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Adductor Canal Block With Continuous Infusion Versus Intermittent Boluses and Morphine Consumption: A Randomized, Blinded, Controlled Clinical Trial

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BACKGROUND: Based on the assumption that relatively large volumes of local anesthetic optimize an adductor canal block (ACB), we theorized that an ACB administered as repeated boluses would improve analgesia without compromising mobility, compared with a continuous infusion.
METHODS: We performed a randomized, blinded, controlled study, including patients scheduled for total knee arthroplasty with spinal anesthesia. Patients received 0.2% ropivacaine via a catheter in the adductor canal administered as either repeated intermittent boluses (21 mL/3 h) or continuous infusion (7 mL/h). The primary outcome was total (postoperative day [POD], 0–2) opioid consumption (mg), administered as patient-controlled analgesia. Pain, ambulation, and quadriceps muscle strength were secondary outcomes.
RESULTS: We randomized 110 patients, of whom 107 were analyzed. Total opioid consumption (POD, 0–2) was a median (range) of 23 mg (0–139) in the bolus group and 26 mg (3–120) in the infusion group (estimated median difference, 4 mg; 95% confidence interval [CI], −13 to 5; $P = .29$). Linear mixed-model analyses revealed no difference in pain during knee flexion (mean difference, 2.6 mm; 95% CI, −2.9 to 8.0) or at rest (mean difference, 1.7 mm; 95% CI, −1.5 to 4.9). Patients in the bolus group had improved quadriceps sparing on POD 2 (median difference, 7.4%; 95% CI, 0.5%–15.5%). However, this difference was not present on POD 1 or reflected in the ambulation tests ($P > .05$).
CONCLUSIONS: Changing the mode of administration for an ACB from continuous infusion to repeated intermittent boluses did not decrease opioid consumption, pain, nor mobility. (Anesth Analg 2018;126:2069–77)

KEY POINTS

- **Question:** Does an adductor canal block administered as repeated boluses improve analgesia compared with a continuous infusion?
- **Findings:** Changing the mode of administration from a basal infusion to repeated boluses did not reduce opioid consumption or pain after total knee arthroplasty.
- **Meaning:** The mode of administration did not affect analgesia nor muscle strength, and both administration forms can be used for an adductor canal block.

The adductor canal block (ACB) is an effective, motor-sparing method to treat postoperative pain after knee surgery.[1-3] Being a relatively new treatment, there are still numerous unresolved issues concerning the technique. Although the optimal volume for an ACB has yet to be determined, experimental studies suggest that relatively large volumes (at least 20 mL) are needed to ensure spread to the vastus medialis nerve[4] and to the distal part of the canal (and thus a potential spread to the obturator nerve).[5]

Based on the assumption that relatively large volumes of local anesthetic optimize an ACB, we aimed to investigate whether using repeated boluses for a perineural ACB catheter would improve analgesia without compromising mobility, compared with a continuous infusion. We assumed

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Conflicts of Interest: See Disclosures at the end of the article.

The abstract has been accepted for presentation at the annual meeting of the American Society of Regional Anesthesia, San Francisco, CA, January 6–8, 2017, and at the IX SIMPAR-ISURA SIMPAR-ISURA (Study In Multidisciplinary Pain Research-International Symposium of Ultrasound for Regional Anesthesia and Pain Medicine) Congress, Florence, Italy, March 29 to April 1, 2017.

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that administering a large volume of local anesthetic over a short time (repeated boluses) would result in superior spread compared with the same volume infused over a longer time, and that this increased spread would improve analgesia and reduce opioid consumption. There is certainly precedence for this theory: when epidural analgesia is used for labor, it has been demonstrated that intermittent boluses provide superior analgesia over continuous infusions.[6–9] However, the results for peripheral nerve blocks are contradictory.[10–16] To date, no study has investigated the effect of different infusion methods for an ACB in patients after major knee surgery.

In the present study, we aimed to investigate the effect of 2 different administration regimens via a catheter in the adductor canal for patients after total knee arthroplasty (TKA). We hypothesized that opioid consumption over the first 2 postoperative days (PODs) (primary outcome) and pain scores during this period (secondary outcomes) would be reduced when the ACB was administered as intermittent boluses compared with a continuous infusion. Other secondary outcomes included muscle strength and mobilization.

METHODS

We performed a blinded, randomized, controlled study with parallel groups in accordance with the guidelines of the Helsinki Declaration. We registered the study prospectively at clinicaltrials.gov (NCT02539628, P.J., March 13, 2015). The Good Clinical Practice unit of Copenhagen University Hospital monitored the study, and the local Regional Ethics Committee (H-2-2014-114), the Danish Medicines Agency (2014-005642-22), and the Danish Data Protection Agency approved all study procedures. The study was conducted at Gentofte Hospital (Hellerup, Denmark). Written informed consent was obtained from all participants before inclusion. This manuscript adheres to the Consolidated Standards of Reporting Trials (CONSORT) guidelines. There were no changes to the methods or trial outcomes after the trial commenced, and we performed no interim analysis.

Eligible participants were patients scheduled for unilateral, primary TKA with spinal anesthesia, age 18 years old or older, with an American Society of Anesthesiologists physical status classification of I–III, and with the ability to perform the timed up and go (TUG) test preoperatively. Exclusion criteria encompassed body mass index exceeding 40 kg/m^2, daily intake of "strong" opioids (eg, morphine, oxycodone, ketobemidone, methadone, fentanyl) during the last 4 weeks, allergy to the medicines used in the study, rheumatoid arthritis, neuromuscular pathology in the lower limbs, pregnancy, inability to cooperate, non-Danish speakers, and alcohol and/or drug abuse (based on the investigator's assessment).

Treatment Allocation and Blinding

Randomization was based on a computer-generated block randomization list in a 1:1 ratio (blocks of 10). Patients were randomized to one of 2 treatments: repeated intermittent boluses or a continuous infusion. Two independent researchers, not otherwise involved in the study, prepared the randomization list. To ensure allocation concealment, they prepared 110 sealed and signed, opaque envelopes, consecutively numbered. Envelopes were only opened after successful block performance by the investigators (B. Gottschau, B. Graungaard, and U.G.) responsible for block performance, programming, and connecting the infusion pump. To ensure blinding, the pump was kept in a locked and isolated infusion pump bag with opaque tape concealing the pump settings. All patients, outcome assessors, and clinical staff were blinded to the intervention. Unmasking did not occur until statistical analysis was complete.

Standard Analgesia and Anesthesia Treatment

Premedication consisted of oral acetaminophen (1 g) and celecoxib (400 mg) 1 hour preoperatively, and methylprednisolone (125 mg intravenously [IV]) given perioperatively. All patients received spinal anesthesia with 2–2.5 mL of 0.5% bupivacaine. Fluids and sedation (propofol only) were provided at the discretion of the anesthetist. Local infiltration analgesia was administered by the surgeon at the end of surgery consisting of 150-mL ropivacaine 0.2% and 30-mg ketorolac. Fifty milliliters of this mixture was injected subcutaneously; thereafter, 0.5-mL epinephrine 1 mg/mL was added to the remaining mixture and the injectate divided between the capsulotomy and the posterior capsule.

Patients were given a standardized analgesia protocol consisting of oral acetaminophen (1 g every 6 hours) and ibuprofen (400 mg every 8 hours). In addition, all patients received patient-controlled analgesia with IV morphine, providing bolus doses of 2.5 mg with a lockout time of 10 minutes (no background infusion). Moderate–pronounced nausea was treated with ondansetron.

Perineural Catheter Insertion and Study Medication

All patients received an adductor canal catheter in their operative extremity at the postanesthesia care unit before the spinal resolved using a technique published previously but with a modification toward an out-of-plane technique.[16] A dynamic ultrasound scan (GE logiq e; GE Healthcare, Waukesha, WI) was performed in the midthigh area, with a short-axis view, identifying the saphenous nerve in the adductor canal anterolateral to the superficial femoral artery. Using dynamic needle tip positioning and an out-of-plane technique, a 100-mm Tuohy needle was inserted into the adductor canal in an approximate 45° angle (cranial to caudal), piercing the sartorius muscle. Ten milliliters of isotonic saline was used to expand the canal and to ensure proper spread. A triple-orifice 20 G catheter (Contiplex Tuohy; B.Braun Melsungen AG, Melsungen, Germany) was inserted approximately 5 cm beyond the needle tip. All patients received an initial bolus of 10 mL of lignocaine 1% through the catheter during real-time ultrasound imaging to ensure correct placement of the catheter. In case of improper spread, the catheter was repositioned. Effort was put into catheter fixation using Steri-Strips (3M, St Paul, MN) and transparent adhesive film to prevent dislocation. According to randomization, an infusion pump (CADD Solis v.3; Smiths Medical, St Paul, MN) was programmed to administer 0.2% ropivacaine either as repeated intermittent boluses (21 mL injected at a rate of 500 mL/h, every 3 hours) or as a continuous infusion (7 mL/h). Thus, each

group received the same total volume of ropivacaine every 3 hours. The infusion pump was connected and started immediately after catheter insertion and remained connected until the end of the trial at 12 PM on POD 2.

Clinical Assessments

We registered the total opioid consumption from the end of surgery and until 12 PM on POD 2, as a combination of all opioids injected via the patient-controlled analgesia pump plus any rescue opioids administered (calculated as IV morphine equivalents).

The patients reported their pain intensity on a visual analog scale ranging from 0 to 100 mm (0 mm = no pain and 100 mm = worst imaginable pain). Pain was recorded at rest, during 45° active knee flexion, and as worst pain during the TUG test.

The patients performed 2 different ambulation tests (the TUG test and the 6-minute walk test) at 2 different time points (12 PM on PODs 1 and 2). The TUG test measures how long it takes to get up from a chair, walk a distance of 3 m, turn around, walk back, and sit down again, while the 6-minute walk test measures the distance a patient can walk during a 6-minute period. All patients used a high walker with arm support for the test.

Muscle strength was assessed as maximum voluntary isometric contraction (MVIC) of the quadriceps femoris muscle using a handheld dynamometer (HHD; Lafayette Instrument, Lafayette, IN). The patient was in the sitting position, with the knee flexed 90° and both feet hanging free off the floor. For each time point, 3 consecutive measurements were made with a 30-second intervening rest period.

Finally, to assess catheter displacement, we used an alcohol swab to test for temperature discrimination ability in the saphenous distribution area, assessed once a day, at 12 PM on PODs 1 and 2. Absent cold sensation to the alcohol swab was interpreted as a well-placed catheter.

Opioid consumption and pain were assessed preoperatively (only pain) and postoperatively at the postanesthesia care unit, at 8 PM on the day of surgery, at 8 AM, 12 PM, and 8 PM on POD 1, and finally at 8 AM and 12 PM on POD 2. The ambulation tests, MVIC, and sensory testing were assessed at 12 PM on PODs 1 and 2; in addition, the baseline MVIC values were obtained preoperatively.

Outcomes

The primary outcome was total opioid consumption, from the end of surgery until 12 PM on POD 2. Secondary outcomes were visual analog scale pain scores during 45° active knee flexion and at rest (analyzed using a linear mixed model with the inclusion of all time points), worst pain during the TUG test on PODs 1 and 2, quadriceps femoris MVIC strength on PODs 1 and 2, time to perform the TUG test, and distance walked during the 6-minute walk test on PODs 1 and 2. Finally, we assessed the number of patients within each treatment group able to perform the ambulation tests on PODs 1 and 2.

Statistical Analysis

Statistical analyses were conducted using SPSS 22 (SPSS, Chicago, IL). A Shapiro–Wilk test, calculation of the z-value for skewness and kurtosis, and a visual inspection of their histograms, normal Q-Q plots, and box plots showed that the majority of variables (except from the MVIC measurements) was not normally distributed; hence, we performed nonparametric analysis on all variables. Continuous variables are presented as median (range). Group comparisons were performed using the Mann-Whitney *U* test and by calculating the Hodges–Lehman median difference with a constructed 95% confidence interval (CI). Repeated measurements (pain scores during 45° knee flexion and at rest) were analyzed using a linear mixed model, including all postoperative time points. Time was included as a repeated effect with an autoregressive 1 covariance structure. We assumed with the autoregressive correlation structure that the correlation between time points within a patient decayed as the distance decreased. Treatment, time, and the interaction treatment × time were set as fixed effects, and preoperative pain scores were included as covariates. Ordinal and nominal variables are presented as n (%). MVIC was calculated as the percentage of the baseline value, using the mean value of the 3 readings from each time point. Categorical data (number of patients completing the mobilization tests at PODs 1 and 2) were analyzed using the Fisher exact test (expected frequency <5). The nature of the hypothesis testing was 2-tailed, and $P < .05$ was considered statistically significant. All data were double checked by 2 investigators, and decisions regarding exclusion of patients were taken before performing statistical analyses. All planned statistical analyses were reported on clinicaltrials.gov before inclusion into the study.

Sample Size Calculation

Based on our review of patient records at our institution and on one of our previous studies finding a 24-hour cumulative opioid consumption of 22 mg IV morphine equivalent,[16] we expected the mean 48-hour consumption to be approximately 50 mg for patients receiving a continuous ACB infusion. We considered a reduction by 15 mg in the total opioid consumption (30% reduction) to be clinically relevant. Assuming a standard deviation of 27,[2,16,17] a type 1 failure risk of 5%, and a type 2 failure risk of 20%, a total of 51 patients would be required in each group to detect a reduction of 15 mg IV morphine equivalent over 48 hours. The sample size calculation was based on a 2-group independent *t* test. We planned to include 110 patients in total to compensate for potential dropouts and uncertainty in predicting the actual standard deviation.

RESULTS

We enrolled and analyzed 110 patients from April 2015 to August 2016 (Figure 1). All patients completed the study protocol, except for 3 patients whom withdrew consent in the morning on POD 1; 1 due to excess quadriceps weakness (MVIC = 0 kgF, bolus group), 1 due to morphine side effects (dizziness and pruritus, bolus group), and 1 due to excessive nausea and vomiting (infusion group). All available data from the 110 patients were included in the analyses (intention to treat analyses). Patient characteristics were similar between the groups (Table 1).

There was no difference in total opioid consumption between groups (primary outcome, Figure 2). Total, cumulative median consumption at 12 PM at POD 2 was 23 mg

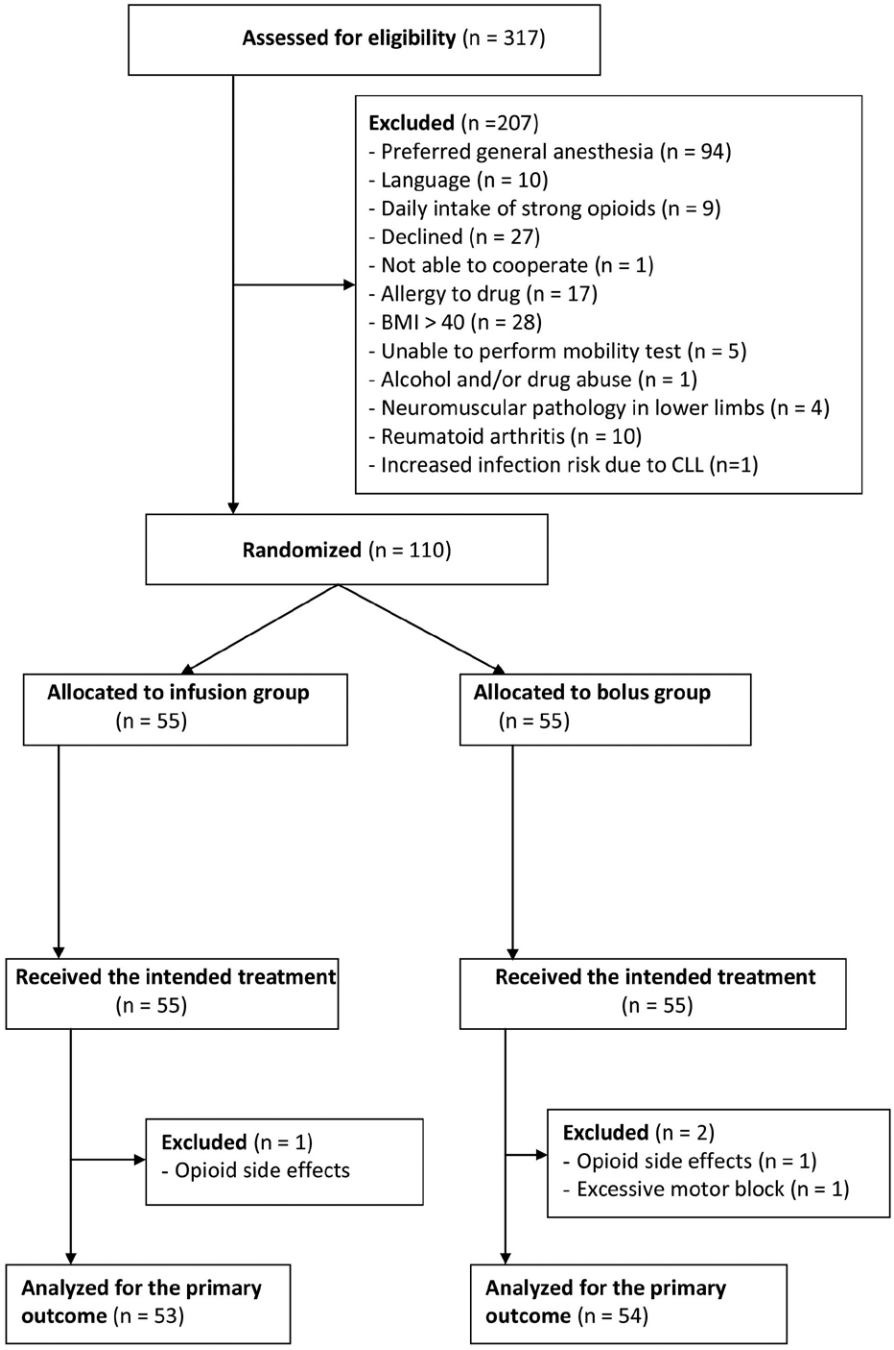

Figure 1. Flow diagram of patient distribution. BMI indicates body mass index; CLL, chronic lymphocytic leukemia.

(0–139) in the bolus group and 26 mg (3–120) in the infusion group (estimated median difference, 4 mg; 95% CI, –13 to 5; $P = .29$). Linear mixed-model analyses showed no difference in pain scores between groups, with an estimated mean difference of 2.6 mm; $P = .35$; 95% CI, –2.9 to 8.0 for pain during knee flexion (Figure 3), and an estimated mean difference of 1.7 mm; $P = .29$; 95% CI, –1.5 to 4.9 mm for pain at rest (Figure 4). The only statistically significant difference between groups was seen in quadriceps strength on POD 2, with patients in the bolus group having retained a median of 7.4% more of their baseline strength than the patients in the infusion group (95% CI, 0.5%–15.5%, Table 2). This difference in muscle strength was not present on POD 1 and was not reflected in the ambulation tests (Table 2). The number of patients able to perform the ambulation tests was 47/53 in the bolus group on POD 1 and 50/53 on POD 2. This number was not statistically significantly different from the number in the continuous group: 50/54 on POD 1 and 53/54 on POD 2, $P = .53$ and $P = .36$, respectively. Finally, 13/53 patients in the bolus group and 14/54 patients in the infusion group had a displaced catheter on POD 2, indicated by normal or only slightly decreased temperature discrimination ability in the saphenous distribution area (Table 1).

One patient had a brief loss of consciousness, sustained a fall, and hit her head during ambulation to the lavatory (bolus group). The episode was interpreted as a vasovagal syncope. Computed tomography scan of the cerebrum showed no signs of hemorrhage. The patient was discharged

as scheduled without further treatment or sequelae, apart from nausea waning within the day. No other adverse or serious adverse events occurred.

DISCUSSION

The adductor canal is considered a compartment block (in contrast to a selective nerve block), in theory, necessitating a relatively large volume of local anesthetic to block the multiple nerves within the canal. Despite using a relatively large bolus volume (21 mL), this blinded, randomized, controlled trial did not find evidence to support our hypothesis that using repeated boluses for a perineural ACB catheter improves analgesia, compared with a continuous basal infusion. The only statistically significant difference between groups was found in quadriceps strength on POD 2, showing that the bolus group retained 7% more of their baseline strength. Although being statistically significant, the finding is of questionable clinical relevance, as it was less than the 10% side-to-side difference that is normal in healthy individuals[18,19] and was not reflected in the ambulation tests. Considering the lack of difference in strength on POD 1 and that the study was not powered to investigate this outcome, it may simply have been a spurious finding (type 1 error). No corrective measure for multiple comparisons was performed, but if we had used the Bonferroni correction for the secondary outcomes, then the significance criterion would have been (α = .05/12 = .004), and the difference in quadriceps strength would no longer have been statistically significant. Nonetheless, we find it reassuring that local anesthetic delivery method does not negatively affect quadriceps strength, even when relatively large volumes are administered.

To avoid a confounding effect of local anesthetic dose, both groups received the same dose of local anesthetics over time. This resulted in a regimen with very frequent injections in the bolus group. Thus, it may be possible to reduce the total amount of local anesthetic in the intermittent bolus group by increasing the interval between boluses, while keeping the same concentration. This would lead to a reduction in total dose. Indeed another possibility would be to reduce the infusion rate, but this may reduce the efficacy of the block.

Only 2 previous studies have compared intermittent boluses to continuous infusion for an ACB catheter, and their results are conflicting. The first study was performed in 24 healthy volunteers.[20] Similar to the present study, investigators found no effect of changing the mode of administration for an ACB, but there are several noteworthy differences between our studies. First, they used a much smaller volume for the hourly boluses: 8 mL every hour versus 20 mL every 3 hours. Second, it was performed in a nonsurgical

Table 1. Patient Characteristics and Perioperative Data

Characteristics	Bolus Group	Infusion Group
Sex (female/male)	30/25	34/21
Age (y)	70 ± 10	70 ± 9
Height (cm)	172 ± 10	170 ± 9
Weight (kg)	82 ± 15	80 ± 15
BMI (kg/m^2)	27 ± 4	28 ± 4
Preoperative analgesics, n (%)		
None	17 (31)	13 (23.5)
Paracetamol and/or NSAIDs	31 (56)	35 (63.5)
Weak opioids	7 (13)	7 (13)
Operated knee (right/left)	23/32	29/26
Duration of surgery (min)	73 ± 11	71 ± 11
Tourniquet pressure (mm Hg)	244 ± 53	251 ± 25
Tourniquet duration (min)	67 ± 19	68 ± 14
Catheter displacements		
Postoperative day 1	3/54	4/54
Postoperative day 2	13/53	14/54

Data are reported as mean ± SD and as n (%) as appropriate.
Abbreviations: BMI, body mass index; NSAID, nonsteroidal anti-inflammatory drug.

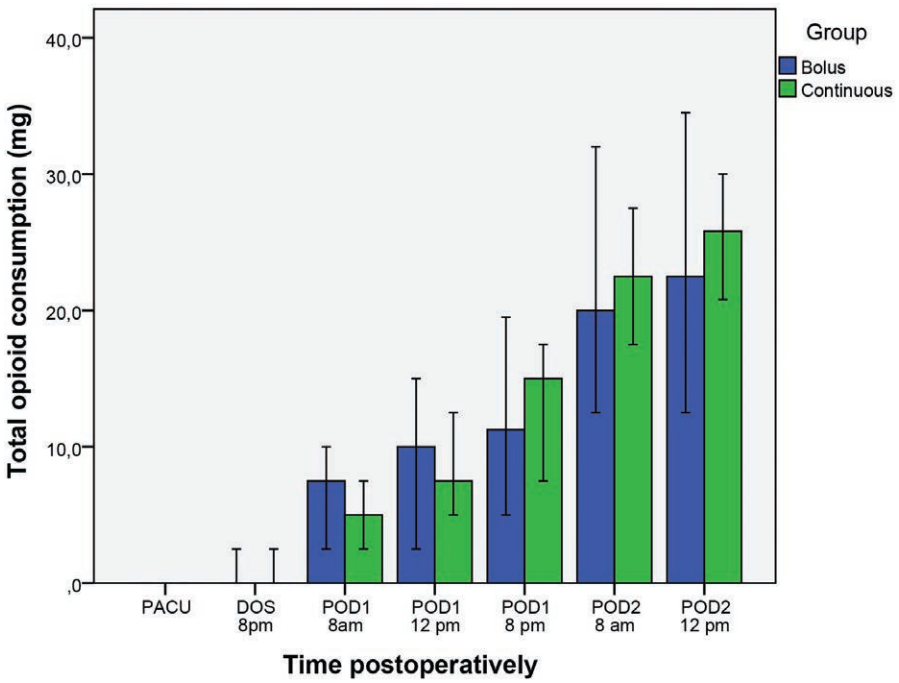

Figure 2. Total opioid consumption across groups. Data are expressed as median, and whiskers represent 95% CI. There was no statistically significant difference between groups at 12 PM on POD 2 (estimated median difference, 4 mg; 95% CI, −13 to 5). CI indicates confidence interval; DOS, day of surgery; PACU, postanesthesia care unit; POD, postoperative day.

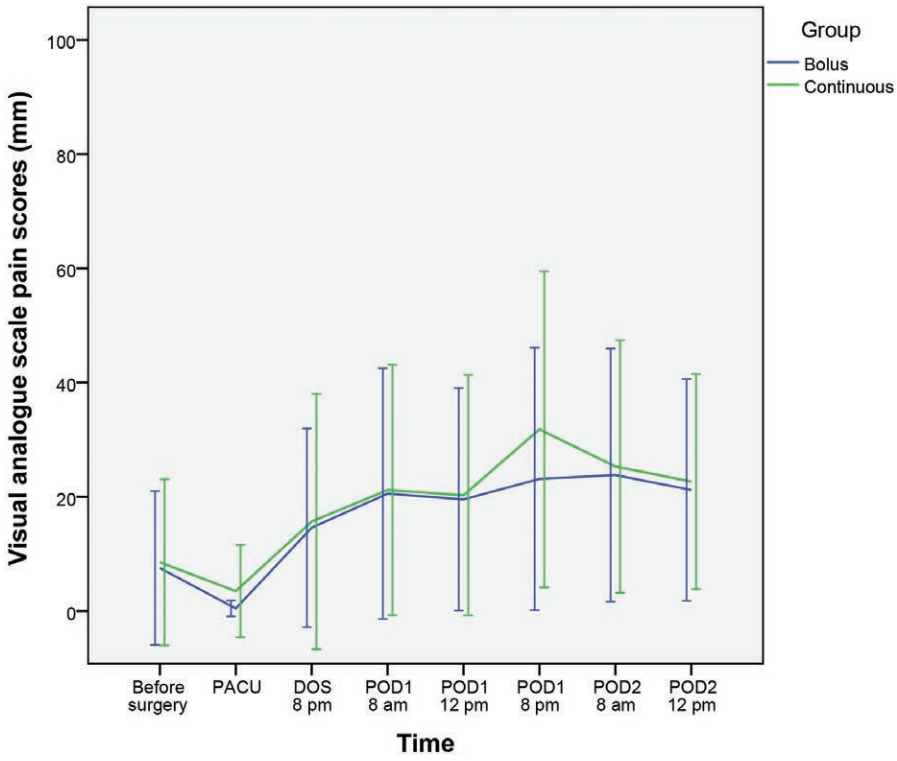

Figure 3. Visual analog scale pain scores during 45° flexion of the knee. Data are expressed as mean ± SD. Comparisons between groups were made using linear mixed-model analyses, showing no difference in pain scores between groups; estimated mean difference of 2.6 mm (95% CI, −2.9 to 8.0 mm). CI indicates confidence interval; DOS, day of surgery; PACU, postanesthesia care unit; POD, postoperative day; SD, standard deviation.

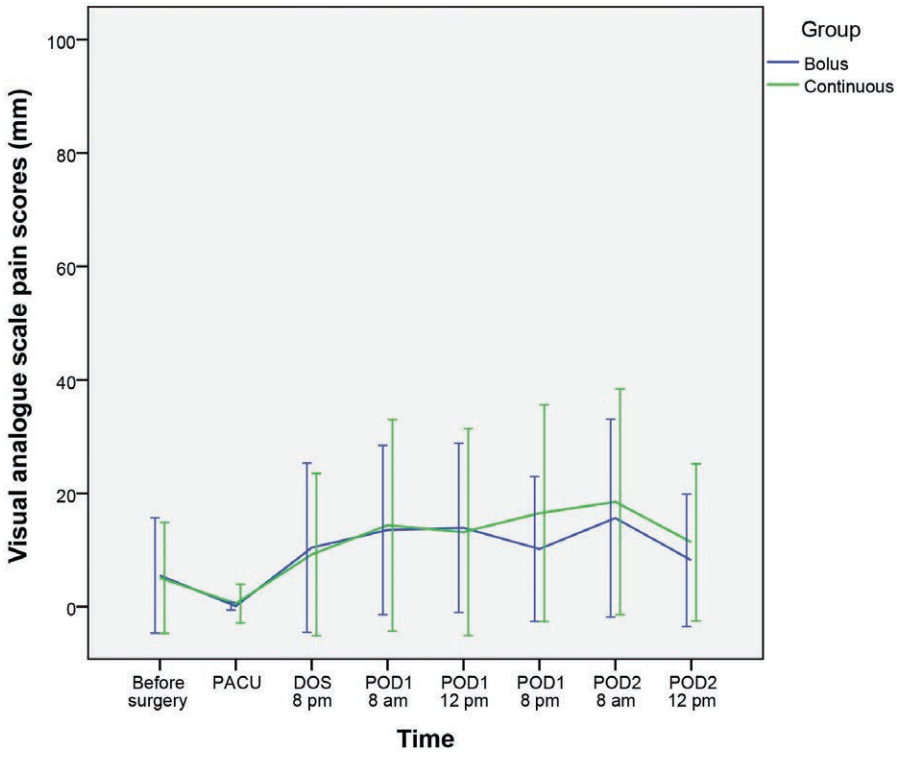

Figure 4. Visual analog scale pain scores at rest. Data are expressed as mean ± SD. Comparisons between groups were made using linear mixed-model analyses, showing no difference in pain scores between groups; estimated mean difference of 1.7 mm (95% CI, −1.5 to 4.9 mm). CI indicates confidence interval; DOS, day of surgery; PACU, postanesthesia care unit; POD, postoperative day; SD, standard deviation.

setting. Third, the analgesic effect was based on tolerance to electrical current in the distribution of the anterior branch of the medial femoral cutaneous nerve. The second study was performed in patients after anterior cruciate ligament reconstruction, showing superior pain relief in the group receiving intermittent boluses.[14] However, this study used a very low infusion rate of 2.5 mL/h, which may have resulted in insufficient analgesia.

It remains undetermined which nerves are anesthetized after an ACB, but in theory, the optimal volume for an ACB should ensure spread to nerves beyond the saphenous nerve—the obturator nerve and the nerve to the vastus

Table 2. Effect of Administration Method (Bolus or Infusion) on Muscle Strength, Mobility, and Dynamic Pain

Assessments	Bolus Group, Median (Range)	Infusion Group, Median (Range)	Estimated Median Difference	95% Confidence Interval		*P* Value
				Lower	Upper	
MVIC day 1 (%)	39 (8–116)	36 (9–160)	3.5	−4.3	11.1	.36
MVIC day 2 (%)	31 (9–139)	26 (0–97)	7.4	0.5	15.5	.03
TUG day 1 (s)	28 (14–72)	29 (15–75)	0.5	−3.9	4.9	.77
TUG day 2 (s)	25 (12–89)	27 (10–107)	−1.2	−5.2	3.0	.58
VAS during TUG day 1 (mm)	22 (0–78)	25 (0–74)	−2	−10	6	.65
VAS during TUG day 2 (mm)	18 (0–74)	23 (0–74)	−4	−11	3	.21
6-min walk test day 1	208 (58–368)	217 (40–380)	−1	−31	30	.96
6-min walk test day 2	229 (78–447)	220 (25–430)	11	−23	41	.52

A *P* value of <.05 was considered statistically significant. Quadriceps muscle strength was assessed as MVIC. Mobility was assessed using the TUG and the 6-minute walk test. Dynamic pain was assessed on a VAS (0–100 mm) during the TUG.
Abbreviations: MVIC, maximum voluntary isometric contraction; TUG, timed up and go test; VAS, visual analog scale.

medialis—but at the same time minimize motor impairment. From assessing cold sensation in the saphenous distribution, we know that there is a high success rate (≥94%) in blocking the saphenous nerve after an ACB.[17,21,22] Apart from the saphenous nerve, the nerve to the vastus medialis runs within the adductor canal[23] and can be blocked by an ACB, but the success rate of this depends on volume. The nerve to the vastus medialis was only blocked in 35% of subjects after an ACB with 10 mL of 1% lignocaine, but by increasing the volume to 20 or 30 mL, the proportion of subjects increased to 84% and 100%, respectively.[3] In a recent cadaver study, it was observed that the nerve to the vastus medialis was the largest contribution from the femoral nerve to the knee, indicating that this may be an important nerve to block after knee surgery, but the implication of this finding in a surgical setting is unknown.[23]

A previous study demonstrated that 20 mL is the minimum effective volume to ensure 95% success probability of spread of local anesthetic to the distal part of the adductor canal.[5] However, this success probability estimate is only valid provided that the obturator branches truly do pass through the canal. Reports made in connection with this subject are contradictory, and the articular branches that allegedly pass through the canal have neither cutaneous nor muscle branches, making it very difficult to demonstrate any affection using currently available methods. Gardner[24] described a consistent contribution of the obturator nerve to the subsartorial plexus in the adductor canal, while 3 other dissection studies[23,25,26] do not mention the nerve, and a last study only found it occasionally.[27] Considering that Gardner[24] only found the obturator nerve in the canal after specifically searching for it,[24] and that neither of the other anatomical studies describe any alternative path for the nerve,[23,25,26] it is difficult to decipher whether the nerve is overlooked or simply absent. On a final note, even if the obturator nerve consistently does send articular branches to the knee through the adductor canal, the implication of this is unknown.

One limitation of the present study is that we did not include a group receiving solely a single-injection block. Even though both groups in the present study reported relatively low morphine consumption and pain scores (mild pain both during the TUG test, knee flexion, and at rest), we do not know whether a catheter provides superior analgesia compared to a single-bolus technique. Thus, it cannot be excluded that the lack of difference in analgesia could be due to an equal effect of the initial bolus across groups with no additional effect of the administrations provided via the catheter. Considering that we used a short-acting local anesthetic for the initial bolus (10 mL of lignocaine 1%), this presumption is not very likely, but nonetheless supported by a relatively high catheter tip displacement rate (based on preserved sensation in the saphenous area) seen both in the present study and in the literature. In the present study, 25% of catheters were displaced in the bolus group and 26% in the infusion group on POD 2 (Table 1). This is comparable to previously reported dislocation rates,[28–30] but still discouraging because the catheters displaced despite careful insertion of the catheters along the canal (out-of-plane technique) and meticulous catheter fixation. Future studies should examine methods to reduce displacement rates and evaluate whether continuous nerve blocks provide superior analgesia to single-injection blocks.

Displacement rate in the present study was based on the assessment of temperature discrimination in the saphenous distribution. Unfortunately, not all patients were tested for normal sensation preoperatively; the proportion of not tested patients being 57% (30/53) in the bolus group and 61% (33/54) in the infusion group. Because unrecognized preoperative sensory dysfunction may be erroneously taken as a successful block, we cannot exclude that the displacement rate might have been even higher, but considering that all the patients who were tested preoperatively had normal sensation, this is improbable. Furthermore, it remains unknown which nerves contribute to analgesia after an ACB. Saphenous block assessments may therefore not be the optimal method for assessing catheter displacement after an ACB, and opioid consumption may as well have reflected pain from the sciatic distribution. Nonetheless, it does not change the conclusion of the study that changing the mode of administration for an ACB did not improve analgesia. Other limitations include the use of opioid consumption as a surrogate outcome for pain relief and that we did not evaluate the success of blinding. Because we did not assess catheter function on day of surgery, it is also unclear whether the displacement rate on POD 1 represents primary catheter failure or a secondary displacement. Finally, the present study findings should not be extrapolated to other types of peripheral nerve blocks and may not be applicable to other types of local anesthetics or different concentrations, volumes, or infusion rates.

In conclusion, changing the mode of administration for an ACB from a basal infusion of 7 mL/h to repeated boluses of 21 mL every 3 hours did not reduce opioid consumption

or pain after TKA, but neither did it impair muscle strength or ambulation.

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DISCLOSURES

Name: Pia Jaeger, MD, PhD.
Contribution: This author helped with the study conception and design, participant recruitment, data collection, data analysis, and writing up the first draft and the final article.
Conflicts of Interest: P. Jaeger has received speaker's honorarium from Smiths Medical, MN, but has no financial interest in the study.
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Contribution: This author helped with participant recruitment, data collection, revising drafts, and final approval of the manuscript.
Conflicts of Interest: None.
Name: Johan K. Sørensen, MD.
Contribution: This author helped with participant recruitment, data collection, revising drafts, and final approval of the manuscript.
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