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ORIGINAL ARTICLE

Ultrasound-guided sciatic nerve block: a comparison between four different infragluteal probe and needle alignment approaches

Tarek F. Tammam

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Abstract
Purpose Our aim was compare onset time of sciatic nerve blockade (SNB) performed distal to the subgluteal fold using four different ultrasound (US)-guided approaches in patients undergoing foot or ankle surgery.
Methods Patients were assigned to one of four groups: SI patients received SNB using short-axis (SA) view of the SN and in-plane (IP) placement of block needle (SA-IP approach); LI patients received SNB using long-axis (LA) view of the SN and IP needle placement (LA-IP approach); SO patients received the block using SA view of the SN and out-of-plane (OP) needle placement (SA-OP approach); LO patients received SNB using LA view of the SN and OP needle placement (LA-OP). Primary outcome included onset time of sensory and motor SNB. Patient satisfaction concerning the postoperative analgesia was noted.
Results The LI group had significantly faster onset of sensory blockade on the distribution of tibial nerve (16.0 ± 5.6 vs. 23.5 ± 3.6) and common peroneal nerve (12.5 ± 4.3 vs. 19.1 ± 5.4 min) in comparison with the LO group. The LI group had significantly faster onset of motor blockade on the distribution of tibial nerve (21.1 ± 6.2 vs. 26 ± 3.1) and common peroneal nerve (17.7 ± 4.8 vs. 23.7 ± 5.8 min.) in comparison with the LO group. The LI group had the highest rate of patient satisfaction for postoperative analgesia and the LO group had the lowest.
Conclusion The LA-IP approach resulted in a rapid onset of SNB and was associated with the best satisfaction for postoperative analgesia in comparison with LA-OP, SA-IP, and SA-OP approaches for patients undergoing foot and ankle surgery.

Keywords Regional anesthesia · Sciatic nerve block technique · Ultrasound-guided block outcome · Peri-operative

T. F. Tammam (✉)
Department of Anesthesia and Intensive Care, Suez Canal University Hospital, Ismailia, Egypt
e-mail: tarek1367@hotmail.com

Introduction

Ultrasound (US)-guided sciatic nerve blockade (SNB) requires appropriate US imaging of the SN, a proficiency in tracking block-needle advancement, and an assessment of local anesthetic spread relative to the nerve. The ability to visualize local anesthetic distribution relative to the SN, as well as the capacity to control its distribution by readjusting the needle tip, should improve SNB quality [1]. The SN distal to the subgluteal fold is easily visualized with US, as it is relatively superficial compared with proximal locations [2, 3]. There is limited information on the significance of using different US axes [long axis (LA) vs. short axis (SA)] for scanning the SN distal to the subgluteal fold in regard to SNB quality. The significance of different needle insertion techniques [in-plane (IP) vs. out-of-plane (OP)] is also underevaluated. The US-guided SNB, performed distal to the subgluteal fold, has four possible approaches: The first involves SA scanning of the SN and IP needle insertion (SA-IP). The second involves SA scanning of the SN and OP needle insertion (SA-OP). The third involves LA scanning of the SN and IP needle insertion (LA-IP). The fourth involves LA scanning of the SN and OP needle insertion (LA-OP). I hypothesized that the four approaches performed distal to the subgluteal fold could provide different SNB onset time. The aim of the study was to compare onset time when the SNB is performed distal to the subgluteal fold using the four different approaches for foot and ankle surgery.

Patients and methods

After obtaining approval of the hospital's Research Ethics Committee and written informed consent from patiens, 144 patients between the ages of 18 and 40 years with American Society of Anesthesiologist (ASA) physical status I–II scheduled for elective foot or ankle surgery under infragluteal SNB were enrolled in this prospective, comparative, randomized clinical study. The study was conducted from March 2010 to January 2012. Patients with local infections, coagulopathies, history of allergy to US, obesity body mass index (BMI) >30 kg/m^2], and neuropathies were excluded from the study. Patients who had a history of chronic analgesic therapy or who refused to participate were also excluded. Patients were randomized into four groups: SI ($n = 36$), in whom US-guided single-injection SNB was performed using the SA-IP approach; LI ($n = 36$), in whom US-guided SNB was performed using the LA-IP approach; SO ($n = 36$), in whom US-guided SNB was performed using the SA-OP approach; and LO ($n = 36$), in whom US-guided SNB was performed using the LA-OP approach.

Patients were randomly assigned on a one-to-one ratio. Randomization was performed by means of a computer-generated random-numbers table. All blocks were performed by anesthesiologists who had the same, substantial, expertise in US-guided SNB and had no prefer of interest in the various SNB approaches. Before block placement, an intravenous access and standard electrocardiogram monitoring, peripheral oxygen saturation, and noninvasive blood pressure levels were established. All patients were premedicated with diazepam (7.5 mg) orally 30 min before blockade, and fentanyl (50 μg) was administered IV to every patient before blockade. Patients were positioned semiprone with the hip flexed at approximately 90°, allowing them to move their feet freely. US scanning (GE LogiBook XP, General Electric Company, Fairfield, CT, USA) of the SN was performed distal to the subgluteal fold and 10 cm away from midline [2, 3], adjusting for depth, frequency, and gain to determine the best SN view. In the LA view, a transverse image of the SN was initially visualized, and the US probe was then rotated through 90° to assist in identifying the nerve longitudinally. After sterile skin preparation with chlorhexidine solution and local infiltration with 1 ml of 1 % lidocaine, a 10-cm, 22-gauge, insulated block needle (Stimuplex, B. Braun Medical, Melsungen, Germany) connected to a nerve stimulator delivering a current of 1.2 mA at a frequency of 2 Hz was advanced slowly until it was in close proximity to the nerve. The needle position was adjusted to maintain an adequate muscular twitch (i.e., foot plantarflexion or dorsiflexion) with a current intensity of ≤0.5 mA. The needle was repositioned until accurately placed based on imaging feedback and confirmed by multiple test injections with 1 ml of 5 % dextrose solution. Thirty milliliters of local anesthetic mixture (1 % lidocaine and 0.25 % bupivacaine, 1:1 ratio) was slowly and incrementally injected using a single needle location. Anesthetic spread was confirmed on LA and SA scans. If a tourniquet was expected to be placed on the leg below the knee, a US-guided femoral nerve block was performed, with the patient in the supine position, using a linear-array US probe at the level of the groin crease in a transverse orientation. Following sterile preparation, a 5-cm, 22-gauge, insulated, stimulating needle attached to the nerve stimulator was used to deposit 10 ml of 0.25 % bupivacaine after quadriceps contraction was elicited with a current <0.5 mA. The femoral nerve block technique was not formally evaluated as regards current investigation. A pneumatic tourniquet was placed on the leg below the knee and inflated to 100 mmHg higher than systolic blood pressure.

No research personnel were involved in block placement, and all were blinded to the randomization schedule. Patient demographics, type and duration of surgery, tourniquet time, and patient's ASA physical status were recorded. Primary outcome comprised onset time of sensory and motor blockade. Secondary outcome was patient satisfaction concerning postoperative analgesia and its duration. Success rate and the incidence of adverse events were noted. Sensory and motor blockade were evaluated every 2 min after block placement until 30 min after injection. Sensory blockade was defined as complete loss of sensation to pinprick in the distribution of both tibial and common peroneal nerves (plantar and dorsal aspect of the foot) within 30 min of anesthetic injection; motor blockade was defined as inability to dorsiflex or plantarflex the foot within 30 min of injection. SNB success was assessed according to the adequacy of surgical anesthesia and was defined as complete loss of pinprick sensation within 30 min of anesthetic administration and if no sedative or analgesic was required during surgery. Partial block was defined as inadequate sensory blockade after 30 min of anesthetic administration and if rescue doses of analgesic (fentanyl) were administered IV. Failed block was considered if general anesthesia was required to complete the proposed surgery. Duration of analgesia was defined as the time of compete sensory blockade to the first request for analgesic. The level of patient satisfaction for postoperative analgesia was evaluated using a numerical rating scale (NRS) (0, no satisfaction; 10, maximum satisfaction).

Table 1 Patient demographics and clinical characteristics

Parameters	Group SO ($n = 36$)	Group LI ($n = 36$)	Group SI ($n = 36$)	Group LO ($n = 36$)
Age (year)	31 ± 9.6	30 ± 8.7	31 ± 8.4	31 ± 9.6
Weight (kg)	73.6 ± 9	73.9 ± 8	72.8 ± 7.6	72.4 ± 7.4
Height (cm)	169 ± 9.2	168 ± 8.9	168 ± 8.8	169 ± 9.6
ASA I/II	29/7	30/6	28/8	30/6
M/F	19/17	18/18	17/19	17/19
Femoral nerve block	34 (94.4 %)	34 (94.4 %)	35 (97.2 %)	34 (94.4 %)
Tourniquet time (min)	62.5 ± 10	62 ± 11.5	61.3 ± 12	63 ± 11.5
Surgery time (min)	90 ± 13.2	92.5 ± 14	90 ± 12.9	93 ± 15
Stimulation current intensity	0.47 ± 0.05	0.48 ± 0.05	0.48 ± 0.05	0.46 ± 0.06

Values are expressed as mean ± standard deviation or absolute numbers. There were no statistically significant differences among groups for all baseline characteristics

M Male, *F* female, *Group SI* nerve in short-axis approach, needle in-plane, *Group LI* nerve in long-axis approach, needle in-plane, *Group SO* nerve in short-axis approach, needle out-of-plane, *Group LO* nerve in long-axis approach, needle out-of-plane

Complications of hematoma, infection, and neuropathies were recorded for the first 48 h postoperatively. Sample size was calculated [4] using the time to SNB as the primary outcome of this study. Alpha error level was fixed at 0.05, power was set at 80 %, and the effect size (f^2) was 0.25. The required study size was 36 patients per group.

Statistical analysis

Data were analyzed using an IBM computer with SPSS version 12 (SPSS Inc, Chicago, IL, USA). Data are presented as mean ± standard deviation (SD) for normally distributed continuous variables, as median [interquartile (IQ) range] for nonnormally distributed continuous quantitative or ordinal variables, and as counts and percentages for nominal variables. One-way analysis of variance (ANOVA) for independent means using Scheffe's test as post hoc for multiple comparison, Pearson's Cci-square test, and Kruskal–Wallis test where appropriate, were used to identify differences between groups.

Results

There were no significant differences between groups with respect to patient characteristics, type and duration of surgery, and number of patients receiving femoral nerve block; $p > 0.05$ (Table 1). There were significant differences in sensory block onset times in tibial (TN) and common peroneal (CPN) nerves among groups, $p = 0.015$ and $p = 0.024$, respectively: in the LI group (16.0 ± 5.6, 12.5 ± 4.3 min, respectively), in comparison with the LO group (23.5 ± 3.6, 19.1 ± 5.4 min., respectively. Sensory block onset time was significantly delayed on the TN and CPN ($p = 0.023$ and $p = 0.026$, respectively,) in the LO group in comparison with SI and SO groups (Table 2). Motor blockade developed significantly faster on the TN and CPN (21.1 ± 6.2 and 17.7 ± 4.8 min., respectively,) in the LI group in comparison with the LO group (26 ± 3.1 and 23.7 ± 5.8 min., respectively) (Table 2). There was a significant difference in longest time to first request for analgesic among groups ($p = 0.032$): LI group 9.8 ± 2.7 h in comparison with LO, SI, and SO groups (5.8 ± 1.2, 7.7 ± 1.6 and 7.8 ± 2.5 h, respectively). Time to onset in the LO group was shortest significantly: 5.8 ± 1.2 h in comparison with SI and SO groups (7.7 ± 1.6 and 7.8 ± 2.5 h, respectively) (Table 2).

There were significant differences in the rate of patient satisfaction for postoperative analgesia among groups ($p < 0.000$): patients in the LI group had the best rate; patients in the LO group had the poorest rate (Table 2). There was no significant difference in the rate of successful SN block among groups (Table 3). There was no failed block in the LI group, one case (2.8 %) each in the SI and SO groups, and two cases (5.6 %) in the LO group (Table 3). One patient reported dysesthesia in CPN distribution in each of the LO and SO groups, which completely resolved in 4 days. No incidence of hematoma or infection were recorded.

Discussion

When applying two different US-guided scanning methods, SA vs. LA, for SNB; four possible approaches: SA-IP, LA-IP, SA-OP, and LA-OP ; and two different needle insertion techniques: IP vs. OP (Fig. 1). This study shows the different outcomes when using each approach. The LA-IP approach resulted in better SNB quality than the LA-OP, SA-IP, and SA-OP approaches. Patients in the LI group were more satisfied with postoperative analgesia than patients in the other groups.

Table 2 Sensory nerve blockade (SNB) technique outcomes and patient satisfaction (NRS) regards postoperative analgesia among groups

Variables	Group SO ($n = 35$)	Group LI ($n = 36$)	Group SI ($n = 35$)	Group LO ($n = 34$)	*P* value
Onset time of sensory block (min)					
TN	18.8 ± 4.7**,*****	16.0 ± 5.6*,**,***	19.3 ± 4.9***,****	23.5 ± 3.6*,*********	0.015
CPN	14.1 ± 4.8*****	12.5 ± 4.3*	14.0 ± 4.7****	19.1 ± 5.4*,****,*****	0.024
Onset time of motor block (min)					
TN	23.9 ± 3.2**	21.1 ± 6.2*,**	23.1 ± 2.9****	26.0 ± 3.1*,****	0.023
CPN	20.7 ± 5.1**,*****	17.7 ± 4.8*,**	20.4 ± 5.1****	23.7 ± 5.8*,*********	0.026
Duration of analgesia (h)	7.8 ± 2.5**,*****	9.8 ± 2.7*,**,***	7.7 ± 1.6***,****	5.8 ± 1.2*,****,*****	0.032
Patient satisfaction [median (IQR)]	7 (1)**,*****	9 (3)*,**,***	7(1)***,****	7 (2)*,****,*****	0.000

CPN common peroneal nerve, *TN* tibial nerve, *Group SI* nerve in short axis, needle in-plane, *Group LI* nerve in long axis, needle in-plane, *Group SO* nerve in short axis, needle out-of-plane, *Group LO* nerve in long axis, needle out-of-plane, *NRS* Numerical Rating Scale

* *P* value significant, comparing LI group with LO group

** *P* value significant, comparing LI group with SO group

***P* value significant, comparing LI group with SI group

**** *P* value significant, comparing LO group with SI group

***** *P* value significant, comparing LO group with SO group

Table 3 Sensory nerve block success rate among groups

Variable	Group SO ($n = 36$)	Group LI ($n = 36$)	Group SI ($n = 36$)	Group LO ($n = 36$)	Significance
Success rate (*n*) %					
Successful	31 (86.11)	33 (91.7)	31 (86.11)	29 (80.6)	NS
Partial	4 (11.10)	3 (8.33)	4 (11.11)	5 (13.89)	NS
Failed	1 (2.8)	0 (0.0)	1 (2.8)	2 (5.6)	NS

Group SI nerve in short-axis approach, needle in-plane, *Group LI* nerve in long-axis approach, needle in-plane, *Group SI* nerve in short-axis approach, needle in-plane, *Group LI* nerve in long-axis approach, needle in-plane, *Group SO* nerve in short-axis approach, needle out-of-plane, *Group LO* nerve in long-axis approach, needle out-of-plane. *NS* $P > 0.05$

Each approach could have its individual impact on the sonographic image of the SN and capacity to control block-needle advancement and local anesthetic distribution relative to the SN. IP approaches (LA-IP and SA-IP) can yield clear images of the needle tip and guide its precise placement when approaching the SN. Identifying the needle tip can be challenging with OP approaches (LA-OP and SA-OP) and is possible only when the needle crosses the US beam [5]. The endpoint for LA injection (LA-OP and SA-OP) is not so clear and may require greater dependence on test injection in order to visualize satisfactory anesthetic distribution. Multiple test injections are often necessary to ensure circumferential coverage of anesthesia around the nerve. Using the LA-IP approach, the SN can be easily tracked as the block needle enters the view. The LA-OP approach requires greater hand–eye coordination. SA scanning of the nerve (SA-OP and SA-IP) clearly displays the SN in the cross-section view. However, it provides limited information only regarding the spread of anesthetic along the longitudinal axis of the SN during injection. Those approaches display the spread anesthetic over a short section of the nerve corresponding to the narrow axis of the US beam. On the other hand, LA-IP and LA-OP display the anesthesia spread over a relatively longer section of the nerve, which corresponds to the LA of the US beam. The key requirement for successful and quick regional blockade onset is to ensure optimal distribution of anesthetic around the SN [6]. Easier repositioning of the needle tip in order to maximize the tangential perineural anesthetic spread along the LA of the SN is the major advantage of the LA-IP approach. That approach can increase the chance of optimum anesthetic deposition in the right plane and the chance of larger volume of anesthetic in direct contact with the SN. This could explain the superiority of the LA-IP approach, as SNB quality is directly related to the nerve length exposed to the anesthetic [7]. Successful perineural catheter placement also correlated with the LA-IP approach [8, 9]. LA SN scanning was more useful than SA scanning for inserting the perineural catheter [8, 9]. The LA-IP approach allows better visual control of catheter insertion [8].

Approaches described in this study show comparable SNB success rates equivalent to those reported in previous studies [10, 11]. Although there is a significant heterogeneity in the definition of successful nerve blockade, US-

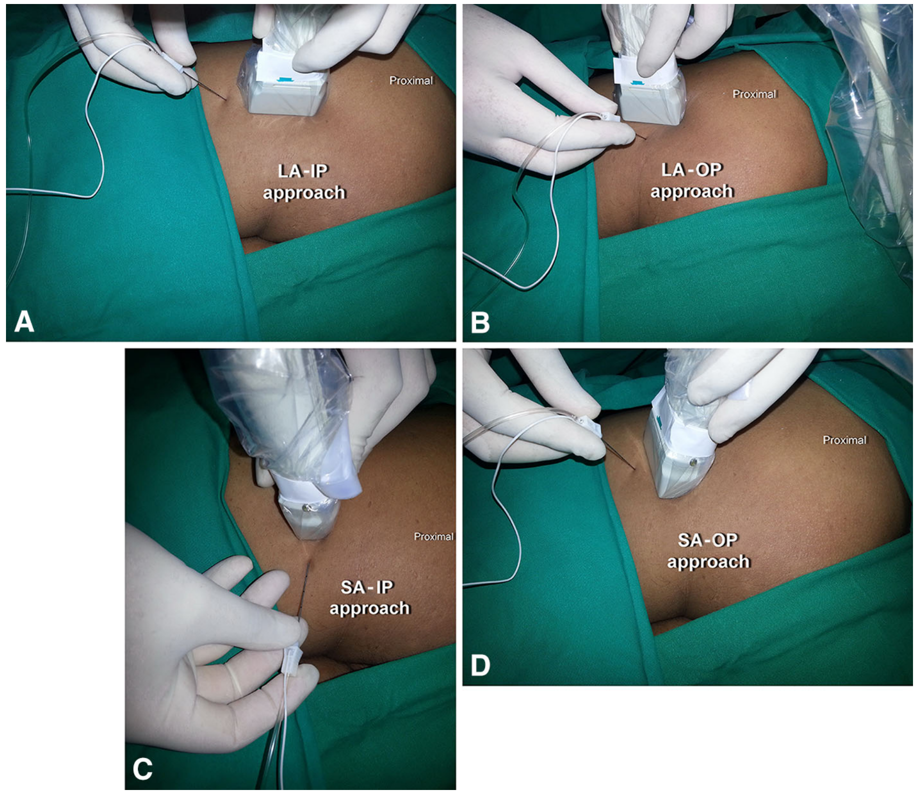

Fig. 1 Ultrasound (US)-guided infragluteal sciatic nerve block (SNB): **a** long-axis, in-plane approach; **b** long-axis, out-of-plane approach; **c** short-axis, in-plane approach; **d** short-axis, out-of-plane approach

guided SNB results in a higher percentage of patients reporting satisfactory blockade [12]. The reported success rate of US-guided SNB ranges from 55 % to 100 % [10, 11]. Analgesia duration in the four approaches we used was also similar with previous studies [13, 14]: single-dose SNB does not provide pain relief >10–15 h, even when a long-acting local anesthetic is used. Unpredictable nerve-block onset and case delays remain barriers that prevent orthopedic surgeons from regularly recommending regional anesthesia to their patients [15]. Use of the LA-IP approach has beneficial effects on SNB onset and quality, which could reduce anesthesia-controlled times and turnover times in the operating room.

The pattern of local anesthetic spread along the SN might be a possible explanation of the main results of this study: spread has not been clearly identified as to whether it was subfascial or extrafascial. Despite circumferential anesthetic spread around the nerve when using 2D US guidance, discontinuous spread was found on 3D US analysis in all patients with extrafascial deposition [16]. Perineural lanesthetic spread along the SN longitudinal axis was observed in 87 % of patients with subfascial deposition and only in 17 % of patients with extrafascial deposition [16]. Further study is required to confirm the subfascial US picture of anesthetic spread around SN among the four approaches described in this study in order to reveal the significance of the LA-IP approach.

Conclusion

The LA-IP approach resulted in a rapid onset of SNB and was associated with the highest rate of patient satisfaction regarding postoperative local analgesia in comparison with LA-OP, SA-IP, and SA-OP approaches for patients undergoing foot and ankle surgery.

Conflict of interest None

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