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Comparison of peripheral nerve block with periarticular injection analgesia after total knee arthroplasty: A randomized, controlled study

Kazuhide Uesugi *, Naoko Kitano, Tadashi Kikuchi, Miho Sekiguchi, Shin-ichi Konno

Department of Orthopaedic Surgery, Fukushima Medical University School of Medicine, Fukushima, Japan

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ABSTRACT

Background: Pain after total knee arthroplasty (TKA) is usually severe. Recently, the usefulness of local periarticular injection analgesia (PAI) and peripheral nerve block (PNB) has been reported. We report a prospective blinded randomized trial of PAI versus PNB in patients undergoing primary TKA, in accordance with the CONSORT statement 2010.

Methods: A total of 210 patients undergoing TKA under spinal anesthesia were randomized to receive PNB group or PAI group. In the PNB group, femoral nerve block and sciatic nerve block were performed. In the PAI group, a special mixture containing ropivacaine, saline, epinephrine, morphine hydrochloride, and dexamethasone was injected into the periarticular soft tissue. Pain intensity at rest was assessed using a numerical rating scale (NRS: 0–10) after surgery. Use of a diclofenac sodium suppository (25 mg) was allowed for all patients at any time after surgery, and the diclofenac sodium suppository usage was assessed. The NRS for patient satisfaction at 48 hours after surgery was examined.

Results: The average NRS for pain at rest up to 48 hours after surgery was low in both groups. Within 48 hours after surgery, the diclofenac sodium suppository usage was similar in both groups. There were no significant differences in the NRS for patient satisfaction in both groups.

Conclusions: The analgesic effects of PAI and PNB are similar. PAI may be considered superior to PNB because it is easier to perform.

Level of Evidence: Therapeutic Level 1.

1. Introduction

Total knee arthroplasty (TKA) is one of the surgical procedures with the best outcomes for osteoarthritis of the knee. Pain management following TKA is an important issue that affects postoperative range of motion of the knee, patient satisfaction, and the duration of hospitalization [1]. The concept of preemptive analgesia has previously been described, and studies have investigated its effectiveness [2]. It is important to administer analgesics after TKA before severe postoperative pain occurs to prevent the establishment of central sensitivity, which amplifies postoperative pain.

Existing methods of pain management following TKA include continuous epidural anesthesia using a local anesthetic and patient-controlled analgesia (PCA) with morphine. Continuous epidural anesthesia and PCA are extremely effective methods of analgesia for severe pain during the acute postoperative period, but they may cause adverse events including nausea, vomiting, delirium, constipation, anuresis, dizziness, sedation, respiratory depression, and itching [3]. In addition, continuous epidural anesthesia requires an advanced skill and intensive labour in its management. Furthermore, epidural anesthesia carries the risk of causing severe neurological complications (epidural haematoma or spinal haematoma), although these are rare [4]. If postoperative anticoagulant therapy is used to prevent deep vein thrombosis during the perioperative period for TKA, methods of analgesia that may cause haematoma should be avoided. It is essential to identify safer procedures for the selection of methods of postoperative analgesia.

In recent years, peripheral nerve block (PNB) and periarticular injection (PAI) have been reported as useful for managing pain after TKA [5,6]. The most common types of PNB are femoral nerve block and sciatic nerve block. It has been reported that femoral/sciatic nerve blocks in TKA provided a quality of analgesia and functional outcomes similar to those of continuous epidural anesthesia, but with fewer side effects [7]. PAI consists of the direct injection of a solution containing local anesthetic, morphine, and steroids into the periarticular area during surgery to reduce postoperative pain and inflammation [8]. These methods of analgesia avoid the risk of postoperative complications specific to continuous epidural analgesia and PCA [9,10].

Both PNB and PAI have been reported to reduce narcotic usage and the pain score during the early postoperative period, particularly within

* Corresponding author at: Department of Orthopaedic Surgery, Fukushima Medical University School of Medicine, 1-Hikarigaoka, Fukushima City, Fukushima, 960-1295, Japan. Tel.: +81 24 547 1276; fax: +81 24 548 5505.
E-mail address: uesugi@fmu.ac.jp (K. Uesugi).

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48 hours. The objective of the present study was to compare the analgesic effectiveness of PNB and PAI during the early postoperative period following TKA.

2. Methods

2.1. Participants

The subjects were patients with osteoarthritis of the knee who were scheduled to undergo TKA. Patients who were scheduled to undergo simultaneous bilateral TKA and those with a previous history of knee joint surgery, rheumatoid arthritis, regular narcotic use, psychiatric disorder, neuromuscular disorder, severe systemic disorder (heart failure, respiratory organ failure, kidney failure, liver failure, or clotting disorder), or drug allergy were excluded. Patients who developed delirium after TKA were also excluded.

This study was approved by the Ethics Committee of Fukushima Medical University (registration number 1462). Written, informed consent was obtained from all subjects before their participation in the study.

2.2. Study design

This study was a prospective, randomized, double-blind comparative trial. Patients were randomly allocated to one of two treatment groups and given either PAI or PNB. Random tables were generated using SPSS for Windows (version 16.0; SPSS Inc., Chicago IL, USA). A total of 210 sealed envelopes were prepared. The recruitment period ran for five months from August 1 to December 30, 2012. The study was performed with neither patients nor the postoperative team (evaluators, nurses, physiotherapists) aware of the group to which each patient belonged.

2.3. Surgery

All patients underwent spinal anesthesia with 3–3.6 ml of 0.5% bupivacaine (Marcain injection 0.5%; AstraZeneca Co., Osaka, Japan). Narcotic or ketamine administration by intravenous injection was not performed. A bladder catheter was inserted. Surgery was performed without the use of a tourniquet. A midline incision was used as the skin incision, and the operation proceeded via the mid-vastus approach. Posterior stabilized components (Scorpio NRG PS; Stryker Orthopaedics, Mahwah, NJ, USA) were fixed with cement (Simplex-P Bone Cement; Stryker, Kalamazoo, MI, USA). No suction drain was placed postoperatively. Tranexamic acid 500 mg was injected into the joint after closure of the articular capsule.

If patients complained of postoperative pain they were given diclofenac sodium suppositories (25 mg). There was no limit on the number of suppositories that could be used. Oral narcotics or NSAIDs were not administered. Low-molecular-weight heparin (enoxaparin sodium, 2000 units twice a day subcutaneously for 14 days) was administered from the day after surgery to prevent deep vein thrombosis.

Patients were required to engage in active movement of the affected leg from the day after surgery. Rehabilitation (passive movement, active movement, range of motion exercises, gait training) was started from day 2 after surgery under the supervision of a physiotherapist. A continuous-passive-motion machine was not used.

2.4. Periarticular injection (PAI) group

The local anesthetic solution was compounded from a mixture of 20 ml of 0.75% ropivacaine (Anapeine injection 7.5 mg/mL; AstraZeneca Co., Osaka, Japan), physiological saline 20 mL, adrenaline 0.3 mg, morphine hydrochloride (men 10 mg, women 5 mg), and dexamethasone 3.3 mg (Table 1). Before the artificial joint was inserted, 20 mL of this solution were injected into the posterior soft tissues (posterior capsule, posteromedial structures, and periarticular synovium) via a 22-gauge needle. After the artificial joint had been inserted, 20 mL of the solution were injected into the anterior soft tissues (pes anserinus, anteromedial capsule, iliotibial band, and quadriceps tendon).

Table 1
The dosages for periarticular injection.

0.75% ropivacaine	20 ml
Saline	20 ml
Adrenaline	0.3 mg
Morphine hydrochloride	male 10 mg/female 5 mg
Dexamethasone	3.3 mg

2.5. Peripheral nerve block (PNB) group

In the PNB group, an electrical stimulation unit (Stimuplex HNS12; B. Braun Medical Inc., Bethlehem, PA) was used to identify the femoral and sciatic nerves after closing the incision. With the patient supine, a 5-cm deep stylet (Stimuplex A; B. Braun Medical Inc.) was used to identify the femoral nerve 1–2 cm distal to the inguinal ligament and 1–2 cm lateral to the femoral artery. Electrical stimulation of 0.3 mA was applied and movement of the patella associated with quadriceps contraction was confirmed, after which 20 mL of 0.75% ropivacaine was injected. The patient was then placed in the lateral position, and a 10-cm deep stylet was used to identify the sciatic nerve between the tuberosity of the ischium and the greater trochanter. Electrical stimulation of 0.3 mA was applied, and plantar flexion or dorsiflexion of the ankle was confirmed, after which 10 mL of 0.75% ropivacaine was injected.

2.6. Outcome measures

Age, sex, height, weight, American Society of Anesthesiologists physical status (ASA-PS) and range of motion of the knee were evaluated at the time of enrollment. The level of pain at rest was evaluated by patients according to a NRS at 3, 6, 12, 18, 24, 30, 36, 42, and 48 hours after surgery. In a patient who was asleep and whose facial expression did not indicate discomfort, the level of pain was considered to be 0. The numbers of diclofenac sodium suppositories (25 mg) used <6 hours, 6–12 hours, 12–18 hours, 18–24 hours, 24–36 hours, and 36–48 hours after surgery were investigated. The development of complications within 48 hours after surgery (new arrhythmia, hypotension with systolic blood pressure <80 mmHg, hypoxia with SpO_2 <95%, nausea, vomiting, dizziness, itching, numbness) was investigated. If nausea or vomiting developed after surgery, metoclopramide 10 mg was injected intravenously. Patients were instructed to press a call button when they felt postoperative pain, and the pain onset time was recorded. To investigate the duration of motor nerve paralysis associated with anesthesia or nerve block, the time required until the patient was capable of plantar flexion or dorsiflexion of the ankle was measured after surgery. Patient satisfaction with postoperative analgesia was evaluated by the patients themselves with the NRS at 48 hours after surgery. We measured the range of motion of the knee at three months after surgery. All evaluations were performed with both subjects and observers unaware of the method of analgesia.

2.7. Statistical analysis

A sample size determination was conducted for the main outcome variable, the numerical rating scale (NRS: 0–10) of postoperative pain, and using R environment version 2.12.0. A preliminary retrospective analysis of 40 patients revealed a standard deviation of postoperative pain score of 2.3 (unpublished data). Previous studies have suggested that a change in pain score of 1–1.3 points is clinically significant [11]. We estimated, for this study design, to show a difference of one point on a NRS with a power of 0.08 ($p = 0.05$, standard deviation of 2.4), a total 183 patients were required. With assumed rate of 5% protocol