

Comparison of Continuous Infusion versus *Automated Bolus for Postoperative Patient-controlled Analgesia with Popliteal Sciatic Nerve Catheters*

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Background: **This investigation was designed to compare a new methodology of automated regular bolus with a continuous infusion of local anesthetic for continuous popliteal sciatic block; both regimens were combined with patient-controlled analgesia (PCA).**

Methods: **Fifty patients undergoing hallux valgus repair were randomly allocated to receive an infusion of 0.125% levobupivacaine administered through a popliteal catheter as an automated regular bolus (n = 25) or as a continuous infusion (n = 25), both combined with PCA. Postoperative pain scores, incremental doses delivered by the PCA, local anesthetic consumed per hour, and the need for rescue tramadol analgesia were recorded.**

Results: **Both dosing regimens provided similar postoperative analgesia. Consumption of local anesthetic (5.14 ml/h, 5–5.75 ml/h) and dose request from the PCA (1, 0–5.4) was lower in the automated bolus group as compared to the continuous infusion group (5.9 ml/h, 5.05–7.8 ml/h; doses by PCA: 6.5, 0–20.5; $P < 0.05$). The need for rescue tramadol was similar in the two groups.**

Conclusion: **In continuous popliteal sciatic block, local anesthetic administered as an automated regular bolus in conjunction with PCA provided similar pain relief as a continuous infusion technique combined with PCA; however, the new dosing regimen reduced the need for additional PCA and the overall consumption of local anesthetic.**

CONTINUOUS popliteal sciatic nerve block plays an important role in postoperative pain control after painful orthopedic procedures of the foot.[1–4] Various factors affect the outcome of continuous peripheral sciatic nerve blocks, including the type of catheters used,[5–9] the volume and concentration of the local anesthetic solution,[9–10] and the type of approach.[11] Another important factor that may increase the efficacy of a continuous regional anesthetic technique is the infusion method.[12] There are three commonly used regimens to provide continuous peripheral nerve block analgesia: continuous infusion (CI) alone, CI combined with bolus doses, and bolus doses only.[12] The latter two are known as patient-controlled analgesia (PCA). There is evidence that combining a CI with PCA provides superior analgesia and improves patient satisfaction when compared to a CI or bolus doses alone.[12]

A recent report[13] dealt wit a new dosing regimen of automated regular bolus (ARB) of local anesthetic for continuous popliteal blockade. Local anesthetic administered by this technique provided better postoperative pain relief than by CI technique; however, PCA was not included in this investigation. A search of the literature revealed that no information is currently available on the previously mentioned new dosing regimen of ARB in conjunction with PCA. It was hypothesized that this regimen of ARB combined with PCA would prove superior to the more conventionally used CI combined with PCA.

The primary objective of this prospective, randomized, double-blind study was to determine if an automated regular perineural bolus combined with PCA decreases postoperative pain more effectively when compared with a continuous perineural infusion combined with PCA. Furthermore, the amount of local anesthetic per hour, the number of incremental doses requested and delivered by the PCA, the need for rescue tramadol, and patient satisfaction were compared.

Materials and Methods

After securing approval from the Hospital Ethics Committee of the University of Santiago de Compostela (Spain) and patients´ written informed consent, 50 patients undergoing hallux valgus repair with osteotomy under combined femoral/sciatic nerve block were prospectively studied. Patients with contraindications to regional anesthesia or suffering from central or peripheral neuropathies, pregnancy, inability to use a PCA device, being anticoagulated, or demonstrating a skin infection at the site of needle insertion were excluded.

After intravenous midazolam premedication (1–2 mg), standard monitoring consisting of an electrocardiogram, noninvasive blood pressure, and pulse oximetry was placed. The popliteal crease was identified with the patient prone. After skin infiltration, a 10-cm, 19-gauge short-beveled stimulating needle (Pajunk Medizintechnologie, Geisingen, Germany) was inserted 10 cm above

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the popliteal crease and 1 cm lateral to the midline. The needle was connected to a nerve stimulator (Pajunk Medizintechnologie), and the needle bevel was directed cephalad at an angle of 45 degrees to the skin. The stimulating current was set initially to 1.5 mA at a frequency of 2 Hz and a time interval of 100 μs. The intensity of the stimulating current was gradually decreased as the needle approached the targeted nerve. A plantar flexion of the foot identified the tibial nerve. This was the evoked motor response elicited in all patients to maintain consistency among groups. In case of peroneal nerve stimulation, the needle was withdrawn and redirected more medially. After an appropriate motor response was obtained with $I < 0.5$ mA, 30 ml of mepivacaine 1.5% was slowly injected under careful intermittent aspirations. A 20-gauge single-port catheter with one open distal end was advanced 4–5 cm beyond the tip of the needle, which was then withdrawn over the catheter. The catheter was secured in place using steri-strip and a transparent plastic dressing. All surgeries required a tourniquet below the knee, so patients were given an additional femoral nerve block at the inguinal level with 15 ml of 1.5% mepivacaine.

Time zero for clinical assessments was defined as the end of local anesthetic solution injection. Sensory and motor blockade on the operated limb was evaluated every 10 min for a total of 30 min. Sensory blockade was evaluated according to the loss of pinprick sensation in the distribution of the tibial and peroneal nerves. Motor blockade of the limb was assessed by asking the patient to plantarflex and dorsiflex the foot. Time required for onset of motor and sensory block was recorded. Success rate was defined as a complete sensory block (absence of sensation in both common peroneal and tibial nerve distributions) and motor block (inability to move the ankle and toes of the operated limb) 30 min after injection of the local anesthetic. Otherwise, nerve blockade was considered incomplete, and the patient was excluded from the study. Data collection was performed by an independent observer not involved in the regional anesthetic procedure. In case of intraoperative pain, the attending anesthesiologist was allowed to administer 50–100 μg of fentanyl intravenously. General anesthesia was induced if this did not provide adequate pain relief.

The perineurally located catheter was connected to an infusion device 30 minutes after injection of the local anesthetic. Using a computer-generated sequence, patients were randomly assigned to receive either a CI of 0.125% levobupivacaine at an infusion rate of 5 ml/h (group CI, n = 25) or an ARB dose of 5 ml every hour of the same local anesthetic (group ARB, n = 25). The independent observer set up two perineural pumps for each subject. One pump administered either the ARB or CI (CADD-Legacy PLUS 6500; Deltec, Inc., St. Paul, MN), and the second pump administered PCA (CADD-Legacy 6300; Deltec, Inc.). The infusion tubing of the pumps was connected by a three-way stopcock to the perineural catheter. The perineural solution for both pumps consisted of 1.25 mg/ml levobupivacaine. Depending on group assignment; the first pump was programmed as follows: the CI pump delivered a CI at 5 ml/h starting immediately after catheter connection, whereas the ARB pump delivered a 5-ml bolus every hour beginning 30 min after catheter connection. The PCA pump was programmed in the two groups to deliver 3-ml patient-controlled boluses with a lockout time of 15 min and a maximum of two doses per hour, allowing a maximum hourly volume of 11 ml/h.

All patients were given 30 mg of ketorolac intravenously every 8 h. In case of insufficient pain control, additional 100 mg of intravenous tramadol was administered every 6 h. An investigator blinded to the study evaluated the degree of pain at 6 and 24 h postoperatively. It was measured using a 100-point verbal rating scale (VRS): 0 = no pain; 100 = worst possible pain imaginable. At the same time points, the degree of motor block on the operated foot was also evaluated. At 24 h, the following data were recorded: the worst and the average pain score during that day, the number of incremental doses requested and delivered by the PCA, the consumption of local anesthetic per hour, the need for rescue tramadol, technical problems related to the catheter or the device, and the occurrence of complications or side effects. Furthermore, the acceptance of the analgesic technique was evaluated at this time point by using a three-point score: 1 = very satisfactory; 2 = satisfactory; 3 = unsatisfactory. The catheters were removed before discharging the patients.

Statistical Analyses

Sample size of patients per group was determined according to the primary hypothesis that the use of an automated regular perineural bolus combined with PCA decreases postoperative pain compared with a continuous perineural infusion combined with PCA. In previous studies using continuous popliteal block for postoperative analgesia,[9,11] a high variability of VRS-scores with standard deviations of 20–30 was observed. Assuming a SD of 25, a difference of 25 points in VRS scores between the two groups was considered clinically relevant. As a result, a sample size of 17 patients per group was calculated to allow for detection of a possible difference of 25 points in VRS scores with an α error of 5% and a statistical power of 80%. Eight more patients were included in each group for possible dropouts.

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS for Windows, version 11.0; SPSS Inc., Chicago, IL). Data distribution was first evaluated using the Shapiro-Wilkensen test. Continuous variables between groups were compared using either two-sampled Student *t* test or the Mann–Whitney *U* test, according to data distribution. Discrete variables

Table 1. Demographic and Anesthetic Data of the Two Study Groups

	ARB Group (n = 25)	CI Group (n = 25)
Age, yr	57 ± 10	56 ± 12
Weight, kg	70 ± 8	69 ± 10
Height, cm	160 ± 6	157 ± 5
Gender, male/female	2/23	2/23
Intensity of needle stimulation, mA	0.44 ± 0.04	0.42 ± 0.05
Onset time of sensory block, min		
Peroneal nerve distribution	20 ± 8	19 ± 8
Tibial nerve distribution	21 ± 9	21 ± 8
Onset time of motor block, min		
Peroneal nerve (dorsiflexion)	23 ± 7	23 ± 7
Tibial nerve (plantarflexion)	24 ± 7	23 ± 8
Additional intraoperative fentanyl	3 (12%)	3 (12%)

Data are mean ± SD, except for the gender and the amount of fentanyl administered intraoperatively (number and percentage of patients). There were no statistically significant differences between groups.

ARB group = automated regular bolus group; CI group = continuous infusion group.

between groups were compared using chi-square or Fisher exact test when numbers were small. A P value $<$ 0.05 was considered statistically significant. Qualitative data are presented as numbers (percentage), and continuous variables are presented as mean ± SD, except for VRS scores and doses requested and delivered by the PCA (median with 10th–90th percentiles).

Results

Fifty patients were enrolled in the study. No differences in age, sex, weight, and height were observed between the groups (table 1). This table also shows the onset times of sensory and motor block in the studied patients. Three patients in each group required 100 fentanyl intravenously for pain control during surgery (P = ns).

Table 2 shows the evolution of VRS scores postoperatively. No differences were observed between groups. However, the consumption of local anesthetic per hour and the number of incremental doses requested and delivered by the PCA were lower with the ARB technique compared with the CI technique (table 3; $P <$ 0.05). One patient in the ARB group and six patients in the CI group required intravenous rescue tramadol medication during the first 24 h postoperatively (P = ns).

Table 2. Degree of Pain during 24 h Assessed with VRS (1–100)

	ARB Group (n = 25)	CI Group (n = 25)
VRS at 6 h	0 (0–44)	10 (0–50)
VRS at 20–24 h	0 (0–14)	5 (0–20)
Average VRS	5 (0–24)	12.5 (0–45)
Worst reported VRS	20 (0–58)	35 (5–70)

Data are medians and 10th–90th percentiles. There were no statistically significant differences between the two groups.

ARB group = automated regular bolus group; CI group = continuous infusion group; VRS = Verbal rating scale for pain.

Table 3. Infusion Data

	ARB Group (n = 25)	CI Group (n = 25)
Length of the introduced catheter, cm	4.5 ± 0.2	4.6 ± 0.2
Infusion time, h	21.8 ± 1.4	21.4 ± 1.6
Consumption of local anesthetic, ml/h	5.14 (5–5.75)	5.95 (5.05–7.8)
Incremental doses requested from the PCA	1 (0–10.8)	7 (0–88)*
Incremental doses delivered by the PCA	1 (0–5.4)	6.5 (0–20.5)*
Patients not demanding PCA	9 (36%)	3 (12%)
Patients requiring tramadol	1 (4%)	6 (24%)
Motor block at 6 h	5 (20%)	2 (8%)
Satisfaction with the analgesic technique		
Very satisfactory	17 (68%)	15 (60%)
Satisfactory	8 (32%)	7 (28%)
Unsatisfactory	0	3 (12%)

Data are mean ± SD or medians and 10th–90th percentiles, except for patients requiring tramadol and satisfaction with the anesthetic technique (number and percentage of patients) and attempts to successful catheter placement (number of attempts).

* $P < 0.05$, ARB group *versus* CI group.

ARB group = automated regular bolus group; CI group = continuous infusion group; PCA = patient-controlled analgesia.

The degree of motor block at 6 h after infusion onset was similar in the two groups (table 3, P = ns). Three patients in the ARB group and one patient in the CI group had complete motor block of the operated foot at the end of the study (P = ns). Patients regained full sensibility in the sciatic nerve distribution 4 h after catheter removal. No catheter was dislodged, and no leakage of local anesthetic was observed.

Patients' overall satisfaction with the anesthetic procedure is displayed in table 3. No differences were found between groups.

Discussion

The current prospective, randomized, double-blinded study demonstrated that local anesthetic administered as ARB in conjunction with PCA provided similar pain relief than a CI technique combined with PCA. However, the new dosing regimen reduced the need for PCA and the overall consumption of local anesthetic.

Previously published studies have compared different regimens of continuous sciatic block.[12] Ilfeld[12] showed that a CI is necessary to increase the efficacy of continuous popliteal sciatic nerve block. Adding PCA decreased local anesthetic consumption as compared with a CI or bolus dosing alone. A recent report[13] dealt with a new dosing regimen of ARB of local anesthetic for

continuous popliteal block; however, no information is yet available using this new dosing regimen of ARB combined with PCA in continuous peripheral nerve blocks.

When a blind catheter insertion technique is used as in the present investigation, the final position of the catheter tip may become located distant from the targeted nerve, resulting in inadequate postoperative analgesia in 10–40% of patients.[14–16] A possible explanation may be that this unpredictable final position of the catheter may prove difficult or even impossible for the local anesthetic to cover the distance between the catheter tip and the two trunks of the sciatic nerve when a slow CI of 5 ml/h is administered. In the present investigation, the two dosing regimens proved satisfactory with respect to low VRS scores and pain relief. However, differences in the request of PCA and consumption of local anesthetic were observed. When the new regimen of ARBs of 5 ml every hour was used, less consumption of local anesthetic and less need for PCA were seen. Very likely, every bolus generates a higher injection pressure as compared to the previously mentioned slow infusion. This pressure might help in overcoming anatomical distances between the catheter tip and the targeted nerve, reaching the two trunks of the sciatic nerve more easily and providing effective pain relief by reducing overall consumption of local anesthetic. In addition, the need for PCA in these patients was low. Patients receiving a CI of 5 ml/h required more local anesthetic and PCA; maybe, as stated previously, this infusion was insufficient to reach the two trunks of the sciatic nerve.

Advantages of ARB administration were observed by other investigators in epidural labor analgesia. This new dosing regimen reduced the amount of medication and provided better pain relief than a continuous epidural infusion.[17–19] Sia *et al.*[20] recently compared a basal infusion with automated intermittent boluses in labor epidural analgesia. He showed, as was the case in the current investigation, that the use of an intermittent epidural bolus reduced local anesthetic consumption and the need for additional PCA. He also suggested that the reduced need for patients´ self-supplementation could be attributed to the improved spread of local anesthetic with intermittent epidural boluses as compared to a slow CI. Experimental studies also demonstrated that the use of an intermittent bolus was found to result in a wider and more uniform spread of solution in the epidural space when compared with a CI.[21–22]

To further improve postoperative analgesia in continuous sciatic nerve blockade, some investigators have suggested the use of stimulating catheters[5,7,9] or ultrasound[23–25] as a means to confirm proper perineural positioning of the catheter tip. Future studies are necessary to show if the new dosing regimen of ARB administration proves superior to a CI of local anesthetic when stimulating catheters are used. In the current investigation, we used a single end-port catheter. The results obtained comparing these two infusion methods might differ using a catheter with a different port configuration.

In conclusion, the current investigation demonstrated that local anesthetic administered as an ARB combined with PCA provided similar pain relief in continuous popliteal sciatic block as a CI technique combined with PCA; however, the new dosing regimen reduced the need for PCA and the consumption of local anesthetic. More studies are needed to determine the optimal volume, time interval, and drug concentration for use with this technique and whether this technique offers benefits for other peripheral nerve blocks.

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ANESTHESIOLOGY REFLECTIONS

Bengué Methyl Chloride Cylinder

The brass and copper cylinder (pictured here) features a refrigerant first popularized as a cooling topical and then as a general anesthetic by French pharmacist Jules Bengué. Translated from the French, the cylinder's plaque reads "Pure Methyl Chloride of Doctor Bengué; Patented Devices, Airtight Guarantee; Dr. Bengué Pharmacist, 16 Ballu Street, Paris." By 1901 use of the chemical had grown, largely because methyl chloride comprised 30% of Somnoform, an irrational general anesthetic mixture. Two decades later, methyl chloride (leaking from a refrigerator) may have contributed to a nightclub fire in 1942 inside Boston's Cocoanut Grove. Today, methyl chloride's flammability and spectacular profile of side effects (neurotoxicity, birth defects, and even frostbite) have sidelined its clinical and most of its industrial use. Luckily for Dr. Bengué, his business in balms outlasted his one in anesthetics. Today, Americans know the late pharmacist's arthritis liniments as "Bengay®." (Copyright © the American Society of Anesthesiologists, Inc. This image appears in the *Anesthesiology Reflections* online collection available at www.anesthesiology.org.)

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