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Signa Vitae

ORIGINAL RESEARCH

Effects of adductor canal block combined with infiltration between the popliteal artery and capsule of the knee on pain management and early rehabilitation compared with epidural analgesia for patients undergoing total knee arthroplasty: a prospective randomised controlled trial

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Abstract

Total knee arthroplasty (TKA) is often regarded as one of the most painful orthopedic operations. Variety of regional anesthetic procedures are used to reduce this pain. Infiltration between the popliteal artery and capsule of the posterior knee (IPACK) is increasingly being utilized in conjunction with adductor canal block (ACB) to provide adequate analgesia for TKA. The aim of study is to assess the analgesic effectiveness of ACB + IPACK block and epidural analgesia (EA) after TKA during the early stages of physical therapy. This prospective study included 58 patients who underwent unilateral TKA surgery. Patients were randomized into two groups as EA group (n = 30) and ACB + IPACK group (n = 28). The visual analogue scale (VAS) scores of the patients at the postoperative 8th (PO8th) hour, 1st postoperative day (POD1), and postoperative 2nd day (POD2) during the active and passive physical therapy movements, VAS scores during the ambulation, and active and passive range of movement values in POD1 were recorded. In addition, ambulation rates of the patients at the PO8th hour, 25 meters ambulation times in POD1, and completion times of 10 assisted squats in POD1 were recorded. The ACB + IPACK group had a substantially higher PO8th hour VAS score (p = 0.038). However, there was no significant difference in POD1, POD2 VAS scores. The analgesics consumption and VAS scores during ambulation were comparable among groups. Ambulation rate (22 (78.5%) *vs.* 16 (53.3%), p = 0.043) and speed (139.65 $\pm$ 57.12 sec. *vs.* 188.66 $\pm$ 77.95 sec., p = 0.023) were significantly better in the ACB + IPACK group. The strength of quadriceps contractions was similar in both groups. The use of a combination of ACB + IPACK block for postoperative analgesia in TKA patients is not only successful in reducing postoperative pain, but also a promising treatment with favourable effects on early ambulation and rehabilitation.

Keywords

Postoperative pain management; Peripheral nerve block; Epidural analgesia; Knee arthroplasty; Rehabilitation; Ultrasound-guidance

1. Introduction

Total knee arthroplasty (TKA) is considered to be one of the most painful procedures in orthopaedic surgeries [1]. Analgesia management after TKA is an important issue of particular concern for recovery and rehabilitation. Pain management in these surgeries aims to achieve more effective and functional results by using regional analgesia techniques alone or in combination, such as epidural analgesia (EA), femoral nerve block (FNB), sciatic nerve block (SNB), per articular injection, adductor canal block (ACB), infiltration between the popliteal artery and capsule of the knee (IPACK) block [2].

Epidural analgesia is one of the most effective methods of post-TKA pain control and is frequently used [3]. Owing to the risk of serious complications of neuraxial analgesia, such as motor block, nerve injury, epidural hematoma, and infection; alternative regional analgesic techniques for EA are becoming increasingly popular [4]. ACB is a regional analgesia approach that preserves motor function while providing sufficient analgesia for postoperative physical therapy [5]. Although ACB provides adequate analgesia in the anterior and medial parts of the knee, it cannot provide sufficient analgesia in the posterior

part [6]. IPACK block, which is performed with local anaesthetic infiltration between the popliteal artery and the capsule of the knee, is a new technique that provides effective analgesia in the posterior part of the knee joint without causing a motor block [7, 8]. It can be used with ACB as a complementary block to provide adequate analgesia to the entire knee joint [9].

Many studies have compared regional anaesthesia methods for postoperative pain management after TKA. However, no study has directly compared the application of ACB + IPACK, which is the current combination, with EA. The primary aim of our study was to compare the analgesic efficacy of the combination of EA and ACB + IPACK block in postoperative analgesia after TKA in the postoperative early physical therapy period and in terms of secondary goals, such as ambulation parameters and muscle strength characteristics. We hypothesised that in patients undergoing TKA surgery, those who underwent ACB + IPACK block for postoperative analgesia consumed fewer opioids, achieved the same or better postoperative pain score, ambulation, and patient comfort than those who received EA.

2. Methods

This was a prospective, randomised comparative study conducted in a tertiary hospital. All patients were seen in their clinic rooms on the morning of the surgery and were informed about the study, supported by pictures.

In the study, adult patients aged between 18 and 90 years who underwent unilateral TKA at our centre between 01 June 2021, and 30 June 2022, and were found to have American Society of Anaesthesiologists (ASA) scores of 1–3 according to the ASA, with body mass indexes (BMIs) between 18 and 40 kg/m^2, and who were fully oriented and cooperative were included. The exclusion criteria were refusal to participate in the study and any contraindication to neuraxial anaesthesia, lower extremity neuropathy, local anaesthetic allergy, revision surgery, or advanced liver, heart, or kidney failure. Patients were randomly allocated into two groups. Randomization was performed using a computer-generated randomization sequence concealed in sealed opaque envelopes. Group EA included patients who received EA. Group ACB + IPACK included patients who received IPACK block in addition to ACB (Fig. 1). In both groups, surgical anaesthesia was induced by spinal anaesthesia. Spinal anaesthesia was performed using 15 mg of 0.5% hyperbaric bupivacaine in the sitting position with a 25 G pencil point needle at the L3–L4 or L4–L5 intervertebral space.

In group EA, combined spinal-epidural anaesthesia (CSEA) was performed in the sitting position at the L3–L4 or L4–L5 intervertebral space with a midline approach using a CSEA set that contains an 18 G Tuohy epidural needle, a 27 G spinal needle, and an epidural catheter. At the end of the surgery, a continuous infusion (with patient controlled analgesia (PCA) device without voluntary bolus) of 5 mL/h of 0.125% levobupivacaine was administered through the epidural catheter in the post-anaesthesia care unit for postoperative analgesia. The catheter was removed at the end of the second day in all patients who had an epidural catheter.

In case of loss of spinal anaesthesia due to a longer surgery than planned in the ACB + IPACK and EA groups, switching to general anaesthesia and epidural anaesthesia respectively, was planned. During the surgery, no medication was routinely administered to the patients for premedication or for any other purpose.

In the ACB + IPACK group, the appropriate position was given at the end of the surgery, and ACB + IPACK blocks were applied under ultrasonographic (USG) guidance. Both blocks were performed in the supine position using a 10 cm 22 G block needle and a 6–13 MHz linear probe (Edge, FUJIFILM Sonosite, USA).

2.1 Adductor canal block

The hip joint was externally rotated and slightly flexed for imaging purposes. The USG probe was placed between the patella and thigh and moved upward towards the medial thigh. The femoral artery and vein were detected in the vastus medialis, sartorius muscles and adductor canal. The saphenous nerve, a branch of the femoral nerve, was visualised lateral to the femoral artery under the sartorius muscle. Subsequently, the needle was advanced using the in-plane technique, and a local anaesthetic injection into the nerve sheath was performed with negative aspiration. The needle was then advanced to the underside of the vasto-adductor membrane by passing the sartorius muscle from lateral to medial using the in-plane technique, and the anterior of the femoral artery was reached (Fig. 2). After negative aspiration, 20 mL of local anaesthetic consisting of 0.25% bupivacaine was injected.

2.2 IPACK block

The popliteal artery was visualized by placing the USG (Edge, FUJIFILM Sonosite) probe in the popliteal fold, which was followed through the cephal to the level where the femoral condyles met the shaft of the femur. The tibial and peroneal nerves were visualised in the superficial popliteal artery (Fig. 3). After defining the space between the femur and popliteal artery, the needle was advanced laterally to medially using the in-plane technique. The needle tip was positioned near the middle of the femur and the lateral border of the periosteum (Fig. 4). After negative aspiration, a local anaesthetic injection consisting of 20 mL of 0.25% bupivacaine was administered. While the needle was withdrawn slowly, a local anaesthetic was gradually injected between the femur and artery.

Patients with grade IV osteoarthritis of the knee according to the Kellgren-Lawrence Classification were admitted to the operating room without any premedication. All surgeries were performed by the same senior surgeon and surgical team using the medial parapatellar approach of TKA. The surgeries were performed using a tourniquet, which was inflated during draping and released after skin closure. Posterior stabilised components (Vanguard PS Zimmer Biomet, Warsaw, India) were fixed with cement. A vacuum drain was inserted before joint closure and removed on the first postoperative day.

Demographic data of the patients were recorded, including age, sex, weight, height, BMI, comorbidities, and ASA. Preoperative knee pain visual analogue scale (VAS) scores and analgesic uses were recorded. During the intraoperative

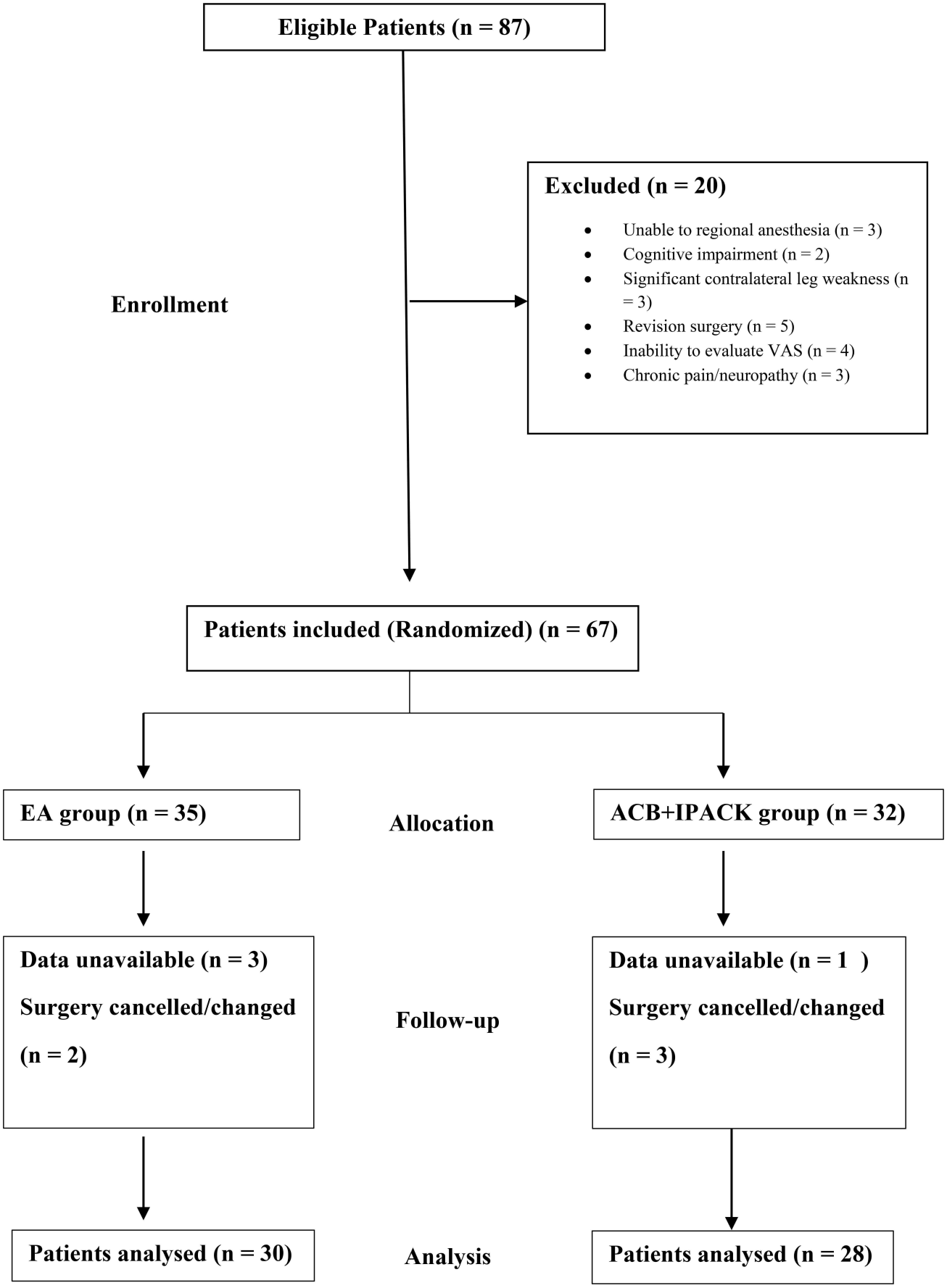

FIGURE 1. Flow chart of patients selection. VAS: visual analogue scale; EA: epidural analgesia; ACB: adductor canal block; IPACK: Infiltration Between the Popliteal Artery and Capsule of the Posterior knee.

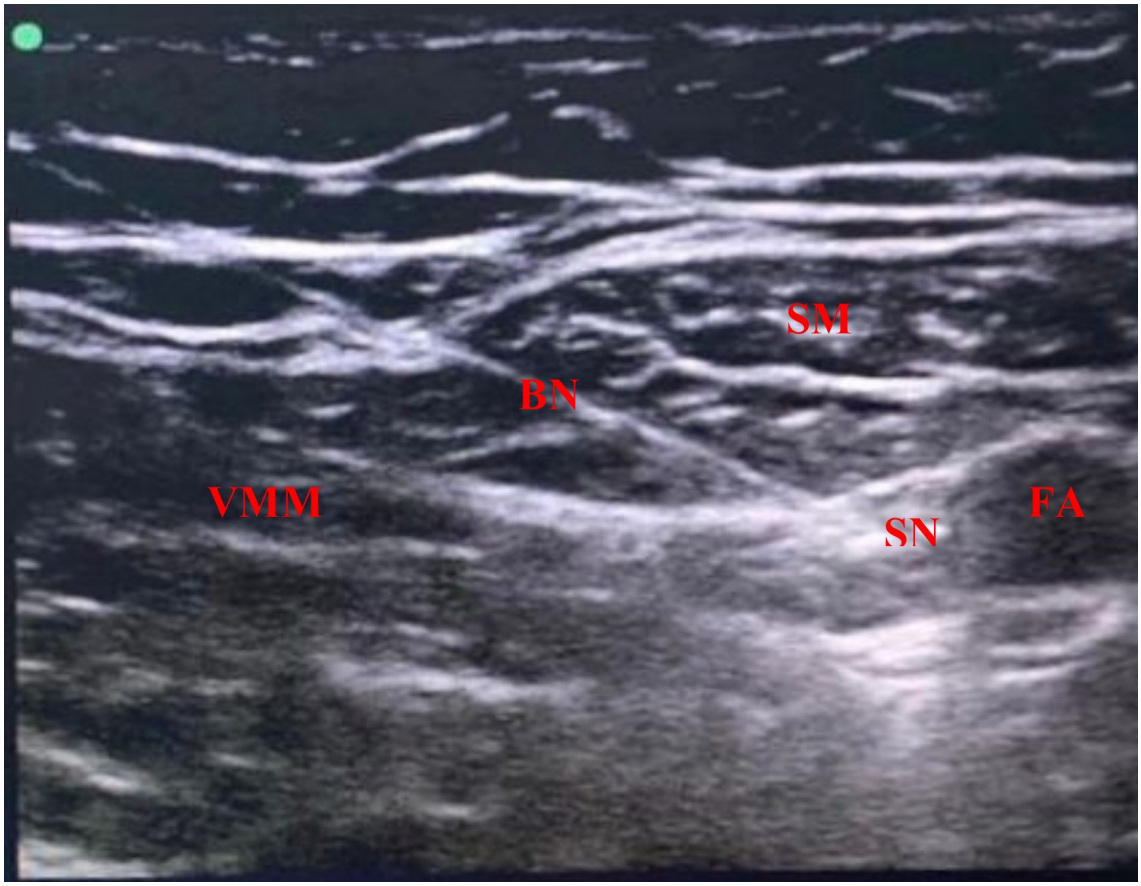

FIGURE 2. Adductor Canal Block; Ultrasound Anatomy. BN, block needle; SN, saphenous nerve; FA, femoral artery; SM, sartorius muscle; VMM, vastus medialis muscle.

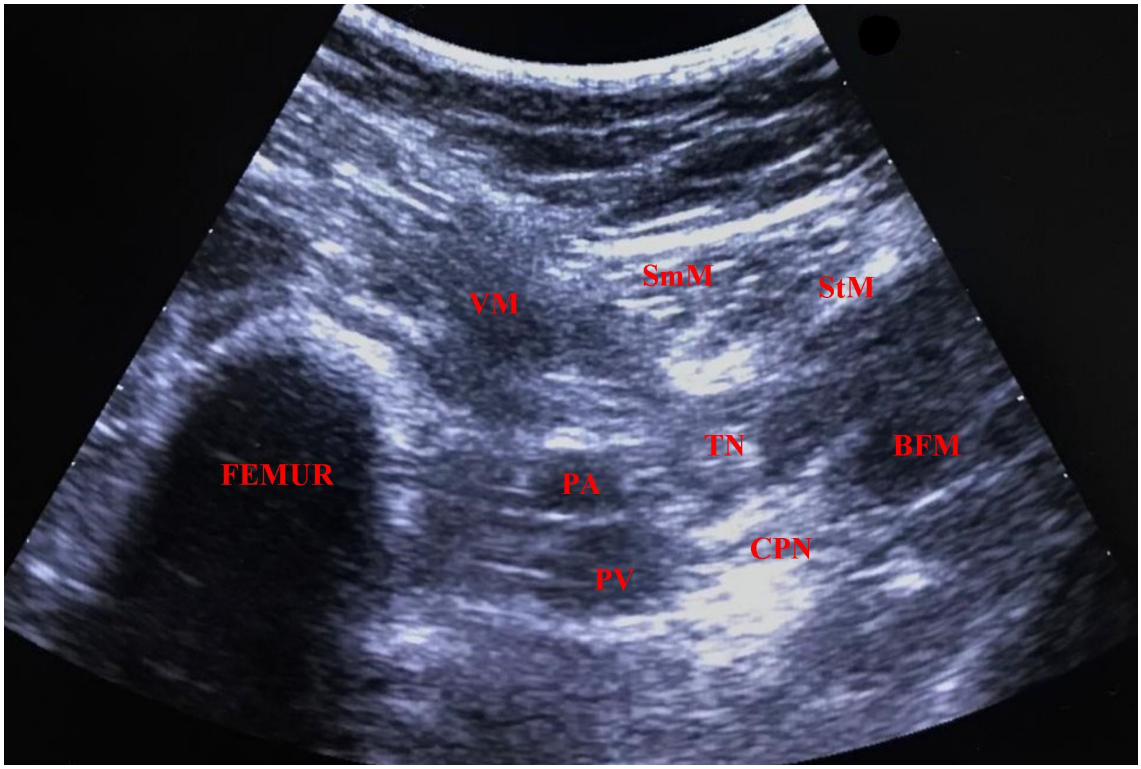

FIGURE 3. IPACK block; Reverse Ultrasound Anatomy. SmM, semimembranosus muscle; StM, semitendinosus muscle; VMM, vastus medialis muscle; BFM, biceps femoris muscle; PA, popliteal artery; PV, popliteal vein; TN, tibial nerve; CPN, common peroneal nerve.

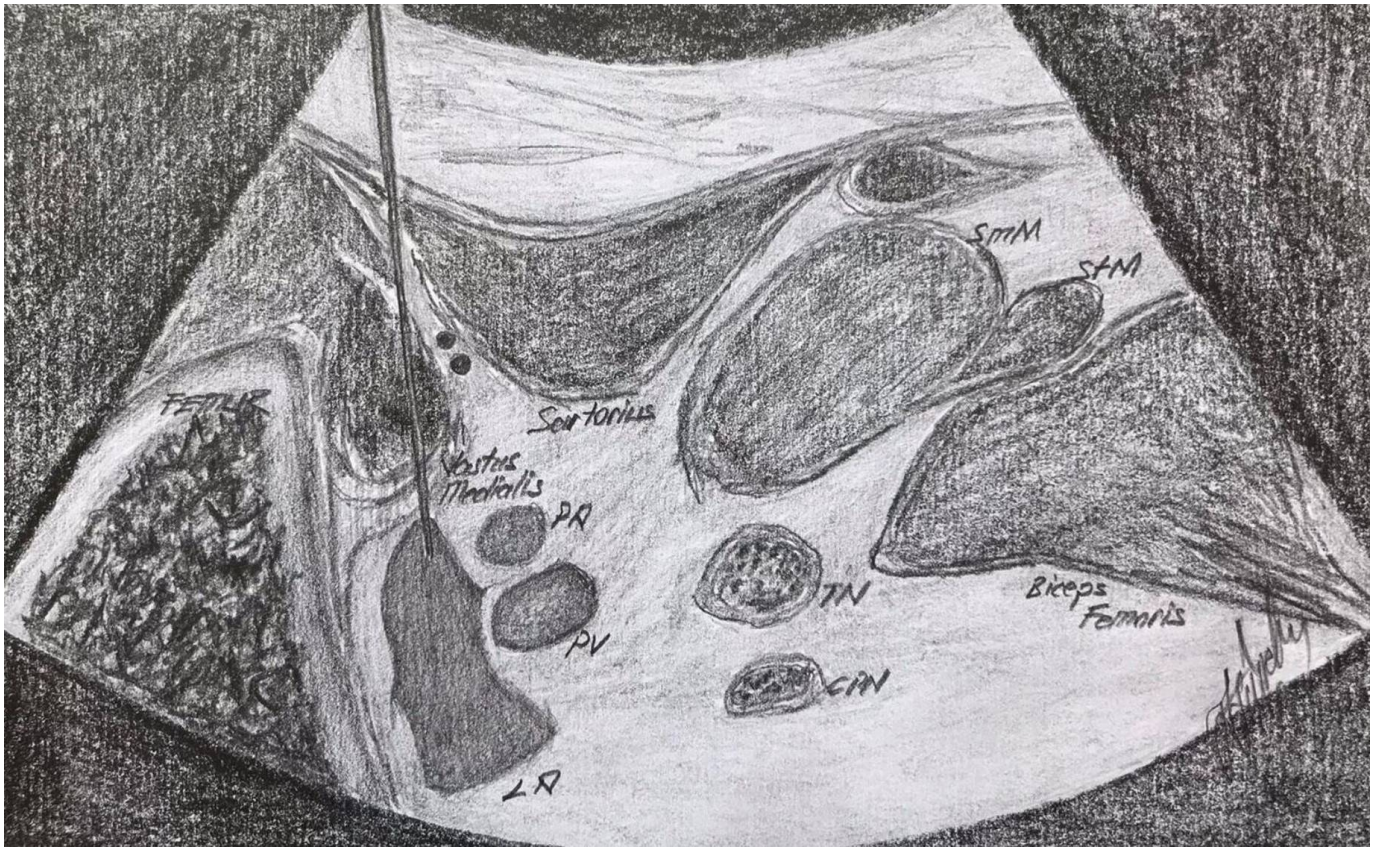

FIGURE 4. IPACK block; Reverse Ultrasound Anatomy. SmM, semimembranosus muscle; StM, semitendinosus muscle; PA, popliteal artery; PV, popliteal vein; TN, tibial nerve; CPN, common peroneal nerve; LA, local anaesthetic.

TABLE 1. Demographics and preoperative data.

Patient characteristics	Group EA (n = 30)	Group ACB + IPACK (n = 28)	*p* value
Age (y), median (IQR)	62.5 (9)	65.0 (13)	0.143
Gender (male/female), n	45042	45040	1.000
Weight (kg), median (IQR)	80 (10)	80 (12)	0.716
Height (cm), median (IQR)	160.0 (6)	159.5 (4)	0.207
BMI (kg/m), median (IQR)	31.28 (4.36)	31.40 (5.76)	0.469
Have additional disease, n(%)	24 (80.0)	25 (89.3)	0.473
ASA (I/II/III), n	5/21/4	3/18/7	0.477
Preoperative VAS score, mean ± SD	3.9 ± 2.0	3.79 ± 2.51	0.848
Preoperatively Habitual analgesic intake, n (%)			
None	5 (16.7)	8 (28.6)	
Paracetamol/NSAID	22 (73.3)	19 (67.9)	0.398
Weak opioids	3 (10.0)	1 (3.6)	
Surgery time (min), median (IQR)	111 (49)	120 (29)	0.196
Tourniquet time (min), median (IQR)	106.5 (33)	111.5 (40)	0.371
Operative knee, (right/left), n	15/15	45188	0.168

EA: Epidural Analgesia; ACB: Knee Adductor Canal Block; IPACK: Infiltration Between the Popliteal Artery and Capsule of the Posterior; VAS: Visual Analog Scale; ASA: American Society of Anesthesiologists; NSAID: Non-Steroidal Anti-Inflammatory Drug; IQR: Intel Quartile Range; kg: Kilogram; cm: Centimeter; n: Number; SD: Standard Deviation; min: Minute.

period, surgery duration and tourniquet time were recorded. The patients were followed up regularly by the same research assistant and physiotherapist. During their hospital stay, patients in both groups were administered 1 g of paracetamol and 50 mg of tramadol IV as rescue analgesics if the VAS score was >3. The analgesic consumption of the patients was recorded during the daily follow-up.

All patients were ambulated as standard on the eighth postoperative hour (PO8th), first postoperative day (POD1), and second postoperative day (POD2), and physical therapy was applied. The VAS scores of the patients at the PO8th, POD1 and POD2 during the active (implementation of the movement by the patient) and passive (having of the physiotherapist the movement performed) physical therapy movements, VAS scores during the ambulation, and active and passive range of movement (ROM) values on POD1 were recorded. In addition, the ambulation rates of the patients on PO8th, 25 m ambulation times (s) on POD1 (to measure ambulation rates), and completion times (s) of 10 assisted squats on POD1 (to measure quadriceps contraction strength) were recorded.

2.3 Sample size and statistical analysis

To calculate the sample size in the study, a preliminary study was conducted in two groups of 10 patients (EA and ACB + IPACK groups). As a result of the preliminary study, the VAS pain scores with ambulation on PO8th were 4.5 ± 1.4 in the EA group and 3.6 ± 0.8 in the ACB + IPACK group. In line with the mean and standard deviation (SD) values obtained from the preliminary study, it was determined that the minimum number of patients required for each group should be at least 27 in the sampling calculation made by taking the alpha error of 0.05, power 80% and effect size d = 0.80 in the G*Power (v3.1.9, HHU, Kiel, Germany) program.

Data were evaluated with Statistical Package for the Social Sciences 25.0. Categorical data are presented as numbers (n) and percentages (%), parametric data are presented as mean ± SD, and nonparametric data are presented as median (IQR). The conformity of continuous data to normal distribution was examined using the Kolmogorov-Smirnov test. The Mann-Whitney U test was used to compare non-normally distributed numerical data. The chi-square or Fisher's exact test was used to compare categorical data. The results were evaluated at a confidence interval of 95% and significance level of $p < 0.05$.

3. Results

In this study, data from 58 patients were analysed. Thirty patients were assigned to the EA group, and 28 patients were assigned to the ACB + IPACK group. The overall demographic and perioperative characteristics of both groups were similar (Table 1).

Although the VAS scores were significantly higher in the ACB + IPACK group than in the EA group in passive physiotherapy on PO8th (7.54 ± 2.20 *vs.* 6.40 ± 2.29 respectively; $p = 0.038$), no significant difference was found in other time intervals evaluated in active and passive physiotherapy. There was no statistically significant difference between the active and passive ROM values measured on POD1. The mean VAS scores of the patients during ambulation were lower in the ACB + IPACK group than in the EA group at all time intervals (PO8th, POD1 and POD2); however, the difference was not statistically significant ($p = 0.710$, $p = 0.420$ and $p = 0.180$, respectively) (Table 2).

The postoperative rescue analgesic consumption of the patients was similar between the groups. The number of patients who could be ambulated on PO8th was higher in the ACB + IPACK group than in the EA group (22 (78.5%) *vs.* 16 (53.3%), respectively; $p = 0.043$). On POD1, 25-m ambulation times were lower in the ACB + IPACK group than in the EA group (139.65 ± 57.12 *vs.* 188.66 ± 77.95 s, respectively; $p = 0.023$). However, the duration of the assisted 10 squats on POD1 was similar (Table 3). There were no problems were encountered during the application of the blocks. One patient in the EA group experienced a fall during mobilisation.

4. Discussion

In the present study, we evaluated the analgesic efficacy of the two procedures in TKA in terms of the early postoperative VAS score, ambulation, function and ROM. The results revealed that the ACB + IPACK combination had similar analgesic efficacy and analgesic consumption as EA, except for the early postoperative period after TKA. These also showed that the combination of ACB + IPACK was better in the early ambulation and postoperative rehabilitation processes.

Pain after TKA is severe postoperative pain that is exacerbated by physiotherapy that should be started in the early period [10, 11]. Pain management after TKA is closely related to the healing and physiotherapy processes. EA is considered one of the most effective methods for the management of this pain [12]. However, recent studies mention that neuraxial complications, such as nerve damage and motor block formation, which negatively affect the physiotherapy process, limit the use of EA [13]. In the present study, one patient in the EA group fell because of a block in the intact leg. Thus, interest in peripheral nerve blocks is increasing owing to their low complication rates, preservation of muscle strength, and analgesic activity at a similar level [14].

FNB is accepted as the gold standard among peripheral nerve blocks for postoperative pain management after TKA [15]. The disadvantage of FNB is that it negatively affects the rehabilitation process by causing a loss of strength in the quadriceps muscle [16, 17]. This has led to the introduction of alternative techniques. Among these, ACB provides effective analgesia in the anterior and medial part of the knee without causing quadriceps weakness [18]. However, the inability of ACB to provide sufficient analgesia in the posterior knee revealed at combination of IPACK block and ACB [19]. In recent literature, the combination of ACB + IPACK has been shown to be more effective in improving pain scores than ACB alone [9, 10, 20]. Et *et al.* [21] compared ACB, ACB + IPACK, and periarticular infiltration (PAI) + ACB groups and found significantly lower movement numeric rating scale (NRS) scores in the IPACK + ACB group than in the PAI + ACB and ACB groups.

Kayupov *et al.* [22] compared continuous ACB and EA, and found lower postoperative pain scores in the continuous ACB

TABLE 2. The comparison of postoperative VAS scores.

VAS scores after physical therapy	Group EA (n = 30)	Group ACB + IPACK (n = 28)	*p* value
Active			
VAS 8 h PO	4.97 ± 2.29	6.11 ± 2.18	0.058
VAS POD 1	5.20 ± 1.88	5.71 ± 1.82	0.296
VAS POD 2	4.03 ± 1.75	4.00 ± 1.82	0.944
ROM (°)	51.83 ± 18.07	49.64 ± 19.04	0.594
Passive			
VAS 8 h PO	6.40 ± 2.29	7.54 ± 2.20	0.038
VAS POD 1	6.73 ± 2.01	7.21 ± 2.23	0.392
VAS POD 2	5.63 ± 1.99	5.46 ± 1.68	0.861
ROM (°)	95.17 ± 11.85	94.11 ± 15.93	0.875
VAS scores with ambulation			
VAS 8 h PO	4.85 ± 2.03	4.50 ± 2.68	0.710
VAS POD 1	4.90 ± 2.29	4.42 ± 2.27	0.420
VAS POD 2	3.87 ± 2.28	3.11 ± 1.78	0.180

EA: Epidural Analgesia; ACB: Knee Adductor Canal Block; IPACK: Infiltration Between the Popliteal Artery and Capsule of the Posterior; VAS: Visual Analog Scale; PO: Postoperative; POD1: 1st Postoperative Day; POD2: 2nd Postoperative Day; ROM: Range of Movement.

TABLE 3. Opioid consumption and physical therapy ambulation speed.

	Group EA (n = 30)	Group ACB + IPACK (n = 28)	*p* value
Opioid consumption, n(%)			
0–24 h	24 (80)	25 (89.2)	0.329
24–48 h	19 (63.3)	16 (57.1)	0.630
Postoperative 8 hr ambulation, n(%)	16 (53.3)	22 (78.5)	0.043
Ambulation speed (25 m)	188.66 ± 77.95	139.65 ± 57.12	0.023
Quadriceps contraction strength (10 assisted squat)	32.65 ± 7.45	30.68 ± 17.38	0.964

EA: Epidural Analgesia; ACB: Knee Adductor Canal Block; IPACK: Infiltration Between the Popliteal Artery and Capsule of the Posterior; hr: Hour; n: Number.

group. In our study, we showed that a single dose of the ACB + IPACK combination provided analgesic activity similar to that of EA. In terms of the study methodology, the catheter technique will be evaluated based on the results obtained after a single injection technique for the effectiveness of the total knee prosthesis of a new block, the ACB + IPACK block. Because two separate blocks are applied, the single-injection use of new generation local anaesthetic agents with a possible future effect, instead of the catheter technique, appears to be more attractive. In addition, our aim as an anaesthesia clinic is to prefer catheter-free methods according to the ERAS surgical protocols.

Elliot *et al.* [23] compared the ACB + IPACK and FNB/IPACK groups and showed that physiotherapy performance was better in the ACB + IPACK group. Sankineani *et al.* [9] reported that the ACB + IPACK combination had better results in terms of range of motion and walking distance than ACB alone. Salman *et al.* [8] compared the FNB, FNB + IPACK, and ACB + IPACK groups and found better physiotherapy performance in the ACB + IPACK group. Zheng *et al.* [24] compared the ACB + IPACK, and FNB + single-injection popliteal sciatic nerve block (SPSNB) groups and found better quadriceps femoris muscle strength scores in the ACB + IPACK group. Similarly, Reddy *et al.* [25] showed that the ambulation rate was better in combinations that included IPACK. Alsheikh *et al.* [26]compared the ACB and EA groups and found that the initial mobilization rate was better in the ACB group. In our study, similar to previous studies, we showed that ambulation rates and 25m ambulation times were better in the ACB + IPACK group.

The VAS score with physical therapy on PO8th was significantly worse in the block group than in the EA group with passive movement. The PO8th is a period in which the ACB + IPACK block effect should still be maintained. However,

we believe that, especially starting physiotherapy, the anxiety it creates and comparing it with a central technique, such as EA in the other arm of the study cause the block effect to be perceived as low at this point.

The structures to be displayed during the IPACK block application are located deep. When imaging these structures, the convex ultrasound probe provides a better field of view and increases the success rate of the procedure. However, linear probes with high image quality and MHz (6–13), such as our ultrasound (Edge, FUJIFILM Sonosite), can also be used for imaging, and during our block applications, we preferred to use a linear probe that we use in our routine practice and can provide adequate imaging.

Insufficient analgesia causes an increase in the need for opioids and undesirable side effects due to opioids [27]. Alsheikh *et al*. [26] compared the ACB and EA groups and found that the VAS scores and need for additional analgesics (non-opioid) were significantly higher in the EA group, whereas opioid consumption was similar. Matthew *et al*. [5] reported that ACB and FNB had similar results in terms of opioid consumption. In our study, we found that the additional analgesic consumption was similar between the groups.

5. Limitations

Our study has some limitations. First, owing to the practitioner's skill and patient diversity, it was difficult to achieve objectively similar rates of blockage in all patients using the current methods. Second, the patient's quadriceps muscle strength was subjectively assessed by only one physiotherapist instead of an accepted test to evaluate mobilisation. Because of its nature, our study could not be applied blindly, therefore, it was applied in an open-label manner. Furthermore, the duration of hospital stay was not evaluated. Although this is seen as a disadvantage in the combination of ACB + IPACK, where two different injections are applied, it has advantages such as ensuring similar analgesic activity at once and the patient is not dependent on the PCA device compared with a catheter technique that provides continuous analgesic infusion.

6. Conclusions

In conclusion, our study results suggest that the combination of ACB + IPACK provided similar analgesic efficacy to EA, and was superior in terms of early mobilisation and physiotherapy performance in TKA procedures. However, it was also shown that physiotherapy in the immediate (8 h) postoperative stage was more painful (higher VAS score) in the ACB + IPACK group than in the EA group.

AVAILABILITY OF DATA AND MATERIALS

The data from this study is available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

FS—created the methodology, conceptualized, and supervised the study. UK—provided resources and visualization. MEI—took part in investigation. EDO and SFK—provided data curation. FS and YE—administered the project. MBE—wrote the original draft. FS and AC—reviewed and edited the original draft.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The ethical approval of this study was authorized by the Gulhane Training and Research Hospital, University of Health Sciences Medical Research Assessment Committee with the decision number 2021/28 on the 26 May 2021 and conducted in accordance with the ethical principles stated in the Declaration of Helsinki. Verbal and written informed consent was obtained from all patients for publication of clinical and radiological details and photographs of the participants.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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