Anesthesiology 2006; 105:566–73

Effect of Patient-controlled Perineural Analgesia on Rehabilitation and Pain after Ambulatory Orthopedic Surgery

A Multicenter Randomized Trial

Xavier Capdevila, M.D., Ph.D., Christophe Dadure, M.D.,† Sophie Bringuier, Pharm.D., M.Sc.,‡ Nathalie Bernard, M.D.,† Philippe Biboulet, M.D.,† Elisabeth Gaertner, M.D.,§ Philippe Macaire, M.D.‖*

Background: **Efficacy of continuous perineural and patient-controlled ropivacaine infusion at home after orthopedic surgery was compared with patient-controlled intravenous morphine for functional recovery and postoperative analgesia in a multicenter randomized trial.**

Methods: **Eighty-three patients scheduled to undergo acromioplasty or hallux valgus surgery received an interscalene (n = 40) or popliteal (n = 43) peripheral nerve block with 30 ml ropivacaine, 0.5%. After randomization, patients were discharged home 24 h after surgery with a disposable infusion pump delivering either patient-controlled intravenous morphine (n = 23) or perineural 0.2% ropivacaine infusion, either continuous infusion without bolus (n = 30) or basal infusion plus bolus (n = 30). The patients recorded pain scores on movement and/or walking and were directed to take paracetamol and rescue analgesics if necessary. The time necessary to be able to walk for 10 min; daily activities on days 1, 2, and 3; adverse events; and overall satisfaction scores were noted and graded by the patient.**

Results: **Basal–bolus ropivacaine decreased the time to 10 minutes' walk, optimized daily activities ($P < 0.01$), and decreased the amount of ropivacaine used. The morphine group had greater pain scores and consumption of morphine and ketoprofen compared with both ropivacaine groups ($P < 0.05$). The incidence of nausea/vomiting, sleep disturbance, and dizziness increased, and the patient satisfaction score decreased in the morphine group ($P < 0.05$).**

Conclusions: **After ambulatory orthopedic surgery, 0.2% ropivacaine delivered as a perineural infusion using a disposable elastomeric pump with patient-controlled anesthesia bolus doses optimizes functional recovery and pain relief while decreasing the consumption of rescue analgesics and ropivacaine, and the number of adverse events.**

This article is featured in "This Month in Anesthesiology." Please see this issue of ANESTHESIOLOGY, page 5A.

* Professor and Head of Department, † Staff Anesthesiologist, ‡ Clinical Research Coordinator, Department of Anesthesiology and Critical Care Medicine, Lapeyronie University Hospital. § Staff Anesthesiologist, Department of Anesthesiology and Critical Care Medicine, Hautepierre University Hospital, Strasbourg, France. ‖ Staff Anesthesiologist, Department of Anesthesiology and Critical Care Medicine, Centre Clinical, Soyaux, France.

Received from the Department of Anesthesiology and Critical Care Medicine, Lapeyronie University Hospital, Montpellier, France. Submitted for publication November 17, 2005. Accepted for publication May 26, 2005. Support was provided solely from institutional and/or departmental sources. Presented in part at the Annual Meeting of the American Society of Anesthesiologists, Las Vegas, Nevada, October 23–27, 2004.

Address correspondence to Dr. Capdevila: Department of Anesthesiology and Critical Care Medicine, Lapeyronie University Hospital, Avenue du Doyen G Giraud, Montpellier, France. x-capdevila@chu-montpellier.fr.

POSTOPERATIVE pain and recovery are major challenges in the practice of anesthesia for ambulatory orthopedic surgery.[1–3] Nerve block anesthesia provides superior same-day recovery[4] and decreases hospital readmission[5] compared with general anesthesia. Despite the use of long-acting local anesthetics in peripheral nerve blocks, 11% of patients reported wound pain during the first 24–48 postoperative hours, and 17–22% of patients required opioid analgesics 7 days after surgery.[6,7] Single-injection regional anesthesia provides early but not long-term benefit compared with general anesthesia.[8] Continuous perineural infusion of local anesthetic at home decreases postoperative pain, opioid use, opioid-related side effects, and sleep disturbances after moderately painful orthopedic surgery.[9–15] Furthermore, continuous infusion of local anesthetic combined with patient-controlled bolus doses optimizes analgesia and increases the duration of infusion in comparison with continuous infusion or bolus alone.[12,13] These studies are placebo-controlled trials[9,10,11,15] where placebo group patients received rescue oral or intravenous opioids or comparisons of dosing regimens of local anesthetic.[12,13] Among the multiple aspects of this analgesic technique, no comparisons with patient-controlled analgesia intravenous morphine and, most importantly, no information on how additional outcomes (*e.g.*, patient's daily activity and functional capacity) are affected by ambulatory continuous peripheral nerve blocks are available. Inpatient data suggested that continuous peripheral nerve blocks improve pain relief and early rehabilitation after orthopedic surgery, thereby hastening convalescence.[16–18] We hypothesized that patient-controlled perineural analgesia at home enhances the patient's postoperative health-related quality of life and reduces pain compared with intravenous morphine patient-controlled analgesia. The primary objective of this multicenter randomized comparative trial was to determine whether patient-controlled perineural analgesia provides optimal postoperative patient functional exercise capacity and daily activity at home. Secondary outcomes investigated postoperative analgesia, opioid-related side effects, and overall satisfaction.

Materials and Methods

After obtaining approval from the Institutional Review Board of Lapeyronie University Hospital Center (Mont-

pellier, France) and written informed consent, we prospectively enrolled 85 adult patients scheduled to undergo ambulatory, unilateral, acromioplasty, or hallux valgus surgery, who desired peripheral nerve block for the perioperative period, in two university hospitals and one private institution. Inclusion criteria were age 18 yr or older; American Society of Anesthesiologists physical status I, II, or III; understanding of the possible complications related to local anesthetic, the study protocol, and care of the catheter and elastomeric pump; and a nurse from a home care service managing the patient twice a day and capable of removing the catheter in the evening of postoperative day 3. Patients who did not cooperate and those who had psychological disorders or linguistic difficulties that might interfere with pain assessments were excluded. Medical exclusion criteria were severe bronchopulmonary disease, blood clotting impairment, hepatic or renal insufficiency, history of recent local or systemic infection, known allergy to the trial drugs, any previous damage to the nerve, plexus neuropathy or neuraxis disease, and cardiac conduction problems (second- or third-degree atrioventricular block). In addition, patients who refused, patients who had participated less than 1 month previously in a therapeutic trial, and those who were already participating in another study were not included in the study.

Continuous Peripheral Nerve Block Procedure

Patients were premedicated with 0.1 mg/kg oral midazolam 1 h before surgery. They had a peripheral intravenous catheter inserted and were placed in the prone position for popliteal nerve block and supine for interscalene block. Preoperatively, patients were monitored during peripheral nerve blocks according to the standard guidelines published by the French Society of Anesthesiology and Critical Care Medicine. Oxygen (6 l/min) was administered *via* a facemask. Experienced anesthetists performed all of the blocks. The following procedures were standardized: a conventional aseptic procedure was used to insert interscalene block for those undergoing acromioplasty and popliteal block catheters for those undergoing hallux valgus surgery; the anesthesiologist wore a mask, cap, sterile gown, and gloves. The puncture site was prepared with 10% povidone iodine solution, and surrounding areas were covered with sterile drapes. The continuous interscalene and popliteal blocks were performed in all patients using nerve stimulators (Stimuplex® HNS 11; B. Braun Melsungen AG, Melsungen, Germany) according to the modified lateral technique for interscalene block[19] and the Singelyn technique for popliteal block[20] before perioperative sedation or induction of general anesthesia. Insulated short-beveled needles (Plexolong®; Pajunk, Geisingen, Germany, or Contiplex®; B. Braun Melsungen AG) were connected to the nerve stimulator. The placement of the needle was considered successful when a specific muscle contraction (triceps muscle or plantar flexion) was obtained with a current output of less than 0.5 mA (frequency 1 Hz and impulse duration 100 μs). The nonstimulating 20-gauge catheter was then inserted through the needle for 3 cm (interscalene block) to 5 cm (popliteal block). The catheter was subcutaneously tunneled for 4 cm through the insulated needle and secured with adhesive strips and a transparent adhesive dressing (Opsite®; Smith and Nephew Medical Ltd., Hull, United Kingdom). If the catheter could not be placed after three attempts, the patient was withdrawn from the study. After tests for endovascular placement (aspiration; injection of 2 ml lidocaine, 2%, with 1:200,000 epinephrine), anesthesia was induced *via* the catheter with 30 ml ropivacaine, 0.5%, with gentle aspiration between divided doses. A block was considered successful when sensory (inability to recognize cold temperatures with an ether-soaked cotton swab on the tip of the first and third finger [interscalene block] or dorsal and plantar parts of the foot [popliteal block]) and motor block (inability to extend the arm [interscalene block] involving the radial and median nerve or plantar and dorsal flexion abolished [popliteal block]) were present 30 min after injection of ropivacaine. Specific nerve distribution of sensory blockade was evaluated. The block was considered to have failed when sensory and motor blocks were not noted or when patients needed general anesthesia because of pain during surgery. Intraoperatively, patients received a 10- to 30-$\mu g \cdot kg^{-1} \cdot min^{-1}$ propofol infusion titrated to the patient's desired level of sedation. If preferred by the patient, higher doses of propofol were used to administer general anesthesia, and mechanical ventilation was applied *via* a Proseal® laryngeal mask (Laryngeal Mask Company, Henley-on-Thames, United Kingdom) with a 1:1 mixture of nitrous oxide and oxygen. Durations of surgery and tourniquet were noted. After surgery, patients were admitted to the postanesthesia care unit after a wound dressing and an arm or leg splint had been applied. All patients received 4 mg intravenous ondansetron as standard antiemetic prophylaxis.

Randomization

After successful placement of the block and catheter, patients were randomly assigned to one of three groups using a computer-generated table (fig. 1). Ten minutes after arriving at the postanesthesia care unit, patients received either patient-controlled intravenous morphine (PCA morphine group, 0.5 mg/ml, bolus 2 ml, lockout period 12 min, no basal infusion) *via* 250-ml-reservoir disposable pumps with PCA chambers (PCA infusor®; Baxter, Maurepas, France) or 0.2% ropivacaine in one of the two dosing regimens: 7-ml/h continuous infusion without bolus (continuous infusion group) or 5-ml/h basal infusion and a patient-controlled bolus dose of 2 ml available every 12 min (basal–bolus group) *via* the same type of disposable pump (Multirate infusor®; Baxter). In

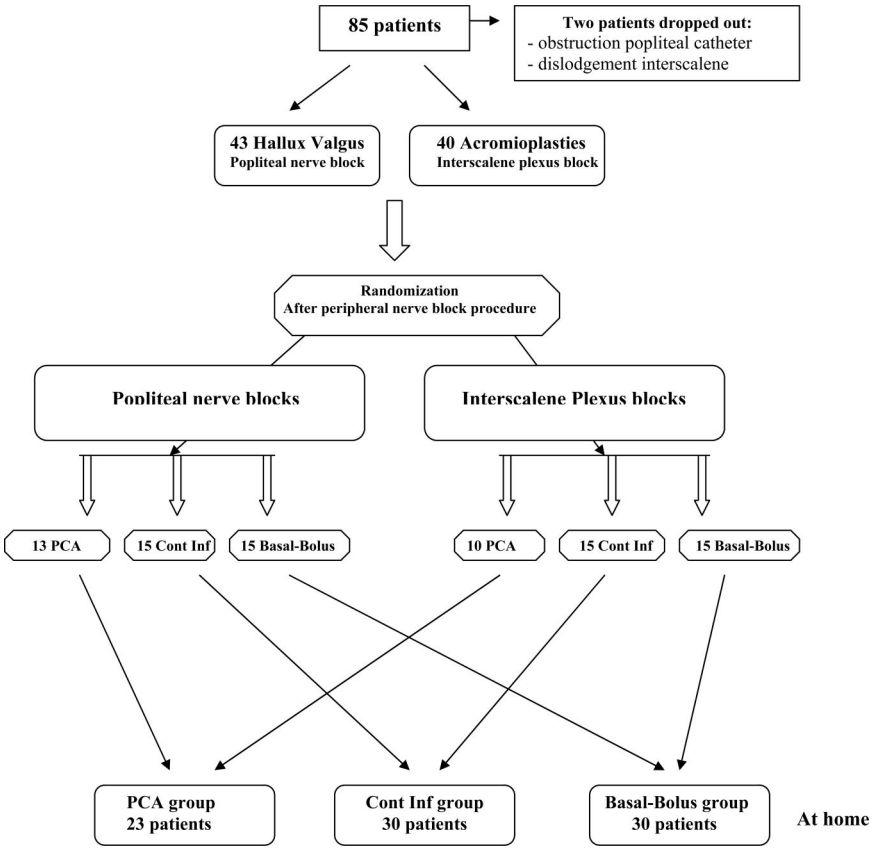

Fig. 1. Distribution of the patients in the three groups after randomization and dropout numbers. Basal–Bolus = basal–bolus group; Cont Inf = continuous infusion group; PCA = patient-controlled anesthesia morphine group.

the PCA morphine group, the perineural catheter was removed in the postanesthesia care unit.

Postoperative Patient Follow-up

The patients were transferred to the surgical ward for the first postoperative night. A nurse or an anesthesiologist blinded to the trial made a follow-up visit on the morning of the first postoperative day, and the patients were discharged home with the disposable pump if they met discharge-to-home criteria (satisfactory pain control and the ability to mobilize safely with or without assistance devices as assessed by a physical therapist).

The patient and nurse from the home care service were given standard postoperative outpatient instructions and written instructions on the use of the elastomeric pump. The nurse managed the patient twice a day at home and was instructed to fill and change the elastomeric pump with a new one if necessary. The patient was given a form to record the worst visual analog scale (VAS) pain scores (ranging from 0 mm for no pain to 100 mm for the worst imaginable pain) recorded 10 min after arrival in the postanesthesia care unit (H0); 1, 4, and 12 hours after H0; and every morning during physiotherapy or walking over 72 h. Throughout the study period, patients were directed to take 1 g paracetamol orally four times a day. The use of rescue analgesia was standardized. If the VAS score remained more than 30 mm, 100 mg ketoprofen was taken orally, and then a new VAS value was reported on the form 1 h after. The maximal dose was 300 mg daily. Consumption of morphine, ropivacaine, and rescue analgesics, as well as the number of boluses used, were noted at the end of the study period. Patients and nurses could contact a physician at any time during the study period by telephone. Follow-up telephone evaluations were performed by a blinded observer (S.B.) at 24, 48, and 72 h after surgery to determine the number of doses of oral analgesics consumed, the occurrence of any side effects (*e.g.*, local anesthetic toxicity signs [nurse], dizziness, weakness, paresthesia, nausea and vomiting, pruritus, urinary retention, mechanical problems with the catheter, ileus, sleep disturbance, sedation, acute respiratory failure, local vein inflammation, fever). According to the type or the patient's impact of the side effect, the observer informed the anesthetist responsible for the patient and possibly asked for a hospital admission. If complete anesthesia of the patient's surgical extremity appeared at any time, the nurse was instructed to clamp the disposable pump until the patient regained feeling and then restart the infusion. The catheter was removed by the nurse in the evening of the third day. The patients and physicians graded their satisfaction with the technique at the end of the study period (very satisfied, satisfied, mild satisfied, not satisfied).

Functional Outcome

Every morning, a physical therapist visited the patients. The physical therapist initiated early rehabilita-

tion in accordance with the objectives of the surgical team on the day after surgery and every morning at home during the study period. In hallux valgus surgery patients, he applied passive plantar and dorsal flexion movements and encouraged the patients to walk as long as possible at home. The patients wore a Barouk shoe. This heel weight–bearing shoe with total relief of forefoot pressure enhanced early mobilization. In patients scheduled to undergo acromioplasty, a sling was applied in the operating room. Every morning, the physical therapist applied passive pendular exercises: flexion below 60°, abduction below 30°, and circumduction. He supervised the patient in doing slight isometric exercises: external rotation, internal rotation, and extension.

For all patients, the time when a patient was able to walk for 10 min, free of any symptoms or adverse events and without any aid devices or human help, was noted by the physical therapist in the hospital or at home. The patients reported their daily activities in their diary on the evening of days 1, 2, and 3: walk in the house, professional occupation, domestic work in the kitchen, took a shower, mental activity, occupied with the children; and graded it: no activity, activity with assistance, free activity. They also reported the reasons for the absence of activity or the need for assistance: pain, fatigue, nausea/vomiting, numbness, paresthesia, dizziness, fear of falling, other cause of activity limitation. The diary was returned to the surgical center in an envelope *via* the French Postal Service.

Statistical Analysis

Statistical analysis was performed using SAS software version 8.2 (SAS Institute, Cary, NC) in the Medical Computer Programming Department of the University Hospital of Montpellier, France.

Sample size calculations were centered around our two hypotheses that a basal infusion of ropivacaine *via* a perineural catheter combined with patient-controlled bolus dose on one hand optimizes postoperative functional recovery and on the other hand decreases postoperative pain compared with patient-controlled intravenous morphine. We considered a 50% reduction in the time when a patient was able to walk for 10 min (mean time decreases from 40 h to 20 h) and in pain scores (mean pain score decreases from 30 mm to 15 mm on a scale of 0–100) to be clinically relevant. Based on an SD of 15 for the 10-min walking test and of 20 for the pain score values and assuming a two-sided type I error protection of 0.05 and a power of 0.80, 21.4 patients in each group were required to reveal a clinically significant difference for the 10-min walking test, and 30 patients were required for pain scores values. We chose the highest value to demonstrate statistically significant data on functional recovery and pain management. Postoperative rehabilitation data on day 1 were chosen as the primary criteria for analysis. The normality of distribution was determined using the Shapiro-Wilk test.

Table 1. Demographic Characteristics of Patients and Durations of Surgery and Tourniquet

	PCA Morphine	Continuous Infusion	Basal–Bolus
Age, yr	50 ± 12	57 ± 10	49 ± 11
Sex, F/M	14/9	20/10	20/10
Height, cm	166 ± 10	165 ± 7	167 ± 8
Weight, kg	66 ± 15	63 ± 21	69 ± 14
Surgery duration, min	69 ± 13	63 ± 21	69 ± 31
Tourniquet duration, min	73 ± 32	75 ± 18	77 ± 23

PCA = patient-controlled anesthesia.

Parametric data are reported as mean ± SD. Nonparametric data are graphically reported as median with 25th–75th and 10th–90th percentile whiskers or textually noted using the median (25th–75th centiles). For normally distributed data, multiple comparisons were made using one-way analysis of variance. For nonparametric data, the Kruskal-Wallis test was used when appropriate.

Categorical data were analyzed using the chi-square test or Fisher exact test when appropriate. When a significant difference appeared, a two-by-two comparison was performed and a Bonferroni correction was applied. $P < 0.05$ was considered significant.

Results

Eighty-five patients were approached for inclusion in the study. Of the 85 patients, 2 were eliminated from the data analysis because of obstruction of a popliteal catheter in a continuous infusion group patient and dislodgement of an interscalene catheter in a basal–bolus group patient, both in the operating room. Fifteen interscalene and 15 popliteal nerve blocks were included in each of the two perineural analgesia groups of patients. Ten acromioplasties and 13 hallux valgus surgeries were included in the PCA morphine group (fig. 1). There were no statistically significant differences between the groups in demographics or duration of surgery or tourniquet (table 1). All patients studied had complete motor and sensory blockades before surgery. Eight patients had supplemental general anesthesia during surgery in each group (patients' choice). The 22nd patient of the PCA morphine group was readmitted to hospital on day 2 for an acute respiratory depression because he received half of the entire content of the elastomeric pump during the second night after surgery. A mechanical problem with the PCA chamber was responsible for this adverse event. This patient received 50 mg intravenous morphine in 12 h. Although the study was originally designed to include 30 patients per group for VAS pain scores and 21.4 for functional recovery exercises, an interim analy-

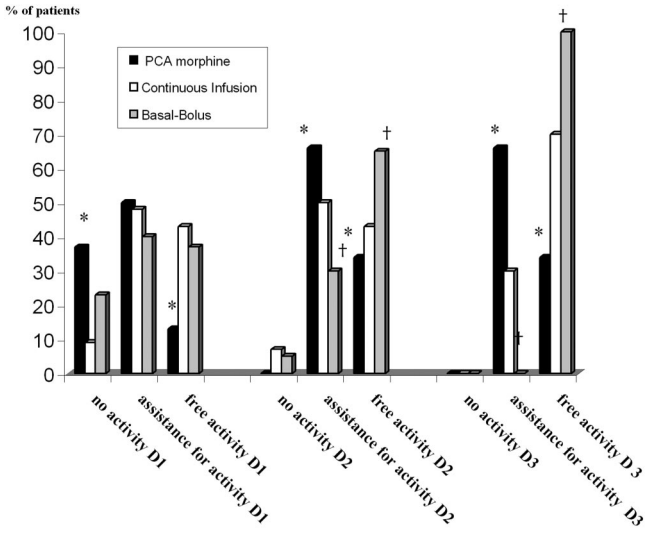

Fig. 2. Percentages of patients without daily activity, with assistance for daily activity, or with complete free activity at home in the three groups of patients. * $P < 0.05$ *versus* both regional anesthesia groups. † $P < 0.05$ *versus* the other two groups. PCA = patient-controlled anesthesia.

sis indicated a highly significant increase in functional exercise capacity and reduction in VAS pain scores and opioid-related side effects of the patients in both continuous perineural analgesia groups. Consequently, in compliance with the recommendations of our institutional review board, the study was aborted after the 23rd patient was tested in the PCA morphine group. The β risk remained at 20% after the reduction in our patient population. Six patients in the PCA morphine group, 2 patients in the continuous infusion group, and 1 patient in the basal–bolus group had episodes of breakthrough pain and were discharged from the hospital on day 2 ($P < 0.05$).

The time when a patient was able to walk for 10 min was significantly higher in the PCA morphine group: 40.5 (16–44) h, 20.5 (17–42) h, and 12.5 (4.5–20) h, respectively, for the PCA morphine, continuous infusion, and basal–bolus groups in median (25th–75th centile) values. The basal–bolus infusion of ropivacaine significantly optimized the patient's daily activities at home (fig. 2). One hundred percent of the basal–bolus group patients had complete free activity on day 3. The reasons for no activity or need for assistance during home activity are reported in table 2. The reasons were quite different in the PCA morphine group compared with both perineural analgesia groups, in particular regarding pain and fatigue.

During the 72-h infusion period, both groups of patients receiving ropivacaine experienced significantly less postoperative pain during movement compared with patients receiving PCA intravenous morphine (fig. 3). The total amount of ketoprofen (500 ± 100, 200 ± 100, and 100 ± 100 mg in the PCA morphine, continuous infusion, and basal–bolus groups, respectively) was

Table 2. Reasons for Activity Limitation in the Three Groups

	PCA Morphine, %	Continuous Infusion, %	Basal–Bolus, %
Fatigue	52*	33	16
Postoperative pain	47*	23	10
Paresthesia	0*	40†	23
Nausea/vomiting	33*	10	7
Numbness	0*	23	16
Dizziness	33*	10	10
Fear of falling	33	50‡	33
Other	13	10	10

* $P < 0.05$ *vs.* both regional anesthesia groups. † $P < 0.05$ *vs.* basal–bolus group. ‡ $P < 0.05$ *vs.* basal–bolus and patient-controlled anesthesia (PCA) morphine groups.

significantly increased in the PCA morphine group. The basal–bolus group had significantly decreased consumption of ropivacaine (377 ± 22 ml or 754 ± 44 mg *vs.* 488 ± 14 ml or 976 ± 28 mg). Nausea/vomiting, local vein inflammation, sleep disturbance, mechanical problems with the catheter, and dizziness significantly increased in the PCA morphine group (table 3). Patients experienced significantly more paresthesia in the continuous infusion group (table 3) in comparison with the basal–bolus group. No infection, local anesthetic toxicity, dyspnea (interscalene block), or disposable elastomeric pump problems were noted in the perineural infusion groups.

There were significant differences between the PCA morphine group and both perineural analgesia groups with regard to satisfaction with analgesia techniques for

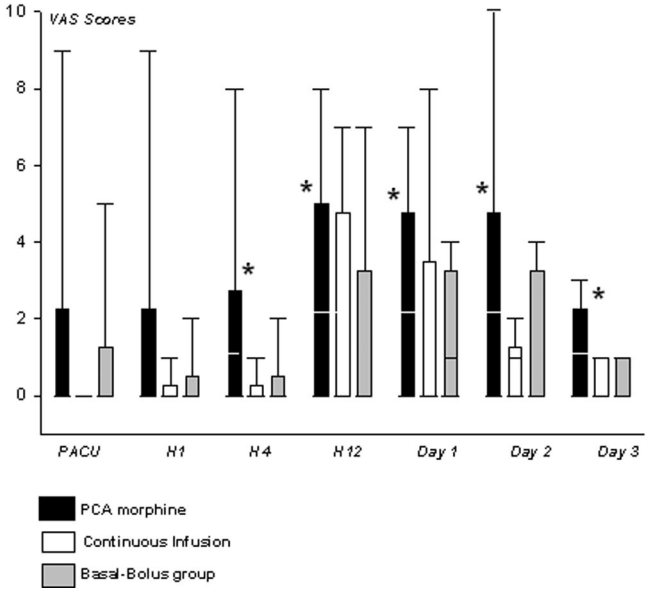

Fig. 3. Values of visual analog scale (VAS) pain score on movement in all patients in the postoperative period. The *black* and the *white lines* are the medians. The *box* represents the 25th–75th percentiles. The *extended bars* represent the 10th–90th percentiles. * $P < 0.05$ *versus* both regional anesthesia groups. Days 1, 2, and 3 = VAS pain scores during physiotherapy or movement in the morning of days 1, 2, and 3; H1, H4, and H12 = 1, 4, and 12 h after the first postanesthesia care unit measurement; PACU = 10 min after arrival in the postanesthesia care unit. PCA = patient-controlled anesthesia.

Table 3. Incidences of Adverse Events due to Technique and Drugs in the Postoperative Period

Adverse Event	PCA Morphine, %	Continuous Infusion, %	Basal–Bolus, %
Nausea/vomiting	39*	13	10
Dizziness	39*	10	6
Sleep disturbances	22†	10	3
Pruritus	13	7	0
Local vein inflammation	17*	0	0
Slight paresthesia	9	33‡	17
Numbness	0	6	3
Mechanical problem with IV or PNB catheter (kinking, dislodgment, occlusion)	39*	13	17

* $P < 0.05$ *vs.* both regional anesthesia groups. † $P < 0.05$ *vs.* basal–bolus group. ‡ $P < 0.05$ *vs.* basal–bolus and patient-controlled anesthesia (PCA) morphine groups.

IV = intravenous; PNB = popliteal nerve block.

patients and physicians. The basal–bolus group had a higher number of satisfied patients and physicians (table 4).

Discussion

This multicenter randomized clinical trial demonstrates that, in comparison with PCA intravenous morphine, a perineural infusion of ropivacaine at home *via* a disposable elastomeric pump provides statistically significant improvements in patients' functional exercise capacity and free home daily activity after ambulatory orthopedic surgery. VAS pain scores during physiotherapy and patient satisfaction were also improved. The basal–bolus infusion was the ideal technique because it decreased the consumption of ropivacaine and reduced the number of adverse events.

Study Limitations

Each group was divided equally into patients scheduled to undergo acromioplasties and hallux valgus surgeries. These procedures are eligible for ambulatory practice and are similar regarding the level of postoperative pain.[21] Other published studies have focused on shoulder or foot surgery regrouped hallux valgus correction and ankle open reduction or open rotator cuff repair and arthroscopic capsulotomy.[10–12,15] The postoperative pain and surgical management of these procedures are completely different.

The pain evaluations during the postoperative days were not performed under blinded conditions because of the clinical setting of the study. Rigorous scientific methods would have required placing a perineural catheter and attaching a PCA morphine pump in all patients (morphine or saline depending on the group). Because only the analgesic technique tested in each group would be used, obvious ethical reasons restrained our application of this method.

Outcome Measurements

The novelty of this study lies in the 72-h postoperative analysis of the postoperative analgesic technique impact on the quality of patients' daily activities and functional exercise capacity. We demonstrated that the basal–bolus infusion of ropivacaine significantly optimized the patients' daily activities at home on days 2 and 3 and that PCA morphine increased the time necessary for a patient to walk freely during 10 min. To our knowledge, it is the first time that a randomized multicenter study has demonstrated that patients receiving a perineural infusion for 72 h had higher quality functional outcome during the course of the first 3 days after ambulatory orthopedic surgery. The difference reported between both perineural infusion groups may be due to (although not significant) an increase in some adverse events in the continuous infusion regimen (*i.e.*, sleep disturbance, slight paresthesia, dizziness). Interestingly, the main reasons for no activity or need for assistance during home activ-

Table 4. Overall Patient and Physician Satisfaction Scores in the Three Groups

Overall Satisfaction Score	Not Satisfied, %	Mildly Satisfied, %	Satisfied, %	Very Satisfied, %
Patient satisfaction				
PCA morphine	9	35*	24	22*
Continuous infusion	3	17	23	57
Basal–bolus	7	13	17	63
Physician satisfaction				
PCA morphine	13	26	26	35*
Continuous infusion	3	17	17	63
Basal–bolus	13	0†	17	70

* $P < 0.05$ *vs.* both regional anesthesia groups. † $P < 0.05$ *vs.* the other two groups.

PCA = patient-controlled anesthesia.

ities were essentially pain and fatigue in the PCA morphine group. This result is in agreement with previous studies. Beauregard *et al.*[6] reported that postoperative pain after ambulatory surgery was severe enough to interfere with daily activities in a substantial number of patients. Postoperative pain limited activity level in 73% of patients at 24 h and 61% after 48 h. Walking activity was limited in 69% and 49% of the patients, respectively. Wu *et al.*[22] reported recently that poorly controlled postoperative pain limited physical activity and function of patients after total hip and knee surgery. In our study, 70% and 100% of the patients in the basal–bolus group had no limitation in their activity level or walking activity at 48 and 72 h, respectively. One might infer from the current study that excellent pain relief coupled with a reduction in side effects would contribute to facilitate postoperative mobilization at home. In inpatient shoulder and foot surgery, the effects of continuous perineural analgesia on the success of physical rehabilitation have not been fully studied,[23,24] but studies have reported that the improved analgesia provided by continuous femoral blocks resulted in faster short-term functional recovery of knee flexion.[16,17] For outpatients, such benefits were unknown until now. For clinically relevant reasons, we assessed our patients' functional exercise capacity with the measurement of the time achieved for a patient to walk freely during 10 min. We chose this time and not the distance covered during 10 min because it would be difficult to obtain a credible evaluation of the distance at home. On the other hand, in the postoperative period, we measured the capability of the patients to realize their daily activities at home with or without assistance. Controlled studies have covered hospitalized patients' perception of their recovery in the postoperative period.[22,25–27] However, in the validated survey instruments (Short Form-36 items, Short Form-12 items, Quality of Recovery score-40), some of the items used may not be appropriate for assessment of the quality of postoperative functional recovery; some questions related to limitations of either physical or mental health in patients at work, and redundancies appear between the pain domains of the questionnaires and VAS pain scores. Finally, Wu *et al.* [22] reported that problems are encountered with any health-related quality of life instrument in evaluating the effect of postoperative pain on quality of recovery on a daily basis, because these instruments were not designed to assess recovery in short time frames.

Postoperative Analgesia

Our results regarding painful foot and shoulder surgery confirm the significant superiority of perineural analgesia over opiate analgesia and are in agreement with controlled studies in hospitalized patients[20,28,29] and those involving patients discharged home with a perineural catheter.[10–12,15,30] In-hospital investigations highlighted the difference between perineural blocks and PCA intravenous morphine in providing more effective pain control during physiotherapy and mobilization,[16,17,20,28,29] but this comparison lacks a placebo-controlled trial regarding postoperative pain management at home.[9–11,15,30] Home PCA morphine is not considered standard after ambulatory surgery, but studies provide evidence that in the postoperative period, PCA morphine improves pain control and decreases opioid-related adverse effects compared with conventional opioid treatment.[31,32] As such, we thought that authors may have overstated the difference in postoperative pain measurements at home between patients receiving perineural infusion of local anesthetic and those receiving only oral analgesics in the event of breakthrough pain.[9–13] Our data suggest that the use of perineural analgesia to decrease levels of postoperative pain can facilitate earlier discharge from the hospital. White *et al.*[30] reported that 40% of the patients in a continuous popliteal nerve block group (*vs.* none in the placebo group) were able to be discharged home on the day of their foot surgery. Similarly, 26% of our PCA morphine group patients were not discharged home on the morning of day 1 because of episodes of breakthrough pain *versus* 6% in the continuous infusion group and 3% in the basal–bolus group.

Side Effects

We reported a lower incidence of nausea/vomiting, dizziness, and sleep disturbance in perineural analgesia group patients. These results are similar to previous studies[10–15] after outpatient orthopedic surgery. Patients rated vomiting as the most undesirable side effect after surgery,[33] and dizziness could limit free walking and the patient's daily activities. Consequently, patient satisfaction, as well as physician satisfaction, was significantly reduced in the PCA morphine group. In the current investigation, there were no medical complications attributable to the regional anesthesia technique (local anesthetic toxicity and complications secondary to sensory or motor blockades) in either perineural analgesia group. Continuous infusion group patients reported a higher incidence of slight paresthesia than patients in the other two groups. Borgeat *et al.*[23] and White *et al.*[30] also reported slight paresthesia or "tingling" in 30–80% of patients during continuous interscalene or popliteal nerve block. This adverse event did not affect the patients' ability to ambulate. No patient experienced dyspnea (interscalene block patients). Borgeat *et al.*[34] reported limited diaphragm muscle strength impairment when using 0.2% ropivacaine in continuous interscalene blocks.

As reported by other authors after outpatient orthopedic surgery,[12,13] the use of a 0.2% ropivacaine basal–bolus infusion technique decreased overall ropivacaine consumption compared with a continuous infusion

without limiting perioperative benefits. This limitation is of clinical importance because Zink *et al.*[35,36] demonstrated short- and long-term myotoxic effects of local anesthetics in a clinically relevant porcine model of continuous perineural analgesia.

In summary, our data demonstrate that for outpatient shoulder and foot surgery, a perineural basal–bolus infusion of 0.2% ropivacaine *via* a disposable elastomeric pump optimizes postoperative functional recovery, postoperative analgesia, and patient satisfaction while decreasing opioid requirements and their associated side effects, and consumption of ropivacaine. In the past decade, advances have been made to reduce postoperative pain at home. Investigations should now be focused on improvements in quality of functional outcome. Continuous peripheral nerve blocks are probably one of the key elements.

References

1. Chung F, Un V, Su J: Postoperative symptoms 24 hours after ambulatory anaesthesia. Can J Anaesth 1996; 43:1121–7
2. Chung F, Ritchie E, Su J: Postoperative pain in ambulatory surgery. Anesth Analg 1997; 85:808–16
3. Chung F, Mezei G: Factors contributing to a prolonged stay after ambulatory surgery. Anesth Analg 1999; 89:1352–9
4. Hadzic A, Williams BA, Karaca PE, Hobeika P, Unis G, Dermksian J, Yufa M, Thys D, Santos AC: For outpatient rotator cuff surgery, nerve block anesthesia provides superior same-day recovery over general anesthesia. ANESTHESIOLOGY 2005; 102:1001–7
5. Williams BA, Kentor ML, Vogt MT, Vogt WN, Coley KC, Williams JP, Roberts MS, Chelly JE, Harner CD, Fu FH: Economics of nerve block management after anterior cruciate ligament reconstruction. ANESTHESIOLOGY 2004; 100:697–706
6. Beauregard L, Pomp A, Choinière M: Severity and impact of pain after day-surgery. Can J Anaesth 1998; 45:304–11
7. Klein SM, Nielsen KC, Greengrass RA, Warner DS, Martin A, Steele SM: Ambulatory discharge after long-acting peripheral nerve blockade: 2382 blocks with bupivacaine. Anesth Analg 2002; 94:65–70
8. McCartney CJL, Brull R, Chan VS, Katz J, Abbas S, Graham B, Nova H, Rawson R, Anastakis DJ, Von Schroeder H: Early but no long-term benefit of regional compared with general anesthesia for ambulatory hand surgery. ANESTHESIOLOGY 2004; 101:461–7
9. Ifeld BM, Morey TE, Enneking F: Continuous infraclavicular brachial plexus block for postoperative pain control at home. ANESTHESIOLOGY 2002; 96:1297–304
10. Ifeld BM, Moreu TE, Wang D, Enneking K: Continuous popliteal sciatic nerve block for postoperative pain control at home. ANESTHESIOLOGY 2002; 97: 959–65
11. Ifeld BM, Morey TE, Wright TW, Chidgey LK, Enneking FK: Continuous interscalene brachial plexus block for postoperative pain control at home: A randomized, double-blinded, placebo-controlled study. Anesth Analg 2003; 96: 1089–95
12. Ifeld BM, Thanikary LJ, Morey TE, Griend RA, Enneking FK: Popliteal sciatic perineural local anesthetic infusion: A comparison of three dosing regimens for postoperative analgesia. ANESTHESIOLOGY 2004; 101:970–7
13. Ifeld BM, Morey TE, Enneking FK: Infraclavicular perineural local anesthetic infusion: A comparison of three dosing regimens for postoperative analgesia. ANESTHESIOLOGY 2004; 100:395–402
14. Rawal N, Allvin R, Axelsson K, Hallen J, Ekbäck G, Ohlsson T, Amilon A: Patient-controlled regional analgesia (PCRA) at home. ANESTHESIOLOGY 2002; 96: 1290–6
15. Klein SM, Grant SA, Greengrass RA, Nielsen KC, Speer KP, White W, Warner DS, Steele SM: Interscalene brachial plexus block with a continuous catheter insertion system and a disposable infusion pump. Anesth Analg 2000; 91:1473–8
16. Capdevila X, Barthelet Y, Biboulet P, Ryckwaert Y, Rubenovitch J, d'Athis F: Effects of perioperative analgesic technique on the surgical outcome and duration of rehabilitation after major knee surgery. ANESTHESIOLOGY 1999; 91:8–15
17. Singelyn FJ, Deyaert M, Jorist D, Pendeville E, Gouverneur JM: Effects of intravenous patient-controlled analgesia with morphine, continuous epidural analgesia, and continuous three-in-one block on postoperative pain and knee rehabilitation after unilateral total knee arthroplasty. Anesth Analg 1998; 87: 88–92
18. Chelly JE, Greger J, Gebhard R, Coupe K, Clyburn TA, Buckle R, Criswell A: Continuous femoral blocks improve recovery and outcome of patients undergoing total knee arthroplasty. J Arthroplasty 2001; 16:436–45
19. Borgeat A, Dullenkopf A, Ekatodramis G, Nagy L: Evaluation of the lateral modified approach for continuous interscalene block after shoulder surgery. ANESTHESIOLOGY 2003; 99:436–42
20. Singelyn FJ, Aye F, Gouverneur JM: Continuous popliteal sciatic nerve block: An original technique to provide postoperative analgesia after foot surgery. Anesth Analg 1997; 84:383–6
21. Bonica J: Postoperative pain, The Management of Pain, 2nd edition. Edited by Bonica J. Philadelphia, Lea & Febiger, 1990, pp 461–80
22. Wu CL, Naqibuddin M, Rowlingson AJ, Lietman SA, Jermyn RM, Fleischer LA: The effect of pain on health-related quality of life in the immediate postoperative period. Anesth Analg 2003; 97:1078–85
23. Borgeat A, Kalberer F, Jacob H, Ruetsch YA, Gerber C: Patient-controlled interscalene analgesia with ropivacaine 0.2% *versus* bupivacaine 0.15% after major open shoulder surgery: The effects on hand motor function. Anesth Analg 2001; 92:218–23
24. Cohen NP, Levine WN, Marra G, Pollock RG, Flatow EL, Brown AR, Bigliani LU: Indwelling interscalene catheter anesthesia in the surgical management of stiff shoulder: A report of 100 consecutive cases. J Shoulder Elbow Surg 2000; 9:268–74
25. Myles PS, Weitkamp B, Jones K, Melick J, Hensen S: Validity and reliability of a postoperative quality of recovery score: The QoR-40. Br J Anaesth 2000; 84:11–5
26. Myles PS, Hunt JO, Nightingale CE, Fletcher H, Beh T, Tanil D, Nagy A, Rubinstein A, Ponsford JL: Development and psychometric testing of a quality of recovery score after general anesthesia and surgery in adults. Anesth Analg 1999; 88:83–90
27. Wurn WH, Conception M, Sternlicht A, Carabuena JM, Robelen G, Goudas LC, Strassels SA, Carr DB: Preoperative interscalene block for elective shoulder surgery: Loss of benefit over early postoperative block after patient discharge to home. Anesth Analg 2003; 97:1620–6
28. Singelyn FJ, Seguy S, Gouverneur JM: Interscalene brachial plexus analgesia after open shoulder surgery: Continuous *versus* patient-controlled infusion. Anesth Analg 1999; 89:1216–20
29. Borgeat A, Tewes E, Biasca N, Gerber C: Patient-controlled interscalene analgesia with ropivacaine after major shoulder surgery PCIA *versus* PCA. Br J Anaesth 1998; 81:603–5
30. White PF, Issioui T, Skrivanek G, Early JS, Wakefield C: The use of a continuous popliteal sciatic nerve block after surgery involving the foot and ankle: Does it improve the quality of recovery? Anesth Analg 2003; 97:1303–9
31. Walder B, Schafer M, Henzi I, Tramer MR: Efficacy and safety of patient-controlled opioid analgesia for acute postoperative pain: A quantitative systemic review. Acta Anaesthesiol Scand 2001; 45:795–804
32. Wasylak TJ, Abbott FV, English MJ, Jeans ME: Reduction of postoperative morbidity following patient-controlled morphine. Can J Anaesth 1990; 37:726–31
33. Macario A, Weinger M, Carney S, Kim A: Which clinical anesthesia outcomes are important to avoid? The perspective of patients. Anesth Analg 1999; 89:652–8
34. Borgeat A, Perschak H, Bird P, Hodler J, Gerber C: Patient-controlled interscalene 0.2% *versus* patient-controlled intravenous analgesia after major shoulder surgery. ANESTHESIOLOGY 2000; 92:102–8
35. Zink W, Seif C, Bohl JR, Hacke N, Braun PM, Sinner B, Martin E, Fink RH, Graf BM: The acute myotoxic effects of bupivacaine and ropivacaine after continuous peripheral nerve blockades. Anesth Analg 2003; 97:1173–9
36. Zink W, Bohl JR, Hacke N, Sinner B, Martin E, Graf BM: The long term myotoxic effects of bupivacaine and ropivacaine after continuous peripheral nerve blocks. Anesth Analg 2005; 101:548–54