Ain-Shams Journal of Anesthesiology

ORIGINAL ARTICLE

Open Access

# IPACK block with spinal anesthesia compared to fentanyl-based spinal anesthesia for postoperative analgesia following arthroscopic meniscectomy: a randomized, prospective study

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## Abstract

**Background** Local anesthesia and intrathecal narcotics are utilized to provide postoperative analgesia. IPACK (infiltration between the knee capsule and popliteal artery) is a new localized analgesic approach for knee surgery. This randomized study aimed to compare fentanyl-based spinal anesthesia and IPACK block-based spinal anesthesia for postoperative analgesia in patients undergoing arthroscopic meniscectomy.

**Results** In group F, the VAS (visual analog scale) was higher than in group I, whereas the total amount of morphine was lower in group I ($P < .05$). In group F ($3.92 \pm 1.54$), the initial painkiller request occurred earlier than in group I ($8.82 \pm 0.44$). In addition, total morphine administrated in group F ($20.81 \pm 0.69$) was significantly higher than in group I ($9.54 \pm 0.73$) ($P < .05$). Group I had a higher level of patient satisfaction 24 h after surgery than group F ($P < .05$). In the current study, there were no significant adverse effects linked to the use of fentanyl. Moreover, no complications associated with the IPACK block were detected.

**Conclusions** The combination of IPACK block and hyperbaric bupivacaine spinal anesthesia is an effective treatment for initial postoperative pain following arthroscopic meniscectomy, according to the findings of this study. IPACK block prolongs postoperative analgesia more than intrathecal fentanyl.

**Trial registration** This study was registered with Clinical Trials Registry (NCT05833776).

**Keywords** IPACK block, Spinal anesthesia, Fentanyl, Postoperative analgesia, Arthroscopic meniscectomy

## Background

Local anesthesia and intrathecal narcotics are utilized to provide postoperative analgesia. In addition, this combination has a parenteral opioid-sparing effect for the first 24 h (Savjani et al. 2012). However, this technique has been associated with elevated rates of urinary retention, nausea, vomiting, and pruritus.

A new localized analgesic approach, known as IPACK (the region of the knee where the popliteal artery and posterior capsule meet), has been utilized (Elliott and Thobhani 2014). It blocks the medial genicular, lateral genicular, sciatic, and articular branches of the obturator nerve in the popliteal region. Therefore, it provides

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analgesia to the posterior capsule of the knee joint without impairing limb motor function (Thobhani et al. 2017).

The central neuraxial and regional anesthesia and analgesia approaches significantly decrease perioperative morbidity and mortality rates. Additionally, the endocrine and metabolic reactions to surgery are decreased by regional anesthesia procedures (Roy et al. 2018). Early mobilization is essential for these patients to achieve optimal functional outcomes and reduce postoperative immobility complications. Controlling postoperative pain facilitates physiotherapy, improves rehabilitation, decreases hospital stay, and increases patient satisfaction (Ibrahim et al. 2023).

Multiple pain control modalities have been utilized but with multiple side effects. There have been numerous blocks in laparoscopy of the knee joint, such as adductor canal block and block of the femoral nerve (Armanious et al. 2020). There is a risk of delayed mobilization following femoral nerve block (FNB) that provides more effective pain relief than opioid patient-controlled analgesia (PCA) (Jaeger et al. 2012). FNB may be combined with a sciatic nerve block to improve analgesia. However, this may increase the risk of falling due to distal motor block (Yadeau et al. 2013). After knee surgery, the adductor canal blocks (ACB), a new method to the FNB, and controls postoperative pain with a multimodal analgesic (Andersen et al. 2013). Epidural analgesia relieves pain with motor block and the potential for urine retention, while FNB has a high risk of falls due to reduced quadriceps muscle strength (Ilfeld et al. 2010).

Regional (neuraxial block and peripheral nerve block) and systemic (opioid and non-opioid) analgesia are two types of analgesia used in combination to treat pain by working synergistically at different sites and by multiple mechanisms in their pathways of controlling pain with fewer side effects. After knee arthroscopy, postoperative analgesia with early mobilization and motor power preservation is considered the primary challenge for better physiotherapy and early recovery (Coccolini et al. 2022).

This randomized study aimed to compare fentanyl-based spinal anesthesia and IPACK block-based spinal anesthesia for postoperative analgesia in individuals with arthroscopic meniscectomy.

## Methods

This study was registered as a prospective, single-blind, randomized study approved by the local ethical committee (approved no. 00308/2022) with written consent from all patients before the operation.

Sixty-two patients ranged in the period of January 2022 to January 2023, undergoing a one-sided arthroscopic meniscectomy. Patients were equally divided into two equal groups, as shown in the flow diagram for CONSORT (Fig. 1). Group F (31 patients) received intrathecal anesthesia with half percent hyperbaric bupivacaine (3 ml) and fentanyl (25 μg). Group I (31 patients) received hyperbaric bupivacaine (heavy Marcain) half percent (3 ml) intrathecal anesthesia with IPACK block using 0.25% plain isobaric bupivacaine (15 ml).

### Study outcomes

The primary outcome was assessing the postoperative pain by VAS score at first 24 h postoperatively. The secondary outcomes were to assess the mean arterial blood pressure, patient satisfaction, and the occurrence of adverse effects such as hematoma and purities.

The inclusion criteria are as follows: patients consent, both sexes, aged between 25 and 60 with American Society of Anesthesia (ASA) (I and II), and had a body mass index (BMI) of less than 30 $kg/m^2$ in individuals with arthroscopic meniscectomy.

The exclusion criteria are as follows: allergy to local anesthetics, local infection in the knee joint, and spinal anesthesia limitations such as coagulopathy and tight tricuspid or mitral stenosis.

### Randomization

In the current single-blinded study, the patients were equally randomized to two groups before the start of anesthesia using computer-generated random numbers (Windows, version 17) placed in separate opaque envelopes technique. The researcher opened the envelopes before administering spinal anesthesia.

### Anesthetic technique

Preoperative planning for each patient included a medical history, examinations, and tests. In the preoperative zone, a wide IV cannula was placed and connected to basic monitoring devices like a pulse oximeter, noninvasive blood pressure monitor, and electrocardiogram (ECG). Baseline values were measured and recorded.

After 15-min infusions of ringer lactate solution, intrathecal anesthesia was administered at the lumber space 4 or 5 levels with a 25 gauge, 3.5-inch spinal needle, and a 3-ml injection of hyperbaric bupivacaine half percent perfectly sterile circumstances with fentanyl in group F and without fentanyl in group I.

### IPACK block technique

The IPACK block (the region of the knee where the popliteal artery and posterior capsule meet) was delivered only in group I with ultrasound (Sono Site, M-Turbo, USA) guidance. It was done in a supine position with modest knee flexion following spinal anesthesia. The popliteal fossa was probed in a fully aseptic environment

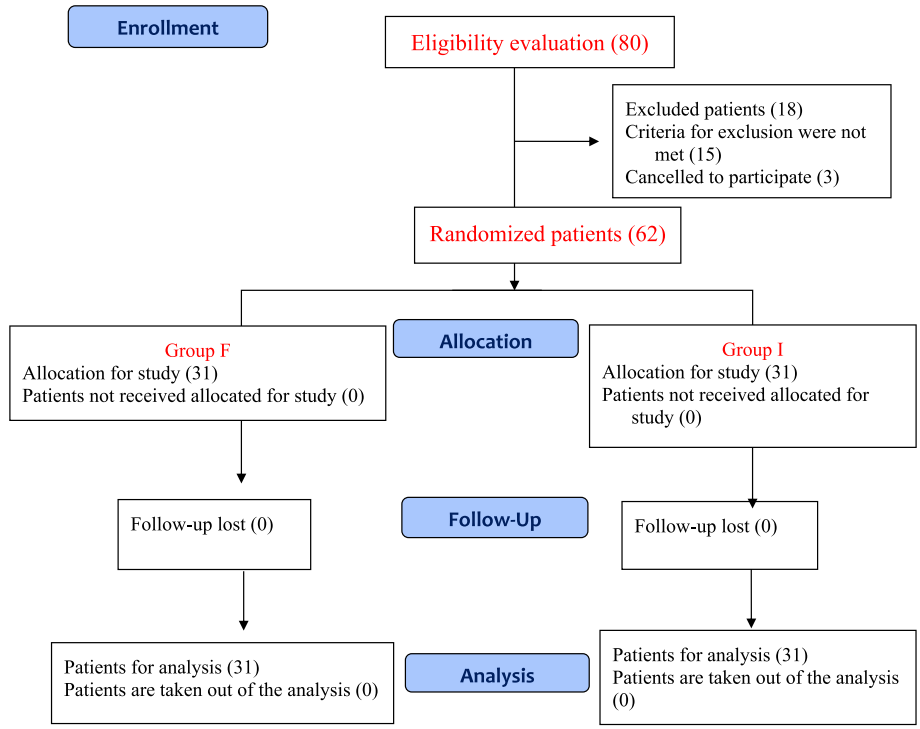


**Fig. 1** Chart of consort

to identify the femur and popliteal artery. After sliding the probe proximally until the humps of the femoral condyles disappeared, and the flat metaphysis was identified, the probe advanced laterally to expose two femoral condyles.

Plain isobaric bupivacaine (0.25) (15 ml) was incrementally injected as the needle was withdrawn after reaching the medial edge of the femur, almost at the level of the popliteal artery, following skin infiltration with (2 ml) of (1%) lidocaine. A spinal needle (25 gauge × 3.5 inches) was then advanced from the lateral aspect and directed throughout the area between the popliteal artery and femur (Figs. 2, 3, and 4). All patients received a standard analgesic regimen of acetaminophen with a dosage of 15 mg/kg every 6 h.

During a knee arthroscopy procedure, a tiny camera was used to view the interior of the knee. The knee is punctured with microscopic incisions in order to implant the camera and other microscopic surgical equipment. The surgeon made two or three small incisions (Phillips and Mihalko 2021). The knee was injected with fluid (saline) to make it more pliable. A thin tube containing a microcamera was inserted through one of the cuts. The surgeon could observe the knee using a camera with an attached video monitor. The surgeon may insert additional small surgical instruments into the knee through the other incisions. The knee problem was repaired or eliminated by the surgeon. The saline was removed from the knee at the conclusion of the procedure (Thompson and Miller 2020).


**Fig. 2** Before injection under guided by ultrasound


**Fig. 3** After injection under guided by ultrasound

#### Parameters for postoperative measurement

The VAS was computed every 2 to 24 h after surgery as a 10-cm-long line with two endpoints: 0 for no pain and 10 for severe pain. If VAS exceeds 3, morphine (5 mg) is administered intravenously as a rescue analgesic. The administered analgesic regimen was evaluated. Intraoperatively, the mean blood pressure was measured at the 30th, 60th, and 120th minutes and 4th, 6th, 12th, and 24th hours. A verbal numeric rating scale of patient satisfaction (no satisfaction, partial satisfaction, and complete satisfaction) was obtained prior to discharge (Subramanian et al. 2017). Incidences of adverse effects such as hematoma, infection, and nerve trauma caused by nerve block were recorded for 24th hours after surgery.

#### Sample size calculation

The MedCalc® program (Ostend) is a statistical calculator used for sample size calculation. The sample size was determined by how long patients received postoperative analgesia. According to a previous study, this used a 95% confidence and 80% power study with a 5% error rate (Amin and Abotaleb 2021). The sample size was calculated using the results, and a minimum sample of 80 cases was sufficient.

#### Statistical analysis

Means, standard deviations, and frequencies were used to express all of the parameters. The Statistical Package for Social Sciences (Windows 21, Chicago, IL, USA) was utilized to carry out the statistical analysis. In order to compare the two groups, an independent *t*-test was utilized. The Fisher exact *t* and the chi-square examination were used to test the group variations. The level of statistical significance was set at a *P*-value of $< 0.05$.

## Results

Eighty patients passed the eligibility criteria. A total of 62 patients were randomly assigned to two groups using sealed envelopes and a computer-generated randomization table, as depicted in the CONSORT flowchart (Fig. 1).

There was no statistically significant difference in weight, age, ASA, gender, or duration of surgery between the groups (Table 1). Table 2 reveals a statistically insignificant difference in the mean arterial blood pressure ($P > 0.05$).

Regarding the VAS, it was calculated every 2 h up to 24 h, and the postoperative VAS was found to be greater in group F than in group I ($P > 0.05$), as depicted in Table 3. In group F, the VAS was higher than in group I.

Comparing the two studied groups based on the number of morphine boluses ($P < 0.05$), Table 4 shows that for prolonged postoperative analgesia in the IPACK group, the total amount of morphine used was less in group I ($P < 0.05$). The total morphine taken in group F ($20.81 \pm 0.69$) was significantly higher than in group I ($9.54 \pm 0.73$) ($P < 0.05$).

**Fig. 4** Probe position and needle direction for IPACK block

**Table 1** Comparison of the groups in terms of characteristic parameters

| | Groups | | |
|---|---|---|---|
| | **Group F (*n* = 31)** | **Group I (*n* = 31)** | ***P* value** |
| **Parameters** | | | |
| **Weight (kg) (mean ± SD)** | 74.4 ± 7.1 | 73.6 ± 6.4 | 0.58 |
| **Age (years) (mean ± SD)** | 47.66 ± 5.3 | 51.2 ± 4.9 | 0.65 |
| **ASA** | | | |
| **I (*n*) (%)** | 18 (58.06%) | 21 (67.7%) | 0.46 |
| **II (*n*) (%)** | 13 (41.9%) | 10 (32.2%) | |
| **Sex (M to F)** | 17:14 | 13:18 | 0.18 |
| **Duration of surgery (min) (mean ± SD)** | 61.4 ± 11.34 | 64.9 ± 12.65 | 0.58 |

Group F: spinal anesthetic with fentanyl

Group I: spinal anesthesia with IPACK block

*N* Number of patients

**Table 2** Comparison of groups based on average blood pressure

| **Mean blood pressure (mean ± SD) (mmHg)** | **Group F (*n* = 31)** | **Group I (*n* = 31)** | ***P* value** |
|---|---|---|---|
| 30th minute | 67.8 ± 2.1 | 88.2 ± 4.6 | 0.63 |
| 60th minute | 78.2 ± 2.8 | 68.5 ± 3.2 | 0.47 |
| 120th minute | 67.0 ± 2.3 | 97.6 ± 5.3 | 0.58 |
| 4th hour | 88.1 ± 2.6 | 69.7 ± 3.8 | 0.40 |
| 6th hour | 77.3 ± 1.9 | 78.3 ± 2.5 | 0.18 |
| 12th hour | 67.7 ± 2.6 | 68.4 ± 4.8 | 0.27 |
| 24th hour | 87.6 ± 2.7 | 75.5 ± 2.9 | 0.21 |

Group F: spinal anesthetic with fentanyl

Group I: spinal anesthesia with IPACK block

**Table 3** Visual analog scale scores of the groups

| | Groups | | |
|---|---|---|---|
| | **Group F (*n* = 31)** | **Group I (*n* = 31)** | ***P* value** |
| **Parameters** | | | |
| **2nd hour** | (0–1) | 1 (0–1) | 0.14 |
| **4th hour** | 2 (2–3) | 1 (1–2) | 0.23 |
| **8th hour** | 3 (2–3) | 2 (1–2) | < 0.05* |
| **12th hour** | 4 (3–4) | 2 (1–2) | < 0.05* |
| **16th hour** | 5 (4–5) | 3 (2–4) | < 0.05* |
| **18th hour** | 5 (4–5) | 4 (2–4) | < 0.05* |
| **20th hour** | 6 (5–6) | 5 (4–5) | < 0.05* |
| **24th hour** | 6 (5–7) | 6 (4–6) | 0.75 |

Data represented by IQR

Group F: spinal anesthetic with fentanyl

Group I: spinal anesthesia with IPACK block

* Statistically significant at *p*-value ≤ 0.05

**Table 4** Comparison of the groups in terms of number of morphine boluses in 1st 24 h

| **Number of morphine boluses** | **Group F (*n* = 31)** | **Group I (*n* = 31)** | ***P* value** |
|---|---|---|---|
| 0 (*n*) (%) | 9 (19.0%) | 19 (61.3%) | 0.038* |
| 1 (*n*) (%) | 7 (22.6%) | 7 (22.6%) | |
| 2 (*n*) (%) | 7 (22.6%) | 4 (13.3%) | |
| 3 (*n*) (%) | 6 (19.3%) | 1 (3.22%) | |
| 4 (*n*) (%) | 2 (6.45%) | 0 (0.0%) | |

Group F: spinal anesthetic with fentanyl

Group I: spinal anesthesia with IPACK block

* Statistically significant of *p*-value ≤ 0.05

**Table 5** Comparison of the groups in terms of total intake of morphine and time for first request of pain killer

| | Groups | | |
|---|---|---|---|
| | **Group F (*n* = 31)** | **Group I (*n* = 31)** | ***P* value** |
| **Parameters** | | | |
| **Total amount of morphine taken (mg) (mean ± SD)** | 19.51 ± 4.49 | 9.18 ± 2.53 | 0.007* |
| **Time for first request of pain killer (h) (mean ± SD)** | 3.55 ± 1.54 | 8.82 ± 0.44 | 0.014* |

Group F: spinal anesthetic with fentanyl

Group I: spinal anesthesia with IPACK block

* Statistically significant of *p*-value ≤ 0.05

The time for the first rescue analgesia (Table 5) demonstrated a statistically significant difference. The time for the initial painkiller request (hours) in group F (3.92 ± 1.54) was earlier than in group I (8.82 ± 0.44).

In terms of patient satisfaction, there was a statistically significant difference ($P < 0.05$; Table 6) between the two research groups ($P < 0.05$) (Table 6). Group I had a higher level of patient satisfaction 24 h after surgery than group F ($P < 0.05$).

In the current study, no significant adverse effects linked to the use of fentanyl and no complications associated with the IPACK block were detected.

## Discussion

IPACK block is a new approach for pain control in the posterior compartment of the knee that does not require the motor blockage associated with a sciatic nerve block, resulting in a shorter hospital stay as well as faster recovery and postoperative patient rehabilitation (Spring 2015).

Using the IPACK block technique described in 2014, a local anesthetic is injected into the knee region where the popliteal artery and posterior capsule meet (Thobhani et al. 2017). Despite the fact that it is an excellent alternative for pain control in the posterior compartment of the knee following arthroplasty, there is limited information in the literature describing and contrasting this novel regional block.

The femoral and obturator nerve blocks do not cover the posterior capsule of the knee, whereas IPACK does, with a reduced motor impact during postoperative recovery. However, there is no consensus regarding which anesthesia technique is superior. In contrast, the FNB has been associated with decreased quadriceps muscle strength, which questions its efficacy in achieving early ambulation, improved pain management, and enhanced rehabilitation.

**Table 6** Patient satisfaction variations between groups

| | Groups | |
|---|---|---|
| | **Group F (*n* = 31)** | **Group I (*n* = 31)** |
| **Parameters** | | |
| **Complete satisfaction (*n*) (%)** | 8 (25.8%) | 16(51.6%) |
| **Partial satisfaction (*n*) (%)** | 15 (38.4%) | 12 (38.6%) |
| **No satisfaction (*n*) (%)** | 8 (25.8%) | 3 (9.7%) |
| ***P* value** | 0.026* | |

Group F: spinal anesthetic with fentanyl

Group I: spinal anesthesia with IPACK block

* Statistically significant of *p*-value ≤ 0.05

In the present study, the main parameters (such as weight, age, gender, ASA, and surgical time) showed no statistically significant differences between the two groups ($P > 0.05$), which is consistent with Patterson et al. (2020). Regarding blood pressure, both groups demonstrated no statistically significant differences ($P > 0.05$).

Regarding VAS, there was a significant difference between research groups with lower VAS scores in group I ($P < 0.05$).

This study found that the time for the initial painkiller request (hours) was shorter in group F (3.92 ± 1.54) than in group I (8.82 ± 0.44), and the total amount of morphine administered was more significant in group F (20.81 ± 0.69) than in group I (9.54 ± 0.73).

Mazy et al. (2019) reported that intrathecal fentanyl is efficient but limited in postoperative analgesia but longer postoperative analgesia when fentanyl is combined with dexmedetomidine or dexamethasone.

According to the study of Amin and Abotaleb (2021), the total morphine requirements in the adductor canal group was 9.81 ± 0.69, and IPACK with adductor canal block was 6.54 ± 0.73. The time to first rescue analgesia in the adductor canal block was 7.92 ± 0.44, while the adductor canal block with the IPACK block group was 9.73 ± 0.63.

Thobhani et al. (2015) found that IPACK decreased opioid consumption in patients with arthroplasty of the knee, providing effective supplemental analgesia compared to blocking the knee via the femoral nerve catheter technique.

According to the Narejo et al. (2021) study, at 4 h postoperatively, the pain score in the IPACK group was significantly lower than the local infiltration group (3.32 versus 4.75; $P = 0.004$). In addition, there was no substantial difference between the two groups at 24 h ($P = 0.82$) or 48 h ($P = 0.40$).

There were significant differences in patient satisfaction reported that 15 cases in group I demonstrated complete satisfaction compared to only 8 cases in group F ($P = 0.026$).

IPACK is a procedure that does not affect muscle strength, reduces pain, improves movement after surgery, and decreases hospital stay (Thobhani et al. 2017).

In enhanced recovery after surgery in order to obtain early limb autonomy, minimize hospital stays, speed up the healing process, and increase patient satisfaction, the patient must control their pain completely after the operative treatment of pain, which is our priority, especially if we can establish that early movement decreases opioid consumption (Brown et al. 2018). The FNB and sciatic nerve block weaken the quadriceps femoris and the calves, reducing early joint activity and autonomic exercise and increasing the risk of falls after surgery.

Moreover, it may cause damage to the peroneal nerve (Grape et al. 2016).

According to the Çelik and Güzel (2023) study, local infiltration and epidural block have a similar effect in pain relief at movement and rest, and both methods effectively control the postoperative stress response in patients undergoing knee arthroplasty.

In the current study, no adverse effects such as pruritus, nausea, vomiting, anxiety, or respiratory depression were observed 24 h after surgery. As per Patterson et al. (2020) and the findings of Amin and Abotaleb (2021), no patients who received IPACK block experienced a hematoma or nerve injury during postoperative follow-up.

## Conclusions

The combination of IPACK block and hyperbaric bupivacaine spinal anesthesia is effective for treating initial postoperative pain following arthroscopic meniscectomy. IPACK block prolongs postoperative analgesia more than intrathecal fentanyl.

#### Abbreviations

| | |
|---|---|
| ACB | Adductor canal block |
| ASA | American society of anesthesia |
| BMI | Body mass index |
| ECG | Electrocardiogram |
| ERAS | Enhanced recovery after surgery |
| FNB | Femoral nerve block |
| IV | Intravenous |
| IPACK | Interspace between the popliteal artery and the capsule of the posterior knee |
| PCA | Patient-controlled analgesia |
| SPSS | Statistical package for social sciences |
| VAS | Visual analog score |

#### Acknowledgements

The authors would like to acknowledge all the technical staff of orthopedic surgery and the patients who gave consent for enrolment for the study.

#### Authors' contributions

M A A A and M A E conceived the study and shared in its design. O S Y undertook the data collection, data capturing, and handling. M A A A coordinated the data analysis. A M A and M A E drafted the manuscript. All authors read and approved the final manuscript.

#### Funding

This research was supported by authors; there was no funding institute or company.

#### Availability of data and materials

The data of this article is available from the corresponding author. The email address of the corresponding author is Abosoad.mohamed2017@gmail.com.

## Declarations

#### Ethics approval and consent to participate

This study was conducted after obtaining approval from the Faculty of Medicine at the Al-Azhar University's Ethical Committee of Scientific Research with approval number 00308 on 3 January 2022 and written informed consent from all patients before the operation. This study was registered with Clinical Trials Registry, ***ClinicalTrials.gov identifier (NCT number):*** CT05833776.

#### Consent for publication

Nil.

#### Competing interests

The authors declare no competing interests.

Received: 18 January 2023 Accepted: 5 August 2023
Published online: 15 August 2023

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## Publisher's Note