Three-in-One Nerve Block With Different Concentrations of Bupivacaine in Total Knee Arthroplasty

Randomized, Placebo-Controlled, Double-Blind Trial

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Abstract: Pain after total knee arthroplasty may be severe and lead to adverse outcomes. Using 2 concentrations of bupivacaine, we investigated 3-in-1 nerve block's effect on pain control, narcotic use, sedation, and patient satisfaction. One hundred five patients undergoing unilateral total knee arthroplasty were randomized into 3 groups: low-dose or high-dose bupivacaine or placebo. Ninety-nine patients completed the study. Three-in-1 nerve block reduced patient-controlled opioid analgesia usage and improved pain relief in the early postoperative period but had little effect beyond postoperative day 1. There were no significant differences among groups with respect to nausea or sedation. Patients in each group exhibited high overall satisfaction. Low-dose bupivacaine was superior to high-dose bupivacaine for pain relief, narcotic consumption, and patient satisfaction in the early postoperative period. **Keywords:** three-in-one nerve block, total knee arthroplasty, bupivacaine, postoperative pain, patient satisfaction.

Total knee arthroplasty (TKA) offers significant long-term relief for patients having osteoarthritis. However, pain after TKA can be severe, and despite significant improvements in our understanding and advances in management of postoperative pain, it is still inadequately addressed [1]. The consequences of pain include physiologic stress that may lead to hypercoagulability, venous stasis with resultant deep vein thrombosis, and a compromised immune system that contributes to increased rates of infection, fatigue, and delayed return of muscle function [2,3].

Among the multiple modalities of postoperative pain management are oral and intravenous anti-inflammatory medications, patient-controlled opioid analgesia (PCA), peripheral nerve blocks, and epidural anesthesia [4-7]. Each modality has its advantages and disadvantages. Opioid administration can lead to significant side effects including nausea, vomiting, pruritis, constipation, drowsiness, and respiratory depression [1,6]. Because of risk of epidural hematoma formation, epidural analgesia may interfere with the appropriate administration of postoperative deep vein thrombosis prophylaxis [8-10].

Peripheral nerve blocks have been used to improve postoperative pain management after TKA and other orthopedic procedures. Single-administration or continuous-administration nerve blocks have improved pain analogue scores, diminished narcotic requirements, assisted early hospital discharge, and improved early range of motion [3,4,6,7,11-17]. Patients with single administration 3-in-1 (femoral, obturator, and lateral femoral cutaneous nerves) nerve block (TIOB) have exhibited a reduction in morphine consumption for the first 24 hours postoperatively compared with patients with spinal anesthetic blocks [3,18]. Continuous TIOB can provide pain control beyond 24 hours postoperatively. However, the benefits of this modality also come

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with additional risks, such as catheter infection, increased local anesthetic toxicity, and prolonged motor block [3,4,19,20,21]. Preoperative administration of regional anesthesia (peripheral and neuraxial) for joint arthroplasty also has been reported to be associated with a reduction in blood loss, postoperative transfusions, intraoperative narcotic, or anesthetic use as well as increased overall cardiovascular stability [4-7].

There have been several publications investigating regional anesthesia in TKA. Despite this body of literature, many studies are limited by low participant enrollment; short-term follow-up; lack of randomization and placebo-controlled comparison; or investigator blinding. In addition, there is a paucity of information exploring the administration of different concentrations of local anesthetic single-injection TIOB and their effect on postoperative pain, narcotic usage, and patient satisfaction. We conducted a randomized, placebo-controlled, double-blinded study to investigate TIOB effect on outcome measures, including quality of pain control, sedation level, narcotic side effects, and patient satisfaction. In addition, we used 2 different concentrations of bupivacaine to determine the optimal level at which potential unintended side effects and prolonged motor blockade are avoided. We hypothesized that preoperative administration TIOB would improve short-term outcomes after TKA even with the use of lower dose bupivacaine.

Materials and Methods

After institutional review board approval and informed patient consent, 105 patients undergoing unilateral TKA were randomized into 1 of 3 equally sized TIOB treatment groups: placebo (30-mL normal saline) or low-dose (30-mL 0.25% bupivacaine with 1:200 000 epinephrine) or high-dose bupivacaine (30-mL 0.50% bupivacaine with 1:200 000 epinephrine). These drugs were formulated by our pharmacists and were labeled with numbers only. The anesthesiologists and surgeons were blinded to the drugs. All patients received a posterior cruciate substituting TKA (Zimmer NexGen, Warsaw, Ind) via a standard medial parapatellar arthrotomy. The exclusion criteria for the study are shown in Table 1. The patients, anesthesia, and surgical teams were blinded to treatment assignment. All patients received either general or spinal anesthesia depending on the decision of the patients after consultation with their anesthesiologists. Three-in-1 nerve block was performed before the induction of general or spinal anesthesia. For postoperative pain management, all patients received opioid PCA, which was converted to oral pain medication on either postoperative day 1 or 2.

Patients were followed up postoperatively for 96 hours or until discharge, whichever came first, to assess differences in PCA usage, narcotic-related symptoms (nausea, pain, and sedation), and satisfaction. Patient-controlled opioid analgesia usage was recorded during the first 24 hours and then totaled over 3 days. Nausea, pain, and sedation were measured in the PACU and at 24, 48, and 72 hours after surgery using a 6-point Likert scale with response options ranging from 0 to 5. The data represent overall assessment for the period in the PACU, from the PACU to 24 hours, 24 to 48 hours, and 48 to 72 hours postoperatively. Overall patient satisfaction with postoperative pain management experience using the 6-point Likert scale was measured in the PACU on postoperative day 1 and at discharge.

Table 1. Criteria for Patients Participating in TIOB Study

Inclusion Criteria
Patients undergoing an unilateral TKA
Exclusion Criteria
Age <18 or >90 y
ASA physical status >3
Coagulopathy
Cellulitis at the injection site
Severe morbid obesity, defined as BMI <40
Seizure disorder
Severe liver or renal disease
Opioid dependency
Mental or psychiatric disease affecting ability to comprehend pain scale
Preexisting neurologic deficits or neuropathy in the lower extremities

ASA indicates American Society of Anesthesiologists; BMI, body mass index.

In the primary statistical analysis, unadjusted effects of treatment on PCA usage, symptoms, and satisfaction were evaluated using nonparametric tests and linear, logistic, and ordinal logistic regression. Multivariable models were then used to determine whether treatment effects were modified by patient age and sex or type of anesthesia. Secondary analyses evaluated associations between outcomes (PCA dose, symptoms, satisfaction) and age, sex, and type of anesthesia. Before analysis, a logarithmic transformation was applied to total and 24-hour PCA dose measurements to achieve approximate normality. After linear regression of log PCA dose on treatment group, treatment contrasts were exponentiated to yield percentage differences between groups on the original scale of measurement.

Although nausea, sedation, and pain were measured through postoperative day 3, treatment effects on these symptoms were considered clinically relevant only through postoperative day 1. The effects of treatment on these outcomes were tested using the Kruskal-Wallis analysis of variance in the original measurement scale and logistic and ordinal logistic regression for categorized responses. Pain and sedation scores were categorized as "none or minimal" (scores 0 and 1), "moderate" (scores 2 and 3), and "considerable" (scores 4 and 5). Nausea was dichotomized into "any" vs "none" (score >0) or as "more than minimal" (score >1). Patient satisfaction was dichotomized as "very high" (score, 5) and also collapsed into 3 ordinal categories (scores 0-3, 4, and 5).