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Effects of ultrasound-guided adductor canal block at different volumes on postoperative analgesia management in patients undergoing total knee arthroplasty: a prospective clinical study

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Abstract

Background Many different analgesia techniques are performed in knee arthroplasty. Adductor canal block is one of the analgesia techniques following knee arthroplasty. The aim of this study was to evaluate the effectiveness of adductor canal block performed at different volumes (20 ml, 30 ml, 40 ml) for postoperative analgesia management in patients undergoing total knee arthroplasty.

Methods This single-center prospective randomized controlled study included 90 patients, aged between 18 and 65, with ASA classification I-II-III, who were scheduled for total knee arthroplasty surgery under spinal anesthesia. Patients were randomized into three groups: Group 20, group 30 and group 40. Postoperative pain, opioid consumption, and motor block were evaluated. Statistical analysis was conducted to compare the primary and secondary outcomes between groups.

Results The difference in static NRS scores at all times except the 8th hour and in dynamic NRS scores at all times was found to be statistically significant. Group 40 had significantly lower opioid consumption and additional analgesic requirements compared to Group 20, but no statistically significant difference was found compared to Group 30. Group 40 had a statistically significantly higher rate of motor block in the first 8 h compared to Groups 20 and 30. No statistically significant difference was found between Groups 20 and 30 in terms of motor block at all times.

Conclusions The findings of our study showed that the optimal volume of adductor canal block to provide effective analgesia and preserve muscle strength functions in the postoperative period after total knee arthroplasty was 30 ml.

Clinical trial registration number NCT06084403.

Keywords Anesthesia, Total knee arthroplasty, Postoperative analgesia, Regional anesthesia, Ultrasonography

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Introduction

Knee arthroplasty is increasingly performed due to joint deformities and cartilage degeneration. Severe postoperative pain may occur in these patients due to surgery and the implanted prosthesis. Postoperative analgesia management is crucial for early mobilization and reducing postoperative complications such as thromboembolism [1]. Various methods can be used for postoperative analgesia. One of these methods is epidural analgesia; however, it may not be applicable due to patient refusal or technical difficulties. Another option is intravenous opioid agents, but opioids have side effects such as nausea, vomiting, sedation, and respiratory depression [2]. Femoral nerve block is not recommended as it may cause motor block, delaying mobilization [3, 4]. Epidural analgesia is no longer recommended due to potential adverse effects precluding rapid recovery, and sciatic nerve block is also discouraged due to its negative impact on postoperative functional recovery [4].

Regional analgesia techniques used in knee surgery include the adductor canal block. A single-shot adductor canal block is recommended by the PROSPECT working group [4]; however, there is no certain and standardized dose and volume recommendation available. This block provides analgesia without quadriceps muscle weakness, which is an important advantage for early mobilization since it does not cause motor block in the postoperative period [5, 6]. Blocking motor branches can lead to delayed mobilization and increased risk of falls [3, 6]. The adductor canal block (ACB) affects the two largest sensory nerves leading to the knee from the femoral nerve: the saphenous nerve, the branch of the nerve to vastus medialis, and the articular branches of the obturator nerve. Since ACB is performed distally in the thigh, the innervation of the quadriceps muscle is not affected, thus preserving its motor strength significantly [3, 7]. ACB is typically performed with a volume of 10–30 ml, and studies with different volumes are needed to clearly understand its effectiveness.

This study aimed to evaluate the effectiveness of adductor canal block performed at different volumes (20 ml, 30 ml, 40 ml) for postoperative analgesia management in patients undergoing total knee arthroplasty (TKA). Our primary objective was to compare postoperative opioid consumption, while our secondary objective was to evaluate postoperative pain scores (numeric rating scale - NRS), the presence or absence of motor block, and side effects related to opioid use (nausea, vomiting, etc.).

Materials and methods

Study design

This randomized, prospective study included 90 patients, aged between 18 and 65, with ASA classification I-II-III, who were scheduled for total knee arthroplasty surgery under spinal anesthesia. Patients with a history of bleeding diathesis, receiving anticoagulant treatment, allergies or sensitivity to local anesthetics and opioid drugs, patients with infection in the area where the block will be applied, pregnancy suspicion, pregnant or breastfeeding mothers, and patients who did not accept the procedure were excluded from the study. Ethical approval was obtained from the Bursa City Hospital Ethics Committee on 07.12.2022, protocol number 2022-17/3. Our study was registered on https://clinicaltrials.gov/ with the number NCT06084403. The patient recording and disribution were illustrated by the Consolidated Standards of Reporting Trials (CONSORT) flowchart (Fig. 1).

Patients were randomized into three groups, each containing 30 patients, using a computer program (Group 20 = group receiving ACB with 20 ml, Group 30 = group receiving ACB with 30 ml, Group 40 = group receiving ACB with 40 ml). The practitioners were blind to the data collection, and patients did not know which volume was applied. Postoperative pain scores and opioid consumption were recorded by a pain technician who was blind to the study.

Anesthesia application

After the patients were taken to the operating room, standard monitoring (electrocardiography, noninvasive arterial blood pressure, and peripheral oxygen saturation) was performed, and premedication was administered with 2 mg intravenous midazolam. For spinal anesthesia, the patients were positioned sitting, and following the necessary asepsis and antisepsis rules, a 25-gauge pencil-point spinal needle (B.Braun, Melsungen, Germany) was inserted into the subarachnoid space through a median approach from L3-4 or L4-5. After observing free clear cerebrospinal flow, 15 mg of hyperbaric bupivacaine was administered. To prevent postoperative nausea and vomiting, 4 mg of ondansetron was given intravenously. Total knee arthroplasty surgery was performed by the same surgical team using the same surgical procedure.

Block interventions

The block procedure was performed after the surgery was completed. All adductor canal blocks were performed by two experienced anesthesiologists with advanced clinical expertise in regional anesthesia. After ensuring aseptic conditions, a high-frequency linear ultrasound probe (GE ML6-15-D Matrix Linear, Boston, USA) was covered with a sterile sheath, and a 100 mm block needle (Stimuplex Ultra®, Braun, Melsungen, Germany) was used. The linear ultrasound probe was placed medial to the patella, and the probe was advanced cephalad to visualize the femoral artery, the adductor hiatus, and the apex of the femoral triangle. Then, 5 ml of saline was injected under ultrasound guidance into the midpoint of the adductor

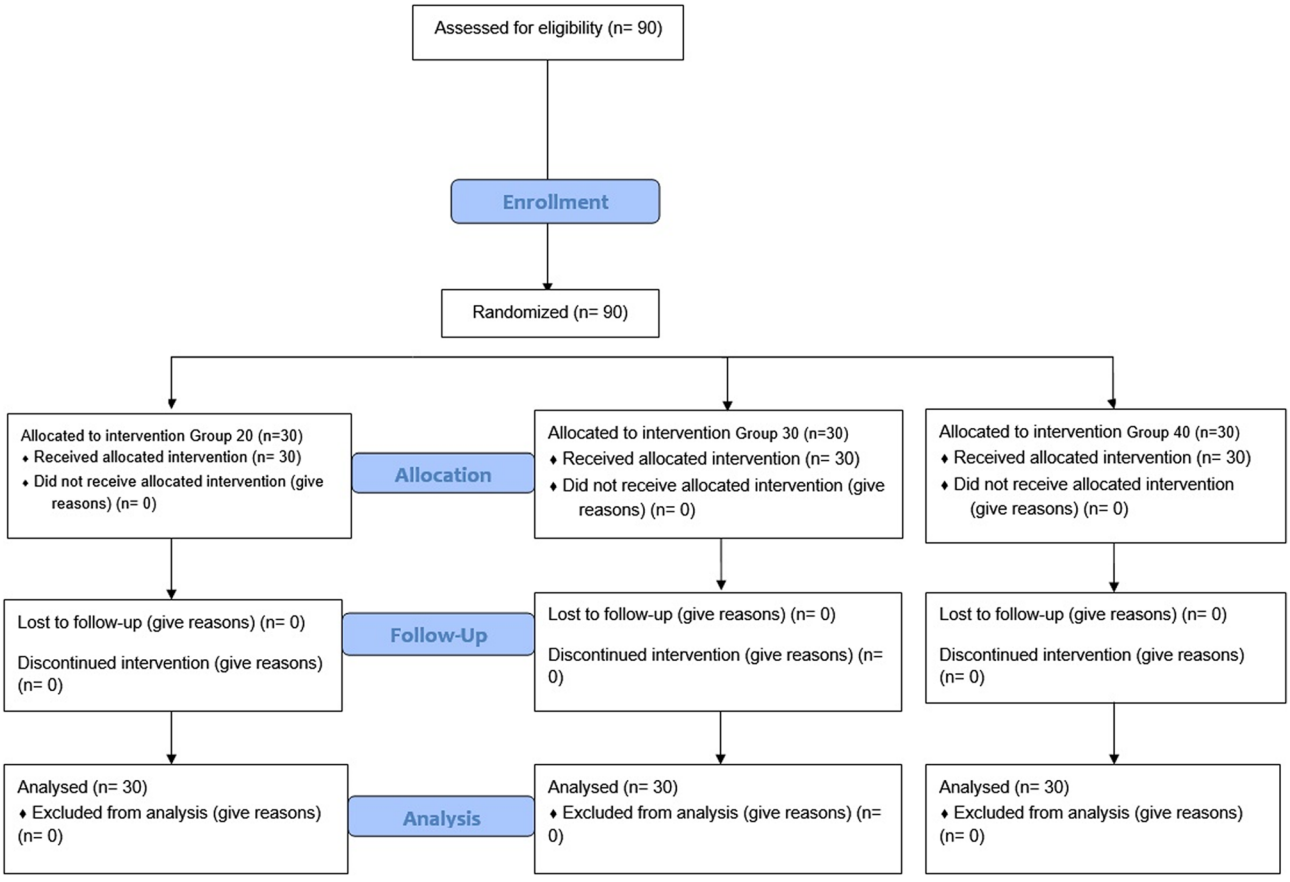

Fig. 1 CONSORT flow diagram of the study

canal to confirm the block site (Fig. 2). Then, local anesthetic solution containing bupivacaine at 0.25% concentration was administered as 20 ml in Group 20, 30 ml in Group 30, and 40 ml in Group 40.

After the operation, patients were taken to the postoperative recovery room. Patients reaching a score of 9 on the Aldrete scoring system were transferred to the ward.

Postoperative analgesia management

All patients received 0.5 mg/kg of intravenous tramadol and 20 mg of tenoxicam 30 min before the end of the surgical procedure. In the postoperative period, patients received 20 mg of tenoxicam intravenously twice a day. A patient-controlled analgesia (PCA) device was connected to all patients as soon as they were taken to the recovery room. The PCA was prepared with tramadol at a concentration of 5 mg/ml, with a lockout interval of 20 min and a bolus dose of 10 mg without a basal infusion. During the ward follow-ups, hourly NRS scores were monitored. If the NRS score was 4 or above, 0.5 mg/kg of intravenous meperidine was administered as a rescue analgesic. NRS scores at designated times as well as rescue analgesic needs and hours were noted in detail.

Postoperative pain assessment was performed using the NRS scoring system (0 = no pain, 10 = worst pain imaginable). Resting and moving NRS scores were evaluated and recorded at 2, 4, 8, 16, 24, and 48 h. If the NRS score was ≥ 4, 0.5 mg/kg of intravenous meperidine was administered as a rescue analgesic.

Motor block was evaluated using the modified Bromage scale (0: can move leg, foot, and knee freely; 1: normal knee and foot movements, but cannot raise leg straight; 2: cannot flex knee; 3: cannot move foot and knee) [8]. The need for rescue analgesics, postoperative opioid consumption, and side effects such as nausea, vomiting, and itching, as well as complications that may arise due to the block, were recorded.

Sample size calculation

The sample size calculation was performed using G*Power software version 3.1.9.2 (Kiel University, Kiel, Germany). Power analysis based on preliminary data on total opioid consumption [Group 20: 107.86 ± 42.17 ($n = 7$), Group 30: 88.57 ± 50.14 ($n = 7$), Group 40: 50.14 ± 51.2 ($n = 7$)] showed an effect size of 0.49, with a 95% confidence interval, an alpha error of 0.05, and a

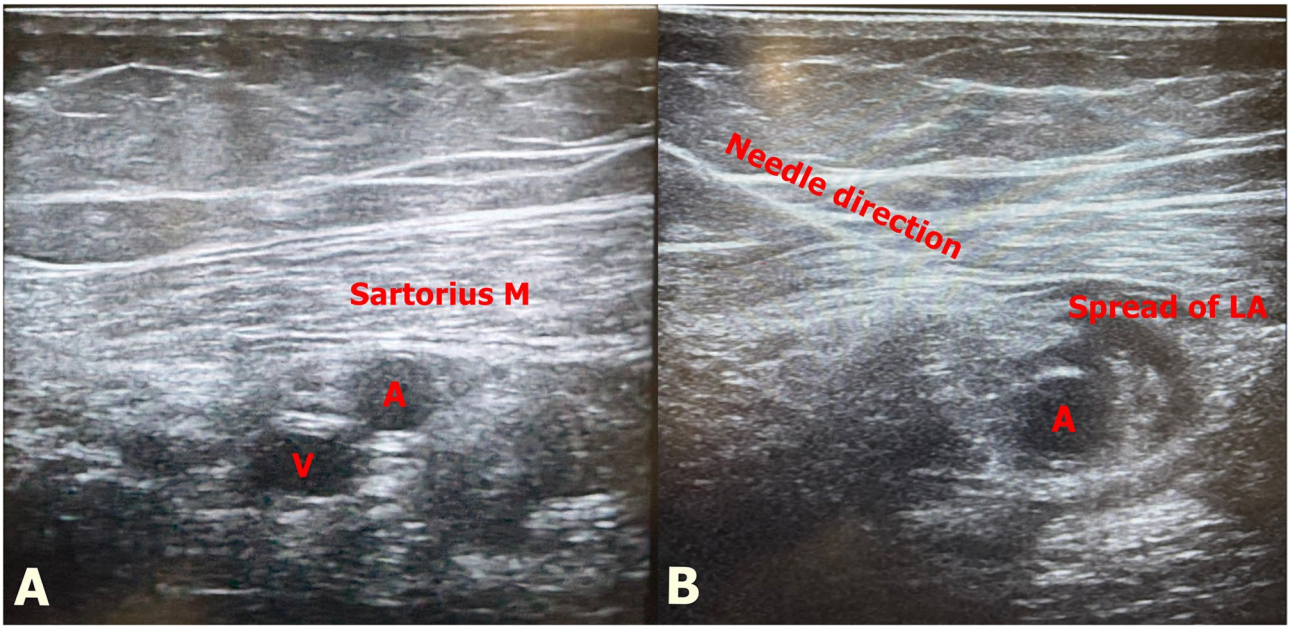

Fig. 2 **A** Adductor canal sonographic anatomy. Sartorius Muscle, A; artery, V; vein. **B** Sonographic anatomy of block. Needle direction, and spread of local anesthetic during block performing. A; artery

power of 0.95. Based on this effect size and confidence interval, a sample size of 22 patients per group was calculated to be sufficient. To account for potential dropouts, 30 patients were planned to be enrolled in each group.

Statistical analysis

Statistical analysis was performed with IBM SPSS v20.0 (SPSS Inc., Chicago, Illinois, USA) software package. The normality distribution of variables was checked with the Kolmogorov-Smirnov and histogram tests. Descriptive data were expressed as median [%25–75] and a number. Categorical variables were expressed as a number and analysed using the Chi-square and Fisher exact tests. Non-normally distributed continuous variables were analyzed using the Kruskal-Wallis test, followed by Dunn's test for post-hoc analysis to assess differences among groups. For the statistical analysis, $p < 0.05$ was considered statistically significant.

Results

A total of 90 participants were included in the study, divided into groups of 30 each. No significant differences were observed between the groups regarding demographic data such as age, height, weight, gender, ASA classification, surgical duration, and anesthesia duration, with $p > 0.05$ (Table 1).

The difference in static NRS scores at all times except the 8th hour was found to be statistically significant ($p < 0.05$). When examined between the groups, Group 20 had statistically higher NRS scores than Group 30 at the 16th hour, and Group 20 had statistically higher NRS scores than Group 40 at the 4th, 8th, 16th, and 24th hours ($p < 0.05$). Group 30 had statistically higher static NRS scores compared to Group 40 at the 4th and 24th hours ($p < 0.05$) (Table 2).

The difference in dynamic NRS scores at all time points was found to be statistically significant ($p < 0.05$). Dynamic NRS scores were statistically significantly higher in Group 20 compared to Groups 30 and 40 at

Table 1 Demographic datas and comparison of duration times between Group 20, Group 30 and Group 40

	Group 20 (n:30)	Group 30 (n:30)	Group 40 (n:30)	p
Age (years)	62 [56-64]	61[50-64]	59[53-62]	0.228[a]
Height (cm)	162[159-171]	162[160-171]	167[160-170]	0.563[a]
Weight (kg)	80[72-89]	79[74-89]	75[70-80]	0.066[a]
Gender (M/F)	10/20	11/19	10/20	0.952[b]
ASA (I/II/III)	5/17/8	4/18/8	8/19/3	0.370[b]
Duration Time of Surgery (min)	90[80-95]	85[75-105]	85[75-100]	0.788[a]
Duration Time of Anesthesia (min)	112.5[100-125]	110[100-125]	107.5[100-125]	0.871[a]

Values are expressed median [%25-75] or number, kg; kilogram, cm; centimeter, M; male, F; Female, ASA; American Society of Anesthesiologist, min: minutes

[a]Kruskal Wallis test between groups

[b]Chi-square test between groups

Table 2 The Comparison of postoperative static and dynamic NRS values between Group 20, Group 30 and Group 40

NRS	Group 20 (n:30)	Group 30 (n:30)	Group 40 (n:30)	20 vs 30	20 vs 40	30 vs 40	p[a]
Static 2nd	3[2-5]	3[1-4]	2[2-3]	0.187	0.44	N	**0.038**
Static 4th	3[2-4]	3[2-4]	2[1-2]	0.363	**<0.001**	**0.008**	**<0.001**
Static 8th	3[2-4]	2[1-4]	2[1-3]	0.137	**0.016**	0.705	0.069
Static 16th	3[2-4]	2[1-3]	1[1-2]	**0.02**	**<0.001**	0.267	**<0.001**
Static 24th	2[1-3]	2[0-2]	0[0-1]	0.33	**<0.001**	**0.014**	**<0.001**
Static 48th	2[1-2]	2[0-3]	1[0-1]	N	0.059	0.163	**0.045**
Dynamic 2nd	5[4-7]	4[2-5]	3[2-4]	**0.010**	**<0.001**	N	**<0.001**
Dynamic 4th	5[5-7]	4[2-6]	3[2-3]	**0.003**	**<0.001**	**0.016**	**<0.001**
Dynamic 8th	5[4-6]	4[2-5]	3[2-4]	**0.018**	**<0.001**	0.290	**<0.001**
Dynamic 16th	4[3-5]	3[1-4]	2[1-2]	**0.024**	**<0.001**	**0.005**	**<0.001**
Dynamic 24th	3[3-4]	3[1-3]	1[0-1]	**0.029**	**<0.001**	**0.001**	**<0.001**
Dynamic 48th	3[2-3]	2[1-3]	1[1-3]	**0.022**	**0.002**	N	**0.002**[a]

Values are expressed median [%25-75], N; nonsignificant

[a]Kruskal Wallis test with Dunn test for post hoc between groups.

Table 3 The Comparison of postoperative motor block between Group 20, Group 30 and Group 40

Motor Block (0/1/2)	Group 20 (n:30)	Group 30 (n:30)	Group 40 (n:30)	20 vs 30	20 vs 40[b]	30 vs 40[b]	p[a]
4thhours	28/2/0	26/4/0	12/16/2	0.671 [a]	**<0.001**	**0.001**	**<0.001**
8thhours	30/0/0	29/1/0	23/7/0	N	**0.011**	0.052	**0.003**
16thhours	30/0/0	30/0/0	30/0/0	N	N	N	N
24thhours	30/0/0	30/0/0	30/0/0	N	N	N	N

Values are expressed as a number, Motor Block 0; normal, 1; motor weakness, 2; motor paralysis. N; nonsignificant

[a]Chi-square test compared between groups and post-hoc analysis

[b]Fisher exact test for post hoc analysis

all time points ($p<0.05$). Dynamic NRS scores were statistically significantly higher in Group 30 compared to Group 40 at the 4th, 16th, and 24th hours ($p<0.05$) (Table 2).

There was a statistically significant difference in motor block in all groups at the 4th and 8th hours ($p<0.05$). When the groups were compared, statistically significantly more motor block was detected in Group 40 than in Groups 20 and 30 in the first 8 h ($p<0.05$). No statistically significant difference was found between Groups 20 and 30 in terms of motor block at any time point ($p>0.05$) (Table 3).

There was a statistically significant difference between all groups in terms of opioid consumption in the first 16 h ($p<0.05$). A statistically significant difference was found in terms of total opioid consumption and additional analgesic requirements ($p<0.05$). When comparing the groups, Group 40 had significantly lower opioid consumption and additional analgesic requirements compared to Group 20, while no statistically significant difference was found compared to Group 30. No significant difference was found between the groups in terms of patient satisfaction ($p>0.05$) (Table 4).

While there was no statistically significant difference between the groups in terms of nausea and itching, vomiting was statistically more common in group 20 (Table 5).

Discussion

The primary aim of our study was to evaluate the analgesic effectiveness and the impact on motor function of ACB performed with different volumes (20, 30, and 40 ml) in patients undergoing total knee arthroplasty (TKA). While opioid consumption was similar in the 30 ml and 40 ml groups, motor block was more pronounced in the 40 ml group. Although motor preservation was better in the 20 ml group, it was associated with increased opioid use. Importantly, there was no statistically significant difference in motor block between the 20 ml and 30 ml groups, nor in opioid consumption between the 30 ml and 40 ml groups. Taken together, these findings suggest that 30 ml offers the most favorable balance between effective analgesia and motor function preservation.

Peripheral nerve blocks that can be performed after total knee arthroplasty are considered a part of multimodal analgesia. Due to the innervation of the knee joint by multiple nerves, various peripheral blocks can be applied. ACB stands out due to its ease of application, effective analgesia, and motor-sparing properties. For this reason, it has been included in the PROSPECT (Procedure Specific Postoperative Pain Management) recommendations [4]. Although there are studies in the literature focusing on volume, the presence of inconsistent data has shaped our study in this area.

Table 4 The Comparison of opioid consumption and rescue analgesia between Group 20, Group 30 and Group 40

	Group 20 (n:30)	Group 30 (n:30)	Group 40 (n:30)	20 vs 30	20 vs 40	30 vs 40	*p*
Opioid Consumption							
0-8h (mg)	50[40-60]	40[20-40]	20[20-40]	**0.002**	**<0.001**	**0.03**	**<0.001**[a]
8-16h (mg)	20[20-40]	20[20-40]	20[0-20]	0.784	**<0.001**	**0.016**	**<0.001**[a]
16-24h (mg)	0[0-20]	0[0-20]	0[0-0]	0.903	0.061	0.082	0.126[a]
24-48 h (mg)	0[0-30]	0[0-30]	0[0-20]	0.660	0.952	0.636	0.867[a]
Total Consumption (mg)	85[60-140]	70[40-130]	40[40-80]	0.967	**0.004**	0.086	**0.005**[a]
Additional Analgesia	19	11	8	0.70[b]	**0.009**[b]	0.580[b]	**0.012**[b]
Additional Analgesia Consumption (mg)	35[0-80]	0[0-60]	0[0-30]	0.519	**0.022**	0.561	**0.027**[a]
Patient Satisfaction (bad/medium/good/excellent)	4/8/9/9	0/8/10/12	0/5/14/10	0.214[b]	0.173[b]	0.497[b]	0.141 [b]

Values are expressed median [%25-75] and as a number, h;hours, mg; miligram

[a]Kruskal Wallis test with Dunn test for post hoc between groups

[b]Chi-square test compared between groups and post-hoc analysis

Table 5 The Comparison of incidence of side effects between Group 20, Group 30 and Group 40

	Group 20 (n:30)	Group 30 (n:30)	Group 40 (n:30)	*p*[a]
Nausea	8	6	5	0.627
Vomiting	6	1	1	**0.032**
Itching	1	0	1	0.600

Values are expressed as a number

[a]Chi-square test compared between groups

Anatomically, the adductor canal is adjacent to the apex of the femoral triangle.

The femoral nerve with motor function forms the common neural structure. Additionally, the vastus medialis nerve, saphenous nerve, medial femoral cutaneous nerve, and the terminal branch of the posterior obturator nerve comprise four main neural structures involved in knee innervation [9]. Therefore, to achieve optimal analgesia in knee surgery with ACB, it is necessary to completely block the neural structures within the adductor canal while minimizing the spread to the femoral triangle to preserve the motor functions of the quadriceps muscle.

In our study, it appears that we preferred a higher volume of medication compared to current alternative studies in the literature. Jenstrup et al. reported significant reductions in pain scores and morphine consumption in the group that received ACB with 30 ml of 0.75% ropivacaine compared to the control group and they noted greater ambulation ability at 24 h in the ACB group [10]. Similar studies have also reported reductions in pain scores with ACB using the same drug doses [11]. Therefore, we determined the median dose in our study to be 30 ml, as the analgesic effectiveness of ACB is prominent in these studies.

In cadaver studies conducted for ACB, Andersen et al. reported that the optimal volume is 15 ml, while Yanguk Heo et al. indicated that a volume of 5 ml is sufficient [12]. In their dose finding study on healthy volunteers, Jæger et al. stated that the minimum effective dose required for ACB to fill the distal part of the adductor canal in at least 95% of the subjects (ED 95) was 20 ml [13]. Studies using volumes up to 40 ml for adductor canal block have been reported in the literature [14, 15]; therefore, this volume was adopted as the upper limit in our study. However, as these studies were mostly conducted on cadavers or healthy individuals and reported inconsistent findings, the optimal volume required to provide effective analgesia, particularly following total knee arthroplasty (TKA), remains unclear. Accordingly, we evaluated three different volumes (20, 30, and 40 ml) to explore a potential dose–response relationship and allow for clinically meaningful comparisons.

Although ACB fundamentally relies on the blockade of neural structures in the canal due to sufficient filling with medication, the differences in the elasticity of cadaveric tissues compared to living tissues, the unclear factors affecting the pharmacodynamics of the local anesthetic agents used, and the unassessed analgesic effectiveness may lead to inconsistencies in adapting these results to clinical data. In a meta-analysis evaluating the analgesic effectiveness of ACB after TKA, Jiao Guo et al. reported that ACB was insufficient to relieve post-TKA pain, especially in the posterior/posterolateral pain of the knee, and that its combination with infiltration between the popliteal artery and the capsule of the posterior knee (IPACK) block provided better analgesic effectiveness [16]. According to the results obtained from this meta-analysis, in 13 of 14 randomized controlled trials, block was performed with a volume of 20 ml containing different concentrations of ropivacaine during ACB application, and in only one, a volume of 30 ml was applied. These results suggest that ACB with a volume of 20 ml may be inadequate for providing effective analgesia after TKA. In our study, the significant analgesic effectiveness in groups receiving 30 and 40 ml compared to the group receiving 20 ml supports these data.

In the adductor canal block, by filling the canal with a sufficient volume of local anesthetic, the nerve vastus medialis, nerve saphenous and deep genicular branches passing through the canal and responsible for the innervation of the anterolateral region of the knee are blocked [17]. However, for surgeries like TKA that can cause pain in the posterolateral region of the knee, an isolated anterolateral block may be insufficient. In our study, it was observed that blocks performed with 30 and 40 ml provided more effective analgesia compared to 20 ml. This situation supports the hypothesis that local anesthetic may spread to the popliteal fossa through the hiatus distal to the adductor canal and block the branches of the sciatic nerve responsible for the posterolateral innervation of the knee. Further studies are needed to investigate the neural structures contributing to the innervation of the posterolateral region of the knee and their connections with the neural structures innervating the anterolateral region and the adductor canal.

The secondary aim of our study was to evaluate the effects of volume differences in ACB on quadriceps motor functions. David F. Johnston et al. reported that a volume of 46.5 ml was required to achieve a 30% reduction in quadriceps strength in 50% of patients following ACB, and the effective volume calculated for 95% of subjects was 50.32 ml [18]. In another study, Ulrik et al. evaluated quadriceps motor functions and electromyography (EMG) recordings after applying ACB with 10, 20, and 30 ml to three different groups, noting significant differences in EMG waves between groups while stating that there were no significant differences in the impact on quadriceps motor functions [19]. In our study, it was observed that quadriceps motor functions were preserved in the 20 and 30 ml groups, while there was a significant reduction in the 40 ml group. This suggests that the volume of medication performed to the adductor canal will, after a certain point, affect the femoral triangle through proximal spread.

There were some limitations in our study. Firstly, the absence of a control group could have been important in determining the effectiveness of all three groups compared to a control. Secondly, dermatomal assessment could not be performed because the patients were under the effects of spinal anesthesia postoperatively. Finally, larger sample sizes and multicenter studies may be needed.

In conclusion, we believe that the optimal volume for ACB application to provide effective analgesia and preserve muscle strength functions in the postoperative period after TKA is 30 ml. Furthermore, multicenter randomized controlled studies with large groups are needed to answer the question of what the optimal volume for ACB should be.

Abbreviations

ACB	adductor canal block
TKA	total knee arthroplasty
NRS	numerical rating scale
PCA	patient-controlled analgesia
PROSPECT	procedure-specific postoperative pain management
EMG	Electromyography
IPACK	infiltration between the popliteal artery and the capsule of the posterior knee

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12871-025-03383-6.

Supplementary Material 1

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Previous presentation
Not applicable.

Authors' contributions
All of the authors (AK, ME, MD, ME, FB, İA, ECC, BC) made substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data; they have been involved in drafting the manuscript or revising it critically for important intellectual content; have given final approval of the version to be published.

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Data availability
The datasets generated and/or analyzed during the current study are not publicly available, but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study has been approved by University of Health Sciences, Bursa City Hospital Ethics Committee and Turkey Pharmaceuticals and Medical Devices Institution (2022-17/3). Written informed consent was obtained from the participants. All methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication
Not Applicable.

Conflict of interest
No potential conflict of interest relevant to this article was reported.

Competing interests
Bahadir Ciftci is a member of the Editorial Board of BMC Anesthesiology. The authors declare no competing interests.

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References

1. Kim S, Bosque J, Meehan JP, Jamali A, Marder R. Increase in outpatient knee arthroscopy in the United States: a comparison of National surveys of ambulatory surgery, 1996 and 2006. J Bone Joint Surg Am. 2011;93:994–1000.
2. Rahimzadeh P, Faiz HR, Imani F, Hobika GG, Abbasi A, Nader ND. Relieving pain after arthroscopic knee surgery: Ultrasound-guided femoral nerve block or adductor canal block? Turk J Anaesthesiol Reanim. 2017;45:218–24.

3. Jiang X, Wang QQ, Wu CA, Tian W. Analgesic efficacy of adductor canal block in total knee arthroplasty: a meta-analysis and systematic review. Orthop Surg. 2016;8:294–300.
4. Lavand'homme PM, Kehlet H, Rawal N, Joshi GP, PROSPECT Working Group of the European Society of Regional Anaesthesia and Pain Therapy (ESRA). Pain management after total knee arthroplasty: procedure specific postoperative pain management recommendations. Eur J Anaesthesiol. 2022;39:743–57.
5. Lund J, Jenstrup MT, Jaeger P, Sørensen AM, Dahl JB. Continuous adductor-canal-blockade for adjuvant post-operative analgesia after major knee surgery: preliminary results. Acta Anaesthesiol Scand. 2011;55:14–9.
6. Manickam B, Perlas A, Duggan E, Brull R, Chan VW, Ramlogan R. Feasibility and efficacy of ultrasound-guided block of the saphenous nerve in the adductor canal. Reg Anesth Pain Med. 2009;34:578–80.
7. - Kapoor R, Adhikary SD, Siefring C, McQuillan PM. The saphenous nerve and its relationship to the nerve to the Vastus medialis in and around the adductor canal: an anatomical study. Acta Anaesthesiol Scand. 2012;56:365–67.
8. Usta B, Gozdemir M, Demircioglu RI, Muslu B, Sert H, Yaldiz A. Dexmedetomidine for the prevention of shivering during spinal anesthesia. Clinics. 2011;66(7):1187–91.
9. Rasouli MR, Viscusi ER. Adductor canal block for knee surgeries: an emerging analgesic technique. Arch Bone Jt Surg. 2017;5:131–2.
10. Jenstrup MT, Jæger P, Lund J, Fomsgaard JS, Bache S, Mathiesen O, et al. Effects of adductor-canal-blockade on pain and ambulation after total knee arthroplasty: a randomized study. Acta Anaesthesiol Scand. 2012;56:357–64.
11. Jaeger P, Grevstad U, Henningsen MH, Gottschau B, Mathiesen O, Dahl JB. Effect of adductor-canal-blockade on established, severe post-operative pain after total knee arthroplasty: a randomised study. Acta Anaesthesiol Scand. 2012;56:1013–9.
12. - Andersen HL, Andersen SL, Tranum-Jensen J. The spread of injectate during saphenous nerve block at the adductor canal: a cadaver study. Acta Anaesthesiol Scand. 2015;59:238–45.
13. Jæger P, Jenstrup MT, Lund J, Siersma V, Brøndum V, Hilsted KL, et al. Optimal volume of local anaesthetic for adductor canal block: using the continual reassessment method to estimate ED95. Br J Anaesth. 2015;115:920–6.
14. Sonawane K, Dixit H, Mistry T, Gurumoorthi P, Balavenkatasubramanian J. Anatomical and technical considerations of the Hi-PAC (Hi-volume proximal adductor canal) block: a novel motor-sparing regional analgesia technique for below-knee surgeries. Cureus. 2022;14(2):e21953.
15. Sonawane K, Dixit H, Mistry T, Gurumoorthi P. A high-volume proximal adductor canal (Hi-PAC) block-an indirect anterior approach of the popliteal sciatic nerve block. J Clin Anesth. 2021;73:110348–48.
16. - Guo J, Hou M, Shi G, Bai N, Huo M. Ipack block (local anesthetic infiltration of the interspace between the popliteal artery and the posterior knee capsule) added to the adductor canal blocks versus the adductor canal blocks in the pain management after total knee arthroplasty: a systematic review and meta-analysis. J Orthop Surg Res. 2022;17:387.
17. Burckett-St Laurant D, Peng P, Girón Arango L, Niazi AU, Chan VW, Agur A, et al. The nerves of the adductor Canal and the innervation of the knee: an anatomic study. Reg Anesth Pain Med. 2016;41:321–27.
18. Johnston DF, Sondekoppam RV, Giffin R, Litchfield R, Ganapathy S. Determination of ED50 and ED95 of 0.5% ropivacaine in adductor canal block to produce quadriceps weakness: a dose-finding study. Reg Anesth Pain Med. 2017;42:731–6.
19. Grevstad U, Jæger P, Sørensen JK, Gottschau B, Ilfeld B, Ballegaard M, et al. The effect of local anesthetic volume within the adductor canal on quadriceps femoris function evaluated by electromyography: a randomized, observer- and subject-blinded, placebo-controlled study in volunteers. Anesth Analg. 2016;123:493–500.

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