COMPARATIVE STUDY BETWEEN ULTRASOUND AND NERVE STIMULATOR GUIDED SCIATIC NERVE BLOCK THROUGH THE ANTERIOR APPROACH

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Abstract

Introduction: The aim of the current study was to compare block of the sciatic nerve through the anterior approach by two methods, namely, the nerve-stimulator guided and ultrasound-guided, with or without nerve stimulation, with regard to the ease of performance, reliability and safety of this approach.

Patients and Methods: 36 adult patients were randomly allocated equally into one of 2 main groups: “Nerve Stimulator-Guided Group (NSG)” where the nerve was located by nerve stimulator only and “Ultrasound guided group (USG)” where the sciatic nerves were blocked by a stimulated needle under guidance of the ultrasound. Assessment of performing each technique, sensory and motor blockades, occurrence of acute systemic toxicity and haematoma formation were compared.

Results: Only one-third of the sciatic nerves could be visualized by US. This did not affect the block execution time but caused less number of needle passes in a statistically significant value. Sensory and motor block showed significant differences between the 2 groups. Criteria of acute systemic toxicity and occurrence of hematoma were not reported in both groups.

Conclusion: Results of the current study showed that the addition of ultrasound to nerve stimulator in the anterior approach to the sciatic nerve block added only little to the ease of performance, reliability and safety. This was because only one-third of the nerves could be seen. More practice, better machines and new blocking techniques may be needed to overcome the problem of anisotropy of the nerve.

Keywords: Sciatic nerve, anterior approach, ultrasound, nerve stimulator, reliability.
Introduction

Every pass made with the stimulator needle that does not produce a twitch represents a possible pass through the sciatic nerve and since there is no reliable relationship between the current producing the twitch and the proximity of the needle to the nerve, any needle position which does not produce a twitch could be within the body of the nerve i.e., intraneural. One of the major concerns with nerve stimulation is that up to 70% of the patients have no motor response with stimulating currents of up to 1mA despite patients experiencing parasthesia with positive verification of nerve proximity with ultrasound.

The use of the ultrasound with or without nerve stimulation may cause the anterior approach to block the sciatic nerve to be safer and easier and consequently more popular as it needs high experience specially in obese patients. The aim of the current study was to compare block of the sciatic nerve through the anterior approach by two methods, namely, the nerve-stimulator guided and ultrasound-guided, with nerve stimulation, with regard to the ease of performance, reliability and safety of this approach.

Patients and Methods

The current work is a prospective and controlled open clinical trial. After approval of the Local Ethical Committee and obtaining the informed written consent from patients, 36 adult patients of different ages, both genders, and ASA class I-III were enrolled in the study. Patients had received a successful femoral nerve block as well to complete the analgesia for knee and leg surgeries.

Patients refusing the procedure, uncooperative, have allergy to any of the drugs used in the study, with diabetic peripheral neuropathy or have a history of stroke with lesion affecting the side to surgery were excluded form the study. Patients with bleeding disorders or receiving an anticoagulant and those with infection at the site of injection were also excluded.

Patients were randomly allocated into one of two main groups, 18 patients each. Patients received either general anesthesia or spinal anesthesia for the operation. When patient became completely oriented or was able to move his legs, femoral nerve block (with 10 ml of bupivacaine) and sciatic nerve block through the anterior approach were performed for the postoperative pain relief.

Nerve Stimulator-Guided Group (NSG)

Landmarks of the approach included a line drawn between the inferior border of the anterior superior iliac spine (ASIS) and superior angle of the pubic tubercle. Next, a perpendicular line bisecting the initial line was drawn and extended 8 cm caudad. The needle was inserted perpendicular to the skin. Stimuplex HNS11 machine was adjusted at pulse duration of 0.1 ms and a frequency of 2 Hz and a current of 0.7 - 1 mA. After disinfection and local infiltration, a Stimuplex® D Set (120 mm) (B. Braun Melsungen AG) was advanced with a strictly sagittal orientation, with the leg internally rotated from 10-15 degrees, until stimulation of the sciatic nerve in the form of planter and dorsiflexion of the foot was triggered. Stimulation current was lowered until a current of 0.2 mA did not stimulate the nerve. The needle length at this level was recorded and the number of times the needle was proceeded farther than this depth was considered as a pass in the nerve. After negative aspiration test, 20 ml of bupivacaine 0.5% (Marcaine, Astra, Sweden), was injected slowly.

The ultrasound probe was later on used to detect any hematoma formed.

Ultrasound-Guided Group (USG)

Patients in this group had their sciatic nerves blocked by a stimulated needle under guidance of the ultrasound. The upper thigh is widely prepared from the inguinal crease to about mid-thigh. Either General Electric Healthcare (Logiq e BT12) or Toshiba (Viamo SSA-640A) ultrasound machines were used in the examinations. A low frequency ultrasound curved probe (2-5 MHz) was applied, transversely, 10 cm distal and 5 cm medial to the position of the femoral nerve at the inguinal ligament. After establishing right/ left orientation of the ultrasound probe, the scan depth would be adjusted to about 13-15cm. The needle entry point was lateral to the femoral vessels and medial to the femur. If the sciatic nerve could be seen by
the ultrasound, the stimulator was set in the sentinel mode (0.2 mA). The needle (Stimuplex, D plus Set or Stimuplex Ultra, 120 mm) was visually guided until the nerve was reached. When the nerve was stimulated, the needle should be withdrawn by fine adjustments until stimulation stops. This was also considered as a needle pass. After negative aspiration, 20 ml of 0.5% bupivacaine was injected to get a “Dough nut” sign of the nerve. If the nerve could not be seen, we proceeded with the needle to a point just beneath the posterior border of the adductors and straight down from the femoral vessels. This point is marked by the hyperechoic deep layer of the adductor group and also by the fact that the adductor stimulation (flashing) stopped. The Stimulator was adjusted and the number of needle passes was determined by the same way followed in the Nerve Stimulator - Guided Group (NSG). In either case the needle was advanced in out of plane fashion.

**Assessment**

I- Block Technique:

- Block execution time: defined as time from skin puncture to the end of injection.
- Needle depth.
- Number of needle passes.
- Vascular puncture: defined as blood coming in the side way tube or aspirated during the procedure and/or a hematoma collection thereafter diagnosed by the ultrasound.

II- Block Assessment:

Sensory Block:

- Onset of sensory block: from time of injection to the start of sensory changes elicited by cold test.
- Duration of sensory block: measured from the time of injection to the time patient had a VAS of 5/10 or higher.
- Quality of sensory block: measured using Visual Analogue Scale 0-10.

Motor Block:

- Onset of motor block: from time of injection to time of motor changes in any of the sciatic branches.
- Duration: from time of motor changes to the time patient can planter flex fully.

III- Neurological and Hemodynamic Assessment:

- Monitor any agitation or convulsions.
- Electrocardiogram (ECG), heart rate (HR), oxygen saturation (SpO2), were monitored continuously, and systolic arterial pressure (SBP) every 2.5 min during and after injection. Patients were assessed for occurrence of any hemodynamic changes e.g., bradycardia and/or hypotension and treated accordingly.

**Statistical Analysis**

Categorical data were expressed as frequency along with percentage and continuous data values presented in mean ± SD. Descriptive statistics were used to summarize all demographic anthropometric, anthropometric measures and other characteristics of the participants. Quantitative variables means between the two groups (NS and US) were analyzed using unpaired t test. Associations between two or more qualitative variables were assessed using chi-square test. For small cell frequencies, chi-square test with continuity correction factor or Fisher exact test was applied. Pearson’s correlation coefficient was used to assess the strength of linear relationship between two or more quantitative variables. Pictorial presentations of the key results were made using appropriate statistical graphs. A two-sided P value <0.05 was considered to be statistically significant. All statistical analyses were done using the statistical package SPSS 19.0 (SPSS Inc. Chicago, IL).

**Results**

Demographic and Anthropometric Data:

Demographic data showed no significant difference between the 2 groups of patients (p>0.05) (Table 1).
**Table 1**

Demographic data of the patients in the 2 groups (Mean ± SD, frequency and percentage)

<table>
<thead>
<tr>
<th></th>
<th>Nerve Stimulator - Guided Group (NSG) (n=18)</th>
<th>Ultrasound - Guided Group (USG) (n=18)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>41.83 ± 18.09</td>
<td>44.17 ± 14.86</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>77.29 ± 14.99</td>
<td>78.87 ± 13.99</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>176.80 ± 7.91</td>
<td>164.72 ± 12.09</td>
</tr>
<tr>
<td>BMI</td>
<td>26.8 ± 4.55</td>
<td>29.32 ± 5.58</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>16 (88.9 %)</td>
<td>13 (27.8 %)</td>
</tr>
<tr>
<td>Female</td>
<td>2 (11.1 %)</td>
<td>5 (72.2 %)</td>
</tr>
<tr>
<td>Operations</td>
<td>ACL 9, TKR 5, Other 4 Knee operations</td>
<td>ACL 11 TKR 7</td>
</tr>
<tr>
<td>ASA Class</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>6 (33.3 %)</td>
<td>5 (27.8 %)</td>
</tr>
<tr>
<td>II</td>
<td>12 (66.7 %)</td>
<td>11 (61.1 %)</td>
</tr>
<tr>
<td>III</td>
<td>0</td>
<td>2 (11.1 %)</td>
</tr>
</tbody>
</table>

* = Significant value (P< 0.05).

**Table 2**

Block characteristics (mean ± SD) of the 2 groups of patients

<table>
<thead>
<tr>
<th></th>
<th>NSG (n=18)</th>
<th>USG (n=18)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block execution time (min)</td>
<td>7.64±3.4</td>
<td>7.0±2.79</td>
</tr>
<tr>
<td>Number of needle passes</td>
<td>2.72±0.83</td>
<td>1.22±0.89**</td>
</tr>
<tr>
<td>Needle depth (cm)</td>
<td>8.66±1.26</td>
<td>9.22±1.47</td>
</tr>
</tbody>
</table>

* = Significant value (p< 0.05).
** = Highly significant value (p< 0.01).

**Table 3**

Sensory and motor block onsets, durations, and quality of analgesia (Mean ± SD)

<table>
<thead>
<tr>
<th></th>
<th>NSG (n=18)</th>
<th>USG (n=18)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensory Block:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onset (min)</td>
<td>4.89±1.45</td>
<td>3.56±1.29**</td>
</tr>
<tr>
<td>Duration (hrs)</td>
<td>13.61±2.23</td>
<td>20.67±4.10**</td>
</tr>
<tr>
<td>Quality (VAS)</td>
<td>2.11±1.02</td>
<td>1.17±0.92**</td>
</tr>
<tr>
<td>Motor Block:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onset</td>
<td>13.4±3.93</td>
<td>10.5±3.58*</td>
</tr>
<tr>
<td>Duration</td>
<td>11.6±2.59</td>
<td>17.9±2.92**</td>
</tr>
</tbody>
</table>

* = Significant value (p< 0.05).
** = Highly significant value (p< 0.01).

**Table 4**

Frequency of vascular puncture and hematoma formation

<table>
<thead>
<tr>
<th></th>
<th>NSG (n=18)</th>
<th>USG (n=18)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vascular Puncture</td>
<td>0/18</td>
<td>0/18</td>
</tr>
<tr>
<td>Hematoma Formation</td>
<td>0/18</td>
<td>0/18</td>
</tr>
</tbody>
</table>

**Table 5**

Hemodynamic parameters (SBP and HR) and oxygen saturation (SpO2) of the 2 groups of patients before and 5 minutes after injection of the local anesthetic (mean ± SD)

<table>
<thead>
<tr>
<th></th>
<th>NSG</th>
<th>USG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before Injection</td>
<td>5 min after Injection</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>110.5±9.33</td>
<td>107.94±8.08</td>
</tr>
<tr>
<td>Heart Rate (bpm)</td>
<td>77.2±9.5</td>
<td>79±8.9</td>
</tr>
<tr>
<td>SpO2 (%)</td>
<td>98.14±0.8</td>
<td>98.2±0.6</td>
</tr>
</tbody>
</table>

* = Significant value (p< 0.05).
Discussion

Ultrasound guided technique may improve the success and the safety of the sciatic and other peripheral nerve blocks by avoiding vascular structures, and allowing direct observation of local anesthetic spread around neural targets. With nerve stimulator guidance, it is not reliably possible to surround major nerves with local anesthetic. As the anterior approach to the sciatic nerve is specially needed to keep patients in supine position as turning might be painful or complicated, trials to efficiently block it have been continued.

Deep location of the Sciatic nerve from the anterior approach makes visualization by ultrasound difficult and can be also confounded by the surrounding muscles. In the present study only in 6 patients out of the 18 the sciatic nerves could be seen. A similar rate was reported by some ultrasound experts who could demonstrate the sciatic nerve in only one-third of their patients. Ota et al. (2009) could visualize the sciatic nerve in 95% of their patients through the anterior approach. They attributed this high rate to the relatively young (average 38 yrs) and non-obese (BMI 22.7) patients enrolled in their study. They stated that in old patients, the fascia might not be distinguishable with ultrasound due to muscular atrophy, and in the obese the nerve is located deep. Their US probe was placed in the medial side of the thigh, rather than anterior or anteromedial, to shorten the distance to the nerve. In our study the average BMI was 29 and average age was 44 yrs. One possible explanation for problems to visualize the sciatic nerve might be the high anisotropy of the nerve (isoechoic to the surrounding muscles), deep to the relatively thick muscles and is potentially hidden behind the acoustic shadow of the femur. Marhofer, stated that the imaging technique of this nerve needs to be improved to increase the reliability of nerve localization.

Anterior sciatic block execution time in the present study showed no difference between the 2 groups possibly because only one third of the nerves could be seen in the US group. On the other hand, the number of needle passes was significantly higher in the nerve stimulation group because sciatic nerve might not twitch, as the needle might pass through the sensory part of this mixed nerve or through the abundant
connective tissue in that thick nerve. Visualization of this one third with US made the difference to decrease the number of needle passes. Similar results were obtained by Orebaugh and coworkers. The ultrasound helps to locate the sciatic nerve either by visualization or by defining its location anatomically as it lies just beneath the deep fascia of the adductor group at the level of the lesser trochanter. This was in agreement with Ban, who stated that nerve stimulation is a variable and blind technique, and one of the major concerns with it is that up to 70% of patients had no motor response with stimulating currents of up to 1 mA despite patient experiencing parasthesias with positive verification of nerve proximity with ultrasound.

While intraneural injection does not always produce a clinically demonstrable nerve injury, it is a situation that should be avoided if possible. The current study showed that the onset time, duration and quality of sensory block (VAS) were highly significant in the US group compared to the NS Group. Also the onset of motor block was shorter and duration was longer in the US group. This can be attributed to injection in the nearest vicinity of the nerve documented by the US. Abrahams et al., suggested that US guidance of peripheral nerve block produced a higher rate of block success, shorter procedure times, faster onset time, and longer block duration and reduce the risk of inadvertent vascular puncture during block performance. So, US can improve block success rates, especially for the anesthetist who does not frequently perform peripheral nerve blocks.

Ultrasound guidance may reduce the frequency of vascular puncture, but there are no RCTs that confirm or refute an actual reduction of LAST (Local Anesthetic Systemic Toxicity). In the present study, LAST was not a problem in either of the 2 groups as seen from the hemodynamic stability and absence of central nervous system toxicity (agitation and/or seizures). Inadvertent vascular puncture seemed to be absent in the used approach, as no blood was aspirated and no occurrence of hematoma looked at by US in both groups.

Safety of the sciatic nerve and the consequences of the multiple passes through it e.g., neuralgia were not sought. This is one of the limitations of the study. It also seems better to classify patients, for the frequency to visualize the sciatic nerve by US, according to thigh circumference rather than the body weight or BMI.

Results of the current study showed that the addition of ultrasound to nerve stimulator in the anterior approach to the sciatic nerve added only little to the ease of performance, reliability and safety. This was because only one-third of the nerves could be seen. More practice, better machines and new blocking techniques may be needed to overcome the problem of anisotropy of the nerve.

Acknowledgment

The authors would like to thank Dr. Prem Chandra, PhD, for performing the statistics of the study. We would also like to thank all the staff of the Medical Research Center for their kind help and support.
References


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³ Train-of-four
² Post-tetanic count
‡ Second twitch


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References: