

Reduction of Verbal Pain Scores after Anterior Cruciate Ligament Reconstruction with 2-Day Continuous Femoral Nerve Block

A Randomized Clinical Trial

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Background: Single-injection femoral nerve block analgesia and spinal anesthesia have been associated with fewer postoperative nursing interventions and successful same-day discharge after anterior cruciate ligament reconstruction. In the current study, the authors prospectively determined the effect of continuous femoral nerve block on a numeric rating scale (NRS) of pain intensity with movement for 7 postoperative days.

Methods: Patients undergoing this surgery with no history of previous invasive surgery on the same knee were recruited for this study. After standardized spinal anesthesia, intravenous sedation, and perioperative multimodal analgesia, patients received a femoral nerve catheter with (1) saline bolus (30 ml) plus saline infusion (270 ml at 5 ml/h, placebo group); (2) levobupivacaine (0.25%) bolus with saline infusion (group I), or (3) levobupivacaine (0.25%) bolus and infusion (group II). Patients were surveyed preoperatively and on postoperative days 1–4 and 7 to determine NRS scores (scale 0–10).

Results: Data from 233 participants were analyzed. On days 1–2, 50% of placebo patients had NRS scores of 5 or above, whereas among group II patients, only 25% had scores of 5 or above ($P < 0.001$). In regression models for NRS scores during days 1–4, group II was the only factor predicting lower pain scores (odds ratios, 0.3–0.5; $P = 0.001$ –0.03). Overall, patients with preoperative NRS scores greater than 2 were likely to report higher NRS scores during days 1–7 (odds ratios, 3.3–5.2; $P < 0.001$).

Conclusions: Femoral nerve block catheters reliably keep NRS scores below the moderate-to-severe pain threshold for the first 4 days after anterior cruciate ligament reconstruction.

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IN the past several years, our research group has extensively studied patients undergoing anterior cruciate ligament reconstruction (ACLR), and specifically the effects of single-injection femoral nerve block analgesia and anesthetic technique on same-day discharge outcomes.^{1–5} From 1995 through 1999, we retrospectively evaluated the outcomes of 948 patients who underwent ACLR and found that the use of general anesthesia with volatile agents was associated with higher postanesthesia care unit (PACU) requirements, the need for parenteral nursing interventions for pain and postoperative nausea and/or vomiting, and the need for unplanned hospital admission.^{1–3} We reported that when using an anesthetic technique that facilitated PACU bypass and same-day discharge, most commonly spinal with femoral nerve block analgesia, the hospital cost savings potential per patient approximated \$800, when compared with patients who underwent general anesthesia with volatile agents with no nerve block and requiring PACU and hospital admission.⁴

Data from 129 respondents in our institution's ACLR population from 1998 to 1999 indicated that single-injection femoral nerve blocks provided effective but temporary pain relief. The mean numeric rating scale (NRS) pain score (on a scale of 0–10) was 1.8 while the block was effective, but the “rebound” NRS score was 5.3 immediately after nerve block resolution (unpublished data by lead author, July 1999). In two other studies, mean NRS scores on the first postoperative day (POD) after outpatient ACLR ranged from 4.5 to 6.8.^{6,7} It has become clear that pain outcomes after ACLR can be highly variable.⁸ The objective of the current study was to prospectively determine NRS pain score differences after outpatient ACLR that are manifested when a continuous femoral perineural infusion is superimposed on a standardized spinal anesthetic and multimodal analgesic care plan. Our hypothesis was that continuous femoral nerve analgesia independently provides meaningful analgesia above and beyond a standardized perioperative multimodal technique for several days after surgery. To our knowledge, there have been no prospective, randomized clinical trials that explored this specific research question for outpatients undergoing ACLR.

Materials and Methods

To achieve approval by the Institutional Review Board of the University of Pittsburgh Medical Center (Pittsburgh, Pennsylvania), patients were required to undergo a standardized multimodal analgesia regimen and anesthetic technique to offset the pain-related risks of a placebo femoral nerve block treatment, based on previous institutional benchmarks of care. Patients were eligible for participation if they were aged 14–65 yr, had an American Society of Anesthesiologists (ASA) physical status (PS) of I or II, and were scheduled to undergo outpatient ACLR, without additional “complex” knee procedures³ possibly rendering a femoral nerve block and/or multimodal analgesic technique inadequate. Patients were recruited regardless of graft type (conventional allograft, patellar tendon autograft, conventional hamstring autograft, double-bundle allograft, and double-bundle hamstring autograft). In total, 270 patients were recruited, and exclusions after enrollment were not replaced.

Patients were excluded from the study preoperatively if any of the following criteria were met: (1) daily opioid requirement exceeding the equivalent of 5 mg morphine, or daily prescription of corticosteroid, tricyclic antidepressant, gabapentin, or tramadol; (2) current history of chronic pain syndrome, uncontrolled anxiety or history of schizophrenia or related psychiatric disorders, or alcohol or drug abuse; (3) preexisting nerve damage in the surgical extremity; (4) knee surgery (same knee) in the previous 12 weeks; (5) anticipated knee surgery in the other knee planned in the ensuing 6 months; (6) ASA PS of III or greater as determined by the anesthesiologist executing the protocol; (7) diabetic patients with blood sugar values exceeding 250 mg/dl in the previous month; and/or (8) patient reconsideration after initial agreement. Patients were excluded postoperatively, either immediately or before the conclusion of POD 1, if any of the following occurred: (1) the spinal anesthetic was unable to provide sufficient surgical anesthesia, thus requiring a definitive airway device intraoperatively (laryngeal mask or endotracheal tube); (2) ACLR was not performed; (3) additional complex knee procedure³ was performed; or (4) patient or family inability or refusal to follow the carefully written and explained discharge instructions.

Patients were recruited on or before the day of surgery by the lead author or the research coordinator (M. T. B.). After obtaining written informed consent, patients were randomly assigned to one of the following femoral nerve block catheter treatment groups: (1) saline bolus (30 ml) plus saline infusion (270 ml at approximately 5 ml/h, group SbSi); (2) levobupivacaine (0.25%) bolus with saline infusion (group LbSi); or (3) levobupivacaine (0.25%) bolus plus levobupivacaine (0.25%) infusion (group LbLi). To ensure equal allocation of patients to

each arm of the trial over time, a stratified blocked randomization procedure was used, with the research team blinded regarding the size and ordering of the block. A random list of 200 numbers from 1 to 6 (representing the six ordering options for integers 0, 1, and 2 in a block of three) were generated by a computer program and were used to order assignments of patients. The randomization scheme was prepared before the start of the trial. Sequentially numbered and sealed envelopes, opened only by the Investigational Drug Service who prepared the nerve block boluses and infusions for study patients, contained the allocation assignment.

Data Recorded

Patients were asked to report NRS pain scores at rest and with movement (transitioning from rest to ambulation) immediately before surgery and on PODs 1–4 and 7. During the preoperative interview after informed consent for the study was obtained, additional demographic information was elicited (age, sex, ethnicity, height, weight, ASA PS classification, smoking status). For the postoperative assessments, patients were called at a predetermined phone number (home phone and/or cell phone) between 3 and 5 PM on PODs 1–4 and 7.

Standardized Spinal Anesthesia

The anticipated duration of surgery was 1.5–3.5 h, commonly depending on surgeon and graft type. Hyperbaric bupivacaine (0.75% in 8.75% dextrose) was used as the standard intrathecal solution, with no additives. The usual dosing volume was at the discretion of the attending anesthesiologist, ranging from 1.2 to 1.8 ml. No trainees performed any spinal anesthesia procedures. A pencil-point needle (27-gauge) was inserted through a 20-gauge introducer needle after sterile skin preparation with either povidone iodine or a chlorhexidine–alcohol mixture. Patients were maintained in the lateral decubitus position with the surgical extremity down during and/or after intrathecal injection. Injections were placed either at L2–L3 or L3–L4. Intravenous sedation for the spinal anesthesia procedure was limited to 4 mg midazolam and 100 µg fentanyl, by protocol.

Standardized Intraoperative Infusions

Patients received a propofol infusion titrated to the patient's desired level of sedation. Because of the case duration, all patients preferred “complete sleep,” maintaining spontaneous unassisted ventilation. The protocol did not require the use of anesthetic depth monitoring devices.

Perioperative Multimodal Analgesia Other Than Femoral Nerve Block Catheter

Patients received 50 mg rofecoxib orally before surgery (or 20 mg valdecoxib beginning September 30, 2004). Patients also received 0.2 mg/kg ketamine during

intravenous infusion of the first 10 ml (100 mg) of propofol intraoperatively. This dose was selected based on the report of Menigaux *et al.*⁹ Patients also received a standard intraarticular injection of 0.5 mg neostigmine (based on the work of Yang *et al.*¹⁰), 15 mg ketorolac (based on the work of Reuben and Connolly¹¹), and 100 mg meperidine (based on the work of Soderlund *et al.*¹²). Immediate postoperative parenteral analgesia, if needed, consisted of ketorolac (15–30 mg intravenously, only if 4–6 h or more had elapsed from the preoperative rofecoxib dose), then hydromorphone (0.1–0.2 mg intravenously every 5 min based on reported pain scores). Postoperative oral analgesia consisted of 50 mg rofecoxib every morning for the first 6 PODs. Additional oral postoperative analgesia was initiated the night of (*i.e.*, not the night before) surgery with standardized prescriptions for both controlled-release and immediate-release oxycodone. In response to our institutional review board's requirement for meaningful analgesia in the presence of a placebo group, controlled-release oxycodone was prescribed every 12 h based on NRS pain scores with movement (10 mg for pain scores of 0–2 out of 10, 20 mg for pain scores of 3–10, and an additional 10 mg for pain scores persisting at levels of 6–10 despite 20 mg controlled-release oxycodone taken the previous hour). Controlled-release oxycodone doses were reduced by one 10-mg pill per pain score unit on POD 4; therefore, 10 mg was prescribed for NRS scores of 3–10, with an allowable additional 10-mg pill 1 h later for pain that persisted at 6 or more. Immediate-release oxycodone was available for “breakthrough” pain in 5- to 10-mg doses for patients with pain scores of 5 or higher throughout the perioperative course. It should also be noted that all patients received 4 mg dexamethasone as a standard antiemetic, which may also demonstrate antiinflammatory analgesic properties in this patient population¹³; the other standard antiemetics used were perphenazine and ondansetron, per protocol. Patients also received a CryoCuff (Aircast, Summit, NJ), which was applied around-the-clock for the first 3 days postoperatively and then was used as needed, specifically after physical therapy sessions. Preoperative physical therapy teaching demonstrations and postoperative printed physical therapy instructions were standardized, but it was not possible to standardize the outpatient physical therapy providers/centers to which patients reported.

Postoperative Course

After surgery, all patients were transferred to the PACU. PACU bypass scoring² was not performed because all patients underwent perineural femoral catheterization postoperatively in the PACU. Nerve block catheter placement was initiated no sooner than when patients had demonstrated pinch sensitivity in the upper thigh on the surgical side, and demonstrated at least a weak straight leg raise with the surgically placed leg

brace strapped into place. Bromage scale parameters were not formally evaluated or documented for spinal anesthesia resolution. The timing of nerve block catheter insertion was chosen to attempt to “blind” the patient with respect to the presence of low-grade residual numbness being a result of the receding spinal anesthetic *versus* the early effects of the femoral nerve block and catheter procedure. For all procedures, the femoral nerve block and catheter procedure was performed by one of four anesthesiologists (B. A. W., M. L. K., and two other staff colleagues) credentialed by the University of Pittsburgh Institutional Review Board for performance of the procedure on study patients; no trainees were involved in the placement of nerve block catheters. The anesthesiologists performing the procedure were blinded to the use of saline *versus* levobupivacaine. For all procedures, the patient's upper thigh was prepared with povidone iodine or chlorhexidine–alcohol mixture by the anesthesiologist, who wore a sterile gown, sterile gloves, cap, and mask. Sterile towels were placed around the area that was aseptically prepped, and no violations of sterile technique were reported by any of the attending anesthesiologists. A peripheral nerve stimulator was used and was attached to the ProLong[®] PL-50 continuous nerve block set (I-Flow Corporation, Lake Forest, CA) per the usual routine. When a palpable quadriceps-to-patella twitch was appreciated at a current of 0.3–0.5 mA, the blinded bolus syringe was administered, initially in small increments to rule out resistance during injection or focal injection-site pain. Reproduction of quadriceps-to-patella twitch after an initial 1-ml bolus of study medication was not attempted, in an effort to preserve the treatment blinding of the anesthesiologist performing the block procedure. After the catheter was secured *via* a subcutaneous tunnel, sterile tape, and bio-occlusive dressings, the end of the catheter was attached to a Luer connector, and the Luer connector was attached to an elastomeric infusion device (Accufuser[®], 5 ml/h, 270-ml volume; McKinley Medical, Wheat Ridge, CO). All study boluses and infusions were prepared in a blinded fashion under the direction of the University of Pittsburgh Medical Center Investigational Drug Service; the study investigators, research coordinator, and patients were not aware of the contents of the study drugs. The “breaking of the blind” occurred after all 270 patients were enrolled and completed 12 weeks of postoperative follow-up at the surgeons' offices.

It is of note that the study was designed in the years 1999–2000, based on equipment and oral medications available at the time. Despite the evolution of more advanced nerve block catheter infusion devices, and the “falling out of favor” of the prescribed oral analgesics during the course of this 40-month study (July 2001 through October 2004), most every element of the described protocol was maintained throughout. Only 12 patients of 270 were switched from rofecoxib (50 mg

daily) to valdecoxib (20 mg daily) effective September 30, 2004, when rofecoxib was voluntarily withdrawn from the US market by its manufacturer. The last study patient was enrolled October 11, 2004, before any advisories were issued by the US Food and Drug Administration regarding valdecoxib, and well before the voluntary withdrawal of valdecoxib in the United States by its manufacturer on April 7, 2005.

Statistics

A sample size of 90 patients per nerve block treatment group (270 total) was selected to detect a moderate effect size of 0.5 SD based on use of analysis of variance for comparison of continuous variables, with a two-sided α of 0.05. A 5.6% dropout/exclusion rate (5 patients per group of 90) was determined to yield statistical power of 0.90, and a dropout/exclusion rate of 29% (26 patients per group of 90) was determined to yield statistical power of 0.80.

Data were first explored to determine demographic equivalence between treatment groups. The demographic variables of sex, age, race/ethnicity, body mass index, ASA PS, smoking history, and baseline preoperative NRS score at rest and with movement were analyzed for treatment group differences using one-way analysis of variance (for continuous variables) or the chi-square test (for categorical variables). In addition to these preoperative baseline parameters, several intraoperative and immediate postoperative parameters were also recorded and analyzed: use of a surgical tourniquet, intrathecal bupivacaine dose, surgical case duration, parenteral ketorolac and/or hydromorphone dose (in the PACU), and oral oxycodone dose (before discharge home). Finally, indwelling perineural femoral catheter duration was recorded and analyzed for between-group differences.

Oxycodone consumption during PODs 1–4 was then determined by computing both oxycodone milligrams per day and daily cumulative totals. Daily oxycodone consumption was correlated with postoperative NRS scores with movement using the Pearson correlation coefficient. Because oxycodone consumption did not fit a normal distribution, differences among treatment groups were analyzed using the Kruskal-Wallis test.

Numeric rating scale data were evaluated for the presence or absence of normal distributions. NRS data were not normally distributed, so all ACLR patients were analyzed for differences between treatment groups (SbSi *vs.* LbSi *vs.* LbLi) using the Kruskal-Wallis test for PODs 1–2. For PODs 3–7, the two treatment groups that received nerve block infusions of normal saline (placebo) were clustered together for NRS analysis, because these two groups had equivalent pain scores by the second POD; treatment group differences were tested using the Mann-Whitney U test. NRS scores subdivided by surgical graft type (conventional allograft, patellar tendon au-

tograft, hamstring autograft, or double-bundle allograft) were then analyzed similarly based on nerve block treatment group.

Two regression models were run. The first regression model was based on daily NRS scores being dichotomized as at or below daily median *versus* above daily median. The second regression model was based on a threshold NRS score of 5 or greater, reflecting moderate to severe pain. It should be noted that Canadian authors recently used a pain score value of 4 (out of 10) as the threshold for moderate pain,¹⁴ whereas we used a pain score of above 4 (*i.e.*, 5 or more out of 10) to denote the threshold of moderate to severe pain. Our selection of 5 (out of 10) as the threshold of moderate pain was based on the 0–10 Numeric Pain Intensity Scale as defined by the current Agency for Healthcare Research and Quality, based in the United States.¹⁵ In the second model, the dichotomy was NRS score of 4 or below *versus* NRS score of 5 or above. Univariate (not shown) and multivariate (shown) logistic regression was performed with postoperative NRS dichotomous data (for both models) as the dependent variable. Univariate factors with $P \leq 0.15$ were evaluated in the multivariate analysis. In addition to the continuous variables of age and body mass index, the following dichotomous covariates were examined: nerve block treatment group (SbSi as referent *vs.* dummy variables LbSi or LbLi, or LbLi in separate analyses), graft type (all other graft types *vs.* conventional ACLR allograft), preoperative NRS scores with movement (at or below median values *vs.* above median values), sex, ASA PS (ASA PS I *vs.* ASA PS II), ethnicity/race (white *vs.* not), and smoking status (nonsmoker *vs.* smoker).

The incidence of day-of-surgery postoperative nausea and vomiting (PONV) was determined by chart review. Any patient that required an additional parenteral dose of an antiemetic in PACU or in phase II recovery and/or had PONV documented in the narrative note of the recovery nurse was deemed to have encountered PONV.

Number-needed-to-treat analysis is reported for the LbLi treatment group *versus* the other nerve block treatment groups for each POD with respect to the avoidance of pain scores with movement exceeding the median value for that day, as well as for the avoidance of moderate to severe pain (NRS scores ≥ 5 with movement) with LbLi *versus* other treatment groups.

P values less than or equal to 0.05 noted in the tables are considered statistically significant. Appropriate adjustments were made for multiple comparisons. All analyses were conducted using the Statistical Package for the Social Sciences (SPSS for Windows, version 12.0; Chicago, IL).

Intent-to-treat Analysis. Any technical failures related to the nerve block catheter (either with catheter placement or continuous infusion for the entire 270-ml

volume) were included for analysis based on intent-to-treat principles.

Results

Recruitment began in July 2001, and study follow-ups were completed by January 2005. Two hundred seventy patients consented to participate in the study. Thirty-five of the 270 recruited patients were excluded before the end of the day of surgery. Five patients (2%) failed routine screening, whereas 2 were cancelled by the attending anesthesiologist for findings in the preoperative evaluation (upper respiratory infection, and subtle abnormality on screening electrocardiogram). One patient refused to participate after signing the consent form. An additional 16 patients (6%) were excluded because (1) the patient underwent surgery "more invasive" than ACLR ($n = 6$); (2) the patient did not undergo ACLR ($n = 3$); or (3) the duration of surgery was prolonged, forcing conversion from spinal anesthesia to general anesthesia ($n = 7$). One patient was excluded on the evening of the same day after surgery for failure/inability to follow the detailed self-care instructions. Of the remaining 245, 10 were excluded after having undergone a double-bundle hamstring autograft procedure by one of the surgeons. The postoperative pain in these patients was noted by the surgeon to be unacceptable in postoperative office visits, and the surgeon abandoned this surgical technique.

Of the remaining 235, 233 had complete and retrievable data, whereas the other 2 participants had been lost to follow-up beginning at POD 1. All included participants were discharged home the same day (*i.e.*, no unplanned admissions).

All patients included for analysis received a successful femoral nerve bolus (study syringe injected through block needle), two patients had nerve block catheters that were unable to be threaded through the needle, and seven patients had nerve block pumps that did not infuse the entire 270-ml contents primarily due to an untreatable kink in the nerve block catheter beneath the sterile dressing. There were only two technical failures of the nerve block catheter or infusion in the LbLi group in whom the technical failures could have actually influenced delivery of the active treatment local anesthetic levobupivacaine (table 1).

There were no significant differences between treatment groups with respect to sex, age, race/ethnicity, body mass index, ASA PS, smoking history, or baseline preoperative NRS pain scores at rest and with movement (table 1). There were also no treatment group differences in PONV, with the overall PONV rate being recorded as 4% (table 1). Although there were no differences among the three treatment groups in immediate postoperative opioid requirements (hydromorphone in

PACU, oxycodone in phase 2 recovery), there was a trend toward more patients with active femoral nerve block bolus treatments (LbSi and LbLi: 123/155, 79%) who did not require in-hospital postoperative opioids when compared with in-hospital opioid requirements in SbSi placebo patients (53/77, 69%; $P = 0.078$).

Postoperative Oxycodone Consumption at Home

Oxycodone consumption was positively correlated with NRS pain score with movement throughout PODs 1–4 (with Pearson correlation coefficients ranging from 0.31 to 0.46 and all daily P values < 0.001). This indicates that higher pain scores were associated with increasing oxycodone consumption. Illustrations of oxycodone consumption based on NRS scores for PODs 1 and 4 are shown in figure 1. It should be noted that patients were instructed during the first 3 days to take oxycodone even if NRS scores were zero, to provide "bridge analgesia" in the event the nerve block treatment would dissipate in the ensuing few hours.

With respect to oxycodone consumption, placebo SbSi patients consumed significantly more oxycodone during the first POD than did either of the LbSi or LbLi groups, with no difference in daily oxycodone consumption during PODs 2–4 (table 2). When daily cumulative totals were computed, there remained a significant difference/trend in cumulative oxycodone consumed by PODs 2 and 3 ($P = 0.013$ and $P = 0.056$, respectively); on both days, *post hoc* comparison among treatment groups indicated differences in the cumulative totals only between the SbSi and LbLi groups ($P = 0.011$ and $P = 0.059$, respectively, for days 2 and 3, using the Bonferroni correction method).

NRS Pain Score Data Analysis

Numeric rating scale pain scores were not normally distributed. Therefore, differences among all three nerve block treatment groups (for all graft types) were determined for the first 2 PODs (fig. 2) using nonparametric statistics. On both POD 1 and POD 2, the LbLi treatment group had significantly lower pain scores when compared with the other two groups ($P < 0.001$). The LbLi treatment group had a median pain score of 2 on PODs 1 and 2, whereas the placebo SbSi group had median pain score of 4 on PODs 1 and 2. The LbLi treatment group achieved clinically significant pain reduction when compared with the other nerve block treatments through POD 2 (fig. 2).

On POD 1, the LbSi group (median NRS score = 3) had significantly lower pain scores than did the SbSi placebo group (median NRS score = 4), but there were no pain score differences between LbSi and SbSi placebo beyond POD 1 (fig. 2). This finding is consistent with the anticipated effect once the initial bolus wore off. Because LbSi patients' median pain scores returned to the placebo group's pain score level by POD 2, the LbLi NRS

Table 1. Demographic Data of Patients Included, Based on Femoral Nerve Block Catheter Treatment Group

Variable	Placebo Group: Saline Bolus and Infusion	Levobupivacaine Bolus with Saline Infusion	Levobupivacaine Bolus and Infusion	Total
n	78	79	76	233
Age, mean (95% CI); median	28 (26–31); 26.5	28 (25–30); 28	27 (24–30); 22	28 (26–29); 24
ASA PS II (% within categories)	11 (14)	17 (21)	15 (20)	43 (19)
Female (% within categories)	36 (46)	28 (35)	32 (42)	96 (41)
Not white (including African-American, Asian, Hispanic, and from India) (%)	7 (9)	13 (16)	7 (9)	27 (12)
Smoker (%)	4 (5)	4 (5)	9 (12)	17 (7)
Body mass index, mean (95% CI); median	26 (25–27); 26	26 (25–27); 26	26 (25–27); 25.5	26 (25–27); 26
Preoperative NRS pain score at rest, mean (95% CI); median	1.0 (0.6–1.3); 0	0.7 (0.4–1.0); 0	0.8 (0.5–1.0); 0	0.8 (0.6–1.0); 0
Preoperative NRS pain score with movement, mean (95% CI); median	3.2 (2.6–3.9); 2	2.8 (2.3–3.3); 2	2.8 (2.3–3.3); 2	2.9 (2.6–3.3); 2
Surgical tourniquet used, n (%)	41 (53)	36 (46)	40 (53)	117 (50)
Tourniquet duration (if used), mean (95% CI), min	82 (76–89)	82 (74–89)	80 (74–86)	81 (78–85)
Intrathecal bupivacaine dose, mean (95% CI), mg	10.6 (10.4–10.8)	10.6 (10.5–10.8)	10.7 (10.5–10.9)	10.6 (10.5–10.7)
Surgical duration, mean (95% CI), min	103 (95–112)	114 (107–122)	111 (103–119)	110 (105–114)
Ketorolac given in PACU, n (%)	8 (10)	7 (9)	3 (4)	18 (8)
Hydromorphone given in PACU, n (%)	5 (6)	5 (6)	3 (4)	13 (6)
Oxycodone given orally before discharge from same-day surgery, n (%)	22 (29)	13 (16)	14 (18)	49 (20)
Oxycodone dose before discharge, mean (if oxycodone was used) (95% CI), mg	12.3 (10.3–14.3)	10.8 (9.1–12.5)	11.1 (9.4–12.7)	11.5 (10.5–12.6)
No postoperative opioids required and/or given in PACU and/or phase 2 recovery, n (%)	53 (69)	61 (77)	62 (82)	176 (76)
Postoperative nausea and/or vomiting on the day of surgery, n (%)	5 (6)	3 (4)	2 (3)	10 (4)
Intent-to-treat inclusions for catheter technical problems, n (%)	5 (6)	2 (3)	2 (3)	9 (4)
Indwelling catheter duration, mean (95% CI), h (excluding the intent-to-treat inclusions)	50 (47–52)	49 (46–52)	50 (47–53)	50 (48–51)
Conventional allograft (% within categories)	22 (28)	21 (27)	17 (22)	60 (26)
Patellar tendon autograft (% within categories)	36 (46)	31 (39)	32 (42)	99 (43)
Hamstring tendon autograft (% within categories)	16 (21)	23 (29)	20 (26)	59 (25)
Double-bundle allograft (% within categories)	4 (5)	4 (5)	7 (9)	15 (6)

There were no significant demographic differences among treatment groups.

ASA PS = American Society of Anesthesiologists physical status classification; CI = confidence interval; NRS = numeric rating scale (from 0 to 10); PACU = postanesthesia care unit.

scores for PODs 3–4 and 7 were compared with those of placebo and LbSi patients clustered together. LbLi patients (median NRS score = 2) had significantly improved pain scores on PODs 3 and 4 when compared with the LbSi and SbSi groups combined (median NRS score = 3; fig. 3; $P = 0.043$ and $P = 0.018$, respectively, on PODs 3 and 4). By POD 7, there were no significant differences in pain scores among nerve block treatment groups.

For patients in the SbSi placebo and LbSi treatment groups, allograft ACLR was associated with lower NRS scores on PODs 1–3 than were all other graft types clustered together (fig. 4; $P = 0.008$, 0.032, and 0.050, respectively). For patients in the LbLi treatment group, there were no differences in pain scores based on graft type (fig. 4).

Logistic Regression Analysis

Using the NRS pain score data, along with the stated covariates in the Materials and Methods section, predic-

tors of NRS pain scores were determined using multivariate logistic regression.

Preoperative NRS Scores. A body mass index of 30 or greater, indicating obesity, was a predictor of preoperative NRS pain scores at rest above the median value of zero ($P = 0.026$). No other covariates, including age, sex, race/ethnicity, ASA PS, smoking status, or graft type, were significant predictors of preoperative NRS pain scores at rest or with movement.

NRS Pain Scores with Movement on PODs 1–7. The first model of postoperative NRS pain scores was based on daily NRS scores being dichotomized as at or below daily median *versus* above daily median (table 3). Throughout PODs 1–7, preoperative NRS pain scores greater than 2 with movement were also predictive of postoperative NRS pain scores with movement being higher than the daily median. Throughout the 4-day immediate postoperative course, nerve block treatment group LbLi patients were significantly more likely to be at or below daily medians. On the first POD, conven-

Fig. 1. Scatterplot indicating oxycodone consumption of anterior cruciate ligament reconstruction study patients experiencing each possible numeric rating score (NRS) for pain with movement on postoperative (POD) 1 (above) and 4 (below). Correlation coefficient values (Pearson r) between the NRS scores and oxycodone consumed are indicated at the bottom right of each chart within this figure. Placebo SbSi is the placebo treatment group receiving a saline bolus and saline infusion through the femoral nerve block catheter, whereas treatment group LbSi received a levobupivacaine bolus and saline infusion, and LbLi received both a bolus and infusion containing levobupivacaine.

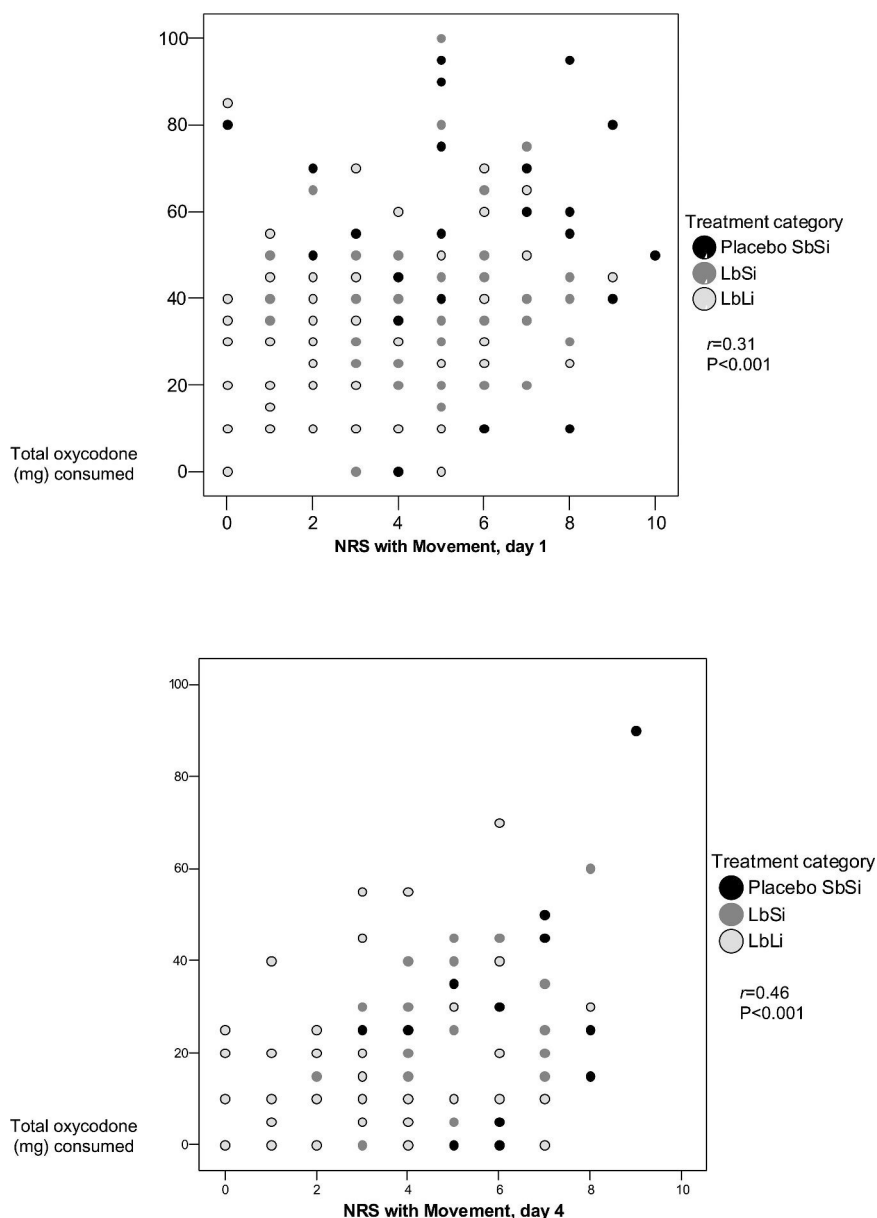


Table 2. Oxycodone Consumption during PODs 1–4 after Outpatient Anterior Cruciate Ligament Reconstruction, Categorized by Nerve Block Treatment Group

POD	Placebo SbSi		LbSi		LbLi	
	Daily	Cumulative	Daily	Cumulative	Daily	Cumulative
1*	42* (37–47)	42 (37–47)	33 (29–37)	33 (29–37)	30 (26–34)	30 (26–34)
2†	27 (23–31)	70† (62–78)	28 (24–32)	60 (57–63)	25 (22–28)	55 (49–61)
3‡	21 (17–25)	90‡ (79–101)	20 (17–24)	79 (71–87)	19 (16–22)	75 (67–83)
4	14 (10–18)	105 (91–119)	13 (10–16)	94 (84–103)	14 (10–17)	88 (77–99)

Data are presented as mean (95% confidence interval), in milligrams. There were no significant differences in daily oxycodone consumption after the first postoperative day (POD).

* $P < 0.001$ by one-way analysis of variance, for oxycodone consumed on the first POD in the saline bolus, saline infusion (SbSi) placebo group significantly exceeding oxycodone consumption in each of the other two treatment groups. † $P = 0.011$ for the cumulative oxycodone doses through PODs 1–2 being significantly higher in the SbSi placebo group versus the levobupivacaine bolus and infusion (LbLi) treatment group. ‡ $P = 0.039$ for the SbSi placebo group consuming more cumulative oxycodone by the end of POD 3 than the levobupivacaine bolus, saline infusion (LbSi) and LbLi treatment groups clustered together.

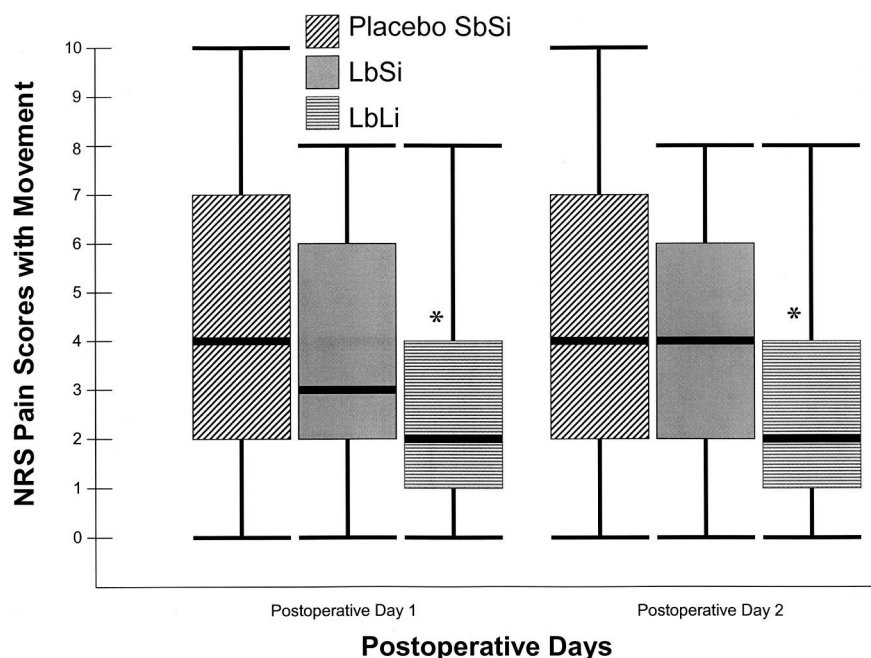


Fig. 2. Box plot demonstrating nerve block treatment group differences after anterior cruciate ligament reconstruction, showing numeric rating scale (NRS) pain scores with movement during the first 2 postoperative days. The **thick black line inside the box** represents the median NRS value. The **lowest bar on the y-axis** represents the 10th percentile, the **bottom and top of the boxes** represent the interquartile range (25th and 75th percentiles), and the **top bar** represents the 90th percentile. Placebo SbSi is the placebo treatment group receiving a saline bolus and saline infusion through the femoral nerve block catheter, whereas treatment group LbSi received a levobupivacaine bolus and saline infusion, and LbLi received both a bolus and infusion containing levobupivacaine. On both days 1 and 2, the LbLi treatment group had significantly lower pain scores when compared with the other two nerve block treatment groups (* $P < 0.001$ by Kruskal-Wallis test).

tional allograft patients (*vs.* all other graft types) were less likely to exceed the NRS pain score of 3 with movement, but graft type was not predictive after POD 1.

Interestingly, smokers showed trends of a greater chance of NRS pain scores above daily median thresholds on PODs 3–4 and 7 (table 3). No other factors were predictive of NRS pain scores throughout the first week after surgery.

The second regression model was based on a threshold NRS pain score of 5 or above, reflecting moderate to severe pain. Throughout PODs 1–7, preoperative NRS pain scores greater than 2 with movement were also

predictive of postoperative NRS pain scores reaching the threshold of moderate to severe pain. Throughout the 4-day immediate postoperative course, nerve block treatment group LbLi patients were significantly more likely to be below the threshold for moderate to severe pain. On the first POD, patients undergoing allograft ACLR (*vs.* all other graft types) were less likely to reach the moderate-to-severe pain threshold, but graft type was not predictive after POD 1.

Neither tourniquet use nor surgical duration was a predictor of postoperative NRS scores at any point postoperatively.

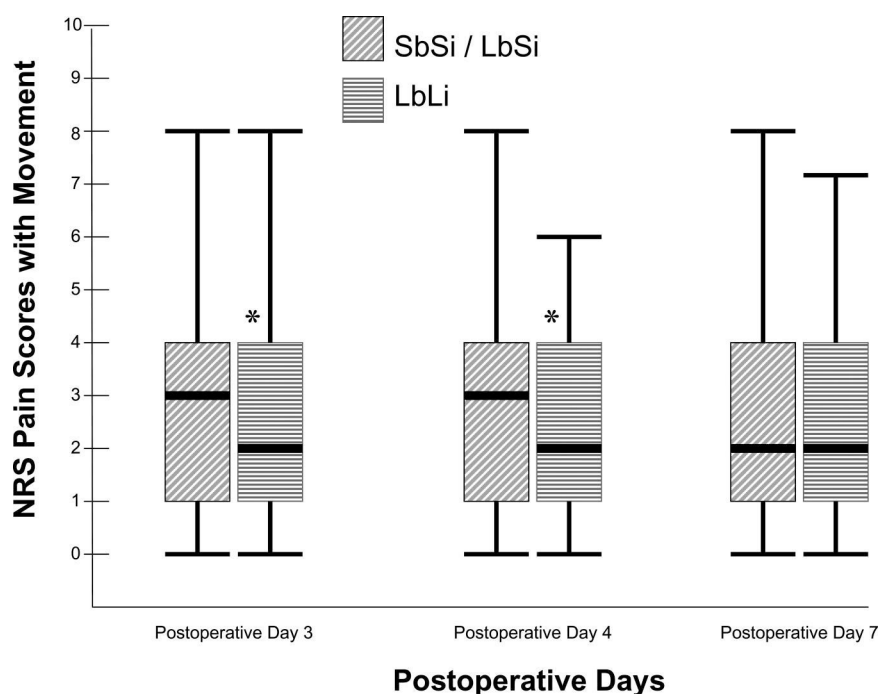
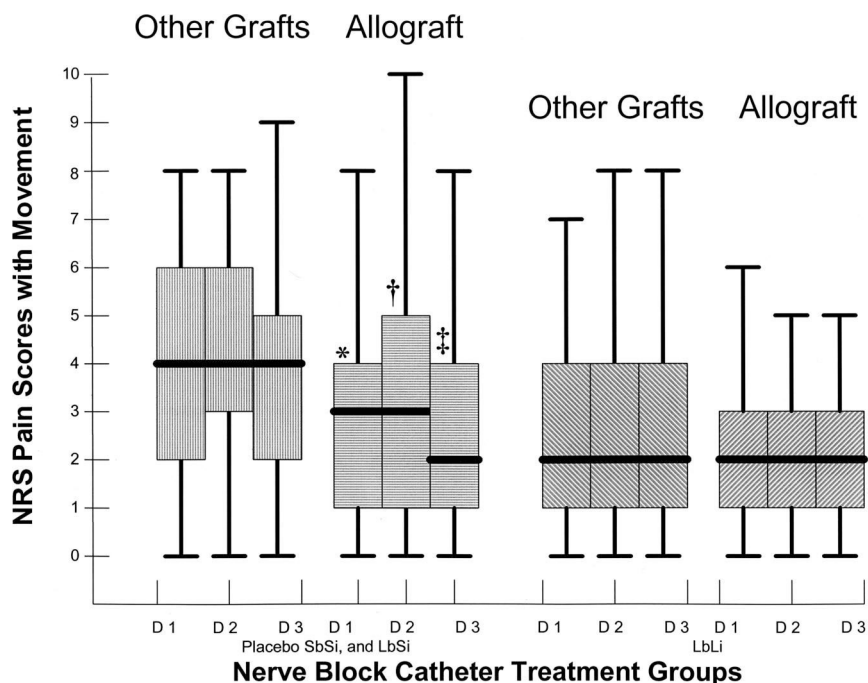


Fig. 3. Box plot demonstrating nerve block treatment group differences in postoperative days 3–4 and 7 after anterior cruciate ligament reconstruction. This plot captures numeric rating scale (NRS) pain scores with movement during postoperative days 3–4 and 7. Placebo SbSi is the placebo treatment group receiving a saline bolus and saline infusion through the femoral nerve block catheter, whereas treatment group LbSi received a levobupivacaine bolus and saline infusion, and LbLi received both a bolus and infusion containing levobupivacaine. On postoperative days 3–4, the LbLi treatment group had significantly lower pain scores when compared with the other two nerve block treatment groups (* $P < 0.05$ by Mann-Whitney U for both individual days). No differences are seen on postoperative day 7.

Fig. 4. Box plot demonstrating nerve block treatment group differences in numeric rating scale (NRS) pain scores based on graft type on postoperative days 1–3 after anterior cruciate ligament reconstruction (ACLR). This plot captures NRS scores with movement during postoperative days 1–3. Placebo SbSi is the placebo treatment group receiving a saline bolus and saline infusion through the femoral nerve block catheter, whereas treatment group LbSi received a levobupivacaine bolus and saline infusion, and LbLi received both a bolus and infusion containing levobupivacaine. For patients in the SbSi placebo and LbSi treatment groups, the conventional ACL allograft yielded lower NRS scores on postoperative days 1–3 than did all other graft types clustered together ($P = *0.008$, $\dagger 0.032$, and $\ddagger 0.050$, respectively, by Mann–Whitney U test). For patients in the LbLi treatment group, there were no differences in pain scores based on graft type. The other graft types were patellar tendon autograft, hamstring tendon autograft, and double-bundle allograft.



Number Needed to Treat. When comparing the potential epidemiologic benefits of the LbLi treatment *versus* the placebo SbSi treatment strategy, significant differences in the proportion of individuals that had a NRS pain score greater than the daily median NRS score were noted on the first 2 PODs (table 4). The numbers needed to treat with the LbLi treatment were 3 and 4 patients on PODs 1 and 2, respectively, to prevent an NRS score greater than 3 in one patient in the placebo group. When comparing the LbLi and LbSi treatment strategies, the number needed to treat with LbLi was five on both PODs 1 and 2 to prevent an NRS score greater than 3 in one LbSi patient. To prevent moderate to severe pain on PODs 1 and 2, 4 and 5 patients, respectively, would need to be treated with LbLi to prevent one placebo patient from experiencing moderate to severe pain with movement, and 7 patients would need to be treated with LbLi to prevent moderate to severe pain in one LbSi patient. For PODs 3–4, the number needed to treat with LbLi was 10 or fewer patients to prevent pain above daily median thresholds, and to prevent moderate to severe pain, in one patient receiving either placebo or LbSi (table 4).

Discussion

In this prospective, randomized clinical trial, we have shown that the use of a continuous femoral perineural infusion (group LbLi), superimposed on an anesthetic technique consisting of spinal anesthesia and multimodal analgesia, provides statistically and clinically significant improvements in postoperative NRS pain scores on PODs 1–4, when compared with the same spinal anes-

thetic technique and multimodal analgesia plan coupled with a placebo femoral nerve catheter. Using number-needed-to-treat analysis, we demonstrated that the LbLi treatment was better than both the placebo and LbSi treatments (clustered together) throughout PODs 1–4. The LbLi treatment was the only predictor of a lower NRS pain score on PODs 1–4. Preoperative NRS pain scores greater than 2 with movement consistently predicted higher postoperative NRS scores throughout PODs 1–7, consistent with previous reports of the effect of preoperative knee pain on postoperative pain.¹⁶ As far as we are aware, this is the first prospective, randomized, placebo-controlled study of outpatients undergoing ACLR who were successfully discharged home with indwelling perineural femoral catheters. This may also be the first report of any outpatient orthopedic procedure in which a continuous perineural infusion was compared with a placebo infusion while patients underwent a multimodal analgesic/regional anesthetic care plan, as opposed to anesthetic care plans consisting of general anesthesia.

In the past 10 yr, population-based studies have shown that postoperative pain is significant and is generally poorly treated. Despite the evolution of multimodal analgesia and nerve block analgesia, there has been little research on patient perceptions of the quality of analgesia care, specifically after outpatient knee surgery. Two studies almost a decade apart but using similar methodologies found that the majority of surgical patients (not restricted to knee surgery) reported moderate to severe pain during the postsurgical period. Warfield and Kahn¹⁷ surveyed hospital patients from 300 hospitals (42% of which had acute pain management programs) and found

Table 3. Predictors of Postoperative NRS Pain Scores with Movement Based on Multivariate Logistic Regression

Time Point/Predictor	Regression Model Based on Daily Median NRS			Regression Model Based on Moderate-Severe NRS		
POD 1, threshold NRS	> 3			≥ 5		
Univariate regression factors with $P \leq 0.15$ evaluated in multivariate equation	Age, BMI, group LbSi-LbLi, conventional allograft, preop NRSm > median			BMI, group LbSi-LbLi, conventional allograft, preop NRSm > median		
Predictors of NRS score above threshold	Odds Ratio	95% CI	P Value	Odds Ratio	95% CI	P Value
Preop NRSm > median	4.3	2.3–7.9	< 0.001	5.2	2.7–10.1	< 0.001
Group LbSi or LbLi	0.3	0.1–0.5	< 0.001	0.3	0.2–0.6	0.001
Conventional allograft	0.5	0.2–0.7	0.003	0.4	0.2–0.9	0.025
POD 2, threshold NRS	> 3			≥ 5		
Univariate regression factors with $P \leq 0.15$ evaluated in multivariate equation	Age, group LbLi, conventional allograft, duration of surgery, preop NRSm > median			Sex, group LbLi, preop NRSm > median		
Predictors of NRS score above threshold	Odds Ratio	95% CI	P Value	Odds Ratio	95% CI	P Value
Preop NRSm > median	3.3	1.8–6.0	< 0.001	3.6	1.9–6.7	< 0.001
Group LbLi	0.3	0.2–0.6	< 0.001	0.4	0.2–0.8	0.009
Age, years $\times -0.04$	0.97	0.94–0.99	0.005			
POD 3, threshold NRS	> 3			≥ 5		
Univariate regression factors with $P \leq 0.15$ evaluated in multivariate equation	BMI, group LbLi, smoker, preop NRSm > median			Group LbLi, use of tourniquet, preop NRSm > median		
Predictors of NRS score above median	Odds Ratio	95% CI	P Value	Odds Ratio	95% CI	P Value
Preop NRSm > median	4.6	2.5–8.5	< 0.001	5.6	2.6–12.1	< 0.001
Group LbLi	0.5	0.2–0.9	0.031	0.3	0.2–0.9	0.030
Smoker	3.0	0.9–9.6	0.068		NA	
POD 4, threshold NRS	> 2			≥ 5		
Univariate regression factors with $P \leq 0.15$ evaluated in multivariate equation	BMI, group LbLi, smoker, preop NRSm > median			BMI, group LbLi, preop NRSm > median		
Predictors of NRS score above median	Odds Ratio	95% CI	P Value	Odds Ratio	95% CI	P Value
Preop NRSm > median	5.9	3.2–11.1	< 0.001	6.1	2.7–13.7	< 0.001
Group LbLi	0.4	0.2–0.9	0.017	0.4	0.2–0.9	0.026
Smoker	2.8	0.8–9.7	0.107		NA	
POD 7, threshold NRS	> 2			≥ 5		
Univariate regression factors with $P \leq 0.15$ evaluated in multivariate equation	Sex, smoker, preop NRSm > median			Sex, preop NRSm > median		
Predictors of NRS score above median	Odds Ratio	95% CI	P Value	Odds Ratio	95% CI	P Value
Preop NRSm > median	2.6	1.5–4.6	0.001	4.9	2.1–11.4	< 0.001
Smoker	3.1	1.0–9.5	0.050		NA	

For ease of reading, the univariate regression analyses are not shown. Odds ratio values > 1 indicate a higher incidence of numeric rating scale (NRS) pain scores exceeding the NRS pain threshold for the given postoperative day (POD), whereas odds ratio values < 1 indicate a greater probability of NRS pain scores not exceeding the median value for the given POD. All NRS pain scores are with patient movement, not at rest.

BMI = body mass index; CI = confidence interval; LbLi = levobupivacaine bolus and infusion; LbSi = levobupivacaine bolus with saline infusion; NA = not applicable; preop NRSm > median = patient's baseline NRS pain scores exceeded the median NRS pain score of 2.

that 77% of patients experienced pain after surgery, with 80% of these respondents categorizing their pain as moderate to severe. In the study by Apfelbaum *et al.*¹⁸ 8 yr

later, 80% of surveyed adults (n = 250) experienced pain after surgery, with 86% of these respondents characterizing the pain as moderate, severe, or extreme. This

Table 4. NNTT Analysis for Reducing NRS Pain Scores with Movement, Based on Nerve Block Treatment Group after Anterior Cruciate Ligament Reconstruction

Parameter	SbSi Placebo Group Data	LbSi Group Data	LbLi Group Data	Significance (P Value)		Absolute Risk Reduction		NNTT	
				SbSi Placebo vs. LbLi	LbSi vs. LbLi	Placebo vs. LbLi	LbSi vs. LbLi	Placebo vs. LbLi	LbSi vs. LbLi
NRS score > 3 on POD 1: median pain	48/76 (63.2%)	37/78 (47.4%)	20/76 (26.3%)	< 0.001	0.007	36.9% (0.369)	21.1% (0.211)	3*	5†
NRS score ≥ 5 on POD 1: moderate–severe pain	35/76 (46.1%)	26/78 (33.3%)	14/76 (18.4%)	< 0.001	0.035	27.7% (0.277)	14.9% (0.149)	4	7
NRS score > 3 on POD 2: median pain	46/76 (60.5%)	42/79 (53.2%)	24/75 (32.0%)	< 0.001	0.008	28.5% (0.285)	21.2% (0.212)	4	5
NRS score ≥ 5 on POD 2: moderate–severe pain	32/76 (42.1%)	28/79 (35.4%)	15/75 (20.0%)	0.003	0.033	22.1% (0.221)	15.4% (0.154)	5	7
Parameter	Clustered SbSi/LbSi Group Data		LbLi Group Data	Significance (P Value)		Absolute Risk Reduction		NNTT	
NRS score > 3 on POD 3: median pain	57/149 (38.3%)		21/76 (27.6%)	0.113		10.7% (0.107)		10	
NRS score ≥ 5 on POD 3: moderate–severe pain	36/149 (24.2%)		10/76 (13.2%)	0.053		11.1% (0.111)		10	
NRS score > 3 on POD 4: median pain	77/147 (52.4%)		27/70 (38.6%)	0.057		13.8% (0.138)		8	
NRS score ≥ 5 on POD 4: moderate–severe pain	36/147 (24.5%)		9/70 (12.9%)	0.048		11.6% (0.116)		9	

* Interpreted as follows for comparing placebo to levobupivacaine bolus and infusion (LbLi): Three patients need to be treated with the LbLi treatment strategy described in the Materials and Methods section to avoid one patient experiencing numeric rating scale (NRS) pain scores with movement above 3 (out of 10) on postoperative day (POD) 1 using the placebo treatment strategy described in the Materials and Methods section. † Interpreted as follows for comparing levobupivacaine bolus and saline infusion (LbSi) to LbLi: Five patients need to be treated with the LbLi treatment strategy described in the Materials and Methods section to avoid one patient experiencing NRS pain scores with movement above 3 (out of 10) on POD 1.

NNTT = number needed to treat; SbSi = saline bolus, saline infusion.

latter study did not characterize the hospital-based acute pain management infrastructure where the respondents underwent surgery.¹⁸ Therefore, in the time between the first development of federal recommendations for acute pain management in 1992¹⁵ and pain management mandates by the Joint Commission for Accreditation of Health Care Organizations in 2001,^{‡‡} patients did not report improved pain management after surgery. More recently, in a Canadian survey of more than 5,700 surgical outpatients of all types (not just orthopedic) reported by McGrath *et al.*,¹⁴ 30% reported moderate to severe pain (pain scores at rest *vs.* movement were not specified), with orthopedic procedures being identified as a surgical subtype where special analgesic planning is needed. McGrath *et al.*¹⁴ reported that 40% of patients experienced moderate to severe pain (verbal pain scores

> 3) 24 h after surgery, despite a single-injection nerve block having been used. In the current study during the first day after surgery, 46% of placebo patients had moderate to severe pain (NRS score of 5 or above), whereas 63% of placebo patients had moderate to severe pain with the threshold NRS score of 4 or more out of 10. Only 18% of LbLi patients reported moderate to severe pain (NRS score of 5 or above), whereas only 26% of LbLi patients had moderate to severe pain with the threshold NRS score of 4 or more out of 10. The LbSi group, which would most logically resemble the concept of the single-injection nerve block, had 33% (26 of 78) reach the moderate-to-severe NRS pain score threshold of 5 out of 10, whereas 47% (37 of 78) reached an NRS score of 4 or more. Therefore, it is important to define the threshold of moderate pain when transforming NRS data, because one unit of difference in the NRS pain score threshold makes a significant difference in the proportion of patients encountering moderate to severe pain.

Pain scores described in the current study (when com-

‡‡ Joint Commission on Accreditation of Healthcare Organizations. Available at: <http://www.jcaho.org/accredited+organizations/hospitals/standards/revisions/index.htm>. Accessed November 27, 2005.

pared with general clinical practice) were also likely influenced by the multimodal regional, parenteral, and oral analgesic techniques used for all patients. This multimodal strategy was used (and required by our institutional review board) to offset the risks of significant postoperative pain in the placebo nerve block catheter treatment group. One of the analgesic modes we used as a standard in all of our treatment groups was orally administered controlled-release oxycodone. Reuben *et al.*⁶ reported that during the first 2 days after surgery, patients in the controlled-release oxycodone treatment group after ACLR had a verbal pain scale interquartile range of 4–5 (out of 10), meaning that 25% of these patients had pain scores below a verbal pain score of 4, which was our 75th percentile threshold for patients in the current study receiving treatment LbLi. The anesthesia treatments by Reuben *et al.*⁶ included multimodal strategies such as preincisional intraarticular bupivacaine and ketorolac, postsurgical intraarticular morphine and bupivacaine, and oral acetaminophen (650 mg every 4 h) and ibuprofen (600 mg every 6 h), and a cryotherapy cuff. The primary anesthetic consisted of isoflurane with nitrous oxide *via* an endotracheal tube. The interquartile ranges for pain scores in the study by Reuben *et al.*⁶ during the first 48 h postoperatively in the treatment groups not receiving controlled-release oxycodone ranged between 5 and 8 (out of 10). Despite the clinically important improvement in analgesia achieved by using controlled-release oxycodone (*vs.* short-acting oxycodone) shown by Reuben *et al.*,⁶ it is unlikely that controlled-release oxycodone can be currently considered a mainstay in postoperative analgesia for various medicolegal reasons.

In 2004, Reuben¹⁹ reported a detailed retrospective review that described acute pain management after ACLR. He described 1,200 patients receiving either multimodal preemptive analgesic protocol ($n = 500$) or a standard postoperative pain protocol ($n = 700$) between the years 1995 and 2001.¹⁹ Patients in the preemptive multimodal group received 1,000 mg acetaminophen every 6 h and 50 mg rofecoxib daily starting 48 h before surgery. In addition, 30 min before surgery, a femoral nerve block and an intraarticular injection of bupivacaine–clonidine–morphine were performed.¹⁹ Postoperative analgesia included acetaminophen, rofecoxib, controlled-release oxycodone, and cryotherapy. In contrast, patients in the “standard” postoperative analgesic group received no analgesics before surgery and were given ibuprofen and acetaminophen with oxycodone on an as-needed basis postoperatively.¹⁹ In this retrospective review, multimodal patients had lower immediate (recovery room) pain scores (1.1 ± 0.4 *vs.* 5.4 ± 1.6 ; $P < 0.0001$), fewer unplanned hospital admissions (4% *vs.* 42%; $P < 0.0001$), lower incidence of anterior knee pain 1 yr after surgery (4% *vs.* 14%; $P < 0.0001$), and lower incidence of chronic regional pain syndrome 1 yr after

surgery (1% *vs.* 4%; $P = 0.008$). It is apparent, based on the findings of our current study and based on this retrospective review of Reuben,¹⁹ that the use of multimodal techniques for analgesia after knee surgery leads to significant reductions in pain during the first 4 days after surgery, as well as the potential for reduced chronic pain risks up to 1 yr after surgery.

The ethical dilemma now is the effective treatment of pain after ACLR without using modern agents that were available in the described studies. Controlled-release oxycodone and type 2 cyclooxygenase inhibitors are no longer easily available without burdensome regulatory scrutiny (*e.g.*, Food and Drug Administration “black box” warning for the use of celecoxib, a type 2 cyclooxygenase inhibitor known to be a less potent analgesic than rofecoxib²⁰) and third-party payers’ common restrictions of not paying for prescriptions of either type 2 cyclooxygenase inhibitors or controlled-release oxycodone unless myriad other analgesics have been tried and failed. Regulatory and third-party-payer scrutiny as described above does not even consider the medicolegal risk that is possible in many countries including the United States, especially when controversial medications are used.

Despite these competing clinical realities that will likely negatively impact patients’ achieving meaningful analgesia after ACLR, there are fortunately a few preemptive and/or preventative analgesic options that are within the control of the anesthesiologist and surgeon, working together as partners in an effort to provide sustained analgesia after surgery while simultaneously achieving same-day discharge. First is the avoidance of volatile agents and their replacement with a spinal anesthetic technique.^{1–4,21,22} Second is the routine coadministration (with propofol) of low-dose ketamine during surgery.^{9,23–25} Third is perioperative multimodal oral analgesia emphasizing around-the-clock acetaminophen^{26,27} (before and after surgery) and a nonsteroidal antiinflammatory drug (after surgery). Next, based on findings from the current study, is the use of continuous femoral nerve block analgesia. Also important is consideration of intraarticular analgesics of modalities known to be efficacious, such as bupivacaine, neostigmine, clonidine, ketorolac, and an opioid.^{11,12,28,29} Studies are needed to determine the best possible multimodal intraarticular approach in an effort to maximize immediate analgesia *via* myriad mechanisms. Another promising oral analgesic taken before surgery is gabapentin,³⁰ which has shown to be efficacious in thermal injury,³¹ breast surgery,^{32,33} and ACLR.³⁴ After these measures, oral opioids are logically best reserved for either rescue analgesia, or the lowest possible around-the-clock dose, to minimize risks and complications known to occur escalating doses of any opioid.³⁵ Given the accumulation of evidence in the past 15 yr, the alternative “care” strategy of not addressing these meaningful postoperative analgesia mechanisms after ACLR could potentially

be interpreted as the equivalent of ignoring the "fifth vital sign" altogether.

In conclusion, this prospective, randomized, placebo-controlled clinical trial of outpatients undergoing ACLR showed that patients receiving active treatment of local anesthetic delivered *via* a perineural femoral catheter had NRS verbal pain scores below the moderate-to-severe pain threshold for the first 4 days after surgery, when compared with higher pain scores for patients receiving normal saline infusion *via* the catheter. We believe that the routine use of the perineural femoral catheter technique applied routinely to patients undergoing this surgery makes a significant advance in providing sustained analgesia on an outpatient basis, while potentially minimizing the need for opioid analgesics throughout the postoperative course.

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