



## Original research

## Improved pain control with adductor canal block using liposomal bupivacaine after total knee replacement: a retrospective cohort study

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## ABSTRACT

**Background:** Adductor canal blocks (ACBs), typically administered with a local anesthetic such as bupivacaine, help control perioperative pain after total knee arthroplasty. Recently, liposomal bupivacaine (LB) was introduced in an attempt to extend the duration of analgesia, used primarily in periarticular injections (PAIs). The purpose of this study was to compare pain control and early perioperative outcomes with ACB using LB vs standard bupivacaine (SB).

**Methods:** We retrospectively compared pain control in a group of 75 patients with ACB and PAI with SB to that of a cohort of 75 patients who received ACB and PAI with LB. The primary outcome measure was pain measured using the visual analog score. The secondary outcome measures were morphine equivalents of pain medication (ME), physical therapy distance ambulated, disposition status, and length of stay.

**Results:** There were no significant differences between the two cohorts for age, gender, body mass index, preoperative diagnosis, or American Society of Anesthesiologists. Visual analog scores were significantly lower in the LB group for postoperative day (POD) 0 (2.1 vs 2.8,  $P = .046$ ), POD 1 (2.2 vs 3.3,  $P < .001$ ), and POD 2 (2.1 vs 3.7,  $P = .001$ ) than those in the SB group. The LB group consumed significantly fewer ME on the POD 0 (18.7 vs 25.2,  $P = .02$ ) and POD 1 (23.4 vs 37.8,  $P = .003$ ), as well as overall ME/day (24.6 vs 41.7,  $P < .001$ ). The LB group walked more on POD 0 (261.6 vs 108.2,  $P < .001$ ) and POD 1 (761.5 vs 372.0,  $P < .001$ ).

**Conclusions:** We report improved outcomes across all measures for the LB group. There were no adverse events. This study supports the use of LB for ACBs in total knee arthroplasty.

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## Introduction

In the last decade, a focus has been on multimodal pain management protocols, more rapid functional recovery, reduced length of hospital stay, and minimizing side effects of pain-treatment strategies while maintaining function and durability during total knee arthroplasty (TKA) [1]. The widespread use of regional

anesthesia has led to improvements in pain control, more rapid functional recovery, and reduced length of stay (LOS) [2]. Adductor canal blocks (ACBs) have become a mainstream modality to help control perioperative pain at many institutions. ACBs, which target the distal femoral nerve, are able to maintain a sensory block for pain control while minimizing any motor blockade that is typically seen in proximal femoral nerve blocks, which would hamper rehabilitation and increase risk of falls [3,4].

ACBs are typically performed using bupivacaine or ropivacaine. In recent years, the development of a longer acting local anesthetic, liposomal bupivacaine, has gained attention [5–9]. A number of studies have examined its use for periarticular injections (PAIs) during TKA, with conflicting results. A number of studies found that liposomal bupivacaine PAIs did not provide an advantage over traditional liposomal bupivacaine injections and may in fact even provide inferior postoperative pain control [6–8]. In contrast, a

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meta-analysis found liposomal bupivacaine PAIs to be successful at reducing hospital LOS and providing longer acting, superior perioperative analgesia [9]. However, few studies have looked at its use in regional nerve blocks. The addition of liposomal bupivacaine with ACBs has the potential for longer perioperative pain control, leading to improved patient satisfaction, lower opioid consumption, and better patient mobility.

The purpose of this retrospective cohort study is to compare the efficacy and safety of ACBs with liposomal bupivacaine vs ACBs with standard bupivacaine for pain management in TKA.

## Material and methods

After obtaining approval from our institutional review board, we reviewed the charts of patients who had undergone TKA between July 2016 and March 2018 by a single surgeon. A total of 75 consecutive patients received ACBs with liposomal bupivacaine and a PAI of liposomal bupivacaine (LB cohort). We then identified a matched cohort of 75 patients for comparison, who received ACB with standard bupivacaine before the surgery and PAI with standard bupivacaine (SB cohort). The two cohorts were matched for age, gender, body mass index (BMI), preoperative diagnosis, and American Society of Anesthesiologists (ASA) scores. Exclusion criteria included patients who received ACB with ropivacaine; patients who received general anesthesia; patients with contraindications to ACB; patients with an allergy to bupivacaine; and patients who underwent unicompartmental knee arthroplasty, bilateral TKA, or revision knee arthroplasty. All included patients in both cohorts received spinal anesthesia.

ACB was performed by the regional anesthesia team before the surgery. The ACB was performed under ultrasound guidance at the midpoint between the anterior superior iliac spine and the superior pole of patella using 15 mL of 0.5% bupivacaine in the SB cohort. PAI was performed intraoperatively by the operating surgeon, with 50 mL of 0.25% standard bupivacaine in the SB cohort. In the LB cohort, ACB was performed by using 5 mL of 1.33% liposomal bupivacaine plus 15 mL of 0.25% bupivacaine, and the PAI was performed by using 15 mL of 1.33% liposomal bupivacaine and 20 mL of 0.25% bupivacaine diluted with 30 mL of 0.9% normal saline. Maximum dose of liposomal bupivacaine was 266 mg. For both cohorts, the PAI included the vastus medialis split, the posterior capsule, the periosteum of the anterior cortex of the femur, the superior and inferior poles of the patella, and the space deep to the medial collateral ligament and medial periosteum.

A standard multimodal pain management protocol was followed for all the included patients, which included a preoperative cocktail of acetaminophen, celecoxib, gabapentin, and a scopolamine patch behind the ear, which was given one to two hours before the surgery. Postoperatively, the patients received acetaminophen, ketorolac followed by celecoxib, gabapentin, oral opioids, and intravenous hydromorphone for breakthrough pain.

Basic patient demographic information (Table 1) data along with hospital LOS; postoperative day 0, 1, 2, 3 visual analog scale (VAS) pain scores; physical therapy performance as measured by the number of steps taken each day; morphine equivalents (MEs) consumed per day; and total ME/day consumed during the hospital stay were collected from the patient charts.

Primary outcome was VAS pain scores in the immediate postoperative period. VAS pain scores were recorded every 4–6 hours by the floor nursing staff throughout the hospital stay. VAS pain scores were averaged for each day, and this average was used for analysis. Hospital LOS, physical therapy distance ambulated during the LOS, ME consumed per day, and ME consumed per LOS were our secondary outcome measures. In addition, the investigators screened

**Table 1**  
Patient demographic information.

Variables	Liposomal bupivacaine, N = 75	Standard bupivacaine, N = 75	P value
Age	70.7 ± 8.6	69.2 ± 8.9	.28
Gender			
Female (%)	49 (65.3%)	56 (74.7%)	
Male (%)	26 (34.7%)	19 (25.3%)	.06 <sup>a</sup>
BMI	31.6 ± 4.8	31.1 ± 6.2	.61
ASA	2.4 ± 0.58	2.2 ± 0.52	.52
Preoperative diagnosis			
OA (%)	73 (97.3%)	74 (98.7%)	
Other (%)	2 (2.7%)	1 (1.3%)	.31 <sup>a</sup>
Operative time (minutes)	115.0 ± 23.0	114.0 ± 23.0	.75

ASA, American Society of Anesthesiologists; OA, osteoarthritis.

<sup>a</sup> Chi-square test.

for any adverse events related to the ACB during or after the hospital stay.

Descriptive statistics such as mean, median, standard deviation, and percentages were used to describe the data in both cohorts. A two-sided paired t-test was used to compare the continuous demographic variables such as age, BMI, and ASA scores between the two cohorts. Fisher's exact test was used to compare categorical variables between the two cohorts. An  $\alpha$  error <0.05 was considered as statistically significant. All the analyses were performed using SPSS version 23.0 (SPSS Inc., Chicago, IL) for windows.

## Results

### Primary outcome

In the LB group, VAS pain scores were significantly lower for POD 0, POD 1, and POD 2 than those in the SB group (POD 0: 2.1 ± 1.6 vs 2.8 ± 2.8,  $P = .046$ ; POD 1: 2.2 ± 1.3 vs 3.3 ± 2.1,  $P < .001$ ; POD 2: 2.1 ± 1.5 vs 3.7 ± 2.4,  $P < .001$ ) (Table 2; Fig. 1).

### Secondary outcomes

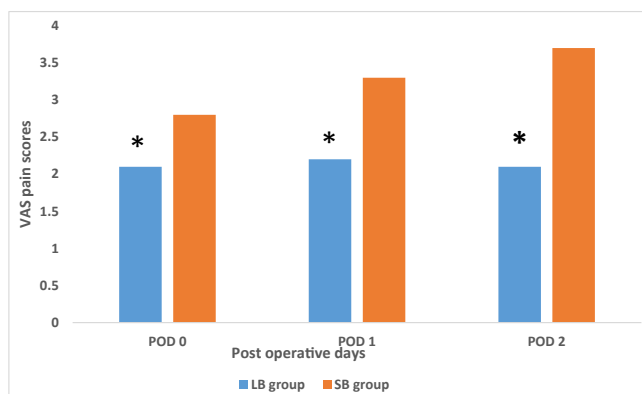
The LB group consumed significantly fewer MEs on POD 0 and POD 1 than the SB group, (POD 0: 18.7 ± 14.5 vs 25.2 ± 19.1 [ $P = .02$ ]; POD 1: 23.4 ± 18.5 vs 37.8 ± 37.7 [ $P = .003$ ]). The LB group consumed significantly fewer MEs and had shorter LOS than the SB group (24.6 ± 14.4 vs 41.7 ± 37.3 [ $P < .001$ ]) (Table 3).

Patients in the LB group were able to ambulate significantly more with physical therapy on POD 0 and POD 1 than those in the SB group (POD 0: 261.6 ± 249.0 steps vs 108.2 ± 128.6 [ $P < .001$ ]; POD 1: 761.5 ± 536.6 steps vs 372.0 ± 253.3 [ $P < .001$ ]).

**Table 2**  
Primary outcome.

Variables	Liposomal bupivacaine, N = 75	Standard bupivacaine, N = 75	P value
VAS pain scores (1–10)			
POD 0	2.1 ± 1.6	2.8 ± 2.8	.046 <sup>a</sup>
POD 1	2.2 ± 1.3	3.3 ± 2.1	<.001 <sup>a</sup>
POD 2	2.1 ± 1.5	3.7 ± 2.4	<.001 <sup>a</sup>

<sup>a</sup> Statistically significant,  $P < .05$ .



**Figure 1.** Comparison of VAS pain scores between the LB and SB groups. The adductor canal block (ACB) with liposomal bupivacaine (LB group) had significantly lower VAS pain scores than ACB with standard bupivacaine (SB group) for POD 0, POD 1, and POD 2. \* Means that  $P < .05$ .

## Discussion

Improving perioperative pain control after TKA can lead to higher patient satisfaction, more rapid functional recovery, less potential for opioid pain medication abuse, and decreased costs. This retrospective cohort study comparing conventional ACB and PAI using standard bupivacaine vs ACB and PAI using liposomal bupivacaine for patients undergoing TKA demonstrated significantly lower pain scores and reduced opioid consumption for patients who received liposomal bupivacaine.

Liposomal bupivacaine has the potential benefit of providing longer acting local anesthesia, purportedly lasting up to 72 hours when infused into soft tissue [5]. In an attempt to improve outcomes related to perioperative pain control, a number of studies have examined its use for PAIs in TKA [6–11]. Surprisingly, these studies have shown conflicting results, with a number of level 1 studies demonstrating no significant benefit to the addition of liposomal bupivacaine for a PAI [6,8–11]. There are expanding indications for the use of liposomal bupivacaine, with recent Food and Drug Administration label changes, including approval for interscalene brachial plexus blocks [12]. Few studies, however, have examined its use in ACBs. To date, there are two retrospective studies that compared lower extremity regional blocks using liposomal bupivacaine with those using standard bupivacaine or ropivacaine [13,14]. Philips and Doshi, in a retrospective cohort

study comparing ACB with liposomal bupivacaine to femoral nerve blocks with standard bupivacaine, reported significantly lower opioid consumption and improved functional outcomes in the liposomal bupivacaine group [13]. Wang et al. [14], in another retrospective cohort study, compared ACB via continuous infusion of ropivacaine pain balls to ACB with liposomal bupivacaine and reported lower pain scores and reduced mean total cost for the liposomal group. Both these studies are significantly limited by the confounding factor of differing modes of delivery between groups (ie, femoral nerve block and continuous infusion). In the present study, there was no difference between delivery method for liposomal bupivacaine group and the standard bupivacaine group (single-shot ACB), which reduces potential for confounding and allows a more direct comparison between treatment arms.

In our study, we found superior performance for ACB with liposomal bupivacaine compared with ACB with standard bupivacaine, with no additional adverse events. For our primary outcome measure, we report significantly lower VAS pain scores with the LB group for POD 0, POD 1, and POD 2. This timeline is in support of the longer acting LB (36–72 hours), showing lower pain scores on POD 0 (when both SB and LB should be functioning) but then further improved pain scores for LB after 24 hours. These findings lead to significant cost savings, outweighing the comparatively small initial increased cost of liposomal bupivacaine over standard bupivacaine. These findings are in agreement with the improved pain scores and cost savings seen in the study by Wang et al. [14]. Unlike Philips and Doshi [13], we did observe significantly lower opioid consumption between groups. The difference in this study (24.6 ME per day vs 41.7 ME per day) was statistically significant. This study did not control for prior opioid consumption, which can lead to a high range of opioid consumption between patients in the perioperative period. We did not find any difference between LOS for the two groups. Larger cohort studies, or a randomized clinical trial, may help elucidate differences in opioid consumption.

This retrospective cohort study had a number of limitations. Although we saw no differences in age, BMI, ASA, preoperative diagnosis, or gender between the groups, we did not match for other factors that could play a role in perioperative outcomes, including preoperative opioid consumption, which can lead to large deviations in opioid consumption, an important outcome measure. In addition, although perioperative protocols were the same between groups, including preoperative and postoperative medications, physical therapy protocols, and neuraxial anesthesia, subtle differences in hospital protocol could have impacted outcome measures. Furthermore, because the use of liposomal bupivacaine in this study did not conform to product labeling, it is regarded as off-label use. Of note, liposomal bupivacaine has been approved for use in regional nerve blocks, specifically for interscalene blocks [12]. Finally, owing to the use of liposomal bupivacaine for both ACB and PAI in this study, this was not a pure direct comparison of ACB with LB alone. Our results demonstrate the benefits of using LB with ACB and PAI over SB with ACB and PAI. Given previous studies showing equivocal benefits for LB with PAI, it is likely that most benefits came from its use with ACB, although further studies are needed to clarify these findings.

## Conclusions

This study demonstrates the potential for ACB with liposomal bupivacaine to lead to improved perioperative outcomes in TKA. Using liposomal bupivacaine for ACB and PAI, we found not only decreased VAS pain scores but also decreased opioid consumption, which has the potential for significant cost savings. A prospective randomized clinical trial is warranted to confirm these findings.

**Table 3**  
Secondary outcomes.

Variables	Liposomal bupivacaine N = 75	Standard bupivacaine N = 75	P value
Length of stay	2.2 ± 1.0	2.4 ± 2.5	.5
Discharge disposition			
Home (%)	61 (81.3%)	59 (77.3%)	
Outside (%)	14 (18.7%)	17 (22.7%)	.41 <sup>a,b</sup>
Number of feet walked			
POD 0	261.6 ± 249.0	108.2 ± 128.6	<.001 <sup>b</sup>
POD 1	761.5 ± 536.6	372.0 ± 253.3	<.001 <sup>b</sup>
POD 2	532.8 ± 371.6	380.3 ± 241.8	.06
Morphine equivalents (mg)			
POD 0	18.7 ± 14.5	25.2 ± 19.1	.02 <sup>b</sup>
POD 1	23.4 ± 18.5	37.8 ± 37.7	.003 <sup>b</sup>
POD 2	22.0 ± 15.6	29.1 ± 25.2	.15
Morphine equivalents/day	24.6 ± 14.4	41.7 ± 37.3	<.001 <sup>b</sup>

<sup>a</sup> Chi-square test.

<sup>b</sup> Statistically significant,  $P < .05$ .

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