Peripheral Nerve Blocks for Lower Extremity Surgery: 
A Prospective Observational Feasibility Study

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Introduction

Various types of anesthesia have been used for lower extremity surgery, including local, peripheral nerve blocks (PNBs), neuraxial and general anesthesia. Compared with general anesthesia, regional anesthesia has many advantages including reduced morbidity and mortality, better postoperative pain control, greater patient satisfaction, and enhanced cost effectiveness. (1-5)

Spinal and epidural blocks are the most commonly used regional anesthesia because of the reliable operative conditions and postoperative analgesia. However, neuraxial anesthesia may also be associated with side effects such as postoperative backache,(6) postdural puncture headache,(7) hypotension, and urinary retention. In addition, there is a risk of vascular injury inducing subsequent bleeding during spinal/epidural needle and catheter placement or removal. The development of epidural or spinal hematomas after neuraxial anesthesia is a special concern in patients receiving anticoagulants.

The PNBs are useful anesthetic techniques for unilateral lower limb surgery, particularly in patients unsuitable for neuraxial anesthesia. Potential advantages include improved postoperative analgesia, decreased nausea/vomiting and urinary retention, and unilateral motor block, resulting in earlier ambulation. The PNBs have been reported to be associated with lower morbidity and cardiovascular effects than neuraxial anesthesia.(8,9) However, lower extremity PNBs are still less commonly used as anesthetic techniques in despite of its advantages.

This prospective observational study was designed to evaluate the feasibility, efficacy, and complications of the PNBs for regional anesthesia of the lower extremity.

Methods

After institutional ethical committee approval and obtaining informed written consent from each patient, 60 American Society of Anesthesiologists physical status I - II patients scheduled for distal femur, knee, ankle, or foot surgery under PNB were prospectively included in the trial. Exclusion criteria were age < 18 years, hip surgery, pregnancy, preexisting neuropathy, allergy to local anesthetics, coagulopathy, and infection at the puncture site.
Table 1. Surgical Characteristics

<table>
<thead>
<tr>
<th>Site of surgery (n)</th>
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<td>distal femur</td>
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<tr>
<td>knee</td>
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<td>tibia</td>
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Duration of surgery (min) 40±24

Values are mean (SD) or numbers.

Standard monitors including electrocardiography, noninvasive blood pressure, and pulse oximetry were used throughout the block procedure and operation. Supplemental oxygen was administered by facemask throughout the operative period. At the anesthesiologist’s discretion, patients could receive midazolam (1-4 mg) and fentanyl (25-75 μg) by IV injection, in divided doses, before the PNBs. All blocks were performed in the recovery room by the same anesthesiologist. The PNBs were performed with a nerve stimulator (Stimuplex® HNS 12, B.Braun, Germany) and insulated 22-gauge needle (Stimuplex® D, B.Braun, Germany) of 120 mm for the sciatic nerve and 50 mm for the femoral nerve. Once the needle was inserted subcutaneously, the nerve stimulator was activated by using a frequency 1 Hz and intensity 1.5 mA, and pulse duration was 0.1 ms. When appropriate muscle contractions were found between 0.2 mA and 0.5 mA, after negative aspiration of blood, 25 mL of local anesthetic mixture containing equal parts of mepivacaine 1.5% and levobupivacaine 0.5% was slowly injected through the needle for each block (except sciatic block for knee arthroscopic surgery, 15 mL of local anesthetic mixture was used). When the use of a tourniquet was planned, a femoral nerve block was also performed using 15 mL of 1.5% mepivacaine. The femoral nerve block was performed with the patient in the supine position. The pulse of the femoral artery was identified. The needle was introduced 1 cm lateral to the femoral artery at the inguinal skin crease and advanced cephalad at an angle of 45-60° to the skin. (10) Correct identification of the nerve was confirmed by quadriceps muscle contraction with the nerve stimulator set between 0.2 and 0.5 mA (0.1 ms, 1 Hz).

The sciatic nerve block was performed using the classic posterior approach. Patients were placed in the lateral decubitus position, with the leg to be blocked uppermost and rolled forward, with the knee flexed at a 90° angle. An insulated needle was inserted 5 cm below the midpoint of a line connecting the posterior superior iliac spine and the greater trochanter. Stimulation was considered acceptable when responses from the tibial nerve (plantar flexion or inversion of the foot) between 0.2 and 0.5 mA (0.1 ms, 1 Hz). In case of combined femoral-sciatic nerve block, the sciatic nerve block was performed first followed by the femoral nerve block.

Block performance time and patient discomfort were recorded by the anesthesia nurse assisting the anesthesiologist performing the block. The block performance time was defined as a time between the block needle insertion and needle withdrawal. Degree of patient discomfort related to the block procedure was reported on a numerical rating scale of 0 to 10 (NRS, 0 indicating no pain, 10 indicating the worst pain ever experienced) after completion of the block.

The patients were transferred to the operating room after 30 minutes and any block that was inadequate for surgery were supplemented with IV fentanyl or general anesthesia, if required. Specific nerve distributions and degree of sensory and motor blockade were not formally evaluated. Upon incision, the attending anesthesiologist assessed the adequacy of the block. A “successful” block was defined as one requiring no supplemental intravenous analgesic to complete surgery. An “adequate” block was defined by requiring
supplementation with small doses of intravenous analgesic (fentanyl 50~100 μg) to complete surgery. An “inadequate” block was defined in case of conversion to general anesthesia. After assessment of block adequacy, sedation was maintained with a propofol infusion (30~50 μg/kg/min) at the discretion of the anesthesiologist. Fentanyl, in 50 μg increments, was given intravenously when patient complained of tourniquet pain. The surgical procedures, surgery time, tourniquet time, and tourniquet pain were recorded. Adverse events such as vascular puncture and local anesthetic systemic toxicity (LAST) were also noted. Following the operation, patients were transferred to the postanesthesia care unit (PACU), where postoperative pain was assessed using a visual analogue scale by PACU nurses.

At 24 hours after surgery, the patients were visited on the ward by a blinded investigator to assess postoperative analgesia and the presence of any dysesthesias in the operative limb. The duration of postoperative analgesia was defined as the time interval between the end of local anesthetic injection and the patient’s first report of postoperative pain at the surgical site. If patients did not report any pain during the 24 hours, the duration of postoperative analgesia was considered 24 hours. Dysesthesias were recorded when the patient complained of numbness, tingling, or pins-and-needles in the operative limb. The patients were also questioned about weakness in the operative extremity. Patient acceptance of the anesthetic technique was also evaluated using a two-point score: 1, satisfactory (if necessary, I will repeat it); and 2, unsatisfactory (different anesthetic technique). Each patient was followed up postoperatively for several weeks by the attendant surgeon, who reported complications or complaints (pain, paresthesia, hematoma or infection).

To calculate the required study size, we took into account results from a previous pilot study which shows 85% of successful block. With these assumptions, 49 patients were needed to determine the accuracy of success rate with a 95% CI±10%. The other eleven patients were included to allow for possible dropouts.

Descriptive statistics were used. Data is presented as median (interquartile range), mean/SD, or numbers (percent) where appropriate. SPSS 12.0 software (SPSS Inc., Chicago, IL) was used for computation and statistical analysis of the data.

**Results**

Data from the 60 patients who precisely fulfilled the criteria of the study protocol are presented in this paper. Patient characteristics were forty men and twenty women with the means (and±SD) of age 52±15 (range, 18~81) years, mean weight 65±11 (range, 49~100) kg, mean height 164±8 (range, 150~180) cm and American Society of Anesthesiologists Physical Status I/II=34/26. The surgical procedures were osteosynthesis, arthroscopic surgery (knee), tendon repair, and hardware removal. The site of surgical procedures is demonstrated in Table 1.

The femoral, sciatic, and combined femoral-sciatic nerve block were performed in 6, 27, and 27 patients, respectively. Block performance time was 2.3±2.1 (range, 0.8~11.8) min in the femoral nerve block and 2.9±1.4 (range, 1.6~7.3) min in the sciatic nerve block. Patient discomfort during the block procedure was 1 (1~2.25) and 2 (1~3) in the femoral and sciatic nerve block, respectively. The median volume of local anesthetic across all blocks was 40 (25~50) mL.

Of the 60 patients, surgery was performed without supplementation of any other anesthetic or analgesic in 51 patients (85%; 95% confidence interval 73.9~91.9%), while 9 patients (15%) required supplemental
analgesia. In no case general anesthesia was required to complete surgery. Eight patients requested sedation for their own comfort. A tourniquet was applied in 46 patients (38±21 min, range 12~99): it was well tolerated in 39 patients but produced pain in 7 patients who required supplemental analgesics for the tourniquet. The occurrence of tourniquet pain was time related in all of the cases (14~72 min after inflation). Six patients (10%) had accidental vascular punctures. Any case of hematoma formation was not observed. Three cases of LAST (5%) were observed, with all developing signs of neurological toxicity during sciatic nerve block requiring anticonvulsant therapy. Arrhythmias were not noted in any of the cases. This had no clinical consequence. In one patient, subgluteal sciatic block was performed due to failed block. In the other patients, surgery proceeded with IV supplementation. In the PACU, no patient required analgesics for pain. The median pain score in the PACU was 0 (range, 0~2).

At 24 hours after surgery, 11 (18.3%) patients reported paresthesia in the operative extremity that disappeared completely within a week. No motor weakness was noted at 24 hours. No neurological deficits were identified at the follow-ups. The duration of postoperative analgesia was 955±50 (range, 340~1440) min. Fourteen patients (23.3%) reported no pain during the first 24 hours of the postoperative period. Patient satisfaction was good and all studied patients indicated a willingness to accept the same anesthetic technique for future operations.

Discussion

While the PNBs are widely used to provide anesthesia and analgesia for upper extremity surgery, the lower extremity PNBs have never been as widely used as other forms of regional anesthesia. Anatomically, the lower extremity is innervated by the lumbosacral plexus. The lumbar plexus is formed within the psoas muscle from the anterior rami of T12-L4. Its terminal branches are the femoral, lateral femoral cutaneous, and obturator nerve. The sacral plexus is formed by the anterior roots of L4 and L5, and the first two or three sacral nerves. The most important branch of the sacral plexus is the sciatic nerve. Thus, unlike the upper extremity, the entire lower extremity cannot be anesthetized with a single-injection. In addition, the PNBs need a longer learning curve than neuraxial anesthesia requiring increased expertise to produce similarly successful anesthesia, an increased time required to perform the anesthetic procedure, and longer time to achieve adequate surgical conditions have been described (12). However, The blocks can be performed in a separate room to save time (2).

The results of this study demonstrate that the PNBs for lower extremity surgery provide adequate anesthesia, effective postoperative analgesia, an infrequent incidence of complications, and a high degree of patient satisfaction. The success rate was 85% in 60 patients and nine patients (15%) required supplemental analgesia, although our criteria of block success are less stringent than used in other studies. The muscle relaxation produced with the PNBs was adequate. This suggests that the PNBs provide a clinically acceptable success rate. The PNBs were performed with single-injection technique in this study. Certainly the success rate observed in this study could be improved with the use of a multiple-injection technique. However, the use of multiple-injections could theoretically increase the incidence of postoperative paresthesia and nerve damage due to redirection of the needle through partially anesthetized nerve, and the pain or paresthesia symptoms of intraneural injection may be missed when present.

The duration of postoperative analgesia was 955±50 min. Orthopedic procedures produce significant post-
operative pain. The control of postoperative pain is essential to facilitate early physical rehabilitation and ambulation. Thus, this relatively prolonged postoperative duration of analgesia enables postoperative pain to be easily controlled, and the need for analgesics is less than after general or neuraxial anesthesia.

Single-injection PNBs with long-acting local anesthetics can provide excellent postoperative analgesia. However, the analgesic benefit of single-injection blocks is typically limited to the duration of the blockade. Continuous PNBs can further lengthen the period of postoperative analgesia. Although we did not assess discharge criteria for each patient upon arrival to the PACU, all patients met discharge criteria and were eligible to bypass PACU. These attributes may reduce the demand on nursing time and hospital cost. The high satisfaction of patients with the anesthetic technique in this study shows the high quality of the PNBs for additional regional anesthesia in lower extremity surgery. However, the tourniquet was poorly tolerated by 7 patients (15%) with supplemental analgesics. In our experience, the PNBs are more appropriate for lower extremity surgery of short duration, although supplemental analgesics can prolong tolerance.

Various factors may affect the success rate of PNBs, such as the use of multiple-injection technique, the concentration and volume of local anesthetics,(13) the use of ultrasound guidance, and physicians’ expertise. The type of evoked motor response is also an important factor that influences the overall success of neurostimulation-guided PNBs.(14) During electrolocation of the femoral nerve, one of two responses may be elicited: sartorius muscle contraction (stimulation of the anterior branch of the femoral nerve) and quadriceps muscle contraction (stimulation of the posterior branch of the femoral nerve). Most authors advocate preferentially searching for the latter response as articular branches derive from the posterior branch. However, Anns et al. (15) reported that both evoked muscle twitch as an end point of stimulation was associated with an equivalent degree of femoral nerve block. In the case of single-injection Labat’s classic sciatic nerve block, Taboada et al.(14) reported that plantar flexion (tibial nerve stimulation) resulted in a higher success rate and shorter onset time than dorsiflexion (peroneal nerve stimulation).

In this study, block performance time is 2.3±2.1 min and 2.9±1.4 min for femoral and sciatic nerve block, respectively. Our results are in agreement with previous studies reporting block procedure times of 3 min for femoral and sciatic nerve each.(16-18) The block was well tolerated by most patients reporting some discomfort (NRS 1-3). Theoretically, the sciatic nerve block may be more painful for the patient compared with the femoral nerve block, mainly because of the thick layer of muscles through which the needle passes when seeking the nerve. A possible explanation for the similar pain score between the blocks in this study could be the use of sedatives and analgesics. Discomfort during block placement may reduce acceptance of the technique for future operations.(19) Especially, electrical stimulation was the most unpleasant component of the anesthetic procedure during the neurostimulation-guided PNB.(20) Acceptance of a painful procedure might improve if sedation/analgesic medication were given. In addition, we would advocate sedation in teaching cases where the performance of the block may be prolonged because of the inexperience of the anesthesiologist. However, excess sedation can impair patient’s ability to communicate regarding symptoms of intraneural or intravascular injections.

The risk of LAST would seem to be high for the lower extremity PNBs. This might be explained by the fact that the lower extremity PNBs generally requires
relatively larger doses of local anesthetic to anesthetize the entire lower extremity. In this study, it is interesting to note that the incidence of LAST after the lower extremity PNBs is considerably higher compared to previous studies.(8,19) This complication was observed in patients who all had undergone sciatic nerve block during the injection or immediately thereafter. This suggests that the mechanism of these adverse effects is an unintentional intravascular injection rather than systemic reabsorption with overdosing. We used 25 mL of local anesthetics for each nerve block except for supplementation. Thus, there is still a possibility that toxicity may occur secondary to delayed tissue absorption,(21,22) highlighting the importance of noting the maximum recommended doses of local anesthetics. For patient safety, additional studies are required to determine the minimum effective volume of the local anesthetics used in this study during the neurostimulation-guided PNBs.

Auroy et al. (8) reported that the incidence of LAST ranges between 3.9:10,000 and 11.2:10,000 (95% confidential interval). Fanelli et al. (19) reported that there were no systemic adverse local anesthetic reactions in 2175 patients undergoing combined sciatic-femoral nerve block. In this study, PNBs had been performed by anesthesiologist trained in these techniques. It is thus unlikely that technical factors played a prominent role. The higher incidence of LAST may be explained by anatomical characteristics of sciatic nerve in the vascularity and presence of deep muscles beds in the area of blockade. Slow injection and frequent aspiration with continuous observation of patient response and vital signs were recommended to reduce the risk of LAST. Ultrasound guidance for the PNBs provides real time visualization of the advancing needle and local anesthetic distribution. In addition, ultrasound-guided techniques can significantly reduce volumes of local anesthetic required to provide successful block compared to other methods (23). Thus, it might theoretically reduce the risk of LAST. Sites et al. (24) reported that the incidence was very low, at 0.08 per 1000 (95% CI, 0.0-0.4) during ultrasound-guided PNBs. However, there are reports of intravascular injection despite its use.(25,26)

Perioperative nerve injury (PNI) is considered one of the major morbidity events associated with the PNBs. In this study, we demonstrated no postoperative neurologic dysfunction after the PNBs with neurostimulation guidance. However, the sample size in this study may have been not large enough to detect this rare complication. The PNI associated with regional anesthesia is rare. Auroy et al. (8) reported an incidence of the PNI related to anesthesia of 0.02%. Barrington et al. (27) reported that the incidence of neurologic complications attributable to PNB was 0.4 per 1000 blocks (95% CI 0.08-1.1 per 1000). Severe neurologic complications rarely occur. Increased utilization of PNB is not associated with an increase in the PNI.(28) Fortunately, most PNIs after regional anesthesia are transient.

The PNI can be due to patient, block, and surgery-related factors or a combination thereof. Such factors include diabetes mellitus, pre-existing neurologic disorders, male sex, direct mechanical trauma, local anesthetic neurotoxicity, ischemic injury, nerve compression from hematoma, and patient positioning or manipulation during surgery, which may occur either alone or in combination. The majority of the PNIs are unrelated to regional anesthesia, with patient and surgical factors contributing.

In this study, a nerve stimulator was used for nerve identification. We did not use ultrasound because we did not have the necessary equipment at that time. As previously described, ultrasound imaging should prevent direct needle trauma to a nerve. This might confer safety benefits compared with neurostimulation. How-
ever, ultrasound guidance has not been proven to reduce the incidence of the PNI due to the PNB.

There are some limitations in this study. First, our study lacks a properly designed control group receiving either general or neuraxial anesthesia. Controlled trials are needed to compare this technique with other anesthetic techniques and to evaluate the efficacy of the PNBs. Second, this study includes only a limited number of surgical procedures and patients. Thus, further studies including a large number of patients and various surgical procedures are warranted to confirm these results. Finally, a shortcoming of this study is the lack of assessment of each nerve block and block onset time, mainly due to difficulty in assessment of each block and operating room efficiency. Block onset time is one of important factors that determines block efficacy.

In conclusion, this study demonstrates the feasibility and efficacy of the PNBs for lower extremity surgery. It may be a good alternate to general and neuraxial anesthesia for lower extremity surgery.

Abstract

**Background:** Peripheral nerve blocks are clinically useful regional anesthetic technique. Although they are less commonly used, they provide a lot of benefits for lower extremity surgery. The aim of this prospective study was to assess the feasibility and side effects of peripheral nerve blocks for lower extremity surgery.

**Methods:** The sixty patients undergoing lower extremity surgery were prospectively included. A sciatic nerve block was performed according to the classic posterior approach. A femoral nerve block was performed with the injection of 1 cm lateral to the femoral artery at skin-crease level. Stimulating needles of 120 mm for the sciatic nerve and 50 mm for the femoral nerve were used with a nerve stimulator. Block procedure time, patient discomfort, success rate, block duration, adverse events, and patient satisfaction were assessed.

**Results:** The sixty patients were enrolled (40 men and 20 women) with the following characteristics: mean (standard deviation) of age was 52 (15) yr, height was 164 (8) cm, and weight was 65 (11) kg. The success rate was 85% (95% confidence interval 73.9 – 91.9%) and 15% of the patients required supplementation. Local anesthetic systemic toxicity was observed in three patients (0.05%), and no neurological deficits occurred. All patients were satisfied with this technique.

**Conclusions:** This study showed that peripheral nerve blocks provide effective anesthesia and analgesia with a small complication rate and a high degree of patient acceptance for lower extremity surgery.

**Key Words:** Lower extremity, Femoral nerve, Nerve block, Sciatic nerve

Reference


