Comparison of Different Concentrations of Ropivacaine Used for Ultrasound-Guided Adductor Canal Block + IPACK Block in Total Knee Arthroplasty

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Abstract

This study aimed to compare the analgesic efficacy of different concentrations of ropivacaine used for the combination of ultrasound-guided adductor canal block (ACB) and infiltration between the popliteal artery and capsule of the posterior knee (IPACK) block in total knee arthroplasty (TKA). Before general anesthesia, 90 patients undergoing TKA were randomized to receive ACB + IPACK block with ropivacaine 0.2, 0.25, or 0.3% (defined as group A, B, and C, respectively). Primary outcome was the reported visual analog scale (VAS) pain scores at rest 30 minutes following arrival to the postanesthesia care unit (PACU). Secondary outcomes were postoperative VAS pain scores, postoperative morphine consumption, the time to first rescue analgesia, functional recovery of knee (including the range of motion and quadriceps strength), and postoperative complications. Compared with group A, group B and group C had significantly lower VAS scores 30 minutes following arrival to the PACU ($p < 0.001$ and $p < 0.001$, respectively). These two groups also had significantly lower VAS pain scores at postoperative 2 hours (at rest: $p = 0.037$ and 0.002; during motion: $p = 0.035$ and 0.001, respectively) and 6 hour (at rest: $p = 0.033$ and 0.002; during motion: $p < 0.001$ and $p < 0.001$, respectively), lower postoperative morphine consumption ($p = 0.001$ and 0.002, respectively), longer time to first rescue analgesia ($p = 0.010$ and 0.009, respectively), and better range of knee motion on the day of surgery ($p = 0.008$ and 0.002, respectively). Group B and group C showed no significant differences in these outcomes between each other ($p > 0.05$). The three groups did not show a significant difference in postoperative quadriceps strength and complication rates ($p > 0.05$). Compared with ropivacaine 0.2%, ropivacaine 0.25 and 0.3% can provide early pain relief in the first 6 hours after surgery. Ropivacaine 0.25 and 0.3% may provide more clinical benefits for patients undergoing outpatient TKA.

Keywords

- total knee arthroplasty
- adductor canal block
- IPACK
- ropivacaine
- concentration

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Total knee arthroplasty (TKA) is one of the most common surgical procedures in the United States.[1] However, more than 60% of patients suffer moderate-to-severe pain after TKA.[2,3] Inadequate pain management can delay postoperative recovery and reduce patient satisfaction.[4,5] The advent of multimodal pain protocols and regional anesthesia has drastically decreased the morbidity and length of hospital stay associated with TKA.[6,7]

Peripheral nerve block is one of the key techniques of multimodal pain protocols after TKA.[8,9] At present, adductor canal block (ACB) is a commonly used method to control postoperative pain after TKA.[10–12] However, many patients who receive ACB still experience severe posterior knee pain because the ACB blocks only the anteromedial sensory nerve of the knee but not the posterior or lateral sensory nerves.[13,14] The ultrasound-guided infiltration between the popliteal artery and capsule of the posterior knee (IPACK) block can solve this problem by providing significant analgesia to the posterior compartment of the knee without compromising foot strength.[15] At present, the combination of ACB and IPACK block is still a focus of research on the multimodal pain protocols and regional analgesia techniques of TKA, and some researchers recommended this combination as important postoperative analgesia in enhanced recovery TKA protocols.[1,12,16–18]

In previous studies, the concentration of ropivacaine used for ACB + IPACK block ranged from 0.2 to 0.5% (including 0.2, 0.25, 0.375, and 0.5%).[12,19–23] The optimal concentration of ropivacaine used for ACB + IPACK block is still unclear. The risk of local anesthetic systemic toxicity should always be contemplated very carefully with all regional anesthesia techniques.[24] A dose-finding study is required for the optimization of ACB + IPACK block, thereby ensuring administration of the appropriate concentration of local anesthetic together with the preservation of maximum clinical efficacy. This prospective, double-blind, randomized controlled trial aimed to compare the analgesic efficacy of different concentrations of ropivacaine used for ACB + IPACK block.

Materials and Methods

This study was approved by the Clinical Trials and Biomedical Ethics Committee of xx (our institution) and written informed consent was obtained from all subjects participating in the trial.

Patient Recruitment

This study recruited patients undergoing primary unilateral TKA at our institution.

Patients eligible for the trial complied with all of the following requirements: (1) scheduled for primary unilateral TKA in our institution; (2) diagnosed with osteoarthritis; (3) age > 18 years at the date of inclusion; (4) American Society of Anesthesiologists functional status of I to III; and (5) with normal quadriceps strength.

Patients meeting one or several of the criteria listed below were not enrolled in the trial: (1) a knee flexion deformity of ≥30°; (2) a varus–valgus deformity of ≥30°; (3) known allergies to the drugs being used in this study; (4) with a history of open surgery of knee; (5) with a history of knee infection; (6) narcotic dependency; (7) with recognized neuromuscular disorders; and (8) unable to communicate verbally.

Randomization

All patients were classified into three groups using a computer-generated list of random numbers (Excel, Microsoft Corporation, Redmond, WA). Based on this list, investigator 1 who was blinded to group allocation and study design prepared sealed opaque envelopes for each patient. On the morning of their surgery, investigator 2 assigned the patients to three groups based on the number in the sealed envelopes. Patients in group A received ropivacaine 0.2%, patients in group B received ropivacaine 0.25%, and patients in group C received ropivacaine 0.3%. Prior to surgery, investigator 2 ensured that the same anesthesiologist prepared the block syringes (containing ropivacaine of corresponding concentration) in the central pharmacy and performed the appropriate nerve block in the operating room. The outcome assessor (investigator 3) and surgeon were both blinded to the treatment group. Statistical analysis was performed by investigator 4, who was also blinded to group allocation.

Baseline Characteristics of Patients

A total of 147 patients were assessed for eligibility, of whom 26 did not meet the eligibility criteria and another 31 were unwilling to give consent. The remaining 90 patients were randomized into three groups. During postoperative outcome assessments, no patients dropped out of the study (►**Fig. 1**). The three groups showed no significant differences in characteristics before surgery (►**Table 1**).

Perioperative Analgesia and Management

On the day before surgery, celecoxib (200 mg) was administered twice. Two hours prior to surgery, celecoxib (200 mg), pregabalin (150 mg), and oxycodone hydrochloride (10 mg) were administered.

Nerve blocks were completed 30 minutes before general anesthesia by administration of ropivacaine of corresponding concentration and 2.0 μg/mL of epinephrine. Nerve blocks were performed after subcutaneous infiltration with 1 mL of 2% lidocaine, with the patients in the supine position.

Adductor Canal Block

ACB was performed as follows (►**Fig. 2A**): a high-frequency linear-array ultrasonic transducer (Anesus ME7, Mindray, Shenzhen, China) was used to scan the middle of the thigh (half the distance between the inguinal crease and the patella) to identify the adductor canal, superficial femoral artery, sartorius, adductor longus, and adductor magnus. The anterolateral hyperechoic structure of the artery (saphenous nerve and nerve to vastus medialis)

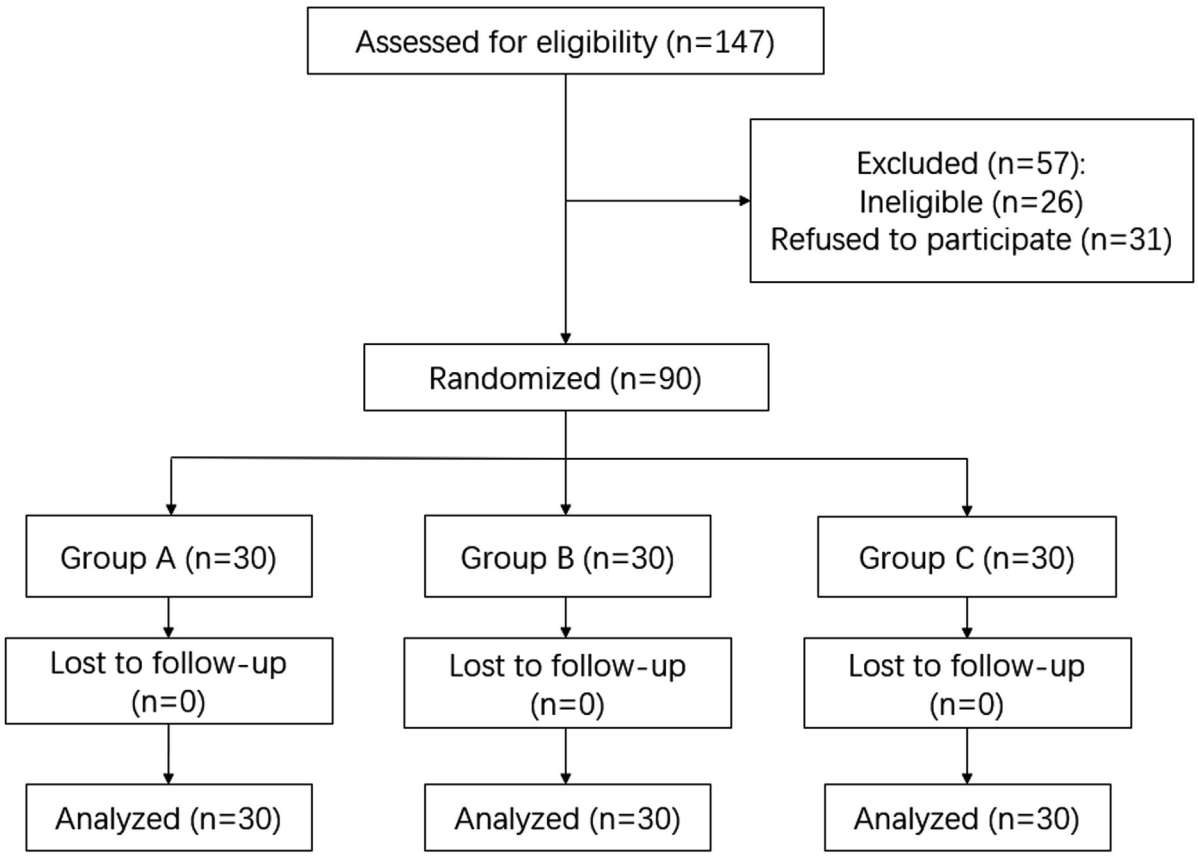

Fig. 1 Flow diagram of patients' selection and exclusion.

was the injection target. A 21-gauge, 100-mm needle (Pajunk, Geisingen, Germany) was introduced in-plane lateral to medial, and then, 20 mL of local anesthetics (ropivacaine + epinephrine) was injected after ensuring the correct placement of the needle using 3 mL of isotonic saline.

IPACK

IPACK was performed under the same ultrasonic transducer mentioned above (►**Fig. 2B**). The anesthesiologist identified the popliteal artery, at the popliteal crease and moved cephalad just beyond the femoral condyles, at the level where the condyles merge with the shaft of the femur.

Table 1 Baseline characteristics of patients.

Characteristic	Group A ($n = 30$)	Group B ($n = 30$)	Group C ($n = 30$)	*p*-Value
Age (years)	65.4 ± 5.8	63.8 ± 6.3	66.9 ± 8.2	0.227[a]
Sex (M/F)	8/22	7/23	10/20	0.679[b]
Weight (kg)	65.1 ± 11.5	64.6 ± 9.6	64.4 ± 9.9	0.958[a]
Height (cm)	161.2 ± 8.6	159.0 ± 6.9	159.3 ± 8.4	0.531[a]
Body mass index (kg/m^2)	25.0 ± 3.3	25.5 ± 3.2	25.3 ± 3.3	0.802[a]
Surgery side (right/left)	15/15	17/13	18/12	0.730[b]
VAS pain score (prior to surgery)	49.0 ± 8.0	50.1 ± 8.2	47.5 ± 10.1	0.548[c]
Knee ROM (prior to surgery)	112.0 ± 9.5	113.8 ± 11.6	112.2 ± 12.8	0.879[c]
ASA status (I/II/III)	1/18/11	0/22/8	0/21/9	0.822[c]

Abbreviations: ASA, American Society of Anesthesiologists; ROM, range of motion; VAS, visual analog scale.
Note: Values are mean ± standard deviation or number of cases.
[a]One-way analysis of variance.
[b]Pearson's chi-square test.
[c]Kruskal–Wallis test.

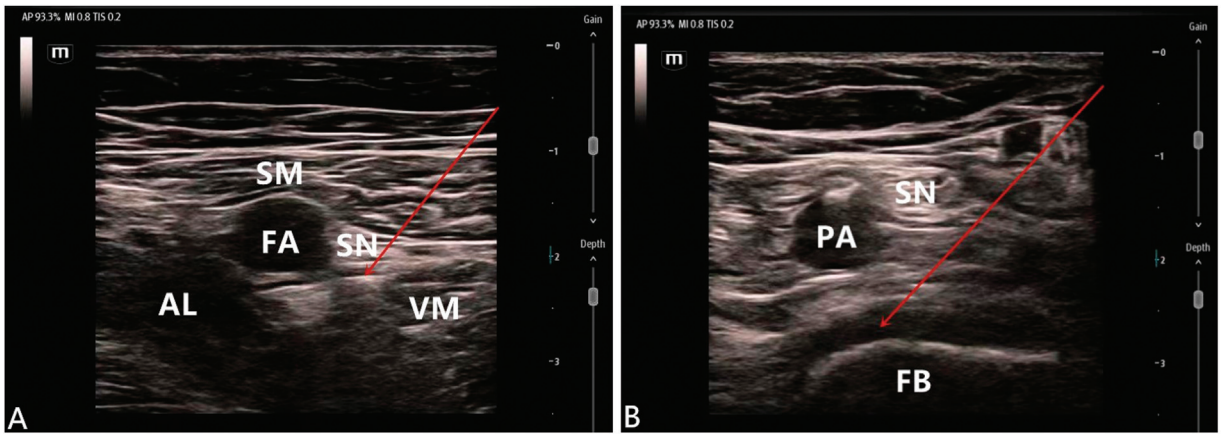

Fig. 2 Ultrasound-guided adductor canal block **(A)** and infiltration between the popliteal artery and capsule of the posterior knee block **(B)**. AL, adductor longus; FA, femoral artery; FB, femoral bone; PA, popliteal artery; SM, sartorius muscle; SN, saphenous nerve; VM, vastus medialis; line, needle insertion point.

The tibial and peroneal nerves were visualized superficially to the popliteal artery. After identifying the space between the femur and popliteal artery, the needle was advanced in-plane from medial to lateral. The tip was positioned at the middle of the femur and near the lateral border near the periosteum. Subsequently, 5 to 10 mL of local anesthetic was injected to ensure adequate spread to the lateral end of the femur. Upon withdrawing the needle, the anesthesiologist further injected the rest of the local anesthetic along the femur, infiltrating 5 mL incrementally in the area between the artery and femur and finishing at the medial end of the femur. IPACK involved a total of 20 mL of local anesthetic.

All surgical procedures in this study were performed by the same group of senior surgeons in our institution. Surgery was performed by making a midline skin incision with a medial parapatellar approach under general anesthesia. We did not perform spinal anesthesia in our institution. During the surgery, cemented prostheses (DePuy Synthes, New Brunswick, NJ) were used, but not pneumatic tourniquets. Five milligrams of tropisetron was given intravenously 20 minutes before the end of surgery to prevent postoperative nausea and vomiting. Drainage tubes were not used before the wound was sutured. At present, there is no definitive clinical evidence to support that the addition of local infiltration analgesia to ACB + IPACK block can improve analgesic outcomes. To avoid interference between the efficacy of ACB + IPACK block and local infiltration analgesia, we did not perform local infiltration analgesia during surgery.

Patients were sent to the postanesthesia care unit (PACU) after regaining consciousness. After awakening from anesthesia, patients were sent to the bed ward and an ice compress was applied around the incision. Celecoxib (200 mg) was administered twice a day to control postoperative pain. If the patient was unable to tolerate the pain, a further 10 mg of morphine hydrochloride as rescue analgesia was injected subcutaneously.

Outcomes and Follow-up

The primary outcome addressed in this study was the reported visual analog scale (VAS) pain scores[25] at rest 30 minutes following arrival to the PACU. The scale ranged from 0 to 100, where 0 indicates no pain and 100 indicates extreme pain.

Secondary outcomes were postoperative VAS pain scores, postoperative morphine consumption, the time to first rescue analgesia, functional recovery of knee (including range of motion and quadriceps strength), and postoperative complications.

Postoperative pain at rest and during motion was measured at 2, 6, 12, 24, and 48 hours after surgery.

The level of supplementary morphine hydrochloride consumption within 24 hours after surgery was recorded.

The functional recovery of the knee was measured by the range of motion and quadriceps strength. The range of motion was measured using a protractor, three times per day, and 6 hours apart, and the best value was used as the day's value. The quadriceps strength was assessed by asking the patients to flex their hip and knee first and then finish knee extension. The outcome assessor gave resistance to the motion of knee extension and touched the contracted muscle in the thigh to evaluate the muscle strength. It was scored as 0 point, no muscle contraction; 1 point, muscle contraction but no joint movement; 2 points, joint movement but no gravity resistance; 3 points, gravity resistance; 4 points, gravity resistance and partial counterforce resistance; and 5 points, normal joint function.

The occurrence of complications was recorded. The complications included nausea, vomiting, nerve damage, local anesthetic intoxication, wound complications, and falls after surgery. The readmission rate within 90 days and related reasons were also recorded.

To assess postoperative pain, all patients were required to stay in the hospital for at least 48 hours after surgery. After discharge, patients chose to go home or go to a rehabilitation facility according to their own wishes.

Statistical Analysis

The sample size was based on the power analysis from a previous systematic review that included 570 randomized clinical trials on pain management after total hip and knee arthroplasty. The systematic review reported that the median minimal clinically important difference (MCID) for pain scores at rest was relative 30%.[26] To achieve the MCID, we calculated that 27 individuals per group would be required to detect a statistically significant difference between groups with a two-sided α level of 0.05 and a power of 90%. Considering the risk of dropouts, 30 patients were included in each of the three groups.

Statistical analysis was performed using SPSS 26.0 (IBM, Chicago, IL). The normality of data was analyzed using histograms and quantile–quantile plots. For normally distributed data, we used one-way analysis of variance (ANOVA) and performed post hoc testing using the least significant difference test. For skewed and ordinal data, we used the Kruskal–Wallis one-way ANOVA test and performed post hoc testing. The *p*-value threshold for statistical significance was calculated using the Bonferroni method to adjust for multiple comparisons among groups. For categorical data, we used Pearson's chi-square test or Fisher's exact probabilities test. The time to first rescue analgesia was analyzed using survival analysis (Kaplan–Meier method with log-rank test). Continuous data were presented as mean and standard deviation, unless otherwise indicated. Categorical data were presented as numbers or percentages. Significance was defined as $p < 0.05$.

Results

Primary Outcome

Compared with group A, group B and group C had significantly lower VAS scores at rest 30 minutes following arrival to the PACU ($p < 0.001$ and $p < 0.001$, respectively; ►**Fig. 3**). For groups B and C, the relative reduction in VAS scores exceeded the reported MCID (30%).[26] This outcome did not differ significantly between group B and group C ($p = 1.000$).

Secondary Outcomes

Postoperative Visual Analog Scale Scores

Compared with group A, group B and group C had significantly lower VAS pain scores at rest and during motion at postoperative 2 hour (at rest: $p = 0.037$ and 0.002; during motion: $p = 0.035$ and 0.001, respectively) and 6 hour (at rest: $p = 0.033$ and 0.002; during motion: $p < 0.001$ and $p < 0.001$, respectively; ►**Figs. 3** and **4**). However, the relative reduction in VAS scores did not exceed the reported MCID.[26] The postoperative VAS pain scores at rest and during motion

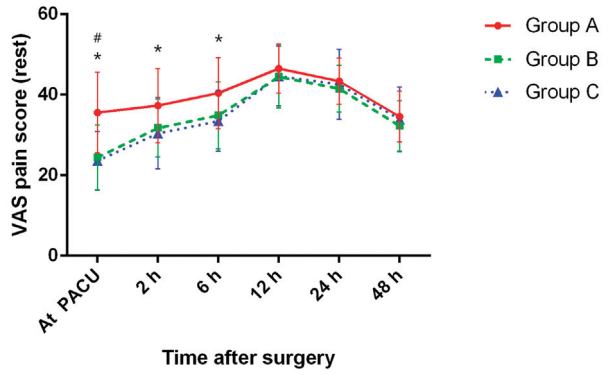

Fig. 3 The average postoperative VAS pain scores at rest of patients in all groups. *$p < 0.05$ compared with group A, group B and group C had significantly lower VAS pain scores at rest. # Compared with group A, the relative reduction in VAS scores of group B and group C exceeded the reported MCID (30%). The error bars indicate the standard deviation of the mean.

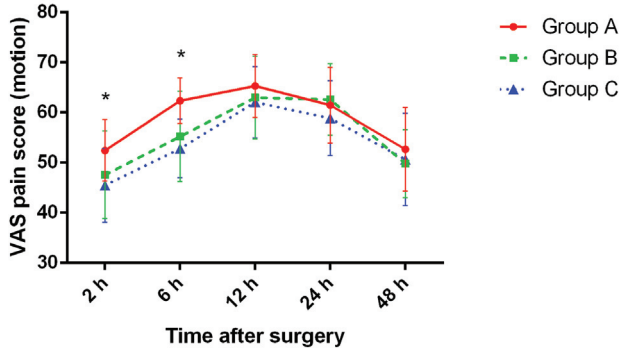

Fig. 4 The average postoperative VAS pain scores during motion of patients in all groups. *$p < 0.05$ compared with group A, group B and group C had significantly lower VAS pain scores during motion. The error bars indicate the standard deviation of the mean.

Table 2 Postoperative rescue analgesia.

				p-Value			
Outcome	Group A (n = 30)	Group B (n = 30)	Group C (n = 30)	A vs. B vs. C	A vs. B	A vs. C	B vs. C
Morphine consumption within 24 hours (mg)	13.3 ± 6.6	7.33 ± 5.2	7.67 ± 5.7	<0.001[a]	0.001	0.002	1.000
Time to first rescue analgesia (hours)	11.5 ± 4.7[c]	13.8 ± 4.9[c]	14.1 ± 5.0[c]		0.010[b]	0.009[b]	0.959[b]

Note: Values are mean ± standard deviation.
[a]Kruskal–Wallis test.
[b]Kaplan–Meier method with log-rank test.
[c]Patients who did not receive rescue analgesia were excluded.

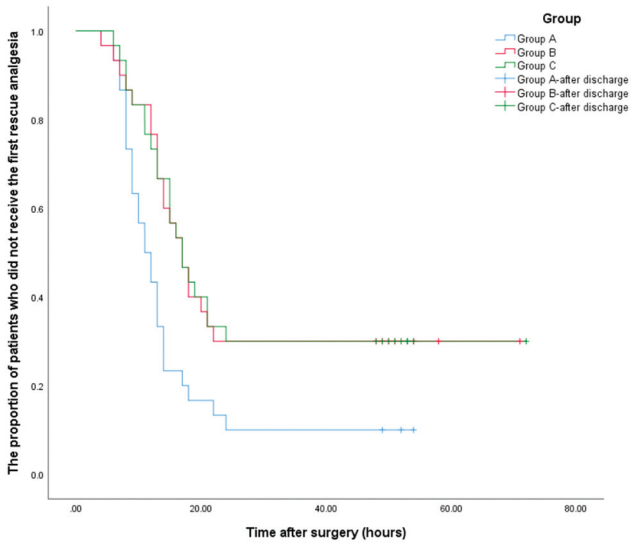

Fig. 5 The survival analysis function of the time to first rescue analgesia.

also were similar at all time points between group B and group C ($p > 0.05$).

Postoperative Morphine Consumption

Compared with group A, group B and group C had significantly lower morphine consumption within 24 hours after surgery ($p = 0.001$ and 0.002, respectively; ►**Table 2**). For groups B and C, the relative change in morphine consumption exceeded the reported MCID (40%).[26] There was no significant difference in postoperative morphine consumption between group B and group C ($p = 1.000$).

The Time to First Rescue Analgesia

Compared with group A, group B and group C had significantly longer time to first rescue analgesia ($p = 0.010$ and 0.009, respectively; ►**Table 2** and ►**Fig. 5**). The MCID of the time to first rescue analgesia has not been reported in the literature. This outcome did not differ significantly between group B and group C ($p = 0.959$).

Functional Recovery of Knee

Compared with group A, group B and group C showed significantly better range of knee motion on postoperative day 0 ($p = 0.008$ and 0.002, respectively; ►**Table 3**). For groups B and C, the absolute change in range of motion exceeded the reported MCID (10 degrees).[27] The range of knee motion did not differ significantly between group B and group C ($p > 0.05$).

The three groups did not show a significant difference in postoperative quadriceps strength ($p > 0.05$; ►**Table 3**).

The Occurrence of Complications

During postoperative hospitalization, the three groups showed similar incidence of nausea ($p = 0.685$), vomiting ($p = 0.914$), and wound complications ($p = 0.856$; ►**Table 4**). Nerve damage, local anesthetic intoxication, or falls did not occur in any group. One patient in group A and two patients in group B were readmitted for delayed wound healing within 90 days after surgery ($p = 0.355$). These patients were discharged after short-term wound care.

Discussion

This study compared the analgesic efficacy of different concentrations of ropivacaine used for ACB + IPACK block. The most important finding of the present study was that in ACB + IPACK block, compared with ropivacaine 0.2%, ropivacaine 0.25 and 0.3% could improve early pain relief in the first 6 hours after surgery, reduce morphine consumption within 24 hours after surgery, and prolong the duration of analgesia.

In recent years, the combination of ACB and IPACK block is still a focus of research on the multimodal pain protocols and regional analgesia techniques of TKA.[12,17,18,28–30]

Table 3 Functional recovery of knee

				p-Value			
Outcome	Group A (n = 30)	Group B (n = 30)	Group C (n = 30)	A vs. B vs. C	A vs. B	A vs. C	B vs. C
Degree of knee ROM (degrees)							
Day 0	83.7 ± 14.9	94.3 ± 11.0	95.2 ± 10.9	0.001[a]	0.008	0.002	1.000
Day 1	97.5 ± 6.7	99.7 ± 6.9		98.8 ± 8.9	0.753[a]		
Day 2	104.5 ± 5.3	106.5 ± 7.3	105.7 ± 6.4	0.670[a]			
Quadricep strength							
Day 0	3.77 ± 0.5		3.60 ± 0.6		3.63 ± 0.7	0.382[a]	
Day 1	4.33 ± 0.7		4.10 ± 0.7		4.07 ± 0.7	0.268[a]	
Day 2	4.73 ± 0.4		4.67 ± 0.5		4.77 ± 0.4	0.682[a]	

Abbreviation: ROM, range of motion.
Note: Values are mean ± standard deviation.
[a]Kruskal–Wallis test.

Table 4 Postoperative complications

Adverse event	Group A (n = 30)	Group B (n = 30)	Group C (n = 30)	*p*-Value
Nausea	10 (33.3%)	7 (23.3%)	9 (30.0%)	0.685[a]
Vomiting	4 (13.3%)	4 (13.3%)	5 (16.7%)	0.914[a]
Wound complications	2 (6.7%)	2 (6.7%)	3 (10.0%)	0.856[a]
90-d readmission	1 (3.3%)	2 (6.7%)	0 (0.0%)	0.355[a]
Nerve damage	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Local anesthetic intoxication	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Fall after surgery	0 (0.0%)	0 (0.0%)	0 (0.0%)	

Note: Values are number of cases (percentage).
[a]Pearson's chi-square test.

The analgesic efficacy of this combination remains controversial. Some studies have reported that the addition of IPACK to ACB can significantly improve analgesic and functional outcomes following TKA.[12,17,18,28] However, other studies have reported that ACB + IPACK block cannot provide clinically significant improvement compared with ACB alone.[29,30] The difference in results may be due to differences in the multimodal pain regimen of each medical center. Some studies performed the periarticular local anesthetic infiltration,[12,29] while others did not.[18,19,30] In addition, the dose of local anesthetic was also different in each study.[12,19–23] The characteristics of previous studies which compared ropivacaine-induced ACB + IPACK block with ACB alone are summarized in ►**Table 5**.

The difference in local anesthetic dose may be an important reason for the inconsistent results of previous studies. Therefore, a dose-finding study is required for the optimization of ACB + IPACK block. In the present study, we selected two concentrations of ropivacaine commonly used for ACB + IPACK block, 0.2 and 0.25%.[12,19,30–32] In addition to these two concentrations, ropivacaine 0.375 and 0.5% have been used in previous studies.[18,20] Considering the potential risk of local anesthetic systemic toxicity, we decided to set 0.3% as the upper limit of ropivacaine concentration because it was closer to 0.2 and 0.25%. According to the drug instructions of ropivacaine (AstraZeneca, London, England), the recommended dose for peripheral nerve block and local infiltration analgesia is no more than 225 mg. Therefore, 0.2, 0.25, and 0.3% of ropivacaine are all diluted and should not pose much of a risk for toxicity. As we speculated, the results showed that the three concentrations selected for this study were safe. Postoperative nerve palsy, local anesthetic intoxication, or falls did not occur in any group.

The reported VAS score at rest 30 minutes following arrival to the PACU was regarded as the primary outcome because this outcome was often used to evaluate whether nerve blocks were successful.[24] In the present study, compared with 0.2%, ropivacaine 0.25 and 0.3% significantly reduced VAS scores at rest 30 minutes following arrival to

Table 5 The characteristics of studies which comparing ropivacaine-induced ACB + IPACK block with ACB alone

Author (year)	Anesthesia type	ACB	IPACK	LIA
Okunlola (2020)[32]	Spinal anesthesia	20-mL 0.25% ropivacaine	20-mL 0.25% ropivacaine	300-mg ropivacaine
Li et al (2020)[12]	General anesthesia	20-mL 0.2% ropivacaine	20-mL 0.2% ropivacaine	60mL 0.2% ropivacaine
Ochroch et al (2019)[18]	Spinal anesthesia	20-mL 0.5% ropivacaine	20-mL 0.5% ropivacaine	Not used
Ling et al (2020)[31]	General anesthesia	20-mL 0.2% ropivacaine	15-mL 0.2% ropivacaine	Not used
Patterson et al (2020)[19]	Spinal anesthesia or general anesthesia	20-mL 0.25% ropivacaine	20-mL 0.25% ropivacaine	Not used
Tak et al (2020)[30]	Spinal anesthesia	20-mL 0.2% ropivacaine	20Â-mL 0.2% ropivacaine	Not used
Wang et al (2020)[28]	General anesthesia	20-mL 0.2% ropivacaine	20-mL 0.2% ropivacaine	Not used
Zadoroznijs (2020)[20]	Spinal anesthesia	20-mL 0.375% ropivacaine	20-mL 0.375% ropivacaine	Not used
Zhou et al (2020)[22]	General anesthesia	25-mL 0.25% ropivacaine	30-mL 0.25% ropivacaine	Not used
Mou et al (2022)[36]	General anesthesia	20-mL 0.25% ropivacaine	20-mL 0.25% ropivacaine	Not used

Abbreviations: ACB, adductor canal block; IPACK, infiltration between the popliteal artery and capsule of the posterior knee; LIA, local infiltration analgesia.

the PACU. The relative reduction in VAS scores exceeded the clinician-perceived MCID (30%),[26] indicating clinical significance. Ropivacaine 0.25 and 0.3% still had statistically lower VAS scores at rest and during motion at postoperative 2 and 6 hours, but the reduction did not exceed the MCID. After postoperative 6 hours, the three groups had similar VAS scores. This indicated that the effective time of ropivacaine may not exceed 12 hours. A previous study also reported that the addition of IPACK to ACB reduced the incidence of posterior knee pain 6 hours postoperatively,[18] which was similar to what we reported.

An important goal of recovery after TKA is excellent postoperative analgesia while minimizing opioid consumption and enhancing rehabilitation.[33] In the present study, ropivacaine 0.25 and 0.3% significantly reduced postoperative morphine consumption, prolonged the duration of analgesia, and improved knee function on the day of surgery. The relative change in morphine consumption and absolute change in the range of motion both exceeded the reported MCID (40% and 10 degrees, respectively).[26,27] These secondary outcomes also demonstrated the superiority of these two concentrations.

Over the last two decades, patients without significant comorbidities are undergoing primary outpatient TKA on an ambulatory or short stay basis (<24 hours).[34,35]

As an enhanced recovery with the use of peripheral nerve blocks has been consistently reported,[8–12] trying to find a combination compatible with outpatient TKA would be interesting. Therefore, compared with ropivacaine 0.2%, ropivacaine 0.25 and 0.3% may provide more clinical benefits for patients undergoing outpatient TKA. Based on our results, researchers can further explore the optimal concentration of ropivacaine used for ACB + IPACK block in future clinical practice and studies.

This study only compared different concentrations of local anesthetic but not volume. In previous studies on ropivacaine-induced ACB + IPACK block, most researchers chose a volume of 20 mL for each block (►**Table 5**). This volume should be the commonly used volume recognized by researchers. Therefore, we also chose this volume based on previous studies.[12,18–20,28,30,32,36] Other volumes of ropivacaine have also been selected for these nerve blocks.[22,31] Whether the results of this study are applicable to other volumes of ropivacaine and the optimal volume requires further investigation. Like most previous studies,[18–20,22,28,30,31,36] local infiltration analgesia was not used in this study. It is not clear whether the analgesic efficacy of ACB + IPACK block combined with local infiltration analgesia is better. In addition, the local anesthetic used in this study was ropivacaine. Other types of local anesthetics such as bupivacaine and levobupivacaine[29,37,38] may bring different results and need to be further explored.

This study has several limitations. First, this study only compared three concentrations on the basis of previous studies. There may be a concentration with better analgesic efficacy, and the optimal concentration of ACB + IPACK block still needs to be explored. Second, our study was limited to the hospitalization period, so we were not able to assess differences in outcomes and complications after discharge. The lack of any form of outcome measure beyond hospital discharge is another shortcoming of this study. Third, as mentioned above, this study only compared the analgesic efficacy of different concentrations of local anesthetic. Further studies are needed to confirm the effect of local anesthetic volume on ACB + IPACK block. Fourth, the multimodal pain regimen used in this study may be different from that in other medical centers or other regions. For example, surgery was performed under general anesthesia and local infiltration analgesia was not used in this study. Therefore, we cannot predict whether the results would be the same if patients received surgery under spinal anesthesia or received local infiltration analgesia during surgery.

Conclusions

In ACB + IPACK block, compared with ropivacaine 0.2%, ropivacaine 0.25 and 0.3% can improve early pain relief in the first 6 hours after surgery, reduce morphine consumption, and improve knee function on the day of surgery. Ropivacaine 0.25 and 0.3% may provide more clinical benefits for patients undergoing outpatient TKA. Based on this study, researchers can further explore the optimal concentration of ropivacaine used for ACB + IPACK block.

Ethical Approval

This study was approved by the Clinical Trials and Biomedical Ethics Committee of Sichuan University West China Hospital. The clinical trial registration number was ChiCTR2100049798 (Chinese Clinical Trial Registry).

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Conflict of Interest

None declared.

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