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Combined Ultrasound Guided Infiltration of The Posterior Capsule of The Knee (IPACK) With Adductor Canal Block Versus Adductor Canal Block Alone in Knee Arthroscopy

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ABSTRACT

Background: The optimal approach to managing pain after reconstruction of anterior cruciate ligament (ACL) remains uncertain. This research aimed to assess the effectiveness and safety of using the IPACK block as an adjunct to adductor canal block for pain relief in cases had reconstruction of ACL.

Methods: This randomized, double-blind, clinical trial involved 66 cases scheduled for ACL reconstruction. The participants were randomly separated into 2 groups of 33. One group had an ultrasound-guided adductor canal block, while the other received a combination of the ACB and an additional ultrasound-guided IPACK block. The 1ry outcome measure was pain severity, assessed with the VAS both at rest as well as throughout movement. The 2ry outcomes comprised the duration until the initial rescue analgesia and the total dosage of morphine given.

Results: Cases who received the combined ultrasound-guided adductor canal and IPACK blocks experienced significantly lower pain scores on both the static and dynamic Visual Analogue Scales. Additionally, they had a notably longer time to 1st rescue analgesia and consumed less total morphine (15.00±3.72 vs 5.61±1.08 minutes, 3.05±0.71 vs 7.56±2.38mg, correspondingly; all p-value below 0.001).

Conclusion: For cases had knee arthroscopy for ACL reconstruction, incorporating an ultrasound-guided IPACK block alongside the adductor canal block effectively and safely improves both static and dynamic postoperative pain relief.

Keywords: *Adductor canal block, pain, IPACK block, knee arthroscopy*

INTRODUCTION

Arthroscopic reconstruction of the ACL in the knee is typically done as an outpatient procedure, where proper pain management and prompt mobilization are essential for recovery and discharge [1].

Various analgesic approaches, including systemic medications like opioids and NSAIDs, as well as intra-articular administration of medicines like α2-agonists, ketorolac, local anesthetics, and opioids have been employed to disrupt the pain pathway [2]. The adoption of neuroaxial anesthesia and peripheral nerve blockade techniques for knee surgery has significantly contributed to pain reduction, decreased opioid utilization and associated side effects,

and improved recovery outcomes [2].

Femoral and sciatic nerve blocks were initially widely used; however, they were associated with motor blockades, leading to a higher risk of falls, delayed ambulation, and prolonged discharge. To alleviate these issues, sensory blocks such as the adductor canal block and the infiltration among the popliteal artery and knee capsule (IPACK) block have been implemented, providing efficient analgesia while preserving lower extremity motor strength [3].

The ACB specifically targets the sensory branches of saphenous nerve & nerve to the vastus medialis in proximity to the knee. In principle, adductor canal block predominantly serves as a sensory blockade, exerting minimal impact on the motor function of the vastus medialis. [4]. Its main advantage is providing effective pain relief in the anterior & medial regions of the knee while preserving or minimally reducing quadriceps strength, thereby facilitating faster rehabilitation and ambulation following knee procedures [5,6]. However, the ACB offers little to no analgesia for the posterior and lateral areas of the knee.

The ultrasound-guided local anesthetic infiltration of the IPACK is a recent technique that has demonstrated promising results [7, 8]. This approach selectively targets the terminal sensory branches of the posterior knee, avoiding motor branches of the tibial & peroneal nerves. As a result, it effectively reduces pain without causing motor weakness [10, 11], Maintaining the motor and sensory functions of the foot and leg. This preservation promotes earlier ambulation, rehabilitation, and healing after different knee operations. [9].

We hypothesized that combining the ACB with the infiltration among the popliteal artery & knee capsule block yields better outcomes in knee arthroscopy surgeries compared to using the adductor canal block alone.

METHODS:

This prospective, randomized, double-blind comparative investigation has been performed in the orthopedic surgery theater at Al Zahraa University Hospital in Cairo, Faculty of Medicine for Girls of Al-Azhar University, from March to December 2022. The purpose of the research was to evaluate and compare the analgesic efficiency of ultrasound-guided combined ACB and infiltration among the popliteal artery & knee capsule vs ultrasound-guided adductor canal block alone in sixty-six cases having knee arthroscopic surgery for ACL reconstruction under general anesthesia. Informed written consent has been acquired from all individuals.

Inclusion Criteria:

Cases aged eighteen to sixty-five years, of either sex, with an American Society of Anesthesiologists (ASA) categorization of I or II, had knee arthroscopy.

Exclusion Criteria:

Patients classified as ASA III or IV, those with a history of hypersensitivity or allergies to local anesthetics, coagulopathies, local skin conditions, pregnancy, significant neurological, neuromuscular, or psychiatric disorders, and those who declined to participate.

Sample size:

Prior to the trial, the requisite number of cases in each group has been established using a power estimate based on the acquired data (Shifaat et al., 2022). In the research, it means VAS score following 4 hrs. In group 1 was 0.19 ± 0.4 compared to group B was 1.31 ± 1.14, based on this assumption through this previous study, the effect size was large (f =0.821). A sample size of sixty-six cases, evenly split into two groups, has been calculated to achieve ninety percent power for an independent samples T-test at a significant level of five percent and a ninety-five percent confidence interval utilizing G. Power program version 3.19.2.

Randomization:

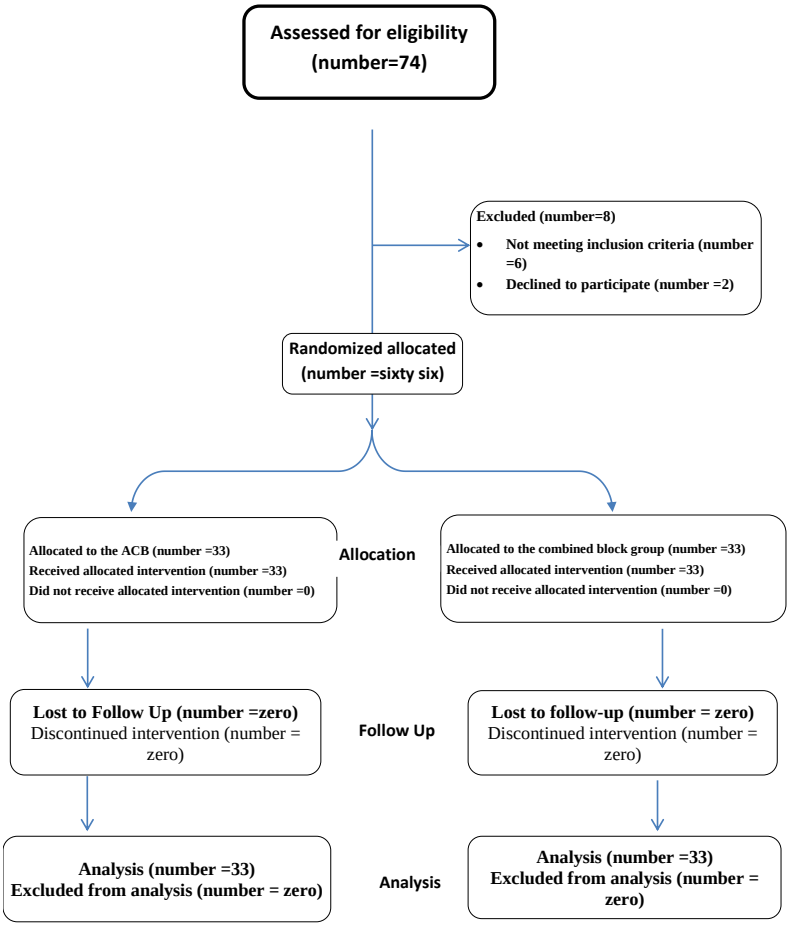
Cases were randomly assigned to groups with a computer-generated program, with the group assignments

concealed in sealed opaque envelopes prepared by research team members not included in data collection. The anesthetist performing the block received the sealed envelopes from an investigator who wasn't involved in the case's care. Data gathering before surgery, pain assessment throughout the 1st twenty-four hours post-operation, and administration of analgesia have been managed by a blinded investigator specializing in anesthesia and pain management. Additionally, neither the patients nor their surgeons were aware of the technique assigned to each patient.

The cases were split into two equal groups: Group A (number=thirty-three) and Group B (number=thirty-three).

- **Group A (combined ACB + IPACK group):** Patients in this group had fifteen milliliters of bupivacaine 0.25 percent plus two milliliters of dexamethasone for the ACB block, along with twenty milliliters of bupivacaine 0.25 percent for the IPACK block.
- **Group B (ACB group):** Patients in this group had 15 ml of bupivacaine 0.25 percent plus two milliliters of dexamethasone for the ACB block.

The principal outcomes were the VAS scores recorded at PACU, two, four, six, eight, twelve, eighteen and twenty-four hours post-surgery, evaluated throughout both rest and movement. The secondary results encompassed the duration till the initial analgesic necessity and all of the morphine usage inside a twenty-four-hour interval.



Flow chart

Anesthesia and Blockade:

All patients enrolled in the study arrived at the preparatory room one hour before the procedure. The VAS, which ranges from 0 (no pain or discomfort) to 10 (severe pain or maximum discomfort), was explained to each patient beforehand. Throughout the procedure, cases have been monitored utilizing noninvasive methods for blood pressure, pulse oximetry, and electrocardiography, with their baseline vital signs recorded. An intravenous (IV) line has been determined for fluid administration, and premedication with midazolam (0.05 milligrams per kilogram) was administered. Standard monitoring techniques, involving noninvasive blood pressure measurement, pulse oximetry, and electrocardiography, were continued once the patients were in the operating room.

Anesthesia induction was performed using fentanyl at one microgram per kilogram and propofol at two milligrams per kilogram, followed by the administration of 0.5 milligrams per kilogram IV atracurium to facilitate endotracheal tube placement. Anesthesia has been preserved with 2% sevoflurane in a mixture of fifty percent oxygen and 50% air, along with a continuous infusion of atracurium at a rate of 0.1 milligram per kilogram per hour. Ventilation aimed for a tidal volume of 6 to 7 milliliters per kilogram and an ETCO2 level between 32 and 36 mmHg. Additionally, all patients received a 1-gram infusion of paracetamol. Once anesthesia was stable, patients were positioned to undergo the regional block.

Each patient received the block according to the group they were assigned to.

Adductor Canal Block Technique [12]

The ACB has been executed with the case in a supine position. The subject has been prepared with sterile methods, and a linear transducer (ten to twelve megahertz) has been positioned on the mid-thigh. The femur has been observed, & transducer has been moved medially to identify the superficial femoral artery, located beneath the sartorius muscle within the adductor canal. Inferior to the sartorius muscle, the femoral artery has been recognized, with the saphenous nerve situated close to it. A 22-gauge, 15° 0.71×80-millimeter nerve block needle has been inserted laterally, parallel to the long axis of the transducer. To verify accurate needle placement, one to two milliliters of normal saline has been administered into the presumed adductor canal. Subsequently, fifteen milliliters of 0.25 percent bupivacaine and two milliliters of dexamethasone have been administered around the saphenous nerve in five milliliter increments, following careful aspiration.

IPACK Block Technique [13]

The IPACK block has been executed with the case in a supine position, the knee raised, and the hip somewhat externally and abducted rotating to enhance access to the medial part of the distal thigh. A curvilinear transducer (ten to twelve megahertz) has been located on medial thigh,1-2 fingerbreadths superior to the patella. The femoral shaft, femur, popliteal artery, & the posterior space of the femoral shaft have been detected. A 22-gauge, 15°, 0.71×80 millimeters nerve block needle has been inserted in-plane to transducer toward posterior space among the popliteal & femur artery. A total of twenty milliliters of 0.25 percent bupivacaine and two milliliters of dexamethasone were administered in five milliliter increments, with careful aspirations to confirm accurate placement.

Surgery was allowed 20 minutes after the block was administered. The block was considered unsuccessful if there was a rise in heart rate and/or blood pressure (BP) of above twenty percent from baseline upon skin incision. In such cases, additional fentanyl (0.5 micrograms per kilogram) was administered, and if fentanyl alone was insufficient, the concentration of sevoflurane was increased. The total dose of fentanyl administered was recorded.

Post-surgery, all patients received 8 mg of ondansetron and were extubated once they met the extubation criteria, after which they have been transferred to the post-anesthesia care unit (PACU) for monitoring. Cases who had breakthrough pain (VAS above 4) were given rescue analgesia (intravenous morphine at 0.05 mg/kg) by the investigator. Additional doses were administered at least 30 minutes apart until the VAS score dropped to 4 or below. If pain persisted with a VAS of 4 or lower, 15 mg of intravenous ketorolac was given. Intravenous paracetamol (1

gram) was administered every 6 hours, regardless of the VAS score.

Postoperative management involved regular pain assessments using the static and dynamic VAS at time zero (the moment the patient recovered from general anesthesia) and then at PACU, 2, 4, 6, 8, 12, 18, and twenty four hours. The time of the 1st analgesic request has been recorded, and the total morphine dosage used within the first 24 hours was documented for each patient.

Complications like nausea, vomiting, hematoma formation, local anesthetic toxicity, sensory and motor impairments, and respiratory depression (defined as a respiratory rate of below eight breaths per minute) were closely monitored & documented.

STATISTICAL ANALYSIS:

The information collected have been examined utilizing the Statistical Package for the Social Sciences, version 26.0 (SPSS Inc., Chicago, Illinois, United States of America). The quantitative data has been expressed as mean ± standard deviation & ranges for parametric distributions, whereas non-parametric variables have been provided as median with inter-quartile range (IQR). Qualitative variables were also provided as numbers & percentages. The data have been assessed for normalcy with the Kolmogorov-Smirnov & Shapiro-Wilk tests. The subsequent tests have been conducted: An independent samples t-test was utilized to compare two means, while the Mann-Whitney U test has been utilized for non-parametric two-group comparisons. The comparison among groups with qualitative data has been conducted utilizing the Chi-square test, while Fisher's exact test has been utilized when the predicted count in any cell was below five. The confidence interval has been established at ninety- five percent, with an accepted margin of error of five percent. The p-value has been deemed significant as follows: Probability (P-value) A P-value of less than 0.05 has been considered significant, a P-value of below 0.001 has been regarded as highly significant, and a P-value above 0.05 has been classified as insignificant.

RESULTS:

The two groups had similarities regarding age, ASA physical condition, body mass index, and length of operation. A statistically insignificant variations have been detected among the groups for these characteristics, as evidenced by a p-value over 0.05 (Table 1).

Table (1): Comparative analysis of baseline characteristics among the groups.

Baseline characteristics	**ACB group (number=thirty-three)**	**Combined block group (number=thirty-three)**	**Test value**	**p-value**
Sex				
Male	25 (75.8%)	28 (84.8%)	0.383	0.536
Female	8 (24.2%)	5 (15.2%)		
Age (year)	39.17±13.07	40.69±13.04	0.473	0.637
Height (m)	1.70±0.05	1.71±0.05	0.812	0.419
Weight (kg.)	73.08±8.02	75.91±7.42	1.488	0.142
BMI (kg/m2)	27.72±3.71	28.98±2.80	1.557	0.124
ASA				
ASA I	18 (54.5%)	21 (63.6%)	0.251	0.617
ASA II	15 (45.5%)	12 (36.4%)		
Duration of Surgery (min.)	100.17±19.87	98.39±23.28	-0.334	0.739

x2: Chi-square test for Number (%) or Fisher's exact test, when appropriate

Using: t-Independent Sample t-test for Mean±SD;

*p-value above 0.05 is insignificant; *p-value below0.05 is significant; **p-value below 0.001 is highly significant*

Regarding the static VAS score, cases in the combined block group had significantly lower median scores than ACB group at four, eight, and 18 hours following surgery (all P<0.05; Figure1), with a highly significant variance between six and twenty-four hours (all P-value below 0.001; Figure1). Similarly, for the dynamic VAS score, the combined block group demonstrated highly significantly lower median scores than ACB group at 2, 4, 6, and twenty-four hours with P-value below 0.001. and significantly lower difference at 8, 18 hours postoperatively with P-value below 0.05 (Figure2).

Compared to the adductor canal block group, the combined block group had a significantly longer duration before the 1st analgesic was needed (15.00±3.72, min vs. 5.61±1.08 min, P-value below 0.001). They are also necessary significantly lower doses of morphine (3.05±0.71 mg vs 7.56±2.38 mg, P<0.001), (Table 2).

No complications following surgery, including hematoma, PONV, or motor and sensory deficits, have been reported.

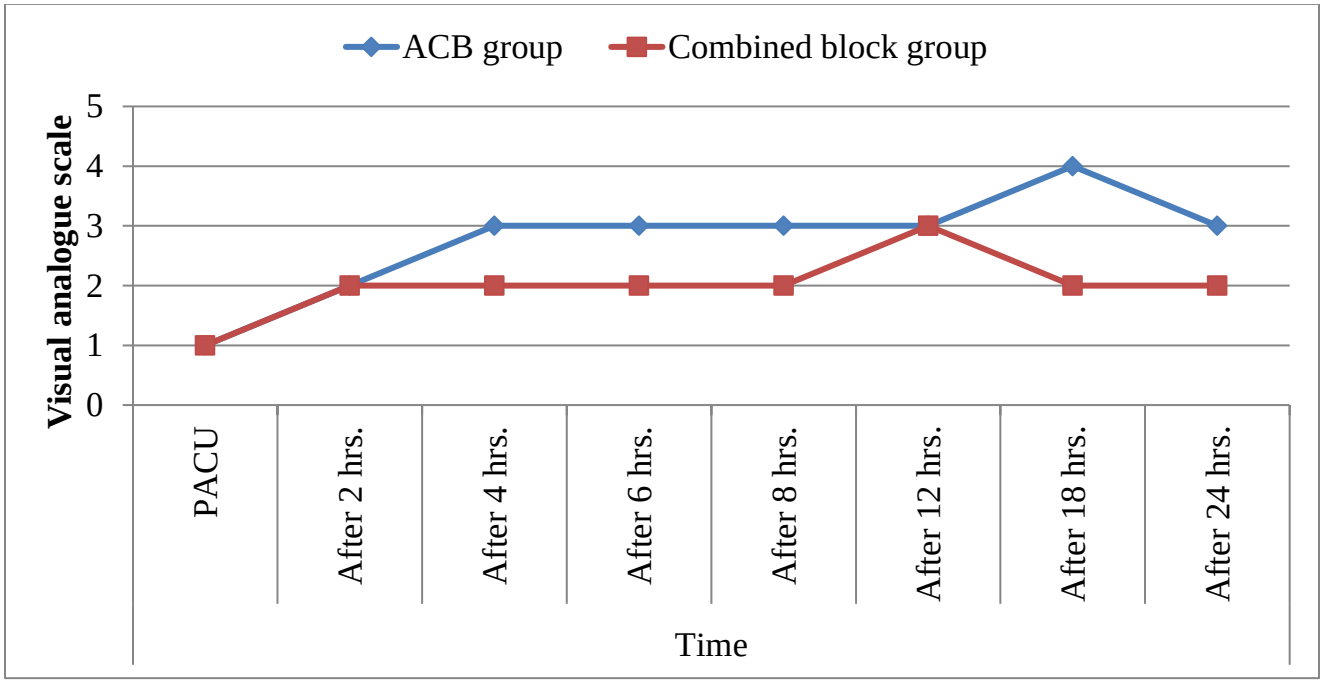


Fig. (1): Comparative analysis of groups based on static visual analogue scale scores.

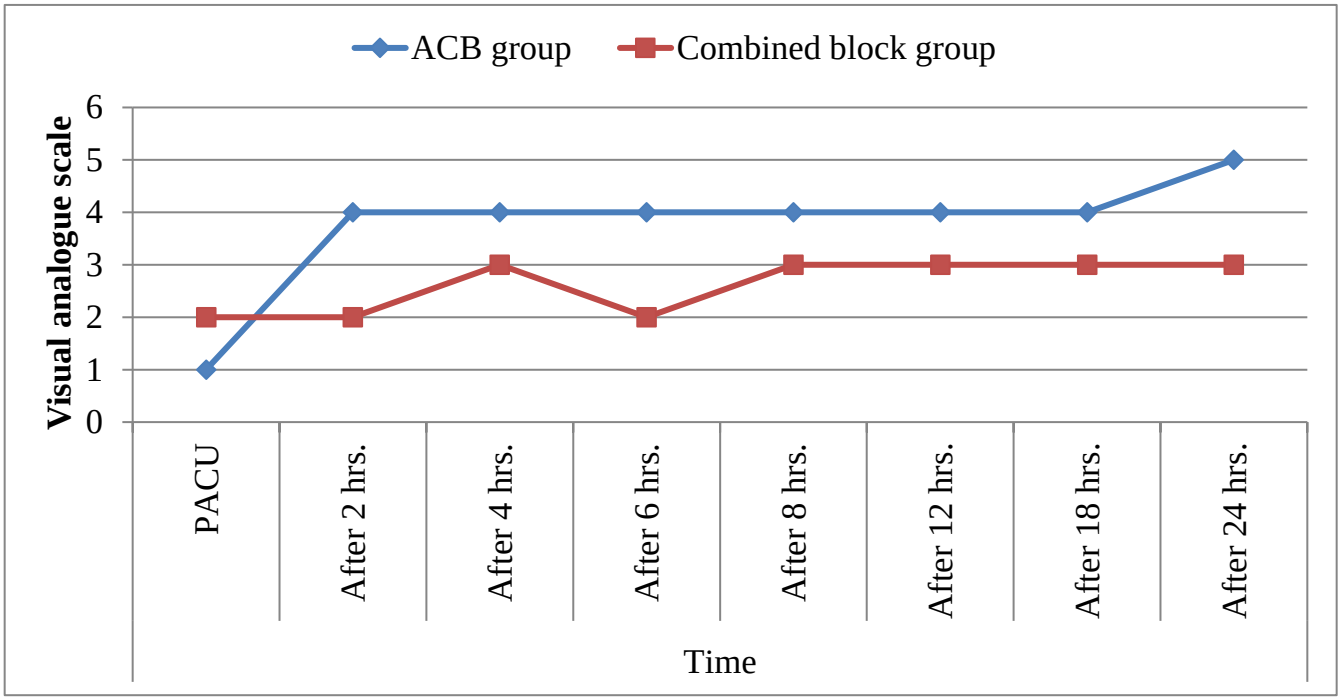


Fig. (2): Comparative analysis among groups according to dynamic visual analogue scales.

Table (2): Comparative analysis among groups according to time to the 1st analgesic necessity and total quantity of morphine.

	ACB group (number=thirty-three)	Combined block group (thirty-three)	Test value	P-value
Time of 1st analgesic requirement (minute.)	5.61±1.08	15.00±3.72	13.925	<0.001*
Total morphine required (mg.)	7.56±2.38	3.05±0.71	-10.431	<0.001*

DISCUSSION:

The growing number of knee arthroscopic procedures worldwide has highlighted the importance of effective pain management strategies. Peripheral nerve block techniques, especially the adductor canal block (ACB), have become increasingly popular due to their pain-relieving properties and their ability to maintain quadriceps function, facilitating early mobility. However, ACB primarily targets pain in the anterior knee and does not influence the deep genicular nerves responsible for posterior knee discomfort. The IPACK approach includes the insertion of anesthetics into the region among popliteal artery & the posterior knee capsule, therefore selectively obstructing sensory nerves while maintaining muscle strength. This investigation assesses the analgesic efficacy of ACB only compared to ACB in conjunction with IPACK in knee surgical procedure [14].

In our prospective observational investigation, sixty-six cases receiving arthroscopic anterior cruciate ligament repair have been recruited. Cases had either a combined ultrasound-guided ACB with IPACK or an ultrasound-guided ACB only. They have been observed for a duration of twenty-four hours. The research indicated that the

average static visual analogue scale (VAS) scores were markedly lower in cases who had the combination block compared to those who got only the ACB at four, six, eight eighteen, and twenty-four hours postoperatively. Nonetheless, VAS scores at PACU, two hours, and twelve hours were similar across the two groups. Similarly, for dynamic VAS scores, the combined block group had considerably lower median scores than the ACB-only group at all time points, except in the PACU and twenty-four hours following surgery, where the scores were comparable.

Our results correspond with those of Shifaat [2], who indicated that the mean visual analogue scale scores were significantly lower in cases administered a combined ACB with IPACK than in those having ACB alone at four, eight, twelve- and eighteen-hours following surgery, whereas VAS scores at two and twenty-four hours exhibited insignificant variation. In a similar vein, Amer [3] performed an investigation indicating that visual analogue scale scores following surgery, both at rest and throughout ambulation, were reduced in cases who had the combined ACB and IPACK block than in those who had ACB with periarticular injection. Their results aligned with the outcomes of our investigation.

In our study, the combined block group had a significantly extended period before requiring the 1st analgesic compared to the ACB-only group. Additionally, they require significantly lower doses of morphine. Several recent studies have reported similar findings.

Donghai [15] found that cases who had adductor canal block combined with infiltration among the popliteal artery and knee capsule had lower pain scores, reduced morphine consumption, and a longer interval of analgesia compared to those who had ACB alone. They also noted minimal differences in mobility between the two groups. Similarly, Tayfun [16] reported that patients in the combined adductor canal block + infiltration between the popliteal artery and knee capsule group experienced shorter discharge and mobilization times, reduced pain, & lower opioid necessities than ACB-only group.

Additionally, a study by Abd-Allah Amin M and Abotaleb UI [17] found that patients who received adductor canal block combined with infiltration among the popliteal artery & knee capsule had lower visual analogue scale scores within the first 48 hours of post-surgery compared to those who had adductor canal block alone.

Similarly, Sankineani [18] reported that VAS scores at 8 hours postoperatively, as well as on the 1st and 2nd days following surgery, were significantly lower in the adductor canal block + infiltration among the popliteal artery and knee capsule group compared to the ACB-only group.

In contrast to our findings, research by Patterson et al. indicated that the addition of infiltration among the popliteal artery and knee capsule to ACB reduced pain scores only in the immediate time following surgery, with no long-term benefits in subsequent pain assessments. They also found insignificant variance in opioid consumption among both groups. Patterson et al. suggested that the IPACK block might be more beneficial in cases where standard multimodal pain management is contraindicated, such as in cases with restrictions on paracetamol or NSAIDs, those with chronic pain, or individuals with opioid dependence [19].

CONCLUSION:

For patients undergoing knee arthroscopy for ACL reconstruction, the combined ACB and IPACK block provides a synergistic effect that enhances pain management and reduces opioid consumption more effectively than ACB alone.

FUNDING: None.

Conflict Of Interest: None.

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