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Is continuous proximal adductor canal analgesia with a periarticular injection comparable to continuous epidural analgesia for postoperative pain after Total Knee Arthroplasty? A retrospective study

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Abstract

Background. The classic adductor canal block (ACB) is a regional technique that aims to introduce local anesthetic to the saphenous nerve as it traverses the adductor canal. It offers the benefit of preserved quadriceps strength, and is ideal for rehabilitation. Proximal ACB (PACB) allows the operator to place the block away from the surgical site, permitting preoperative placement. Our primary outcome was total opioid consumption; secondary outcomes included the highest numerical rating scale scores and total gait distance at the indicated time intervals. **Questions/purposes.** We asked: 1) Does a Continuous Proximal ACB block with Periarticular knee injection (PACB) provide better analgesia than a Continuous Epidural (CSE)?; 2) Do PACB catheter patients do better with physical therapy compared to CSE patients?; 3) Are PACB patients discharged earlier than CSE patients? **Methods.** With IRB approval we performed a retrospective chart review of patients who had underwent primary total knee arthroplasty between October 2015 and September 2016. The selected patients (n = 151) were divided into two groups: CSE group, 72 patients who received a continuous epidural catheter and the PACB group, 79 patients who received at PACB with Periarticular injection. The CSE group received a single-segment combined spinal epidural (CSE) in the operating room. The epidural catheter infusion was started with 0.1% ropivacaine at 8 mL/hour to 14 mL/hour during the post-operative period. The PACB group received a proximal adductor canal catheter with 20 ml of 0.5 % ropivacaine and maintained with ropivacaine 0.2% at 8 ml to 14 ml post operatively. Total opioid consumption, highest numeric rating scores and total gait distance travelled were recorded upon discharge from the PACU and completion of postoperative day (POD) 0, 1, and 2. **Results:** We found that the median cumulative morphine consumption was significantly higher in the CSE group compared to the PACB group (194 (0-498) versus 126 (0-354) mg, p = 0.012), a difference that was most notable on POD 1 (84 (16-243) versus 60 (5-370) mg, p = 0.0001). Mean hospital length of stay was also shorter in the PACB group (2.6 ± 0.67 versus 3.0 ± 1.08 days, p = 0.01). **Conclusion:** PACB group used significantly lower morphine consumption compared to the CSE group; they were better participants during physical therapy and achieved longer gait distances. The mean hospital length of stay was also shorter in the PACB group

Keywords: proximal adductor canal block, periarticular knee injection, combined spinal epidural analgesia, total knee arthroplasty

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Introduction

Total knee arthroplasty (TKA) is a common procedure associated with severe postoperative pain that can last several days. There remains an ongoing search for an optimal postoperative analgesic regimen with minimal side effects that will also promote early rehabilitation.

There has been a recent growing interest in using the adductor canal blocks (ACB), a regional technique that aims to introduce local anesthetic to the saphenous nerve as it traverses the adductor canal [1]. By blocking pain pathways while preserving motor innervation, the ACB is an ideal candidate for TKA-related pain and rehabilitation.

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There is some debate regarding the optimal location for adductor canal catheters. Placement of a catheter using the classic more distal approach may be too close to the surgical field precluding pre -operative placement. A more proximal approach has been described also referred to as the "selective femoral nerve block" [2]. This technique aims at the entrance of the adductor canal just distal to the apex of the femoral triangle and has been shown to spare the motor branches to the quadriceps in a cadaver study [3]. Additionally, insertion of the catheter at a location more consistent with the "selective femoral block" is thought to prevent pain related to tourniquet placement, which can often occur as high as several centimeters above the knee.

The present retrospective review was conducted in order to compare the theoretical advantages of this technique with those of the traditional combined epidural, an approach that is still utilized as a primary form of analgesia for TKA.

Patients and Methods

After receiving Yale University Institutional Review Board approval (03/01/16; HIC/HSC Protocol#: 1502015342), we performed a retrospective examination of the medical records of all patients who underwent a primary unilateral TKA by one surgeon (CL) at the Hospital of St. Raphael at Yale-New Haven between October 2015 and September 2016. Between this period, 297 patients were treated surgically for TKA. Of those, 151 (50.8%) were considered eligible for our study based on inclusion criteria.

Patients older than 18 years with American Society of Anesthesiology (ASA) Classification I and II were included in the review.

Exclusion criteria

- ASA III or higher
- Morbidly obese (BMI > 40)
- Patients with history of chronic pain
- History of alcohol or drug abuse

Of those, 72 patients received an epidural and were thus placed in the CSE group and 79 patients received a PACB with periarticular injection and were thus placed in the PACB group. Perioperative data collected included age, gender, body mass index (BMI), American Society of Anesthesiologists (ASA) classification, type of block, pain scores as classified by the Numerical Rating Scale (NRS) (where 0 – no pain, and 10 – the worse imaginable pain), cumulative opioid consumption (converted to an equianalgesic dose in milligrams of oral morphine), gait distance during physical therapy (measured in median steps taken during individual physical therapy sessions), and hospital length of stay (LOS).

All nerve blocks were performed either by a staff regional anesthesiologist or under the direct supervision of one. Patients in the epidural group received a single-segment combined spinal epidural (CSE) in the operating room. The epidural catheter infusion was started with 0.1% ropivacaine at 8 mL/hour and could be titrated up to 14 mL/hour during the post-operative period at the discretion of the regional anesthesiologist. All epidural catheters were removed at noon on POD 1. Patients in the PACB group received an ultrasound-guided continuous PACB using a previously described technique [2]. The nerve block was placed in the block room under basic monitoring and mild sedation**.** The femoral nerve was initially identified in the short axis using a high-frequency ultrasound linear probe. The transducer was then directed caudally toward the apex of the femoral triangle and distal to the bifurcation of the femoral artery. The medial border of the sartorius muscle was identified as it first covers the superficial femoral artery at the entry to the adductor canal. A 17-guage Tuohy needle (B. Braun Melsungen AG, Melsungen, Germany) was inserted through the skin and directed in-plane towards the nerve until the needle tip passed through the sartorius muscle lateral to the nerve and superficial femoral artery [2]. Twenty milliliters of 0.5% ropivacaine was used for the initial bolus. The PACB catheter was initiated with ropivacaine 0.2% at 8 mL/hour, and the infusion ranged between 8 and 14 mL/hour postoperatively at the discretion of the regional anesthesiologist. The primary anesthetic for the TKA was spinal anesthesia. All patients in the PACB group additionally received a surgeon-administered posterior capsule injection of 40 mL of bupivacaine 0.25% with epinephrine. The surgeon performed the periarticular infiltration after all bony cuts and before cementing the components. The solution was then injected into the posterior capsule of the knee around the attachment of the posterior cruciate ligament.

In addition to the epidural or PACB, all patients were prescribed oral acetaminophen 650 mg/q 6 h scheduled, intravenous ketorolac 30 mg every 6 hours for 48 hours, oral oxycodone 5 to 10 mg every 4 hours PRN and rescue intravenous hydromorphone 0.4 mg i.v. every 4 hours PRN. All peripheral catheters were removed by 4 am on POD day 2.

Our primary outcome was total opioid consumption (any oral opioids as well as intravenous rescue doses received) upon discharge from the PACU and completion of POD 0, 1, and 2. Because various factors can affect a patient's discharge from the PACU, standard PACU time was defined across all patients as the first 2 hours after leaving the operating room. POD 0 began from 2 hours after leaving the operating room until time 23:59 of the operative day; POD 1 was defined as time 0000 to 23:59 on the day after surgery; POD 2 was defined as time 0000 to 23:59 on the second day after surgery. Secondary outcomes included highest NRS scores as well as total gait distance during physical therapy sessions as measured by forward or backward steps. If the patient could not ambulate or could only take side steps, gait distance was considered to be zero. All data collection and review of the electronic medical records was performed by two authors (AW and RL).

Statistical analysis and study size

Differences between categorical variables (gender, ASA classification) were assessed using a chi-square test. Comparison of parametric data was conducted using unpaired t-tests. Continuous variables were presented as median and 25% to 75% interquartile range, and differences between groups were assessed by the Mann-Whitney U test. Statistical significance levels were set at $p < 0.05$. During the study period, 297 patients underwent unilateral TKA.

Results

The two groups were comparable in terms of patient demographics (Table 1).

Eighty-two patients were excluded from analysis for the following reasons: inadequate documentation of regional technique performed (32%), absence of gait distance recorded during physical therapy sessions (21%), preoperative chronic opioid usage (4.8%), dislodged or removed catheter before POD 2 (2.4%), intraoperative conversion to general anesthesia (2.4%), presence of intrathecal pump for pre-existing condition (1.2%), and prolonged hospitalization > 4 days (2.4%). It is important to note that during 2014, our institution began phasing out IV acetaminophen from the pharmacy formulary. Because this change could potentially contribute to increased opioid usage, we excluded patients who had received this drug at any point during their admission (32%). Of the remaining patients eligible for inclusion, 79 underwent an ACB and 134 patients had received a CSE. A random sample tool was employed to generate a cohort of 72 patients from the CSE group (Fig. 1).

Median cumulative morphine consumption was significantly higher in the CSE group compared to the PACB group (194 (0-498) versus 126 (0-354) mg, p = 0.012), a difference that was most notable on POD 1 (84 (16-243) versus 60 (5-370) mg, p = 0.0001). Mean hospital length of stay was also shorter in the PACB group (2.6 ± 0.67 versus 3.0 ± 1.08 days, p = 0.01) (Table 2, Fig. 2).

There were no significant differences in baseline NRS scores between the CSE and PACB groups.

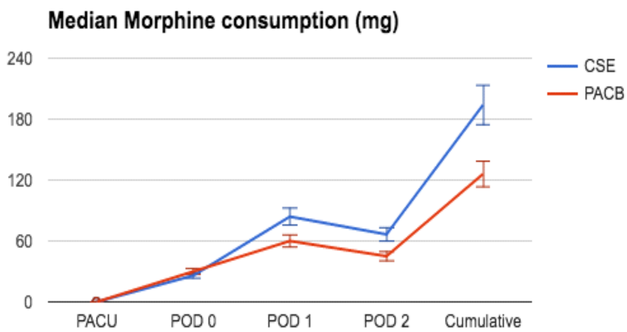

Fig. 2. Median morphine consumption

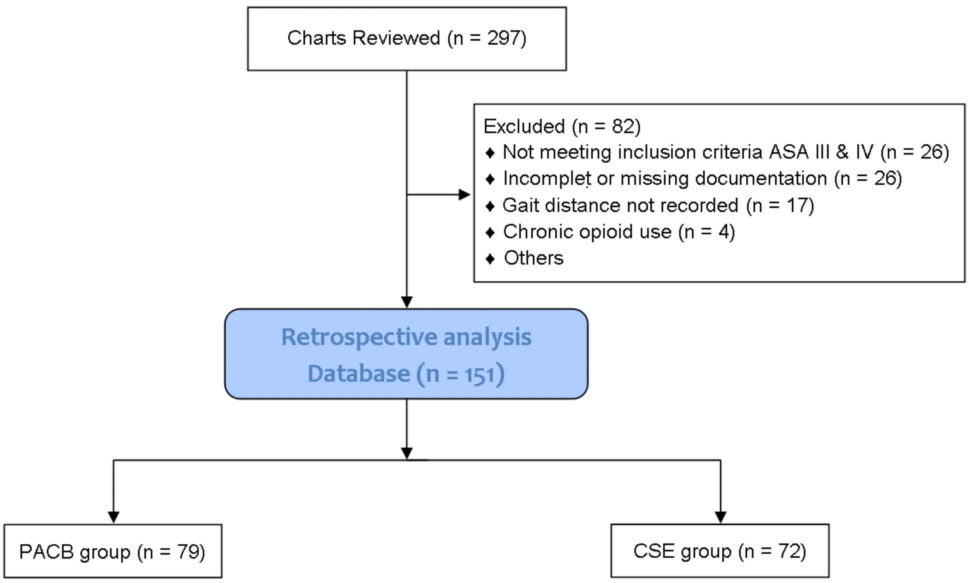

Fig. 1. Flow chart showing data selection

Table 1. Patient demographics

	CSE (n = 72)	CSE IQR	PACB (n = 79)	PACB IQR	p
Male, n (%)	20 (28%)	N/A	28 (35%)		0.31
Female, n (%)	52 (72%)	N/A	51 (65%)		
Age (y; median)	68	(63-73)	67	(59-74)	0.93
Body Mass Index (kg/m^2; median)	32	(28-38)	34	(27-38)	0.81
American Society of Anesthesiologists Classification (median)	2	(2-3)	2	(2-3)	0.33

CSE = combined spinal epidural; IQR = interquartile range 25%-75%; PACB = proximal adductor canal block

Table 2. Median morphine consumption (mg)

	PACU	POD 0	POD 1	POD 2	Cumulative
CSE	0	26 (0-102)	84 (16-243)	66.5 (0-195)	194 (0-498)
PACB	0	30 (0-104)	60 (0-370)	45 (0-200)	126 (0-730)
P value	0.45	0.52	0.0001	0.052	0.012

Resting pain scores were similar except for POD 1, where PACB patients had a slightly smaller but statistically insignificant difference in median pain scores (6 in the PACB group versus 7 in the CSE group). Pain scores during activity were slightly higher in the PACB group on POD 0 and POD 2 (Table 3). PACB patients were consistently better participants during physical therapy; gait distances were significantly superior compared with the CSE group at the first four time points analyzed after surgery (Table 4, Fig. 3). Mean hospital LOS was also shorter in the PACB group (2.6 ± 0.67 versus 3.0 ± 1.08 days, p = 0.01).

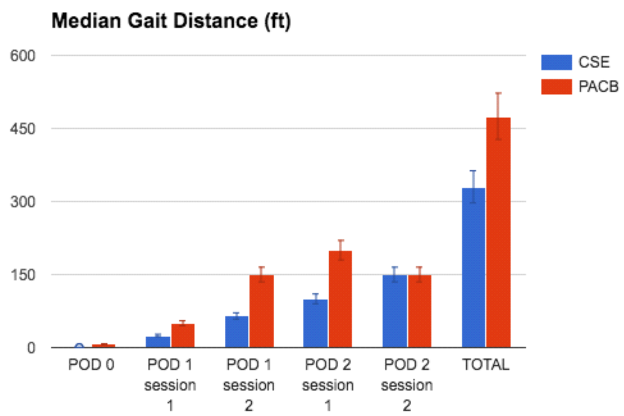

Fig. 3. Median gait distance during physical therapy (in feet)

Discussion

Femoral nerve blocks (FNBs) are commonly used for pain control after TKA, but they are associated with a significant decrease in quadriceps strength [4]. Although it is known that osteoarthritis of the knee and the TKA procedure itself causes quadriceps weakness, an analysis of three previously published, randomized, triple-masked, placebo-controlled studies suggested a causal relationship between continuous FNB and falls. Conversely, there are numerous studies [5, 6] to support the view that FNBs do not negatively

Table 3. Median pain scores

	Baseline resting	Baseline activity	PACU	POD 0 resting	POD 0 activity	POD 1 resting	POD 1 activity	POD 2 resting	POD 2 activity
CSE	0 (0-10)	4 (0-10)	0 (0-10)	5 (0-10)	5 (0-10)	7 (0-10)	6 (0-10)	5 (0-10)	5 (0-10)
PACB	0 (0-7)	0 (0-9)	0 (0-10)	6 (0-10)	7 (0-10)	6 (0-9)	7 (0-10)	5 (0-9)	6 (0-9)
P value	0.42	0.47	0.41	0.7	0.014	0.0067	0.5	0.35	0.048

Table 4. Median gait distance during physical therapy (ft)

	POD 0	POD 1 session 1	POD 1 session 2	POD 2 session 1	POD 2 session 2	Total
CSE	0 (0-50)	25 (0-150)	65 (0-250)	100 (0-400)	150 (0-400)	330 (0-915)
PACB	7 (0-350)	50 (0-400)	150 (0-350)	200 (10-500)	150 (10-500)	475 (30-1350)
P value	0.00012	0.0001	0.00042	0.00614	0.16152	0.0033

impact physical therapy and/or increase the incidence of falls. However, it would be ideal to avoid quadriceps weakness if the analgesia from another nerve block equals that from the FNB.

In 2007, Krombach and Gray were among the first to describe an ultrasound-guided ACB [7]. Their target was the saphenous nerve, where the needle pierced the vasoadductor membrane deep to the sartorius muscle. Tsui and Ozelsel described a slightly more proximal but similar ultrasound-guided block described as the trans-sartorial perifemoral block [8]. Other groups have developed ultrasound-guided techniques using different landmarks, including the saphenous branch of the descending genicular artery [9], midthigh level halfway between the iliac spine and the patella where the femoral vein is located just underneath the femoral artery [10] and the superficial femoral artery in the upper mid-thigh [11].

Since the advent of ACB, several meta-analysis have looked into the efficacy of ACB versus FNB in patients undergoing TKA. Kuang et al. looked at this existing literature and concluded that ACBs not only showed similar pain control to FNB after TKA, they also helped better preserve quadriceps muscle strength and improve mobilization ability [12].

Yet another meta-analysis looked at studies comparing ACB with saline and concluded that ACB decreases analgesic consumption and offers short-term advantages in terms of pain relief. Compared with FNB, ACB was associated with better ability to ambulate and better preservation of quadriceps strength [13].

While the previous meta-analysis has established that ACB provide comparable pain relief and preserved quadriceps strength when compared to epidural analgesia for TKA, there has been a paucity of data directly comparing adductor canal analgesia to epidural analgesia. A very recent randomized controlled trial has attempted to shed more light in this area. Similar to our finding Kayupov et al. concluded that patients who received ACB catheters had superior ambulation and better pain scores than the epidural group [14].

Even though ACBs are often frowned upon due to their incomplete coverage of the knee, we found that the median cumulative morphine consumption and pain scores were lower in the PACB group as compared to the CSE group most pronounced on POD 1.

We also found that the median gait distance was significantly higher in the PACB group in every interval measured, which is probably the most impressive outcome of this review. In fact none of the patients in the CSE group were able to walk on POD 0.This is not surprising since several studies have shown superior ambulation associated ACBs [15-19].

In fact, Ishiguru et al. looked specifically at ambulation and preservation of quadriceps with the proximal adductor canal approach. He further stated that rectus femoris of all the other quadriceps contributes most to knee extension and sparing this muscle by more proximal adductor canal approach is primarily responsible for better ambulation [20].

The PACB group in our study also received a surgeon administered periarticular injection. Periarticular injection as an adjunct to FNB and ACB has been quite successful in covering the posterior knee pain contributing to patient's discomfort [21]. There are several studies in orthopedic literature that have compared periarticular and local anesthetic infiltration to FNB with rather confusing results [22-25]. We utilized periarticular infiltration as an adjunct to PACB to cover the the posterior aspect of the knee. It was primarily utilized as an alternative to a sciatic nerve block as mentioned in the original article by Gi et al. [21].

Our retrospective review confirms the findings of the above authors regarding morphine consumption and ambulation. The data is unique because it looks into the application of the PACB continuous catheter in conjunction with periarticular knee injections and its comparison to epidural analgesia.

This study has several limitations. First, it was a nonrandomized retrospective data review and some selection bias might arise from unblinded operators and patients. Future randomized case control trials with consistent indications should be performed to minimize the bias and improve the comparability of different groups. Second, the introduction of the new technique (PACB) also involved introduction of a new pain team with expertise in regional procedures and acute pain management, which could have affected the opioid consumption even though the pain management order sets remained the same, thus introducing a degree of co-treatment bias. Third, although data on a reasonable number of patients was reviewed, a larger data set would improve the ability to detect greater differences. Fourth, the pain scores showed negative or no correlation with the opioid consumption. This could have been due to the subjective nature of the pain scores. Fifth, the LOS in both groups may have varied over the time period of study for reasons other than the intervention in question, accounting for assessment bias. Fifth, the CSE group received 0.1% ropivacaine infusion to minimize hypotension compared to the PACB group, which received 0.2% ropivacaine infusion, which could have accounted for superior pain control in the PACB group.

Conclusion

PACB is as effective as epidural analgesia for post-operative pain management in patients undergoing

TKA. Moreover, it is associated with significantly better and faster ambulation. The PACB technique is a good alternative if a continuous mode of analgesia is chosen over a single injection ACB.

Conflict of interest

Nothing to declare

Funding

Each author certifies that he or she has no commercial associations (e.g., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article.

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