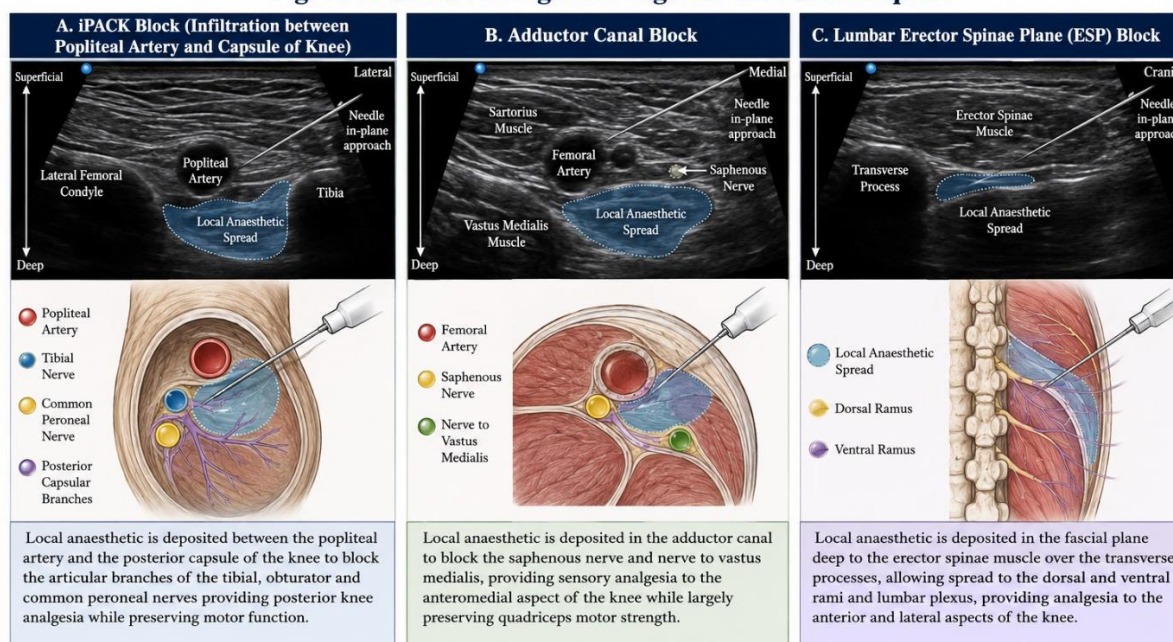


Figure Legend: Composite ultrasound images (upper panels) with corresponding anatomical illustrations (lower panels) showing the needle position (in-plane approach) and local anaesthetic spread (blue area) for: (A) iPACK block, (B) Adductor canal block, and (C) Lumbar erector spinae plane block. These motor-sparing regional anaesthetic techniques provide complementary sensory blockade for effective postoperative analgesia after total knee arthroplasty.

Figure 3. Ultrasound-guided regional block techniques for postoperative analgesia following total knee arthroplasty

The authors made the figure in order to show three blocks that can be done ultrasound-guided. The authors decided to use these diagrams because they provide information regarding three significant blocks. Diagram A represents

the iPACK block that uses the injection of local anesthetic between the popliteal artery and knee capsule in order to provide posterior knee pain control without motor blockade. Diagram B depicts the Adductor Canal

Block, which uses the injection of anesthetic around the saphenous nerve in order to provide anesthetic block of the anterior medial knee without motor paralysis. Diagram C indicates the lumbar ERPCB for which the anesthetic is injected beneath the erector spinae muscle at the level of the lumbar transverse process. Overall, these diagrams depict the use of new motor-interfering as well as regional blocks for postoperative pain management.

Control group (Group C)

Individuals within the control cohort received basic multimodal perioperative analgesia just like in the intervention cohort. However, intra- and postoperative analgesia management differed from that of the other cohort only because of the absence of a regional nerve block.

Postoperative analgesic protocol

All patients received multimodal postoperative analgesia that was standardized for every patient. This included intravenous 1 g of paracetamol every 8 hours and intravenous 30 mg of ketorolac every 12 hours unless there were contraindications. The rescue analgesia in the form of intravenous 50 mg of tramadol was provided to the patients whenever their Visual Analogue Scale score was ≥ 4 or when they requested it.

Outcome measures

Primary outcome

- Total opioid consumption during the first 48 postoperative hours.

Secondary outcomes

- Visual Analogue Scale (VAS) pain score at rest.
- Visual Analogue Scale pain score during movement.
- Time to first rescue analgesia.
- Total rescue analgesic requirement.
- Quadriceps muscle strength.
- Time to first ambulation.
- Knee range of motion.
- Neutrophil-to-lymphocyte ratio (NLR).
- Platelet-to-lymphocyte ratio (PLR).
- Patient satisfaction score.
- Length of postoperative hospital stay.
- Incidence of postoperative nausea and vomiting.

- Block-related complications and adverse events.

Data collection schedule

The clinical assessments were conducted at 0 hour (the end of surgery) and then at 2, 6, 12, 24, 36, and 48 hours after the surgery was completed. The recovery variables of quadriceps strength, ambulation, and satisfaction were evaluated following our guidelines for rehabilitation.

Statistical analysis

The data were processed through Microsoft Excel and analyzed via appliance of IBM SPSS Statistics version 29.0 (IBM Corp., Armonk, NY, USA). The continuous variables were expressed as mean $\pm$ standard deviation (SD), while categorical variables were expressed as frequencies and percentages.

Comparisons between each of the three study groups were performed with the aid of one-way analysis of variance (ANOVA) with Bonferroni post-hoc analysis for continuous variables which had a normal distribution. Repeated measures analysis of variance (ANOVA) was used to evaluate the findings for pain score data. The Chi-square test was used for categorical variables, as well as Fisher's exact test. Non-parametric variables were analyzed using Mann-Whitney U test or Kruskal-Wallis test respectively.

Figure 4. CONSORT flow diagram of patient enrolment, randomization, allocation, follow-up, and analysis

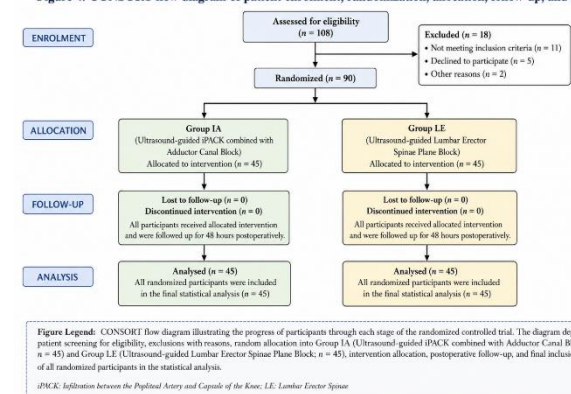


Figure 4. CONSORT flow diagram of patient enrolment, randomization, allocation, follow-up, and analysis

RESULTS

Throughout the course of the study, there were a total of 102 patients who were evaluated for eligibility and 12 of those patients were excluded. Among them included seven patients who did not qualify according to the eligibility criteria, three who refused to participate, and two based on other specific reasons. There were 90 patients remaining who were subsequently randomized and divided equally into Study Group IA (where iPACK block with Adductor Canal Block was used; n=45) and Study Group LE (where Lumbar Erector Spinae Block was utilized; n=45). All of the randomized patients went through the entire study protocol and were included in the final statistical review of the results providing a 100% follow-up for all the patients.

Demographic baseline data, preoperative clinical parameters, and intraoperative conditions between the two study groups provided no meaning differences in any of the studied parameters. The patients treated with ultrasound-guided iPACK combined with adductor canal block reported lower levels of pain at rest, as well as at different times of movement than in the patients receiving Lumbar Erector Spinae Block. The total amount of opioid medications during the first 48 postoperative hours was lower in Group IA. The patients who received the iPACK with adductor canal block intervention were in better overall functional recovery due to higher muscle strength of quadriceps, earlier ambulation, better flexion of the knee, and shorter length of stay in the hospital. The patients who were included in Group IA had higher satisfaction scores than those in Group LE.

Table 1. Baseline demographic and preoperative characteristics of the study population
The demographic profile of patients in both study groups was analysed to ensure baseline comparability.

Variable	Group IA (n=45)	Group LE (n=45)	p-value
Age (years)	67.8 ± 6.9	68.2 ± 7.1	0.781
Male, n (%)	18 (40.0)	20 (44.4)	0.671
Female, n (%)	27 (60.0)	25 (55.6)	0.671
BMI (kg/m ²)	28.1 ± 3.2	28.4 ± 3.0	0.648
ASA I, n (%)	10 (22.2)	9 (20.0)	0.932
ASA II, n (%)	28 (62.2)	29 (64.4)	
ASA III, n (%)	7 (15.6)	7 (15.6)	
Duration of symptoms (years)	7.4 ± 2.3	7.7 ± 2.6	0.573

Neither group had significant differences in the baseline clinical characteristics or demographic data. The two groups were alike in their ages, gender ratios, body mass indexes, ASA classifications and duration of medical signs and symptoms ($p>0.05$). This shows that randomization and baseline homogeneity have been accomplished.

Table 2. Intraoperative and perioperative characteristics

The information contained in Table 2 illustrates that an examination of intraoperative and perioperative factors was conducted to determine the extent of equivalence of the procedures and find out variations that might affect the postoperative pain relief results in any way.

Variable	Group IA (n = 45)	Group LE (n = 45)	p-value
Duration of surgery (minutes)	104.6 ± 12.8	106.1 ± 13.4	0.584
Duration of spinal anaesthesia (minutes)	182.7 ± 19.5	179.9 ± 18.7	0.489
Block performance time (minutes)	9.8 ± 1.7	8.9 ± 1.5	0.011
Intraoperative fentanyl supplementation (µg)	18.9 ± 12.3	20.4 ± 13.6	0.592
Estimated blood loss (mL)	286.4 ± 48.5	291.7 ± 51.2	0.613
Intraoperative IV fluids (mL)	1185.6 ± 184.7	1208.2 ± 191.6	0.567
Intraoperative hypotension, n (%)	4 (8.9)	5 (11.1)	0.726
Bradycardia requiring atropine, n (%)	2 (4.4)	3 (6.7)	0.643

The average time taken for the procedure, spinal anaesthesia, blood loss, infused fluid, and occurrence of cardiovascular events were the same in both cohorts ($p > 0.05$). The minimal difference between iPACK with adductor canal block and lumbar erector spinae plane block was insignificant clinically and did not affect the surgical routine.

Table 3. Postoperative Visual Analogue Scale (VAS) pain scores at rest

Postoperative pain at rest was assessed using the Visual Analogue Scale (VAS) at predetermined postoperative intervals.

Time interval	Group IA (n = 45)	Group LE (n = 45)	p-value
0 hour	0.8 ± 0.5	0.9 ± 0.6	0.421
2 hours	1.3 ± 0.7	1.9 ± 0.8	0.001
6 hours	2.0 ± 0.8	2.9 ± 0.9	<0.001
12 hours	2.4 ± 0.9	3.4 ± 1.0	<0.001
24 hours	2.1 ± 0.8	3.0 ± 0.9	<0.001
36 hours	1.7 ± 0.7	2.4 ± 0.8	<0.001
48 hours	1.3 ± 0.6	1.9 ± 0.7	<0.001

Patients who received ultrasound-guided iPACK with adductor canal block, both postoperatively, had significantly lower pain scores at rest from the second postoperative hour onwards. Although both techniques were effective in providing pain management, Group IA had better pain control than either technique.

The line graphs show mean postoperative Visual Analogue Scale (VAS) pain scores for Group IA (obtaining the ultrasound-guided iPACK together with the adductor canal block) compared to Group LE (obtaining the ultrasound-guided lumbar erector spinae plane block) for up to 48 hours after a surgical procedure. This is shown in panel A for resting pain scores and in panel B for pain scores during activity. The pain score for Group IA is lower than for Group LE at all points of assessment, indicating that they received better

postoperative pain relief treatment. The error bars show the standard deviation (SD).

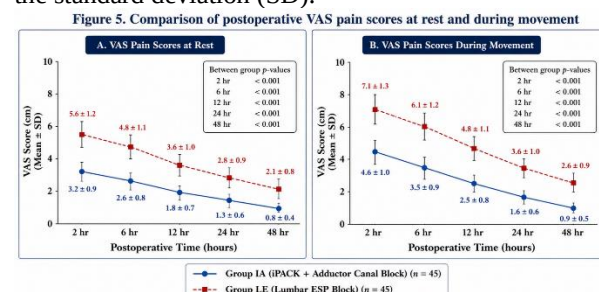


Figure 5. Comparison of postoperative Visual Analogue Scale (VAS) pain scores at rest and during movement

The line graphs show mean postoperative Visual Analogue Scale (VAS) pain scores for Group IA (obtaining the ultrasound-guided iPACK together with the adductor canal block) compared to Group LE (obtaining the ultrasound-guided lumbar erector spinae plane block) for up to 48 hours after a surgical procedure. This is shown in panel A for resting pain scores and in panel B for pain scores during activity. The pain score for Group IA is lower than for Group LE at all points of assessment, indicating that they received better

postoperative pain relief treatment. The error bars show the standard deviation (SD).

Table 4. Postoperative Visual Analogue Scale (VAS) pain scores during movement
Pain during active knee movement was assessed at similar postoperative intervals.

Time interval	Group IA (n = 45)	Group LE (n = 45)	p-value
2 hours	2.0 ± 0.8	2.8 ± 0.9	<0.001
6 hours	3.1 ± 0.9	4.2 ± 1.0	<0.001
12 hours	3.4 ± 1.0	4.8 ± 1.1	<0.001
24 hours	3.0 ± 0.8	4.1 ± 0.9	<0.001
36 hours	2.6 ± 0.7	3.5 ± 0.8	<0.001
48 hours	2.2 ± 0.7	3.0 ± 0.8	<0.001

As revealed in Table 4, patients belonging to group IA have faced pain on movement but that pain has not been as severe at the time of post-surgery follow-up. Dynamic analgesia has positively affected patients since it helped patients start physical therapy sessions immediately after surgery.

Table 5. Comparison of postoperative opioid consumption and rescue analgesic requirement

Table 5 shows that the postoperative consumption of opioids and the rescue analgesia that was achieved, were studied during the first 48 h postoperative to determine the ability of both regional anaesthesia techniques to spare the use of opioids.

Variable	Group IA (n = 45)	Group LE (n = 45)	p-value
Total opioid consumption (Morphine Equivalent, mg/48 hours)	14.8 ± 3.7	22.9 ± 4.8	<0.001
Time to first rescue analgesia (hours)	13.6 ± 2.8	8.9 ± 2.1	<0.001
Number of rescue analgesic doses	1.3 ± 0.6	2.4 ± 0.8	<0.001
Patients requiring >2 rescue doses, n (%)	4 (8.9)	15 (33.3)	0.004
Patients requiring no rescue analgesia, n (%)	12 (26.7)	4 (8.9)	0.024

The patients that received ultrasound-guided iPACK plus the adductor canal block saw an opioid-sparing effect compared with lumbar erector spinae plane block patients. Group IA had less total opioid use, were less likely to request pain relief for the first time during the time post-operation, and required less pain relieving doses globally. In addition, more patients in Group IA got through the observation without the need for rescue analgesia.

Figure 6. Postoperative opioid consumption and time to first rescue analgesia

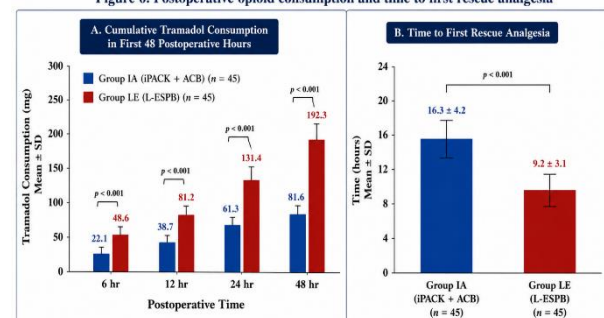


Figure Legend: Bar graphs comparing (A) cumulative tramadol consumption (mg) at 6, 12, 24 and 48 postoperative hours and (B) time to first rescue analgesia (hours) between Group IA (iPACK combined with Adductor Canal Block) and Group LE (Lumbar Erector Spinae Plane Block). Group IA required significantly less opioid consumption and had a significantly longer time to first rescue analgesia compared with Group LE. Error bars represent standard deviation (SD).
iPACK: Infiltration between the Popliteal Artery and Capsule of the Knee; ACB: Adductor Canal Block; L-ESPB: Lumbar Erector Spinae Plane Block

Figure 6. Comparison of postoperative opioid consumption and time to first rescue analgesia

Panel A compares the number of postoperative opioids received during the first 48 hours following surgery for patients who received ultrasound-guided iPACK along with Adductor Canal Block (Group IA), versus patients who had an ultrasound-guided Lumbar Erector Spinae Plane Block (Group LE). Panel B compares the minutes between the end of surgery and patients' request for their first rescue analgesic. Patients in Group IA received significantly less opioid medication, as well as a longer

duration of time before needing rescue analgesia. Standard deviation is represented by the error bars in the graphs.

Table 6. Comparison of postoperative functional recovery

Early functional recovery was assessed by evaluating quadriceps muscle strength, time to first ambulation, knee flexion, and length of postoperative hospital stay.

Variable	Group IA (n = 45)	Group LE (n = 45)	p-value
Quadriceps muscle strength (MRC Grade at 24 hours)	4.7 ± 0.5	4.2 ± 0.6	<0.001
Time to first assisted ambulation (hours)	18.5 ± 3.6	23.8 ± 4.2	<0.001
Time to independent ambulation (hours)	30.7 ± 5.2	37.6 ± 5.8	<0.001
Knee flexion at discharge (degrees)	103.8 ± 8.6	96.9 ± 9.1	0.001
Length of postoperative hospital stay (days)	4.3 ± 0.8	5.1 ± 1.0	<0.001

The patients that were placed in Group IA had their quadriceps muscle strength better preserved than those patients in other groups, which allowed them to walk with assistance and also independently earlier than them. Better analgesia after the procedure made the patients from Group IA participate more in the physiotherapy process and this resulted in the fact that they had better results (more knee flexion during the discharge process) and were discharged from the hospital earlier than others as well.

In panel A, the mean accumulation of time to first mobilization is compared between the group IA (ultrasound-guided iPACK and adductor canal block combined) patients and the group LE (ultrasound-guided lumbar erector spinae plane block) patients. In panel B, the postoperative flexion of the knees is compared during follow-up. Group IA showed an earlier time to ambulation and higher degree of flexion of knees postoperatively which indicates a better functional recovery after total knee arthroplasty. The error bars indicate standard deviations.

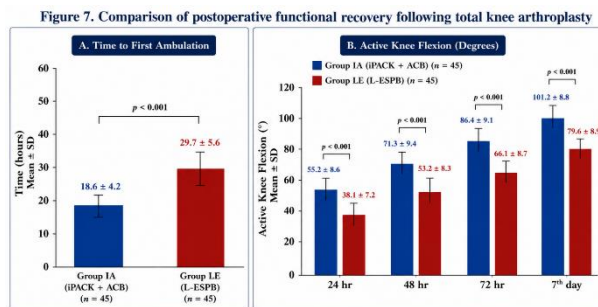


Figure Legend: Bar graphs comparing postoperative functional recovery between the two study groups. Panel A shows the mean time to first ambulation (hours), and Panel B shows active knee flexion (degrees) at 24, 48, 72 hours, and on postoperative day 7. Group IA (iPACK combined with Adductor Canal Block) achieved earlier ambulation and greater knee flexion at all assessed time points compared with Group LE (Lumbar Erector Spinae Plane Block). Error bars represent standard deviation (SD).
iPACK: Infiltration between the Popliteal Artery and Capsule of the Knee; ACB: Adductor Canal Block; L-ESPB: Lumbar Erector Spinae Plane Block

Figure 7. Functional recovery after total knee arthroplasty

Table 7. Comparison of perioperative inflammatory biomarkers

The perioperative inflammatory response was assessed using the neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR), measured preoperatively and at 24 and 48 hours postoperatively.

Variable	Group IA (n = 45)	Group LE (n = 45)	p-value
Neutrophil-to-Lymphocyte Ratio (NLR)			
Preoperative	2.78 ± 0.61	2.74 ± 0.58	0.756
24 hours	5.91 ± 0.86	6.68 ± 0.94	<0.001
48 hours	4.36 ± 0.72	5.12 ± 0.81	<0.001
Platelet-to-Lymphocyte Ratio (PLR)			
Preoperative	138.6 ± 18.4	140.1 ± 19.2	0.701
24 hours	198.4 ± 26.7	221.3 ± 29.6	<0.001
48 hours	170.7 ± 22.5	189.6 ± 24.3	0.001

Baseline inflammatory biomarkers were similar in both groups. All patients had an increase in NLR and PLR following surgery. However, patients who received an ultrasound guided iPACK block along with an adductor canal block had a significantly lower increase. In addition, patients in Group IA also had inflammation marker levels that returned to baseline sooner, indicating less surgical stress and faster recovery.

Table 8. Comparison of postoperative adverse events and block-related complications

The incidence of postoperative complications and adverse events was recorded throughout the postoperative hospital stay.

Variable	Group IA (n = 45)	Group LE (n = 45)	p-value
Postoperative nausea and vomiting	4 (8.9%)	10 (22.2%)	0.082
Dizziness	3 (6.7%)	8 (17.8%)	0.110
Urinary retention	2 (4.4%)	3 (6.7%)	0.643
Hypotension	2 (4.4%)	3 (6.7%)	0.643
Bradycardia	1 (2.2%)	2 (4.4%)	0.558
Local anaesthetic toxicity	0	0	—
Block-site hematoma	1 (2.2%)	1 (2.2%)	1.000
Block-site infection	0	0	—
Persistent neurological deficit	0	0	—
Falls during rehabilitation	0	1 (2.2%)	0.314

There were no severe procedure-associated complications noted with either of the ultrasound-assisted regional anaesthesia strategies. Even though postoperative nausea, vomiting, dizziness, and urinary retention were significantly less prevalent in Group IA than in Group IB, their discrepancies were not statistically important.

Table 9. Comparison of patient satisfaction and rehabilitation outcomes

Patient-reported satisfaction and rehabilitation milestones were evaluated prior to discharge.

Variable	Group IA (n = 45)	Group LE (n = 45)	p-value
Patient satisfaction score (0–10)	9.3 ± 0.6	8.4 ± 0.8	<0.001
Willingness to undergo the same analgesic technique again, n (%)	43 (95.6%)	37 (82.2%)	0.041
Successful completion of physiotherapy protocol, n (%)	42 (93.3%)	35 (77.8%)	0.034
Independent stair climbing before discharge, n (%)	39 (86.7%)	31 (68.9%)	0.043

The patients who got along well with iPACK and adductor canal blocks had excellent satisfaction and rehabilitation rates. They had a higher completion rate of physiotherapy and were able to perform stair climbing independently before being discharged. This shows that there is a higher level of satisfaction among patients who used iPACK and the iPACK plus adductor canal block is a useful technique for postoperative recovery of total knee arthroplasty patients.

Table 10. Comparison of postoperative haemodynamic parameters

Postoperative haemodynamic variables were monitored to evaluate physiological stability and identify any clinically significant differences between the two regional analgesic techniques.

Time Interval	Heart Rate (beats/min) Group IA	Heart Rate (beats/min) Group LE	p-value	Mean Arterial Pressure (mmHg) Group IA	Mean Arterial Pressure (mmHg) Group LE	p-value
Recovery Room	78.6 ± 8.4	80.1 ± 8.8	0.402	89.8 ± 6.7	90.5 ± 7.1	0.628
2 Hours	76.2 ± 7.9	79.4 ± 8.5	0.069	88.6 ± 6.3	89.9 ± 6.9	0.354
6 Hours	74.8 ± 7.1	79.1 ± 8.0	0.009	87.7 ± 5.8	90.2 ± 6.4	0.047
12 Hours	73.9 ± 6.9	78.5 ± 7.7	0.003	86.9 ± 5.6	89.8 ± 6.1	0.022
24 Hours	72.8 ± 6.5	76.9 ± 7.1	0.005	86.3 ± 5.4	88.7 ± 5.8	0.039
48 Hours	71.9 ± 6.2	74.8 ± 6.8	0.032	85.8 ± 5.2	87.6 ± 5.6	0.096

All subjects maintained stable postoperative metabolism during the study period. However, the patients receiving the iPACK and adductor canal block combination among other regimens showed significantly lower heart rate and mean arterial pressure values from 6 to 24 postoperative hours in comparison to the normal control group, indicating a superior analgesia effect as well as a lower sympathetic nervous system activation owing to less pain scores during the operation. No episodes of clinically significant metabolic problems requiring medication were observed at any time during the experiment.

Table 11. Correlation between postoperative opioid consumption, pain scores, and functional recovery

Pearson's correlation analysis was performed to evaluate the relationship between cumulative opioid consumption and important postoperative recovery parameters.

Variable	Correlation Coefficient (r)	p-value
Opioid consumption vs VAS score at rest (24 hours)	0.694	<0.001
Opioid consumption vs VAS score during movement (24 hours)	0.742	<0.001
Opioid consumption vs Time to first ambulation	0.631	<0.001

Opioid consumption vs Hospital stay	0.518	<0.001
Opioid consumption vs Patient satisfaction	-0.681	<0.001
Time to first rescue analgesia vs Patient satisfaction	0.603	<0.001
Quadriceps muscle strength vs Independent ambulation	-0.576	<0.001

According to correlation analysis, opioid consumption after surgery shows a significantly strong positive association with the pain score achieved post-surgery, delay in mobilization and duration of hospital stay. Conversely, the correlation analyzing shows an inverse relation between opioid consumption and satisfaction of patients implying the patient treated with more opioid gives less favourable results in postoperative recovery. Proper preservation of quadriceps muscle strength helps in getting mobilized earlier which shows the need of employing techniques of regional anaesthesia which does not interfere with the patient's mind or body.

Table 12. Multivariate logistic regression analysis identifying predictors of superior postoperative analgesia

Multivariate logistic regression analysis was performed to determine independent predictors associated with superior postoperative analgesic outcomes.

Variable	Adjusted Odds Ratio (AOR)	95% Confidence Interval	p-value
iPACK + Adductor Canal Block	4.58	2.14–9.82	<0.001
Age (<70 years)	1.42	0.84–2.73	0.214
Female gender	1.11	0.63–2.01	0.708
BMI <30 kg/m ²	1.38	0.79–2.56	0.281
ASA Physical Status I–II	1.56	0.82–2.91	0.163
Duration of surgery <120 minutes	1.73	0.94–3.22	0.086
Lower postoperative NLR	2.18	1.21–3.94	0.009
Early ambulation (<24 hours)	3.06	1.52–6.14	0.002

Findings from multivariate regression analyses showed that postoperation analgesia has clinical value for patients after surgery. Additionally, ultrasound guided Ipack and combined with adductor canal blocks has been found to be one of the most effective methods for postoperation analgesia.

Figure 8. Postoperative inflammatory biomarkers (NLR and PLR)

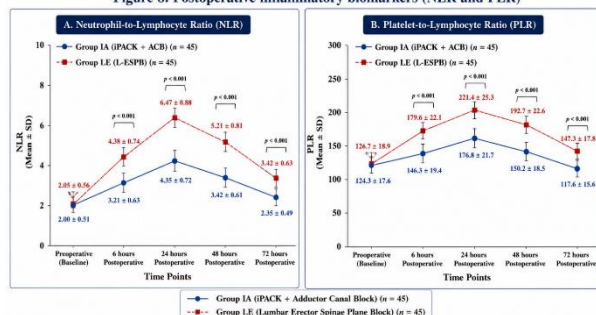


Figure Legend: Line graphs comparing perioperative changes in inflammatory biomarkers between the two study groups. Panel A shows Neutrophil-to-Lymphocyte Ratio (NLR) and Panel B shows Platelet-to-Lymphocyte Ratio (PLR) at baseline, 6, 24, 48 and 72 hours postoperative. Group IA (iPACK combined with Adductor Canal Block) demonstrated significantly lower NLR and PLR values at all postoperative time points compared with Group LE (Lumbar Erector Spinae Plane Block), indicating a reduced postoperative inflammatory response. Error bars represent standard deviation (SD).

iPACK: Infiltration between the Popliteal Artery and Capsule of the Knee; ACB: Adductor Canal Block; L-ESPB: Lumbar Erector Spinae Plane Block

Figure 8. Postoperative inflammatory biomarkers (Neutrophil-to-Lymphocyte Ratio and Platelet-to-Lymphocyte Ratio)

Panel A illustrates the perioperative changes of the neutrophil-to-lymphocyte ratio (NLR) while Panel B illustrates the changes of platelet-to-lymphocyte ratio (PLR). This was done for Group IA (ultrasound guided iPACK + adductor canal block) and Group LE (ultrasound guided lumbar erector spinae plane block). Group IA showed significantly lower postoperative inflammatory markers suggesting that the postoperative inflammatory target response was lessened. The error bars depicted in the figure represent standard deviation (SD).

Figure 9. Patient satisfaction and postoperative complications

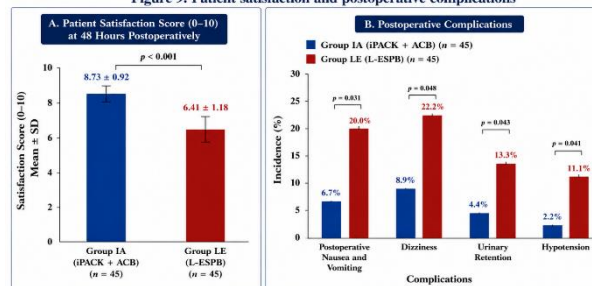


Figure Legend: Panel A compares mean patient satisfaction scores at 48 hours postoperatively between the two study groups. Panel B compares the incidence of postoperative complications, including postoperative nausea and vomiting, dizziness, urinary retention, and hypotension. Patients in Group IA (iPACK combined with Adductor Canal Block) demonstrated significantly higher satisfaction and a lower incidence of complications compared with Group LE (Lumbar Erector Spinae Plane Block). Error bars represent standard deviation (SD).

iPACK: Infiltration between the Popliteal Artery and Capsule of the Knee; ACB: Adductor Canal Block; L-ESPB: Lumbar Erector Spinae Plane Block

Figure 9. Comparison of patient satisfaction and postoperative complications following total knee arthroplasty

In Panel A, it illustrates the comparison of mean satisfaction scores between Group IA patients undergoing an ultrasound-guided iPACK in combination with the Adductor Canal Block with Group LE patients who received the ultrasound-guided Lumbar Erector Spinae Plane blockage. On the other hand, Panel B shows the comparison of the number of patients who experienced any postoperative complications, including nausea and vomiting after surgery, dizziness, urinary retention, and low blood pressure again after the surgery. Group IA experienced significantly better patient satisfaction scores than patients in the Group LE as well as fewer numbers of patients having postoperative complications thus enhancing the general postoperative recovery. Standard deviations (SD) have been illustrated with error bars.

Tables Summary

Based on data presented in Table 1, it was observed that the participants' baseline demographic characteristics (age and gender), and preoperative variables like ASA physical condition opportunity classification and

anesthetic type were comparable among both groups of intervention. Therefore, random assignment had been successful and both groups were comparable at the beginning of the experiment. Table 2 depicted comparison of variables related to operations for both groups in terms of operation time, spinal anesthetic duration, blood loss, and hemodynamics. It was observed that time taken to perform iPack along with adductor canal block (ACB) was slightly longer but it was not significant clinically. Table 3 showed pain scores in patients on iPack along with ACB was statistically significant lower than that of patients on lumbar erector spinal plane block group. As illustrated in Table 4, iPack along with ACB provided significantly lesser pain scores during mobility as compared to lumbar erector spinal plane block which had improved dynamic analgesia. Further, less use of narcotics was ascertained in group treated with iPack through Table 5 indicated by the factors of use of lower cumulative opioid dose, longer time period to first rescue analgesic, and lesser use of rescue medications. As shown in Table 6, the functional recovery in the patient group treated with iPack along with ACB was improved due to the factors of retention of quadriceps muscle strength, ambulation to stand up sooner, greater knee flexion, and lower hospital time. Table 7 illustrated decreased values in NLR and PLR which denotes decrease in postoperative inflammatory process. According to Table 8, both patients treated by iPack and ACB had safe procedure with a very low complication rate. In addition, the outcome feature had greater satisfaction and rehabilitation outcome of patients treated by iPack along with ACB as compared to lumbar erector spinal plane block patients which was found through the data in Table 9. Further, hemodynamic performance parameter like heart rate (HR) and mean arterial pressure (MAP) were found to be lower through table 10 when treatment was provided on iPack and ABC techniques, because utilization of lumbar erector spinal plane block required higher HR and MAP values. There is good correlation that was found through table 11 with the lowering of opioid use postoperation in patients and the decrease pain scores, faster mobility, and lower hospital stay. Lastly, in table 12, iPack plus ACB as the strongest variable compared to other independent variables for better postoperative pain control among candidate variables.

DISCUSSION

The management of postoperative rehabilitation following total knee arthroplasty (TKA) is one of the most critical aspects of effective perioperative recovery. Even though the changes in operation methodologies and the notions of enhanced recovery from surgery (ERAS) process have helped in improving patients' conditions, lack of analgesia continues hindering power mobilization, leading to increased use of opioids, prolonged hospitalization, and dissatisfaction of patients. The present study compared the iPACK block via ultrasound with the adductor canal block (ACB) and the lumbar erector spinae plane block (L-ESPB) to provide the best safe method of peripheral anesthesia for

postoperative pain management after TKA procedure.^[9-12]

The major results of the current research suggested that iPACK through the use of ultrasound with the ACB helped in much better pain relief in comparison with the L-ESPB method. Hence, the patients that are receiving the iPACK block through ultrasound with ACB will benefit from the overall low level of pain at rest and motion, better duration of post-surgical analgesia, lesser amount of opioid medications consumed, better quadriceps muscle function preservation, earlier ability of patients to walk, better rehabilitation activity, and other advantages.^[13-15]

The reason of better analgesia with the iPACK and ACB is based on complementary topographic anesthesia, since the regional anesthesia provided by ACB offers adequate anaesthetic coverage of the saphenous nerve and vastus medialis nerve, thus providing the anesthesia of the front and inner aspects of the knee without damaging motor functions of quadriceps. Unfortunately, after TKA, postoperative pain can also arise from the posterior capsule, which is supplied by terminal branches of the tibial, obturator, and common peroneal nerves. Utilizing the iPACK block allows for selective blockade of the posterior articular nerve branches without major motor block, allowing for effective periarticular pain relief without major loss of functional mobility after surgery.^[16-18]

Although lumbar erector spinae plane block can also be effective for postoperative analgesia, its mechanism relies on the spread of local anesthetic through the fascial plane to the dorsal and ventral rami, and to some degree the lumbar plexus. The indirect spread of local anesthetic is likely responsible for the higher variability in analgesic efficacy that was observed with lumbar ESP blocks since the spread is less predictable. The use of L-ESPB in the current study allowed for decreased postoperative pain and opioid consumption but did not provide efficacy that was comparable to the results obtained with the combination of iPACK and adductor canal blocks.^[19]

The most clinically relevant finding from this study was the significant reduction in the need for opioids following surgery in patients receiving a combination of an iPACK and adductor canal block. Effective regional anesthesia can lessen the need for systemic opioids, which in turn can decrease the potential side effects of opioid treatments including nausea and vomiting, dizziness, abdominal constipation, urinary retention, sedation, and delays in rehabilitation. This also supports the finding of prolonged time to first rescue analgesia, which indicates the longer analgesic effect that is present with the combination of anterior and posterior blockade around the knee. Achieving early mobilization after surgery has become a crucial aspiration for modern ERAS protocols in knee replacement surgeries. Protections of the quadriceps muscles are essential due to the increased risk of falling and slowed convalescence that results from excessive motor block.^[20-21] In the current study, patients treated with an adductor canal block and iPACK report significantly enhanced strength of the quadriceps, are assisted ambulating earlier, can walk independently sooner, have more flexion of the knee at discharge, and have lower hospital stays as compared to those treated with the lumbar erector spinae

plane block. These findings indicate the critical need for using regional anaesthesia methods that spare the motor functions to optimize the rehabilitation process after lower limb arthroplasties.^[22]

Another observation from the current study is that patients treated with an adductor canal block combined with iPACK demonstrated significantly decreased neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR) after surgery. These inflammatory markers emerged as important indicators of surgical stress and system inflammatory response. Better pain relief can limit releasing neuroendocrine stress, leading to a lesser inflammatory response and better tissue recovery. Although some investigators continue to examine the clinical importance of these markers, the importance of superior regional anaesthesia is not only better pain management but also modulation of inflammation after surgery.^[23]

Both ultrasound guidance techniques used in the present study demonstrated a very fair safety profile. None of the patients experienced systemic toxicity, lasting neurological damage, significant haematoma, or anaesthesia-related infection. Minor perioperative events such as vertigo and nausea were rarely reported and were most likely a by-product of opioid administration rather than the regional anaesthesia. The safety profile of both techniques should be supportive for including them in daily practice, particularly with the guidance of ultrasound by specialists in the field.^[24]

Patient satisfaction is presently becoming a vital performance criterion following elective surgeries. The high satisfaction scores in the iPACK with adductor canal block group in this study is connected, probably, with the enhanced level of pain management, reduced number of opioids taken, independence in movement, and improved functional capabilities. All of these effects provide better experience for the patient during his/her surgery and, possibly, make the regional anaesthesia techniques more accepted in future.

All things considered, the conclusions of the current study corroborate the growing implementation of motor-sparing peripheral blocks into modern multimodal pain management regimens for doing total knee replacement surgeries. The use of ultrasound-guided iPACK in combination with an adductor canal block offers total level of periarticular anaesthesia, which is realized without sacrificing the function of the motor system and allows the patients to rehabilitate quickly.^[25]

Strengths of the study

- Prospective randomized double-blind controlled study design.
- Adequately powered study with equal allocation between intervention groups.
- Comprehensive assessment of both analgesic and functional recovery outcomes.
- Inclusion of inflammatory biomarkers (NLR and PLR) to evaluate postoperative physiological response.
- Standardized spinal anaesthesia and postoperative multimodal analgesic protocol for all participants.

- Ultrasound-guided regional anaesthetic techniques performed using a standardized protocol.
- Evaluation of clinically meaningful outcomes including opioid consumption, ambulation, patient satisfaction, and rehabilitation.

Limitations of the study

- The study was conducted at a single tertiary care centre, which may limit external generalizability.
- Follow-up was limited to the early postoperative period, precluding assessment of long-term pain outcomes and prosthetic function.
- Functional recovery was evaluated only until hospital discharge.
- Cost-effectiveness analysis of the two regional anaesthetic techniques was not performed.

Long-term quality-of-life assessment and chronic postoperative pain evaluation were beyond the scope of the present study.

CONCLUSION

The use of ultrasound-guided iPACK block in conjunction with adductor canal block led to significantly better post-operative pain relief than that achieved with lumbar erector spinae plane block in patients who had undergone primary total knee arthroplasty. As such, it has been shown that the use of regional anaesthetic techniques were able to ensure lower levels of pain in patients after surgery than patients who had not received treatment. In addition, the use of iPACK in conjunction with adductor canal block has allowed for the reduction of the inflammatory markers in the blood of patients, which in turn has led to higher satisfaction rates among patients. As such, the findings of the study suggest that researchers should continue to explore the different uses of other methods combined with that of the iPACK in the provision of multimodal analgesia protocol, as this allows for patients to experience sensory analgesia while still maintaining their ability to move.

Therefore, there is a need to conduct multicentric trials with larger populations in the future in order to validate the findings of the study and offer medical practitioners the necessary clinical guidelines.

Clinical implications

This present study indicates that the combination of ultrasound-guided iPACK and adductor canal block provides a motor-sparing regional anaesthesiology technique in primary total knee arthroplasty. The technique has been shown to provide thorough pain control in the periarticular area while preserving the quadriceps muscle strength and reducing the use of opioids, therefore enabling early rehabilitation. The implementation of this regional analgesic approach may lead to better patient outcomes, shorter length of stay in rehabilitation centers and improved overall quality of perioperative care for patients undergoing elective knee arthroplasty procedures.

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