The Use of a Continuous Popliteal Sciatic Nerve Block After Surgery Involving the Foot and Ankle: Does It Improve the Quality of Recovery?

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Popliteal sciatic nerve block is a commonly used technique for surgery involving the foot and ankle. However, pain can be difficult to control as the local anesthetic block wears off. Therefore, we hypothesized that extending the block by using a continuous infusion of bupivacaine (0.25%) would provide improved pain management and might facilitate the recovery process after foot or ankle surgery. In this randomized, double-blinded, placebo-controlled study, 24 consenting patients undergoing foot or ankle surgery with a standardized general anesthetic technique were studied. Before surgery, a popliteal sciatic nerve block was performed in all patients with an 18-gauge Tuohy epidural needle and a peripheral nerve stimulator. After injection of bupivacaine 0.25% 30 mL and placement of a 20-gauge catheter, patients were randomly assigned to receive either 0.9% saline (control) or bupivacaine 0.25% at a constant rate of 5 mL/h for up to 48 h after surgery. An 11-point verbal rating scale (0 = no pain to 10 = worst pain imaginable) was used to assess the severity of pain. Opioid analgesic use was recorded at specific time intervals after surgery. Follow-up evaluations were performed at 24 h, 48 h, 72 h, and 1 week after surgery to assess pain scores, as well as patient satisfaction with their pain management and quality of recovery, by using a 100-point verbal rating scale (1 = highly dissatisfied to 100 = highly satisfied). In the bupivacaine group, there was a statistically significant reduction in the maximal pain scores (>50%) and in opioid use (>60%) during the postoperative period compared with the control group. Patient satisfaction with postoperative pain management (95 ± 3 versus 77 ± 13) and quality of recovery (96 ± 7 versus 83 ± 14) was significantly improved in the bupivacaine group (versus control). In addition, 40% of the patients in the bupivacaine group (versus none in the control group) were able to be discharged home on the day of surgery ($P = 0.087$). In conclusion, a continuous infusion of bupivacaine 0.25% decreased postoperative pain and the need for opioid analgesic rescue medication after orthopedic surgery involving the foot and ankle, leading to improved patient satisfaction and quality of recovery.

(Anesth Analg 2003;97:1303–9)

Continuous peripheral neural blockade (CPNB) techniques were first described >50 yr ago for the management of postoperative pain (1). However, renewed interest in the use of these CPNB techniques is a result of the availability of improved needle and catheter insertion techniques and simplified drug delivery systems, as well as efforts to facilitate an earlier discharge after painful orthopedic procedures. Many reports have described the potential usefulness of these techniques in the postoperative period after major orthopedic procedures involving the lower extremities (2–9). Increasingly, CPNB techniques are being used outside the hospital to treat patients undergoing painful ambulatory surgery procedures (9–12).

In a recently published study, Ilfeld et al. (12) demonstrated that the use of a continuous popliteal sciatic nerve block with an electronic pump for pain control after lower extremity surgery decreased pain, opioid use, and side effects while improving overall patient

The medical supplies required for this study were provided by I-Flow Corporation (Lake Forest, CA) and B. Braun (Bethlehem, PA). Departmental resources and funds from the McDermott Chair of Anesthesiology were used to support Dr. White's clinical research program.

Accepted for publication June 3, 2003.

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DOI: 10.1213/01.ANE.0000082242.84015.D4

0003-2999/03

satisfaction. Although reports describing the successful use of CPNB techniques for pain control after major orthopedic procedures in the ambulatory setting are very encouraging (9–12), there have also been reports describing technical difficulties related to pump malfunctions, as well as misplaced, displaced, and obstructed catheters (13–15). In the study by Ilfeld et al. (12), 30% of the patients required unscheduled phone calls after discharge. A recent report by Capdevila et al. (16) found that the use of disposable elastomeric pumps for CPNB was associated with fewer technical problems and greater patient satisfaction than electronic pumps. Similarly, comparative evaluation of electronic versus nonelectronic patient-controlled analgesic (PCA) devices demonstrated that the use of a nonelectronic device was associated with fewer programming errors and greater patient and nurse satisfaction (17). Therefore, additional studies are needed to evaluate the effect of CPNB by using nonelectronic devices on clinically important patient outcome variables after orthopedic surgery (e.g., pain scores, hospital discharge, resumption of normal activities, and patient satisfaction).

We designed a prospective, randomized, placebo-controlled study to assess the benefits of a CPNB after surgery involving the foot and ankle by using a disposable, nonelectronic (elastomeric) device. We hypothesized that the use of a continuous popliteal perineural block with bupivacaine 0.25% would improve pain management after these orthopedic procedures. We also examined patient outcome with respect to their satisfaction with pain management and the quality of their recovery.

Methods

After we obtained IRB approval at the University of Texas Southwestern Medical Center and written, informed consent, 24 healthy patients (aged 18 to 85 yr) undergoing foot (e.g., bunionectomies or clawtoe/hammertoe corrections) or ankle (e.g., bone fusions or internal fixation) procedures were enrolled in this double-blinded, placebo-controlled study. Patients were excluded if they were allergic to local anesthetics, had an active infection involving their lower extremity, were pregnant (or lactating), had any neurological dysfunction or diabetes, had a history of chronic opioid (narcotic) analgesic use or drug abuse, or had unstable cardiovascular, renal, or hepatic diseases. In addition, patients who were not able and willing to comply with the instructions for using the elastomeric pump after surgery were excluded from participating in the study.

In the preoperative holding area, patients completed a baseline pain assessment by using an 11-point verbal rating scale (VRS), with 0 = no pain to 10 = worst pain imaginable. After standard noninvasive monitors were applied, midazolam 1–2 mg IV and fentanyl 50–150 μg IV were administered for sedation and analgesia, respectively, before the nerve block procedure was performed. An attending anesthesiologist (GDS) experienced in performing popliteal nerve blocks for lower extremity surgery performed all the block procedures by using a modification of the original technique of Singelyn et al. (2) as described by Brown (18).

The patients were placed in the prone position, and the popliteal crease was identified. The cephalo-lateral quadrant was identified, and local skin infiltration was performed by using 1% lidocaine at a point 5 cm above the popliteal crease and 1 cm lateral (Fig. 1A). The Stimuplex HNS11 peripheral nerve stimulator (B. Braun Medical Inc., Bethlehem, PA) was connected to an insulated 18-gauge Tuohy needle; an appropriate motor response was initially achieved by using a 1.0-mA current and was then decreased to 0.5 mA. A total of 30 mL of 0.25% bupivacaine was injected through the needle in all cases. A 20-gauge epidural catheter was inserted approximately 2–3 cm beyond the tip of the needle, and after the needle was removed, the catheter was carefully secured in place (Fig. 1B). Before entering the operating room (OR), patients were assigned to one of two study groups according to a computer-generated randomization number table. The control group received an infusion of 0.9% saline, and the bupivacaine group received an infusion of generic bupivacaine 0.25% at 5 mL/h for up to 48 h after surgery by using a disposable elastomeric pump (C-bloc™ PNB system; I-Flow Corp., Lake Forest, CA) connected to the catheter. The pump reservoir contained 270 mL of the study drug (either 0.9% saline or 0.25% bupivacaine) and was filled by a hospital OR pharmacist who was not directly involved in the study.

The patient was promptly transferred to the OR, and standard monitors were applied. The presence of hypesthesia in the distribution of the popliteal nerve was documented by using a needle tip and alcohol sponge. General anesthesia was induced within 15 min after the block was performed, by using propofol 1.75–2.5 mg/kg IV and fentanyl 0.75–1.5 μg/kg IV. Anesthesia was maintained with desflurane (3% end-tidal concentration) in combination with air (0.5 L/min) and oxygen (0.5 L/min). Supplemental bolus doses of sufentanil 5 μg IV were administered as needed to treat acute autonomic responses and/or purposeful movements during the operation.

On awakening from general anesthesia, patients were transferred to the postanesthesia care unit (PACU). Patients were asked to evaluate the severity of their pain on the 11-point VRS at 1, 2, 4, 8, 24, 48, and 72 h after surgery. Patients with severe pain (VRS scores $\geq$6) in the PACU were administered 1- to 2-mg IV bolus doses of morphine and were started on PCA

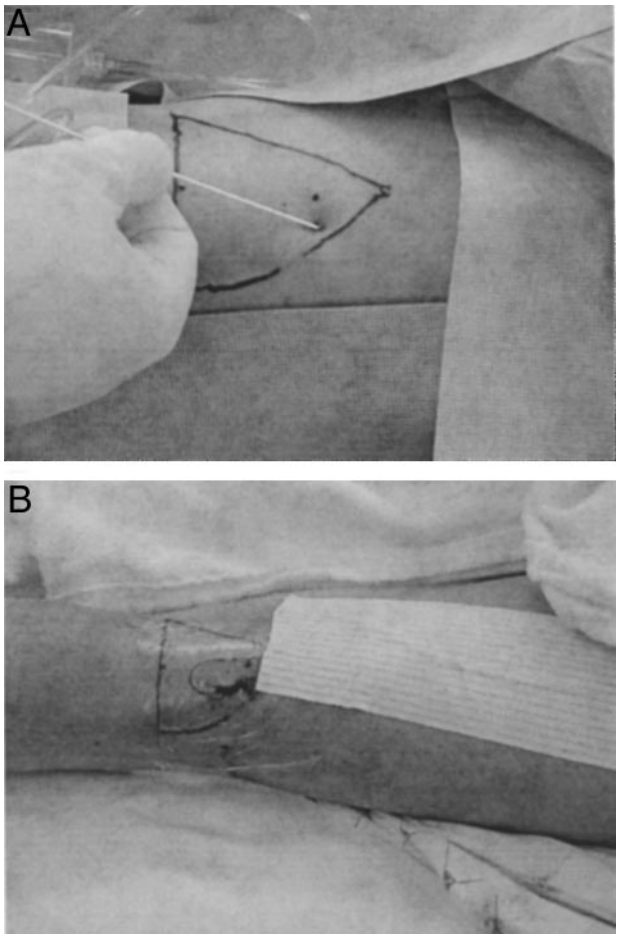

Figure 1. A, Insertion of the needle was performed at a 45°–60° angle, as described by Brown (18). B, The catheter was secured by spraying the skin surface with compound benzoin tincture and applying Tegaderm and silk tape to avoid catheter displacement when the patient began to move the extremity after surgery.

morphine, 1- to 2-mg bolus doses on demand with a 5- to 10-min lockout interval. Patients complaining of moderate pain (VRS >3 and <6) were treated with morphine, 1- to 2-mg IV boluses, until acceptable pain relief was achieved (VRS <3). Patients with VRS pain scores of 2–3 received an oral opioid-containing analgesic (e.g., hydrocodone [5 mg] and acetaminophen [500 mg]). If patients complained of nausea or experienced repeated episodes of vomiting or retching, they were treated with dolasetron 12.5 mg IV, and if the emetic symptoms persisted, promethazine 6.25-mg IV boluses were administered to a total dose of 25 mg.

Postoperative side effects (e.g., pain, dizziness, nausea, and vomiting) and the requirements for rescue analgesic and antiemetic drugs were recorded, along with the duration of stay in the PACU. If the patient's pain was adequately controlled (VRS <3) in the PACU with oral analgesic medication, he or she was considered to be eligible for discharge home on the day of surgery. However, the decision to discharge a patient home after surgery was made by the orthopedic surgeon (JSE) when the patient had achieved specific discharge criteria (e.g., satisfactory pain control with oral analgesics and the ability to mobilize safely with or without assistance devices as assessed by a physical therapist). The patients were carefully instructed in the management of the C-bloc device by an orthopedic nurse before and again after the operation. The catheter was removed by the patients at home when the reservoir was empty.

All patients were asked to record use of oral pain medication and side effects in a diary. Follow-up telephone evaluations were performed by a blinded observer (TI) at 24 h, 48 h, 72 h, and 1 wk after surgery to determine the number of doses of oral analgesic medications consumed after discharge and the occurrence of any side effects (e.g., dizziness, weakness, urinary retention, ileus, and nausea and/or vomiting). Patient satisfaction with postoperative pain management and the quality of the recovery was assessed at 24 h after surgery by using a 100-point VRS, with 1 = poor to 100 = excellent. Patients who rated their satisfaction with pain management as >95 (on the 100-point VRS) were considered to have "complete" satisfaction with their pain control. Finally, the patients also evaluated their maximal (peak) postoperative pain by using the 11-point VRS at 24 h after surgery.

An *a priori* power analysis suggested that minimum group sizes of 9 would be necessary to detect a 60% reduction in the postoperative pain scores in the bupivacaine group (assuming a mean pain score of 5 and an SD of 2 in the control group), with a power of 0.8 and an α of 0.05. Data analysis was performed with StatView for Windows Version 5.0.1 (SAS Institute, Cary, NC). Normally distributed continuous data were analyzed with one-way analysis of variance, and continuous data not normally distributed were analyzed by a Kruskal-Wallis analysis of variance. Postoperative pain scores were analyzed by a repeated-measures analysis of variance. Means were analyzed with a Type III sum of squares analysis of variance where model = treatment. Categorical data and frequencies were analyzed with the χ^2 test with Yates' continuity correction or Fisher's exact test, where appropriate. Data are presented as mean ± SD, median (interquartile range), and numbers or percentages. A P value <0.05 was considered statistically significant.

Results

Of the 24 patients enrolled in the study, 4 were eliminated from the data analysis because of catheter dislodgement before discharge from the hospital. There were no significant differences between the two treatment groups with respect to age, weight, sex, types

and durations of surgery and anesthesia, and types and amounts of anesthetics administered during surgery (Table 1). However, the bupivacaine group required significantly less sufentanil during the intraoperative period (9 ± 9 μg versus 21 ± 16 μg; $P < 0.05$). Although the patients receiving the bupivacaine infusion spent less time in the PACU (69 ± 33 min versus 98 ± 50 min), this difference failed to achieve statistical significance. Fewer patients in the bupivacaine (versus control) group required overnight hospitalization for pain management (6 of 10 versus 10 of 10, respectively; $P = 0.09$), and the average length of the hospital stay was significantly shorter in the bupivacaine (versus control) group (0.7 ± 0.7 days versus 1.4 ± 0.5 days; $P = 0.05$). Of note, two of the six admitted patients in the bupivacaine group remained in the hospital overnight because of "social" reasons (namely, a long travel distance to their home).

The preoperative baseline pain scores were similar in the two groups. However, postoperative pain VRS scores were consistently lower in the bupivacaine group during the 48 h after surgery (Fig. 2). In addition, the maximal (peak) pain scores before and at 24 h after discharge were significantly lower in the bupivacaine (versus control) group (Table 2). Patients in the bupivacaine group required 70% less PCA morphine than those in the control group (Table 2). The need for rescue antiemetic drugs before discharge was also reduced in the bupivacaine group (10% versus 40%).

All the patients in the control group required oral opioid-containing analgesics after surgery. However, 40% of the patients in the bupivacaine group required no oral opioid analgesics after surgery. Although none of the patients complained of leg weakness or numbness, a larger percentage of patients in the bupivacaine (versus control) group reported feeling a tingling sensation in their foot (80% versus 10%; $P < 0.05$) when directly queried about the presence of any abnormal sensations. The percentage of patients who were completely satisfied with their postoperative pain management was also significantly larger in the bupivacaine (versus control) group (90% versus 10%; $P < 0.05$) at the 24-h follow-up assessment period (Table 2). Finally, patient satisfaction with the postoperative pain management and quality of recovery was significantly improved in the bupivacaine (versus control) group (Table 2).

Discussion

Effective pain control after outpatient surgery remains a clinically significant concern because it has a large effect on the recovery process and patient satisfaction with postoperative care (19,20). Local anesthetic infusions are increasingly being used alone and in combination with opioid and non-opioid analgesics for the treatment of pain after orthopedic surgery procedures performed in the ambulatory setting (9–12). In this study involving an adult surgery population undergoing foot and ankle surgery, a continuous popliteal sciatic nerve block with 0.25% bupivacaine during and after surgery was effective in reducing hospital admissions for pain management. These data would suggest that the use of a CPNB to decrease pain and the need for parenteral analgesic medication can facilitate an earlier discharge from the hospital. The opioid-sparing effect also resulted in a less frequent incidence of opioid-related side effects (e.g., a decreased need for rescue antiemetics). Finally, the local anesthetic infusion improved patient satisfaction with pain management and the overall quality of recovery.

In reviewing the existing literature on the use of CPNB for painful orthopedic procedures involving the distal lower extremity (2,7–9,12), various research groups have reported improved pain control and opioid-sparing effects. However, many of the early studies involving CPNB techniques failed to include a placebo (control) group. In a well controlled study by Capdevila et al. (3) involving patients undergoing major knee surgery, it was reported that the use of a CPNB technique facilitated the rehabilitation process. The current study involving patients undergoing major foot and ankle surgery also suggested that the use of a CPNB could facilitate the recovery process by allowing some patients to be discharged home on the day of surgery. Importantly, this study confirmed the recent placebo-controlled study by Ilfeld et al. (12), which also demonstrated an improvement in patient satisfaction with postoperative pain management and overall quality of recovery when a CPNB was used after outpatient surgery involving the foot and ankle.

In a case report, Lierz et al. (21) reported the successful infusion of a local anesthetic over six days in an ambulatory patient, without complications. In addition, Tuominen et al. (22) demonstrated that the use of a 0.25% bupivacaine infusion over 24 hours after shoulder surgery provided effective analgesia and was not associated with detectable (>0.05 μg/mL) serum bupivacaine levels. However, the local anesthetic infusion was interrupted in 6 of the 24 patients because of "a failure of catheter function." Although the current study demonstrated that a 0.25% bupivacaine infusion was effective over 48 hours in both inpatients and outpatients (who were discharged home within 24 hours after foot and ankle procedures), valid concerns regarding patient safety, as well as the efficacy of these techniques when used outside the hospital, will need to be addressed in larger-scale studies (13–15).

A major concern regarding the use of CPNB relates to the ability to maintain the catheter in the correct position as patients increase their physical activity in the postdischarge period. Problems with catheter displacement were observed after ambulation in the first

Table 1. Patient Demographic Characteristics, Type of Surgery, Anesthesia and Surgery Times, and Postoperative Admission Status in the Two Study Groups

Variable	Saline 0.9% (n = 10)	Bupivacaine 0.25% (n = 10)
Age (yr)	50 ± 15	58 ± 11
Weight (kg)	85 ± 26	86 ± 30
Sex (M/F) (n)	3/7	4/6
ASA physical status (I/II/III) (n)	1/7/2	1/6/3
Surgical procedures (n)		
Ankle	2	1
Foot	8	9
Baseline pain score (n)[a]	0 (0–6)	0 (0–4)
Surgery time (min)	109 ± 50	102 ± 69
Anesthesia time (min)	147 ± 44	140 ± 68
Propofol (mg)	169 ± 46	175 ± 53
Fentanyl (μg)	100 ± 54	117 ± 56
Sufentanil (μg)	21 ± 16	9 ± 9*
PACU stay (min)	98 ± 40	69 ± 33
Postoperative status (n)		
Same-day discharge	0	4
23-h admission	6	5
Inpatient admission	4	1
Tingling sensation in leg (%)	10	80*

Values are mean ± SD, median (range), numbers, or percentages.
PACU = postanesthesia care unit.
[a] Verbal rating scale: 0 = no pain to 10 = worst pain imaginable.
* $P < 0.05$ versus saline (control) group.

four patients enrolled in this study (two in each treatment group), necessitating a modification in the procedure used for securing the catheter in the popliteal fossa (Fig. 1B). Inadvertent catheter dislodgements were also reported in 2 of the 30 cases in the recently published study by Ilfeld et al. (12). Other concerns regarding the use of this technique outside the hospital relate to the potential for local anesthetic toxicity and complications secondary to the residual sensory and motor block (14). The lack of high-pressure or occlusion alarms in the disposable nonelectronic elastomeric infusion pump delivery systems may reduce the number of unscheduled phone calls when these devices are used outside the hospital. However, this may also allow catheter occlusions to go undetected with the elastomeric infusion systems. Another potential disadvantage in using a simple constant-rate elastomeric infusion system for CPNB is the inability to adjust the infusion rates or to administer bolus doses of the local anesthetic to treat inadequate analgesia.

It has been suggested that the use of a larger initial dose of bupivacaine (e.g., 35–45 mL) in combination with a vasoconstrictor (e.g., epinephrine) and/or other adjuvants (e.g., clonidine or ketorolac) may achieve a comparable opioid-sparing effect and patient satisfaction without the need for a continuous local anesthetic infusion in the postdischarge period. Furthermore, the addition of an on-demand PCA bolus feature (so-called patient-controlled perineural administration of local anesthesia) may have improved the quality of analgesia produced by the CPNB and further reduced the opioid analgesic requirement (13,16). Although

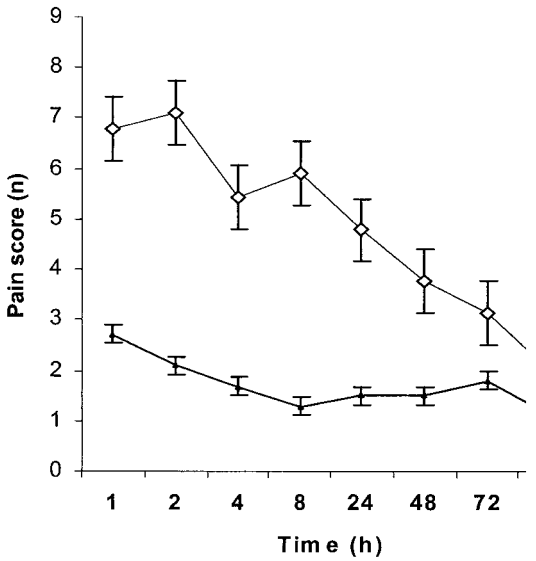

Figure 2. A verbal rating scale was used to assess postoperative pain (with 0 = no pain to 10 = worst pain imaginable) at specific intervals after the end of surgery in the control (-▲-) and bupivacaine (-◇-) treatment groups (n = 10 patients in each group). Values are mean ± SD. *$P < 0.05$ versus control.

Singelyn et al. (5) failed to demonstrate any advantage of a PCA technique over a continuous infusion after total hip arthroplasty procedures, other investigators have reported that supplementing a CPNB with intermittent bolus doses can lead to further improvement in pain control and, thereby, facilitate the rehabilitation process (13).

Table 2. Postoperative Pain Scores, Total Opioid Medication Used, and Patient Satisfaction and Quality of Recovery Scores at 24 Hours After Surgery in the Two Study Groups

Variable	Saline 0.9% (n = 10)	Bupivacaine 0.25% (n = 10)
Postoperative pain score, median (range)[a]		
POD 0	7.5 (2–9)	2.5 (0–10)*
POD 1	5 (2–8)	2 (0–3)*
POD 2	4 (0–6)	2 (0–10)
POD 3	5 (0–8)	2 (0–10)
POD 7	2 (0–5)	2 (0–3)
Rescue analgesic medication in PACU, n (%)	10 (100)	7 (70)
Reason for overnight admission, n (%)		
Pain control	10 (100)	4 (40)
Social (nonmedical) reason[b]	0 (0)	2 (20)
Maximal pain score at hospital (n)[a]	8 (6–10)	4 (0–10)*
Maximal pain score after discharge (n)[a]	7.5 (2–10)	2.5 (0–10)*
Total morphine required (mg)	34.7 ± 19.4	10.3 ± 13.6*
Required oral opioid analgesics, n (%)	10 (100)	6 (60)
Rescue antiemetic therapy, n (%)	4 (40)	1 (10)
Complete satisfaction with pain control (%)	10	90*
Patient satisfaction score[c]		
With anesthetic management (n)	96 ± 8	96 ± 7
With postoperative pain control (n)	77 ± 13	98 ± 3*
Quality of recovery (n)[c]	83 ± 14	96 ± 7*

Values are mean ± SD, median (range), or n (%).
POD = postoperative day; PACU = postanesthesia care unit.
[a] Verbal rating scale: 0 = no pain to 10 = worst pain imaginable.
[b] Excessively long travel distance to their home after the operation.
[c] Verbal rating scale: 1 = highly dissatisfied to 100 = highly satisfied.
* $P < 0.05$ versus saline (control) group.

Although both groups received the same dose of the local anesthetic before the induction of general anesthesia, the administration of the local anesthetic infusion (versus saline) during the operation resulted in an opioid-sparing effect during surgery. These data also suggest that the saline infusion may have diluted the initial 30-mL dose of bupivacaine and reduced its local analgesic efficacy. The additional 8–12 mL of 0.25% bupivacaine received during the operation appears to have improved the quality of the block. However, the primary benefit of this CPNB technique was related to improved postoperative analgesia, including a reduction in postoperative opioid requirements and opioid-related side effects (e.g., nausea and vomiting). In addition, the CPNB may allow even more painful orthopedic procedures to be performed on an ambulatory (or short-stay) basis in the future. However, further controlled studies are needed to determine the cost benefit of using this local analgesic technique. Although 80% of the patients receiving the local anesthetic infusion reported being aware of a tingling sensation in their lower extremity, it failed to adversely affect their ability to ambulate or their satisfaction with the pain management technique. The tingling sensation may have been related, in part, to postoperative tissue swelling.

This study supports the findings of Singelyn et al. (2), Chelly et al. (8), and Ilfeld et al. (12), in which electronic pumps were used to provide CPNB after foot and/or ankle surgery. The use of a disposable, nonelectronic device may facilitate the use of CPNB outside the hospital. Analogous to the findings of Klein et al. (9–11), who successfully used disposable pumps to administer continuous local anesthetic infusions after outpatient orthopedic procedures involving both the upper and lower extremities, we observed no complications related to this CPNB technique. Although this nonelectronic delivery system reduced flexibility with respect to dosage changes, it simplified the technique and reduced the risk of programming errors and unscheduled phone calls to respond to alarms (16,17). Further studies are needed to determine the optimal local anesthetic (e.g., lidocaine, bupivacaine, or ropivacaine), concentration (e.g., 0.125%, 0.25% or 0.5% bupivacaine), and infusion rate (e.g., 2.5, 5, or 10 mL/h) for CPNB techniques. Using a CPNB as part of a multimodal analgesic regimen should further enhance both the safety and efficacy of pain management in the ambulatory setting (23).

In conclusion, continuous popliteal nerve block with an elastomeric pump infusing bupivacaine 0.25% at rate of 5 mL/h decreases postoperative pain and the need for opioid analgesic medication and improves patient satisfaction with pain management after painful orthopedic procedures involving the foot and ankle.

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