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Ultrasound-Guided Single-Penetration Dual-Injection Block for Leg and Foot Surgery
A Prospective, Randomized, Double-blind Study

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Background and Objectives: We describe a new approach to blocking the sciatic and saphenous nerves in the proximal thigh (level of the lesser trochanter or immediately below) using a single-penetration dual-injection (SPEDI) technique. The popliteal-sciatic approach necessitates repositioning of the leg exposing the popliteal fossa and an extra injection for the saphenous nerve (SAN) block at the midthigh level. We introduce an alternative, effective, and possibly faster method.

Methods: Sixty patients undergoing leg and foot surgery under general anesthesia were included. We deposited 15 mL of ropivacaine 0.75% around the sciatic nerve (SCN) and 5 mL of ropivacaine 0.75% at the SAN. Patients were randomized to the popliteal-sciatic/saphenous technique or the SPEDI technique. The primary outcome measure was performance time: Positioning time, pain assessment, nausea in the postanesthesia care unit, sufentanil demand, dermatomal anesthesia, and degree of motor blockade were also recorded.

Results: Performance time was significantly faster with the SPEDI technique (median time, 110 seconds [range, 57–315 seconds]) vs 246 seconds [range, 163–472 seconds]; P < 0.0001). Positioning time was significantly shorter with the SPEDI technique (P < 0.0001). No other statistically significant differences were recorded.

Conclusions: The SPEDI block resulted in significantly faster performance time and reduced positioning time with statistically equal efficacy in relation to pain assessment, nausea, sufentanil demand, dermatomal anesthesia, and motor blockade. The SPEDI block is statistically an equally effective alternative to the traditional popliteal-sciatic/saphenous block combination for leg and foot surgery, but it is faster, requires only 1 skin penetration, and does not require repositioning of the leg.

repositioning the patient. We have coined this new block combination the SPEDI technique.

**METHODS**

**Ethics**

The study was performed in accordance with the World Medical Association Declaration of Helsinki, and the Danish Data Protection Agency. It was registered at ClinicalTrials.gov (NCT01815372), and approved by the Committees on Biomedical Research Ethics for the Capital Region of Denmark (H-4-2012-10). All patients participating in this study provided oral and written informed consent.

**Patients**

Sixty-six patients age 18 years or older, of American Society of Anesthesiologists Physical Status I to III, and scheduled for leg surgery under general anesthesia supplemented with USG blocks of the SCN and the SAN from June 2012 until March 2013 were prospectively screened for inclusion. Exclusion criteria were known allergic reaction to ropivacaine, inadequate language abilities, serious drug or alcohol abuse, and severe peripheral neuropathy. One patient was excluded due to alcohol abuse and another for severe peripheral neuropathy resulting from mismanaged diabetes mellitus. Three other patients were excluded, 2 for logistical issues (ie, late-hour surgery) and another because the residing surgeon requested a change in the anesthesia management plan due to estimated high risk for leg compartment syndrome after surgery (tibial nailing). Sixty patients agreed to participate in the study.

**Design**

The study was conducted as a prospective, randomized, double-blind trial. Patients and investigators performing outcome assessments were blinded to group allocation. On the day of surgery, the patients were randomized to USG blocks of the SCN and SAN using either the traditional popliteal-sciatic approach in combination with a SAN block at the level of the adductor canal in the midthigh or the SPEDI technique performed in the proximal thigh. Patients randomized to the SPEDI block had an additional skin puncture at the lateral thigh 8 to 10 cm above the popliteal crease. This was primarily to ensure patient blinding. Outcome assessors only performed sensory dermatome testing and motor function evaluation below the knee level, and they were specifically asked not to investigate the thigh. Randomization was performed using a physical method with identical sealed envelopes containing treatment allocations indicated by numbers. The blinding process was rigidly ensured at all times, and no conversation regarding block technique was allowed. Patients and postanesthesia care unit (PACU) nurses were all blinded to the allocation throughout the study. The consultant anesthetists administering the USG nerve blocks were 1 of 2 individuals, each experienced with both block techniques.

**Study Parameters**

The primary outcome measure was performance time measured in seconds from the first transducer placement on the skin until the needle was retracted from the site of injection. The time measurement was performed by a blinded investigator timing the process guided by verbal commands (ie, start and end) by the block administrators. Secondary outcome measures were positioning time measured in seconds (time to position the leg before block placement), visibility scale for the SCN and SAN (easy, moderate, and difficult), postanesthesia nausea and vomiting (PONV) at PACU entry measured as numerical rating scale (NRS, 0–10), pain assessment (NRS, 0–10) at PACU entry and discharge, sufentanil demand in the PACU (total amount measured in micrograms), sensory dermatome testing with cold ethanol on skin was recorded on a standard chart at PACU discharge (recording whether the sensation of cold was different to the contralateral leg), motor function (ankle flexion/extension and foot inversion/eversion possible or not) at PACU discharge, and PACU length of stay (LOS) measured in minutes.

**Anesthetic Procedures**

General anesthesia was standard for all patients in the study. Surgery was conducted under induction and maintenance with remifentanil, propofol, and a laryngeal mask airway. The monitoring consisted of 3-lead electrocardiogram, noninvasive blood pressure, and pulse oximetry. The standard analgesic regimen for postoperative pain management prescribed at our hospital for surgical procedures of the leg and foot in general anesthesia and supplemented with peripheral nerve blockade was administered to all patients. This standard analgesic regimen consisted of sufentanil 0.1 μg/kg administered intravenously by the nurse anesthetists at the end of surgery. No further analgesics were administered in the operating room.

**Surgical Procedures**

These consisted of several procedures evenly divided between the 2 intervention groups. Fracture of distal tibia or fibula, with internal/external fixation (n = 28); fracture of distal tibia of fibula, removal of osteosynthesis material (n = 9); ankle joint instability, ligament surgery (n = 5); arthroscopy of the ankle joint (n = 3); chronic compartment syndrome, fasciectomy (n = 3); hallux valgus, osteotomy, and osteoplasty (n = 2); soft tissue revision of lower extremity: wound or ganglion (n = 7); and major bone surgery: amputation, open exploration, and transplant (n = 3).

**Study Interventions**

After induction of general anesthesia, one of the 2 USG block combinations on trial was performed. For the popliteal-sciatic/saphenous technique, the SCN was blocked approximately 6 to 8 cm above the popliteal crease at the SCN bifurcation and combined with blockade of the SAN at the midthigh level in the adductor canal. This was performed using a SonoSite EDGE ultrasound unit (SonoSite Inc, Bothell, Washington) with a linear array transducer (15-6 MHz, HFL 50). For the SPEDI technique, the block combination was performed using ultrasound guidance with the same ultrasound unit but with a curved array transducer (6-2 MHz, C-60). A sterile plastic sheath (Sanderson sterile saphenous guide, Saferonic Medizinprodukte Handels, Ybbs, Austria) was applied on both transducers. A 21-gauge, 120-mm-long needle (Polymedic ultrasound needle 30-degree bevel; Temena SAS, Carrières sur Seine, France) was used. Before the nerve block administration, the skin of the thigh was disinfected using 2% chlorhexidine/70% isopropyl alcohol. The various USG blocks were performed after induction of anesthesia with the patient in the supine position: (1) For the popliteal-sciatic block, the leg was lifted up, contingent bandages and plaster were removed and the leg positioned on a multilayer cushion buildup system to expose the popliteal fossa for the scanning process (Fig 1A). Timing of this procedure was recorded as positioning time. (2) The transducer was placed in the popliteal fossa localizing the popliteal artery in the transverse scanning position. The tibial nerve was then localized between the artery and skin and...
the nerve was followed by sliding the transducer gradually more cephalad until the common peroneal nerve (PEN) merged with the TIB. At this point of the SCN bifurcation, the needle was inserted at a very shallow angle to the transducer from the lateral side of the thigh and advanced in-plane in a lateral-to-medial direction with the end point between the 2 nerves (AB). Magnetic resonance (MR) imaging in the sagittal plane depicts the distribution of the injectate in and above the popliteal fossa spreading both cephalad and caudal to surround the SCN.

FIGURE 1. The popliteal-sciatic block. Model photograph. Scanning of the popliteal fossa (A). The popliteal artery (PA) is seen in the cross-sectional view (B). The tibial nerve (TIB) is localized between the PA and the skin (B). The TIB is then followed by sliding the transducer cephalad until the common peroneal nerve (PEN) merges with the TIB. At this point of the SCN bifurcation, the needle is inserted at a very shallow angle to the transducer from the lateral side of the thigh and advanced in-plane in a lateral-to-medial direction with the end point between the 2 nerves (AB). Magnetic resonance (MR) imaging in the sagittal plane depicts the distribution of the injectate in and above the popliteal fossa spreading both cephalad and caudal to surround the SCN.

FIGURE 2. The sailing block. Model photograph. Lateral view of the adductor canal (A). The femoral vessels (VJ) and SAN (AB) are seen in the transverse plane (B). The needle is inserted at a 35- to 45-degree angle to the transducer from its lateral end and advanced in-plane in a lateral-to-medial direction with the end point just lateral to the SAN (C). Fifteen-milliliter ropivacaine 0.75% was injected surrounding the SAN (Fig. 2A and B). The timing of these 2 block procedures was recorded as total performance time for the SPEDI technique.

Magnetic Resonance Imaging

To evaluate the resulting spread of the injectate around the nerves with both block combination techniques, one of the principal authors administered a combination block with the SPEDI technique on 1 thigh and on the contralateral thigh a combination block with the traditional popliteal-sciatic/saphenous technique. This procedure was conducted before the study commencement. The injectate consisted of 20 mL isotonic saline; ie, 15 mL around the SCN and 5 mL at the SAN and was administered with the subject placed on a magnetic resonance (MR) certified stretcher during the whole séance. A T2 spin echo fat-saturated sequence was performed in 3 planes, namely, coronal, sagittal, and axial on a 3-T Siemens Verio MR imaging scanner using a field of view of 360 mm and a matrix of 384 × 230. The scans were performed...
both before as well as directly after the fluid injections to rule out the presence of preinjection fluid or other findings.

**PACU Procedures**

Pain assessments (NRS score, 0–10) at rest were made upon arrival in the PACU. If the score was higher than 3, 5 μg sufentanil was administered intravenously. PONV assessments (NRS, 0–10) were also made upon arrival in the PACU and ondansetron 4 mg administered intravenously if necessary. PACU nurses involved in this assessment process had no other connection to the study. According to the protocol and standard PACU procedures, patients were assessed every 15 minutes until discharge. If block failure was evident, then the consultant anesthetist residing in the PACU could supplement the block at his discretion and document this in the patients case report file (CRF). Just before departure from the PACU, or before any supplemental blocks were administered, a standard sensory testing of dermatomes was performed by the PACU nurse using cold test with ethanol. The number of anesthetized dermatomes was recorded on a specific chart in the CRF. The same nurse also recorded the degree of motor block by recording the ability of the patient to perform ankle flexion/extension and foot inversion/eversion. Rating of both measures were dichotomous (yes/no). The PACU nurses were blinded to the trial procedure. Finally, LOS in the PACU and accumulated sufentanil demand were recorded in the CRF. Interrater reliability between all involved data collectors was not assessed in our study.

**Statistical Analysis**

The estimated sample size for the primary outcome measure was calculated based on an assumption of a minimal relevant difference (MIREDF) in the performance time of 90 seconds. A MIREDF of 15% is normally considered relevant for clinical trials. Performance time for the traditional block combination technique was shown to range from 2 to 10 minutes in a retrospective analysis with a Gaussian distribution with a mean performance time of 6 minutes. Because a MIREDF of 90 seconds equals 25% of the estimated mean performance time, we evaluated our assumption to be clinically relevant. We assumed a 5% significance level, a power of 80%, and a standard deviation of \((10 - 2) * 0.95/4 = 1.9\). These calculations resulted in a total sample size of 26 patients in both groups. Allowing for dropouts, a total of 60 patients were included in the study.

Mann-Whitney U test was used for nonparametric comparison of ordinal or continuous data. Fisher exact test was used for comparison of 2 proportions using 2 × 2 contingency tables. Fisher exact test with Freeman-Halton extension was used for comparison of 2 proportions using 2 × 3 contingency tables.

**RESULTS**

Thirty patients were included in each group. No significant differences in the demographic data were seen between the 2 study groups (Table 1). All results from the study are presented in Table 2. Performance time was significantly faster with the SPEDI technique compared with the traditional block combination

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**FIGURE 2.** The saphenous block. Model photograph. A cross-sectional view of the femoral artery (FA) at the midthigh level in the adductor canal with the sartorius muscle (SA) anteriorly and the SAN lateral to the pulsating FA (AB). The needle is inserted at a 35- to 45-degree angle to the transducer from its lateral end and advanced in-plane in a lateral-to-medial direction with the end point just lateral to the SAN under the subsartorial fascia (AB). Magnetic resonance (MR) imaging in the sagittal plane (C) depicts the distribution of the injectate spreading in the adductor canal. The same injectate distribution is also visualized in the axial plane (right thigh) (D).
technique, that is, median time 110 seconds (range, 57–315 seconds) versus 246 seconds (range, 163–472 seconds) \( (P < 0.0001) \), respectively. Positioning time was also significantly shorter with the SPEDI technique compared with the traditional technique, that is, median time 0 seconds (range, 0–0 seconds) versus median time 87 seconds (range, 17–53 seconds) \( (P < 0.0001) \), respectively. There were no significant differences in visibility scale (easy/moderate/difficult) for the SCN and SAN \( (P = 0.76 \text{ and } P = 0.41) \), respectively) between the 2 groups. The number of patients with a pain assessment scores NRS

### TABLE 1. Demographics

<table>
<thead>
<tr>
<th></th>
<th>Popliteal Sciatic/Saphenous</th>
<th>SPEDI</th>
<th>( P )</th>
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<tbody>
<tr>
<td>Sex (males/females), number</td>
<td>13/17</td>
<td>17/13</td>
<td>0.44</td>
</tr>
<tr>
<td>Age, median (range), y</td>
<td>47 (18–87)</td>
<td>34 (20–84)</td>
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<tr>
<td>BMI, median (range), kg/m²</td>
<td>25.0 (18.8–33.9)</td>
<td>23.9 (17.6–43.4)</td>
<td>0.49</td>
</tr>
</tbody>
</table>
TABLE 2. Results

<table>
<thead>
<tr>
<th></th>
<th>Popliteal-Sciatic/Saphenous</th>
<th>SPEDI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure time, median (range), s</td>
<td>246 (163–472)</td>
<td>110 (57–315)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Positioning time, median (range), s</td>
<td>87 (17–253)</td>
<td>0 (0–0)</td>
<td>&lt;0.0001</td>
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<tr>
<td>Total time, median (range), s</td>
<td>358 (216–660)</td>
<td>110 (57–315)</td>
<td>&lt;0.0001</td>
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<tr>
<td>Sciatic visibility score (easy/moderate/difficult), numbers</td>
<td>20/7/3</td>
<td>17/8/5</td>
<td>0.76</td>
</tr>
<tr>
<td>Saphenous visibility score (easy/moderate/difficult), numbers</td>
<td>18/10/2</td>
<td>16/8/6</td>
<td>0.41</td>
</tr>
<tr>
<td>PONV at PACU entry, number</td>
<td>2</td>
<td>3</td>
<td>1.00</td>
</tr>
<tr>
<td>Pain assessment—NRS &gt;3 at PACU entry (no. patients)</td>
<td>2</td>
<td>4</td>
<td>0.67</td>
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<tr>
<td>Pain assessment—NRS at PACU discharge, median (range) [NRS, 0–10]</td>
<td>0 (0–4)</td>
<td>0 (0–3)</td>
<td>0.21</td>
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<tr>
<td>Sufentanil demand in PACU, median (range), μg</td>
<td>0 (0–15)</td>
<td>0 (0–24)</td>
<td>0.39</td>
</tr>
<tr>
<td>Failed blocks, number</td>
<td>1</td>
<td>4</td>
<td>0.35</td>
</tr>
<tr>
<td>L3 dermatome block failure, number</td>
<td>4</td>
<td>6</td>
<td>0.73</td>
</tr>
<tr>
<td>L4 dermatome block failure, number</td>
<td>1</td>
<td>5</td>
<td>0.19</td>
</tr>
<tr>
<td>L5 dermatome block failure, number</td>
<td>1</td>
<td>4</td>
<td>0.35</td>
</tr>
<tr>
<td>S1 dermatome block failure, number</td>
<td>1</td>
<td>4</td>
<td>0.35</td>
</tr>
<tr>
<td>S2 dermatome block failure, number</td>
<td>6</td>
<td>7</td>
<td>1.00</td>
</tr>
<tr>
<td>Ankle flexion possible, yes</td>
<td>3</td>
<td>2</td>
<td>0.67</td>
</tr>
<tr>
<td>Foot inversion and eversion possible, yes</td>
<td>1</td>
<td>2</td>
<td>1.00</td>
</tr>
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</table>

The results from this prospective, randomized, double-blind study of 60 patients undergoing various surgical procedures of the leg and foot under general anesthesia showed that the new USG SPEDI block was significantly faster to perform ($P < 0.0001$) and required significantly less time for positioning of the leg before the block procedure ($P < 0.0001$). Importantly, the SPEDI block technique compared with the traditional popliteal-sciatic/saphenous technique was statistically as effective in providing sufficient postoperative pain management and low sufentanil demand in the PACU, extensive dermatomal anesthesia and equal motor blockade as compared to the traditional popliteal-sciatic/saphenous approach. Further, the 2 consultant anesthetists who performed the blocks found no obvious difference in the level of difficulty in visualizing the SCN and SAN, depending on which block combination technique the patients were randomized to.

In our department, we find that the most valuable result from the present study is that our residents and consultants now have an additional USG technique in the armamentarium of regional anesthetic techniques. Further, we have found the SPEDI block technique to be especially useful in the emergency department when patients present with open or dislocated fractures of the leg, ankle, and foot. A significant number of these patients experience severe pain; many are strapped to a spine-board and require quick relocation of the fractures. In such cases, elevation of the leg or turning the patient in the lateral or prone position is contraindicated or at least extremely painful for the patient. We find the SPEDI block technique very effective under such clinically challenging circumstances.

When comparing the 2 study groups within the described frame of the current study, our results show that there are no statistical differences in pain scores at PACU entry or discharge, no differences in PONV, similar sufentanil demands in the PACU, and no differences in dermatomal anesthesia, degree of motor blockade, or LOS in the PACU. This was our expectation before the study because we would be blocking the same nerves although at different locations. In addition, we could record that there was no significant difference in the visibility score (easy/moderate/difficult) of the SCN and SAN recorded by the 2 consultant anesthetists performing the blocks. For both groups, most patients were in the easy or moderate group, whereas only a few were in the difficult group (Table 2). This is somewhat surprising because many anesthetists would classify the popliteal-sciatic block as an easy block, whereas the anterior approach to

**DISCUSSION**

The results from this prospective, randomized, double-blind study of 60 patients undergoing various surgical procedures of the leg and foot under general anesthesia showed that the new...
the SCN has been described as a medium- to advanced-level block (www.usra.ca). However, in this particular study, 2 anesthetists performed all the blocks; because both were familiar with both block combinations and experienced in the placement of USG blocks, our results may not be representative in all departments. In general, we find that it is important to adhere to pattern recognition with the administration of USG blocks. This is also true in relation to the SPEDI block. The hyperechoic femur with its anechoic shadow is seen laterally in the sonographic image (Fig. 4A). More medially and deep the hyperechoic SCN is sandwiched between the adductor magnus and the gluteus maximus/long head of biceps muscles, respectively (Fig. 4A).

Much closer to the skin and without moving the curved array transducer from the position in the proximal thigh the pulsating femoral artery is visualized deep to the sartorius muscle and the small hyperechoic SAN is seen lateral to the artery (Fig. 4A). A somewhat similar structural organization is seen in the confirmatory MR image (Fig. 4B). However, it is noteworthy that the axial MR image (Fig. 4B) is at a level slightly below the lesser trochanter, and the SCN is here seen sandwiched between the adductor magnus and the long head of the biceps muscle. In Figure 4C, we have drawn a figure depicting the axial plane of the proximal thigh at the level of the lesser trochanter to show all anatomical structures relevant to the administration of the SPEDI block.

New USG block techniques aiming to provide effective anesthesia and analgesia in patients undergoing leg and foot surgery continue to be developed.7–12 The use of ultrasound in anesthesia practice has contributed to the development of better and faster techniques. We believe that the description of the SPEDI block in the current study contributes to this ongoing research and development.

The study has some limitations. First, with performance time as the primary outcome measure and a MIREDIF of 90 seconds, there may be discussion regarding the clinical relevance of this difference in time. We argue in the statistics section that the difference is clinically relevant. We chose to conduct our study in the controlled environment of the operating room rather than the hectic and sometimes stressful environment of the emergency department; we also felt that the ethical and logistic problems of including emergency trauma patients in significant pain would complicate matters. Second, we have included in our study 60 patients undergoing many different surgical procedures, including some that did not affect areas innervated directly by the SAN, potentially introducing bias in the assessment of some secondary outcome measures (eg, pain scores and spread of dermatomal anesthesia). However, the various surgical procedures were unbiased and randomly distributed between the 2 groups. Further, at our department, we routinely include a blockade of the SAN to supplement a block of the SCN both preoperatively and postoperatively even if the surgical procedure will not necessarily involve the area innervated by the SAN. Third, this study relied on third-party investigators blinded to the group allocation, making assessment of performance time, positioning time, pain scores,
PONV, sensory dermatome testing, and degree of motor blockade possible; these investigators were sampling data according to standard departmental procedures. However, interrater reliability between all involved data collectors was not assessed in our study, and our results should be interpreted in this context.

A final limitation of this study is that, as with most procedure-related studies, it was not possible to blind the operator to group allocation. To minimize the possibility of bias, both anesthesiologists performing the blocks adhered to a strict protocol procedure when administering the local anesthetic, as described. Despite this measure, performance bias cannot be ruled out.

In conclusion, the current study suggests that the new USG SPEDI block is significantly faster to perform, requires only 1 skin penetration, takes significantly less time to position the lower extremity, and is statistically as effective in providing sufficient postoperative pain management compared with the traditional popliteal-sciatic/saphenous combination block. We propose that the SPEDI block should be included in the armamentarium of regional anesthetic techniques in the daily anesthesia and emergency medicine clinical practice.

REFERENCES