Incidence of intraneural needle insertion in ultrasound-guided femoral nerve block: A comparison between the out-of-plane versus the in-plane approaches

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Abstract

Background: The optimal method of ultrasound-guided femoral nerve block (in-plane vs. out-of-plane) has not been established. We tested the hypothesis that the incidence of needle-nerve contact may be higher with out-of-plane than with in-plane needle insertion.

Methods: Forty-four patients with hip fracture (American Society of Anaesthesiologists physical status I–III) were randomized to receive the femoral block with an out-of-plane approach (needle inserted at a 45–60° angle 1 cm caudal to the midpoint of the ultrasound probe just above the femoral nerve) or with an in-plane technique (needle inserted 0.2–0.4 cm from the side of the probe lateral to the femoral nerve). Data collected included depth of needle insertion, response to nerve electric stimulation, and distribution of the injected volume in relation to the nerve (anterior vs. posterior, the latter assuming needle-nerve contact). The sensory block onset was tested at 20 min and block recovery and any neurologic symptoms were evaluated at 24 h.

Results: The incidence of needle-nerve contact was significantly higher with the out-of-plane approach (14/22 patients [64%]) than with the in-plane approach (2/22 patients [9%]) (p < 0.001) (OR = 17.5, 95% CI: 4–79). The rate of paraesthesia on crossing the fascia iliaca was similar in the two groups. All blocks uneventfully regressed; and no patient developed neurologic symptoms.

Conclusions: Under the conditions of our study, needle-nerve contact during femoral nerve block occurs frequently with the out-of-plane approach. An in-plane approach results in an equally effective femoral block and less incidence of needle-nerve contact.

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Incidencia de inserción intraneural en bloqueo femoral guiado por ecografía: comparación entre los enfoques en plano y fuera de plano

Resumen

Antecedentes: No ha quedado establecido un método adecuado para el bloqueo femoral guiado por ecografía (en plano frente a fuera de plano). Probatimos la hipótesis de que la incidencia del contacto entre la aguja y un nervio puede ser mayor en la inserción fuera de plano que en el abordaje en plano.

Métodos: Cuarenta y cuatro pacientes con fractura de cadera (estadio I–III según la Sociedad Americana de Anestesiólogos) recibieron un bloqueo femoral con un enfoque fuera de plano (inserción de la aguja en ángulo de 45–60° y 1 cm caudal a la sonda de ecografía sobre el nervio femoral) o con una técnica en plano (inserción de la aguja 0,2–0,4 cm desde el lado de la sonda lateral al nervio femoral). Entre los datos recopilados se incluían la incidencia de inserción de la aguja, la reacción a la estimulación nerviosa y la distribución del volumen inyectado en función del nervio (anterior comparado con posterior, este último con contacto entre la aguja y un nervio). Se analizó el inicio del bloqueo a los 20 min y se evaluaron la recuperación del bloqueo y los síntomas neurológicos después de 24 h.

Resultados: La incidencia del contacto entre la aguja y los nervios fue significativamente mayor con el enfoque fuera de plano (14/22 pacientes [64%]) que con el abordaje en plano (2/22 pacientes [9%]) (p < 0,001) (OR = 17,5 [95%]; IC: 4–79). El grado de parestesia en aponeurosis fue similar en ambos grupos. Se revirtieron todos los bloqueos sin incidentes; ningún paciente desarrolló síntomas neurológicos.

Conclusiones: En las condiciones de nuestro estudio, el contacto entre la aguja y un nervio durante el bloqueo femoral sucede a menudo con el enfoque fuera de plano. Un abordaje en plano tiene como resultado un bloqueo femoral igualmente efectivo, y una incidencia menor del contacto entre la aguja y un nervio.

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Introduction

The femoral nerve block is widely used for regional anesthesia because it is simple and highly effective.1,2 The femoral nerve is separated from the femoral artery by the fibrous aponeurotic union of the fascia iliaca and the fascia lata, an elastic structure which presents resistance to needle passage.1,2 However, once the needle crosses the fascial layers, the loss of resistance and consequent further advancement may result in needle-nerve contact or impalement of the femoral nerve.3,4

We hypothesized that the incidence of needle-nerve contact is higher with the out-of-plane approach (insertion needle into the fascia at the midpoint over the femoral nerve) than with the in-plane approach (insertion needle lateral to the femoral nerve). Incidence of needle-nerve contact during femoral nerve block was compared between the two approaches in patients undergoing hip replacement surgery.

Patients and methods

American Society of Anaesthesiologists (ASA) physical status I to III patients with a diagnosis of trochanteric or cervical hip fracture and referred for hip replacement under spinal anesthesia were enrolled. Patients under the age of 65 years or over the age of 90 years were excluded. The study was approved by the ethics committee of the Hospital Clinic de Barcelona (ref: R-6345) and registered at www.clinicaltrial.gov identifier NCT01554722. All patients gave their written informed consent to participate in the study.

Prior to seating the patients for spinal puncture, an ultrasound-guided femoral nerve block (SonoSite Turbo Ultrasound machine; SonoSite, Bothell, WA, USA) was performed by means of a multifrequency probe (6–12 MHz). A short-axis view of the femoral nerve in the center of the screen just distal to the inguinal ligament was obtained. Femoral nerve depth (distance from skin to nerve) was measured. Patients were randomly assigned to either the out-of-plane (n = 22) or the in-plane (n = 22) approach by means of sealed envelopes. In the out-of-plane group, the needle was inserted 1 cm caudal to the midpoint of the ultrasound probe just over the femoral nerve, at an angle between 45° and 60°, according to nerve depth; the needle was advanced until it was seen and felt to cross the iliac fascia iliaca. In the in-plane group, the needle was inserted 0.2–0.4 cm from the external side of the probe and advanced through the tissues to a position lateral to the femoral nerve, then advanced through the fascia iliaca.

After the needle crossed the fascia iliaca, a nerve stimulator (Stimuplex NHS, B. Braun, Melgunsen, Germany) was set to a frequency of 2 Hz to deliver a stimulus of 0.1 ms. The intensity was gradually increased until 1 mA or until a motor response (sartorius or quadriceps muscle contraction with evident movement of the vastus medialis, vastus lateralis or rectus femoris) was observed. One milliliter of
a 5% dextrose solution was administered. Anesthesiologist performing the block assessed the distribution of the fluid, anterior or posterior to the nerve.

If injection of the solution occurred posterior to the nerve, indicating that needle has crossed the femoral nerve (needle-nerve contact), the needle was withdrawn slowly and sited anterior to the nerve and 10 mL of 0.75% ropivacaine were injected. The depth of the needle’s tip was recorded just before the start of the injection.

The extent of sensory-motor blockade was recorded at 20 min by an anesthesiologist who was not aware of the study group. Sensory block was assessed by skin-prick test over the patella and distal third of the anterior aspect of thigh (response scale, 1–3), whereas, motor block was assessed on the Oxford scale (1–3). The severity of the hip pain during positioning for spinal anesthesia was assessed using a verbal numerical scale (1–10). Spinal anesthesia was performed at the L3-L4 interspace; a 26-gauge Quincke spinal needle (BD Spinal Needle®; Becton Dickinson SA, San Agustin de Guadalix, Madrid, Spain) was used to inject 11 mg of 0.5% bupivacaine with 10 μg of fentanyl.

Twenty-four hours after block placement, skin sensory perception was assessed by skin-prick test above the patella, motor response (knee extension) was assessed on the Oxford scale, and pain was assessed using the numerical scale. All patients were prescribed a combination of intravenous paracetamol (1 g per 8 h) and intravenous dexketoprofen (50 mg/8 h) for postoperative analgesia. Onset or persistence of sensory-motor symptoms, as reported by the patients, or neurologic deficits during exam, were recorded.

Sample size was estimated to identify a 40% difference in the incidence of needle-nerve contact (incidence estimated at 50% for the out-of-plane group and at 10% for the in-plane group) with an alpha error of 5% and power 80%. Forty-four patients (22 per group) were needed. Data are expressed as mean (± SD) for continuous variables, and number (%) for categorical variables. The t test for independent samples or the chi square test of proportions (or Fisher test, as appropriate) was used to test differences between the groups. A p-value < 0.05 was considered statistically significant. Risk was estimated by the odds ratio (OR) with 95% confidence interval (CI). Analyses were performed using the Statistical Package for the Social Sciences (SPSS for Windows, version 15.0.1, 2006, Chicago, IL, USA).

Results

The groups were similar regarding ASA physical status, surgical procedure, depth of the femoral nerve, and in length of needle advanced (Table 1).

The proportion of patients with needle-nerve contact was higher in the out-of-plane group (14/22, 64%) than in the in-plane group (2/22, 9%), (p < 0.001). Risk for needle-nerve contact was higher with the out-of-plane approach than with the in-plane approach (OR = 17.5, 95% CI 4–79). The overall incidence of paraesthesia when the needle crossed the fascia iliaca was similar in the two groups (out-of-plane group, 10 patients [46%]; in-plane group, 12 patients [55%]; p = 0.76). Eighteen patients in the out-of-plane group (82%) and all patients in the in-plane group (100%) had a motor response to nerve stimulation after the needle passed through the iliac fascia (p = 0.1) (Fig. 1). In patients who had motor response to nerve stimulation, the median intensity of stimulus was 0.5 (IQR, 0.45–0.6 mA), with no between-group differences (out-of-plane group 0.5 mA [IQR, 0.4–0.6 mA]; in-plane group 0.5 mA [IQR, 0.5–0.6 mA]) (p = 0.77).

Effectiveness of the block for pain during positioning for spinal anesthesia was similar in the two groups. Mean pain assessment scores were similar after 20 min of femoral nerve block in the two groups, at rest (1.4 [± 0.9] for the out-of-plane group and 1.3 [± 1] for the in-plane group; p = 0.76) and during the sitting maneuverer (4 [± 0.9] for the out-of-plane group and 4.1 [± 1] for the in-plane group; p = 0.64). Knee movement against resistance was observed in 32% of patients in the in-plane group vs. none in the out-of-plane group (p = 0.008) at 20 min. However, normal sensory perception at 24 h was more often observed in the in-plane group than in out-of-plain group (77% vs. 36%; p = 0.014) (Table 2). No patients reported neurologic symptoms or had

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Patient characteristics.</th>
</tr>
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<tbody>
<tr>
<td><strong>Anterior, out-of-plane (n = 22)</strong></td>
<td><strong>Lateral, in-plane (n = 22)</strong></td>
</tr>
<tr>
<td><strong>ASA status I, II, III</strong></td>
<td>1, 11, 10</td>
</tr>
<tr>
<td><strong>Sex, M/F</strong></td>
<td>6/16</td>
</tr>
<tr>
<td><strong>Age (SD), yr</strong></td>
<td>78 (10)</td>
</tr>
<tr>
<td><strong>Weight (SD), kg</strong></td>
<td>66 (9)</td>
</tr>
<tr>
<td><strong>Height (SD), cm</strong></td>
<td>165 (5)</td>
</tr>
<tr>
<td><strong>Type of prosthetic surgery</strong></td>
<td></td>
</tr>
<tr>
<td>Moore</td>
<td>7</td>
</tr>
<tr>
<td>Dynamic hip screws</td>
<td>10</td>
</tr>
<tr>
<td>Biarticular</td>
<td>4</td>
</tr>
<tr>
<td>Total hip replacement</td>
<td>1</td>
</tr>
<tr>
<td><strong>Depth of femoral nerve (SD), cm</strong></td>
<td>1.9 (0.7)</td>
</tr>
<tr>
<td><strong>Depth of needle advanced (SD), cm</strong></td>
<td>3.6 (0.9)</td>
</tr>
</tbody>
</table>

ASA indicates American Society of Anesthesiologists; M, male; F, female. Data are reported as number, or as mean (SD).
signs of neurologic dysfunction during examination at 24 h after the block.

Discussion

Under the conditions of our study, the incidence of needle-nerve contact (as defined in the Methods section) was significantly higher with the out-of-plane approach to femoral nerve block, in which the needle is inserted through the fascia directly over the femoral nerve at an angle ≥ 45°.

The traditional femoral nerve block, using feedback provided by nerve stimulation, begins by identifying the femoral artery pulse in order to take an anterior approach to the nerve. In this approach, the puncture site used to be just lateral to the pulse of the femoral artery. Of note, this approach is similar to the ultrasound-guided out-of-plane approach we used in our study. However, the incidence of needle-nerve contact (needle passage through the nerve) appears to be high after passing the fascia, whose elastic/dense characteristics resist further needle advancement. This using the in-plane technique may reduce the incidence of needle-nerve contact. This approach, similar to that of Dalens in pediatric patients,6 minimizes the incidence of needle transversing the nerve because the needle does not find the femoral nerve immediately upon traversing the fascia (Fig. 2).

We found a high incidence of femoral needle-nerve contact even though no clinical evidence of nerve injury was detected in our patients. One case of injection of the anesthetic into the femoral nerve, without further nerve damage, has been reported,7 but the incidence of intra-nerve puncture or injection inside the nerve has not been previously assessed in relation to different approaches to the

![Figure 1](image-url)  Incidence of paraesthesia and motor response to nerve stimulation. Data are reported as number of patients, n(%). (*) p < 0.001.

![Figure 2](image-url)  Demonstration of the needle placement and location of the injection with in-plane (A) and out-of-plane (B) needle insertion.
Incidence of intraneural needle insertion in ultrasound-guided femoral nerve block

Table 2  Assessment of sensory and motor function of femoral nerve after 20 min and 24 h.

<table>
<thead>
<tr>
<th></th>
<th>OOP group (n = 22)</th>
<th>IP group (n = 22)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PPT (a) 1/2/3</td>
<td></td>
</tr>
<tr>
<td>20 min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(%)</td>
<td>17/5/0</td>
<td>13/7/2</td>
</tr>
<tr>
<td>OS</td>
<td>1/11/0</td>
<td>7/8/7</td>
</tr>
<tr>
<td>(%)</td>
<td>50/50/0</td>
<td>32/36/32</td>
</tr>
<tr>
<td>24 h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(%)</td>
<td>0/14/8</td>
<td>0/5/17</td>
</tr>
<tr>
<td>OS</td>
<td>3/19/0</td>
<td>5/15/2</td>
</tr>
<tr>
<td>(%)</td>
<td>14/86/0</td>
<td>23/68/9</td>
</tr>
</tbody>
</table>

Data in no. of patients (percentage).

(a) Pin-prick test: 1, touch noted but not painful; 2, discomfort or slight pain; 3, normal sensitivity.

(b) Oxford scale: 1, no movement; 2, movement against gravity; 3, movement against resistance.

femoral nerve. The structural characteristics of the femoral nerve at this level probably decrease the risk for damage caused by the needle or injection into the nerve, as has been reported for the sciatic nerve. However, some cases of neurologic complications, presumably due to needle trauma to the femoral nerve, have been reported and this event may be under-reported.

In conclusion, our study suggests that needle-nerve contact may be more likely with an out-of-plane than with an in-plane needle insertion during US-guided FNB. Introducing the needle in-plane through the fascia iliaca lateral to the nerve results in similar nerve block quality may reduce the risk for nerve puncture.

Conflict of interest

The authors declare no conflicts of interest.

References