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Novel Regional Techniques for Total Knee Arthroplasty Promote Reduced Hospital Length of Stay: An Analysis of 106 Patients

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Background: Novel regional techniques, including the adductor canal block (ACB) and the local anesthetic infiltration between the popliteal artery and capsule of the knee (IPACK) block, provide an alternative approach for controlling pain following total knee arthroplasty (TKA). This study compared 3 regional techniques (femoral nerve catheter [FNC] block alone, FNC block with IPACK, and ACB with IPACK) on pain scores, opioid consumption, performance during physical therapy, and hospital length of stay in patients undergoing TKA.

Methods: All patients had a continuous perineural infusion, either FNC block or ACB. Patients in the IPACK block groups also received a single injection 30-mL IPACK block of 0.25% ropivacaine. Pain scores and opioid consumption were recorded at postanesthesia care unit discharge and again at 8-hour intervals for 48 hours. Physical therapy performance was measured on postoperative days (POD) 1 and 2, and hospital length of stay was recorded.

Results: We found no significant differences in the 3 groups with regard to baseline patient demographics. Although we observed no differences in pain scores between the 3 groups, opioid consumption was significantly reduced in the FNC with IPACK group. Physical therapy performance was significantly better on POD 1 in the ACB with IPACK group compared to the other 2 groups. Hospital length of stay was significantly shorter in the ACB with IPACK group.

Conclusion: This study demonstrated that an IPACK block reduced opioid consumption by providing effective supplemental analgesia following TKA compared to the FNC-only technique. ACB with IPACK provided equivalent analgesia and improved physical therapy performance, allowing earlier hospital discharge.

Keywords: *Acute pain service, length of stay, nerve block, pain–postoperative, regional anesthesia, replacement–total knee*

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INTRODUCTION

Total knee arthroplasty (TKA) can involve severe postoperative pain,[1,2] and, in the past, opioid medications were the primary postoperative pain control modality. However, opioids alone may provide incomplete pain control and can be associated with unwanted side effects such as nausea, constipation, sedation, itching, and respiratory depression.[1-3] Multimodal analgesia, including regional anesthesia, has attracted significant focus for its ability to improve pain control and reduce opioid-related side effects after TKA.[3] Effective pain control after TKA is challenging, as the operative procedure often affects 2 main innervations to the knee: (1) the femoral nerve, which innervates the anterior and, to a lesser degree, the medial aspects of the knee and (2) the sciatic nerve, which innervates the posterior aspects of the knee.[4,5]

Although a continuous femoral nerve catheter (FNC) block has been reported to provide excellent postoperative analgesia and to decrease opioid consumption,[2,3,6-10] patients who receive an FNC block often encounter a significant degree of quadriceps weakness that limits their participation in early physical rehabilitation.[6,11-13] The adductor canal block (ACB) has been shown to provide similar analgesia to a single-shot FNC block and to allow improved postoperative physical therapy performance.[14]

However, patients who undergo TKA and receive an FNC block or ACB frequently encounter postoperative posterior knee pain requiring supplemental opioid medications.[10,15,16] The sciatic nerve block has been shown to improve analgesia and reduce opioid consumption when combined with the FNC block.[17] However, a sciatic nerve block can lead to sensory and motor deficits below the knee

and may increase the risk of falls.[3] Therefore, an ideal regional anesthetic technique would include a regional block that provides analgesia to the posterior knee but does not cause distal neurologic deficits. A novel nerve block technique described by Sanjay Sinha, MD, from Hartford, CT, is an ultrasound (US)-guided local anesthetic infiltration between the popliteal artery and the capsule of the knee (IPACK) (unpublished observations). By targeting only the terminal branches of the sciatic nerve, the IPACK block provides an alternative for controlling posterior knee pain following TKA and greatly reduces the incidence of foot drop.[18] However, clinical evidence comparing the effectiveness of analgesia, postoperative physical rehabilitation, and opioid sparing with the addition of an IPACK block to an FNC block or ACB is limited. The objective of this study was to evaluate the effect of an IPACK block supplementing an FNC block or an ACB on postoperative pain scale scores, opioid consumption, performance during early physical therapy, and duration of hospital length of stay in patients undergoing unilateral TKA.

METHODS

After institutional review board approval, we performed a retrospective examination of 106 consecutive medical records of adult patients (≥18 years) who underwent a primary unilateral TKA between September 1, 2014, and January 8, 2015. Perioperative data collected were age, body mass index, sex, American Society of Anesthesiologists physical status (ASA PS) classification, type of regional anesthetic used for postoperative pain, postoperative pain visual analog scale (VAS) scores, cumulative postoperative opioid consumption, gait distance during physical therapy, and duration of hospital length of stay. All nerve blocks were performed at Ochsner Medical Center by a fellow or resident under the direct supervision of a fellowship-trained regional anesthesiologist.

Patients were divided into 3 groups: FNC only, FNC with IPACK, and ACB with IPACK. A US-guided FNC block was performed with a perineural infiltration of 30-mL 0.25% ropivacaine and perineural catheter placement. After TKA and during arrival in the postanesthesia care unit (PACU), 0.2% ropivacaine at 6-8 mL/hour was continuously infused via the catheter until removed on postoperative day (POD) 2.

Patients in the FNC with IPACK group received a preoperative FNC block as described above and a US-guided, single-shot injection IPACK block with 30-mL 0.25% ropivacaine. The IPACK block was performed by scanning the popliteal fossa using a curvilinear 60-mm (2-5 MHz) US probe at or proximal to the popliteal crease until the femoral condyles were visualized (Figure 1). The US probe was then proximally aligned until the condyles disappeared and the shaft of the femur was visible. At this level, the block needle was inserted in plane in the medial thigh using an anteromedial to posterolateral direction between the popliteal artery and the femur until the needle tip was 1 cm beyond the lateral edge of the popliteal artery (Figure 2) where 20-mL 0.25% ropivacaine was injected in aliquots, and, as the needle was slowly withdrawn, another 10-mL 0.25% ropivacaine in aliquots was injected.

The ACB with IPACK group underwent US-guided ACB at the midthigh with 30-mL 0.25% ropivacaine, followed by

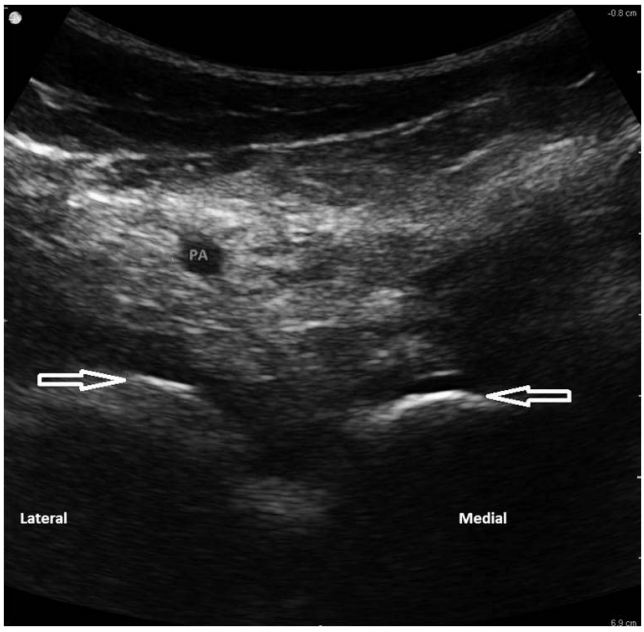

Figure 1. Infiltration between the popliteal artery (PA) and the capsule of the knee block image shows the orientation and anatomy of the popliteal fossa. The PA and the femoral condyles (white arrows) are visible.

placement of a perineural catheter. A single-injection IPACK block was also performed. Upon arrival in the PACU, an infusion of 0.2% ropivacaine at 6-8 mL/hour was started via the perineural catheter.

The primary anesthetic administered for the TKA was either a neuraxial block or general anesthesia at the

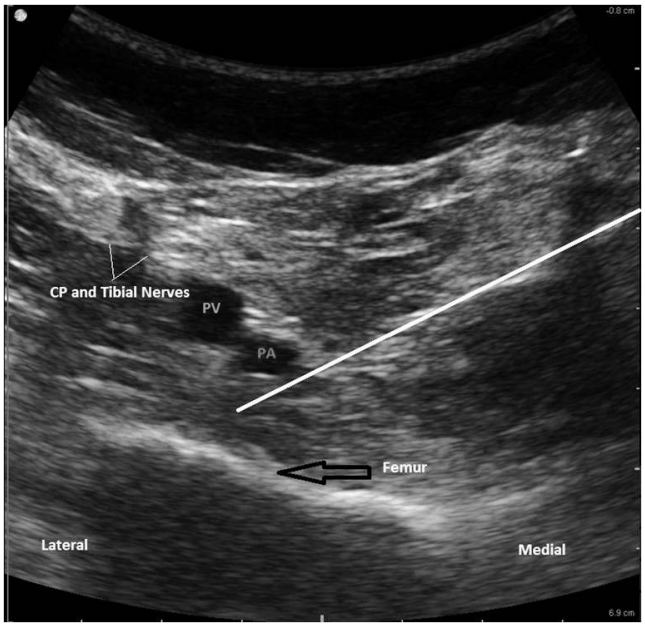

Figure 2. Infiltration between the popliteal artery (PA) and the capsule of the knee block image proximally aligned to visualize the shaft of the femur (black arrow) with the common peroneal (CP) and tibial nerves. The popliteal vein (PV) and PA are both visible, and the stylized needle (white line) identifies the site for local anesthetic deposition.

discretion of the staff anesthesiologist. Preoperatively, all patients received 10-mg sustained-release oxycodone and 150-mg pregabalin (75 mg in patients with serum creatinine >1.4 mg/dL or patients aged >70 years). During the postoperative period, the following multimodal regimen was prescribed: 1,000-mg intravenous acetaminophen in the PACU followed by 1,000-mg oral acetaminophen every 6 hours, 400-mg oral celecoxib in the PACU followed by 200 mg daily, 75-mg or 150-mg oral pregabalin daily, 10-mg oral sustained-release oxycodone twice daily for 4 doses beginning with a preoperatively administered dose. Oxycodone immediate-release tablets, intravenous morphine, and/or intravenous hydromorphone were immediately available for breakthrough pain. All opioid administrations were recorded and converted to oral morphine equivalents for this study.

Postoperative pain VAS scores and cumulative opioid consumption in oral morphine equivalents were documented at PACU discharge and at 8-hour intervals for 48 hours. Using the VAS, the patient verbally reports pain on a scale of 0 (representing no pain) to 10 (representing worst pain imaginable). Because pain may be different during the immediate postoperative phase, depending on the use of general anesthetic vs neuraxial anesthetic, we only included pain scores at discharge from the PACU and thereafter. At the time of discharge from the PACU, the patient should have complete resolution of the neuraxial block. Patients initiated physical therapy on POD 1, and gait distance in the hospital was recorded for the first 48 hours. Duration of hospital length of stay was recorded. The criteria for hospital discharge included adequate analgesia controlled with oral pain medication, the ability to perform activities of daily living with minimal to no assistance, the ability to perform a sit-to-stand maneuver with minimal to no assistance, the ability to ambulate a minimum of 25 feet independently or with a walker, the ability to climb stairs for patients with stairs at home, and no documented postoperative complications.

Our primary outcome was hospital length of stay. Secondary outcomes included postoperative VAS pain scores, cumulative opioid consumption, and physical therapy performance measured by gait distance in feet.

Categorical variables in the 3 block groups are presented as counts and percentages, with differences between the groups assessed using chi-square tests. Continuous variables with skewed distributions are presented as median and 25%-75% interquartile range (IQR) and assessed with the Wilcoxon rank-sum test. We considered P values <0.05 statistically significant.

RESULTS

The objective of this study was to evaluate the effect of an IPACK block supplementing an FNC block or ACB on postoperative outcomes of unilateral TKA. A total of 106 patients was included in the study, with 61 patients in the FNC-only group, 23 patients in the FNC with IPACK group, and 22 patients in the ACB with IPACK group. We noted no statistically significant differences in demographics (Table 1) or in VAS pain scores (Table 2) between the 3 groups. However, opioid consumption was significantly reduced in the FNC with IPACK group compared to the other groups (Table 3). On POD 1, the gait distance traveled during physical therapy was significantly higher in the ACB with IPACK group compared to the other 2 groups (Table 4). Finally, hospital length of stay was significantly shorter in the ACB with IPACK group compared to the other groups (Table 5). On POD 1, 9% of patients in the ACB with IPACK group were discharged, while no patients in the other groups were eligible for discharge. Furthermore, 73% of patients in the ACB with IPACK group were discharged by POD 2, while only 39% and 30% were discharged by POD 2 in the FNC-only group and the FNC with IPACK group, respectively. All patients in the ACB with IPACK group were discharged by POD 3 compared to 80% and 83% in the FNC-only group and the FNC with IPACK group, respectively.

DISCUSSION

The results of this study demonstrate that the combination of ACB with an IPACK block provides adequate analgesia, promotes improved physical therapy performance, and allows for earlier hospital discharge compared to the other 2 regional techniques.

As clinicians improve healthcare, a common goal is to maintain quality measures while reducing hospital length of stay. Advancements in postoperative regional analgesia, specifically the introduction of the ACB, have been pivotal in optimizing care for patients undergoing TKA.[2,13,14] Studies have shown similar postoperative analgesia levels after TKA when comparing the ACB to the FNC block, but the ACB preserves quadriceps strength and allows improved physical therapy performance compared to the FNC block.[11-14,19-21] Our results are consistent with these prior ACB studies in that the ACB provided equivalent analgesia and improved physical therapy performance compared to the FNC block. Early and improved participation in physical therapy allows patients to reach discharge goals sooner and reduces hospital length of stay. In our study, 73% of the patients in the ACB group were discharged by POD 2 compared to <40% of patients in the FNC block groups. Furthermore, some patients who received ACB were discharged on POD 1, while no patients in the groups that received FNC block were eligible for discharge.

We compared the present study data to data from the previous year at our institution. The average length of stay for patients undergoing a primary unilateral TKA in 2013 was 3.4 days, and during that time period, no patients received an ACB with IPACK block. After implementation of these novel regional nerve block techniques during the present study time period, average length of stay decreased to 2.2 days. This 35% reduction in length of stay is clinically and economically significant. To our knowledge, only 2 previous studies have demonstrated the association between the ACB and early hospital discharge.[22,23] However, to our knowledge, our study is first to report this finding when combined with the IPACK block.

We observed a reduction in gait distance during the afternoon session of physical therapy on POD 2 in the ACB with IPACK group compared to the other groups. As mentioned above, 73% of patients in the ACB with IPACK group were discharged on POD 2 and as a result did not participate in the afternoon session of physical therapy on POD 2. We suspect that the only patients remaining during the afternoon of POD 2 in the ACB with IPACK group were lower-performing patients. We believe the data are skewed

Table 1. Demographic Characteristics of Patients Undergoing Primary Unilateral Total Knee Arthroplasty (n=106)

Variable	FNC n=61	FNC + IPACK n=23	ACB + IPACK n=22	*P* Value
Age, years, median (IQR)	67 (62-72)	69 (64-73)	63 (60-70)	0.1895
Female sex, %	62.3	60.9	63.6	0.9818
BMI, kg/m^2, median (IQR)	33 (29-40)	32 (29-39)	36 (29-42)	0.5048
ASA PS, %				
II	37.7	21.7	40.9	0.2945
III/IV	62.3	78.3	59.9	

ACB, adductor canal block; ASA PS, American Society of Anesthesiologists physical status; BMI, body mass index; FNC, femoral nerve catheter block; IPACK, infiltration between the popliteal artery and capsule of the knee block.
Note: Age and BMI values are presented as median (25%-75% interquartile range [IQR]).

Table 2. Visual Analog Scale Pain Scores Following Primary Unilateral Total Knee Arthroplasty (n=106)

Postoperative Time Point	FNC n=61	FNC + IPACK n=23	ACB + IPACK n=22	*P* Value
PACU discharge	1 (0-3)	2 (0-2)	2 (2-4)	0.1361
8 hours	2 (0-5)	4 (0-6)	4 (0-6)	0.5169
16 hours	2 (0-6)	2 (0-5)	3 (0-4)	0.7178
24 hours	4 (1-6)	4 (0-7)	3 (0-5)	0.3956
32 hours	3 (0-6)	3 (0-6)	2 (0-5)	0.2903
40 hours	3 (0-6)	2 (0-6)	4 (0-5)	0.7377
48 hours	4 (2-6)	4 (0-6)	4 (0-5)	0.3240

ACB, adductor canal block; FNC, femoral nerve catheter block; IPACK, infiltration between the popliteal artery and capsule of the knee block; PACU, postanesthesia care unit.
Note: The visual analog scale measures pain on a scale of 0 (no pain) to 10 (worst pain imaginable). All values are reported as median scores (25%-75% interquartile range).

Table 3. Opioid Consumption Following Primary Unilateral Total Knee Arthroplasty (n=106)

Postoperative Time Point	FNC n=61	FNC + IPACK n=23	ACB + IPACK n=22	*P* Value
PACU discharge	30 (15-45)	15 (15-27)	30 (15-40)	0.0077
8 hours	38 (23-52)	19 (15-30)	41 (30-79)	0.0001
16 hours	45 (33-92)	30 (15-50)	59 (43-90)	0.0004
24 hours	66 (41-105)	45 (30-68)	82 (66-118)	0.0002
32 hours	87 (59-123)	57 (45-83)	109 (68-152)	0.0018
40 hours	119 (79-145)	75 (45-124)	134 (81-172)	0.0133
48 hours	146 (98-164)	93 (72-124)	150 (107-186)	0.0101

ACB, adductor canal block; FNC, femoral nerve catheter block; IPACK, infiltration between the popliteal artery and capsule of the knee block; PACU, postanesthesia care unit.
Note: Opioid consumption is expressed in median oral morphine equivalents in mg (25%-75% interquartile range).

Table 4. Gait Distance Traveled During Physical Therapy Following Primary Unilateral Total Knee Arthroplasty (n=106)

Postoperative Time Point	FNC n=61	FNC + IPACK n=23	ACB + IPACK n=22	*P* Value
POD 1 morning	4 (0-12)	4 (1-11)	14 (6-44)	0.0004
POD 1 afternoon	20 (2-25)	25 (9-35)	42 (22-106)	<0.0001
POD 2 morning	60 (18-110)	60 (25-80)	100 (30-150)	0.1813
POD 2 afternoon	100 (60-150)	100 (60-135)	57 (40-115)	0.3913

ACB, adductor canal block; FNC, femoral nerve catheter block; IPACK, infiltration between the popliteal artery and capsule of the knee block; POD, postoperative day.
Note: Gait distance traveled is expressed in median feet (25%-75% interquartile range).

Table 5. Day of Discharge Following Primary Unilateral Total Knee Arthroplasty (n=106)

Postoperative Time Point	FNC n=61	FNC + IPACK n=23	ACB + IPACK n=22	*P* Value
POD 1	0 (0)	0 (0)	2 (9)	
POD 2	24 (39)	7 (30)	14 (73)	
POD 3	25 (80)	12 (83)	6 (100)	0.0024
POD 4	9 (95)	4 (100)		
POD 5	3 (100)			

ACB, adductor canal block; FNC, femoral nerve catheter block; IPACK, infiltration between the popliteal artery and capsule of the knee block; POD, postoperative day.
Note: Data are reported as number of patients discharged (cumulative percentage).

because the patients in the ACB with IPACK group who performed well during physical therapy—the majority of patients—had already been discharged prior to the afternoon session of physical therapy on POD 2. We consider the more significant findings to be the improved physical therapy performance during earlier sessions and the earlier discharge home experienced by the majority of the patients in the ACB with IPACK group.

An additional novel finding of this study is the significant opioid sparing with the IPACK block. Adequate pain management following TKA requires addressing both anterior and posterior knee pain. While the FNC block and ACB can provide adequate analgesia to the anterior knee, other modalities such as opioids are necessary to control posterior knee pain. A sciatic nerve block combined with an FNC block or ACB may provide more complete analgesia following TKA than an FNC block or ACB alone. Evidence supports that a sciatic nerve block combined with an FNC block reduces opioid consumption and improves pain scores, especially during the first 24 hours after TKA.[24] The utility of a sciatic nerve block may be limited by sensory and motor effects below the knee, including impaired dorsiflexion,[15] that may impair postoperative physical therapy. The IPACK block targets the terminal branches of the sciatic nerve as they enter the posterior capsule of the knee, and this block can be employed to address posterior knee pain without development of significant sensory and motor deficits below the knee. In the present study, the addition of the IPACK block to the FNC block led to a significant reduction in opioid consumption. We did not observe the same opioid-sparing effect when the IPACK block was combined with the ACB. Despite this finding, patients in the ACB with IPACK group had equivalent pain scores but much improved functional outcomes, including physical therapy performance and earlier discharge.

Limitations

Because we identified no patients who would fit the criteria to receive ACB only during the study period, this study lacks a group that received ACB only, which would allow better analysis of the contribution of the IPACK block to an ACB. Because the ACB has gained attention by providing adequate analgesia to the anterior knee while minimizing motor impairment,[11-14,19-21] addition of the IPACK block could improve posterior knee analgesia without sacrificing distal motor and sensory impairment. Comparing ACB only to ACB with IPACK block should be a goal for future research. Nevertheless, no prior publications have described the effects of the IPACK block for addressing posterior knee pain following TKA, and thus the opioid-sparing effect of the IPACK block when combined with the FNC block is a novel finding.

Retrospective studies may suffer from assignment bias, possibly resulting in baseline differences between groups. However, the consecutive enrollment of patients in this study may have limited selection bias. In addition, our investigation was a descriptive study of the benefits of a novel approach to regional analgesia for a common surgical procedure. An investigator needs to know a clinical delta, the difference in expectation that one regional technique provides compared to another technique, to calculate sample size. Because of the novel approach of this study, such information was not available, so this study could suffer from assignment bias. However, a strength of this study is that it allows other investigator groups to validate our findings, and when needed, to use our results to calculate a clinical delta for the appropriate sample size needed for a prospective randomized controlled trial.

CONCLUSION

This study demonstrates that a single-shot IPACK block reduces opioid consumption by providing effective supplemental analgesia for TKA. Furthermore, the ACB with IPACK block improves physical therapy performance and allows earlier hospital discharge than an FNC block alone or an FNC block with IPACK block.

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