Regional anaesthesia

Lidocaine use in ultrasound-guided femoral nerve block: what is the minimum effective anaesthetic concentration (MEAC$_{90}$)?†

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Editor’s key points
- Regional anaesthesia can provide good intraoperative analgesia with minimal central side-effects.
- Lower limb blocks may require large doses of local anaesthetic (LA) to be effective.
- The use of ultrasound allows reduction in the dose of LA required.
- This study investigated the minimum effective dose of lidocaine needed for femoral nerve block.
- As part of a regional technique, 15 ml of 0.93% lidocaine was effective in 90% of patients.

Background. This study aimed to estimate the minimum effective anaesthetic concentrations of lidocaine required to block the femoral nerve under ultrasound (US) guidance in 90% (MEAC$_{90}$) of patients.

Methods. A minimum of 45 patients who had undergone knee arthroscopy were included in this observational study. All the patients received US-guided sciatic, obturator, and femoral nerve blocks. The femoral nerve block was performed using 15 ml of lidocaine. The lidocaine concentration given to a patient was determined by the response of the previous patient (a biased-coin design up–down sequential method). If a patient had a negative response, the lidocaine concentration was increased by 0.1% w/v in the next patient. If a patient had a positive response, the next patient was randomized to receive the same lidocaine concentration (with a probability of 0.89) or to receive a concentration 0.1% w/v less (with a probability of 0.11). A positive response was defined as complete sensory and motor block. The patients’ responses were analysed to calculate the mean MEAC$_{90}$.

Results. Fifty-two patients were required to complete the study; 45 had a positive response and seven had a negative response. The mean MEAC$_{90}$ was estimated to be 0.93% w/v [95% confidence interval (CI), 0.8–1.03%]. Lidocaine 0.93% w/v was estimated to produce a successful block in 89% (95% CI, 78–100%) of patients.

Conclusions. Perineural injection of 15 ml of lidocaine 0.93% w/v under US guidance could provide successful femoral nerve block in 90% of patients.

Keywords: anaesthetic techniques, regional, femoral; anaesthetics local, lidocaine; equipment, ultrasound machines

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Peripheral nerve block is considered by many anaesthetists to be the ideal outpatient anaesthetic technique. It has a superior recovery profile and allows early discharge.† Lidocaine is a widely used local anaesthetic (LA) for nerve block in outpatient surgeries. To achieve painless lower limb surgery; a combination of nerve blocks is usually needed, and a high dose of lidocaine (beyond the maximum recommended dose) is usually required. The ability to minimize the LA dose required to achieve a successful lower limb nerve block is therefore important. The goal of this study was to estimate the minimum effective anaesthetic concentrations of lidocaine required to block the femoral nerve under ultrasound (US) guidance in 90% of patients (MEAC$_{90}$).

Methods

This observational study was approved by the Research and Ethical Committee of Abu Dhabi Knee and Sport Medicine Centre (# 1:03:12:11). The clinical part of the study was conducted from December 2011 to March 2012. After obtaining the patients' written informed consent, a minimum of 45
patients who had been scheduled to knee arthroscopy formed the study group. All arthroscopic knee procedures, except anterior cruciate ligament reconstruction, were included.

After application of routine monitoring and supplemental oxygen, all the patients received 3 mg of midazolam i.v. All blocks were performed by one experienced anaesthetist (A.M.T.) using an S-Nerve machine (SonoSite Inc., Bothell, WA, USA). All the patients received US-guided parasacral sciatic, proximal intertubular obturator, and lateral femoral cutaneous nerve blocks,\textsuperscript{10–12} using 20 ml (1.6%), 10 ml (1%), and 2 ml (1%) of lidocaine with epinephrine, respectively. The US-guided femoral nerve block\textsuperscript{13} was then performed. The patient was placed in the supine position. Skin asepsis and sterile draping were performed. A linear US probe (HFL 38, 13–6 MHz) was sheathed and placed on the inguinal crease with a slight anterior tilt. The femoral artery and the nerve were identified. A 5 cm needle (21G, Locoplex, Vygon, Ecouen, France) was inserted lateral to the probe and advanced by in-plane approach towards the femoral nerve. Fifteen millilitres of lidocaine (Lidocaine, Laboratoire Aguettant, Lyon, France) were slowly injected. The needle was repositioned to ensure circumferential perineural spread of the LA injection. Intraneural injection was avoided.

The femoral sensory block was assessed by testing the pinprick sensation along the medial aspect of the leg. The sensory block was graded as follows: grade 0, normal sharpness sensation (compared with the contralateral side); grade I, reduced sharpness or a non-sharp sensation (touch or pressure); grade II, unable to recognize pinprick sensation. For motor block assessment, the patient’s knee was fully flexed, and the patient was then asked to extend it. The motor block was classified as follows: grade 0, normal muscle power; grade I, motor weakness; grade II, complete motor paralysis. The assessment was performed every 10 min until grade II sensory and motor blocks were achieved or to a maximum of 30 min.

Surgery was started only after complete femoral, sciatic, obturator, and lateral femoral cutaneous nerve blocks had been clinically confirmed.\textsuperscript{14} Only patients with grade II sensory and motor femoral blocks within 30 min were considered to have a positive response. Otherwise, they were considered to have a negative response and received a light general anaesthesia. At the end of the surgery, 20 ml of saline containing ropivacaine 40 mg, morphine 10 mg, ketorolac 30 mg, and epinephrine 0.1 mg was injected intra-articularly. All the patients were assessed neurologically before hospital discharge and also during the physiotherapy visits for 3 weeks after operation. The positive or negative responses, intraoperative pain, and any complications were recorded. All the measurements were assessed by the assistant who was unaware of the lidocaine concentration used.

**Statistical analysis**

The lidocaine concentration given to a patient was determined by the response of the previous patient (a biased-coin design up–down sequential method).\textsuperscript{9} If a patient had a negative response, the lidocaine concentration was increased by 0.1% w/v in the next patient. If a patient had a positive response, the next patient was randomized to receive the same lidocaine concentration (with a probability of 0.89) or to receive a concentration 0.1% w/v less (with a probability of 0.11). Because the MEAC of lidocaine for femoral block, to our knowledge, has not yet been estimated, the initial concentration was 0.7% w/v based on our past experience.

To estimate the MEAC\textsubscript{90}, a minimum of 45 positive responses were required.\textsuperscript{9} The MEAC\textsubscript{90} was calculated using isotonic regression with bias-corrected 95% confidence interval (CI) derived by bootstrapping.\textsuperscript{15} We used the dose estimator \( \mu,3 \), defined as the linearly interpolated estimator of the target dose. It was derived from the two consecutive concentrations that success rates enclose the value of probability of effect ‘1’ (which is 0.9 in this study). This estimator was proved to be more advantageous than the other estimators.\textsuperscript{15–17} The mean value of the estimate (\( \mu,3 \)) was obtained from the 2000 bootstrap samples. We thought it may be more appropriate to state the mean value with its CI. Statistical analysis was performed using the Minitab\textsuperscript{15} 15.1 Statistical Software 2007 (Minitab, Inc., State College, PA, USA) and Microsoft\textsuperscript{6} Excel 2003 (Microsoft, Seattle, WA, USA). Continuous variables are presented as mean [standard deviation (SD)] or median (range), while categorical variables are presented as frequency (%).

**Results**

Fifty-two patients were required to complete the study (Table 1). The mean MEAC\textsubscript{90} was estimated to be 0.93% w/v (95% CI, 0.8–1.03%) (Fig. 1). Lidocaine 0.93% w/v was estimated to produce a successful block in 89% (95% CI, 78–100%) of patients. In 13 middle-aged patients 31.5 (9) yr, injection of lidocaine 0.9% w/v was associated with a positive response, whereas in two elderly patients (71 and 81 yr), a negative response was obtained with the same concentration (Table 2). All the patients with positive responses had painless surgery. In three of these patients, the tourniquet was inflated, for 76.7 (47.5) min, with no pain. The sciatic and lateral femoral cutaneous nerve blocks were successfully supplemented before operation in three and one patients, respectively. No complications were noted.

**Discussion**

Lidocaine is the most commonly used LA in outpatient surgeries.\textsuperscript{2} It is widely available and relatively safe and has a suitable duration of action. Unlike with the upper limb, when lower limb surgery is performed using nerve blocks, combined blocks are usually needed.\textsuperscript{3} These combined blocks usually require a large dose of lidocaine.\textsuperscript{1} The LA dose is the major factor affecting its peak plasma concentration and hence its toxicity. To prevent this potentially fatal complication, reducing the LA dose is of great importance.\textsuperscript{4–9}
**Table 1** Patient characteristics. ASA, American Society of Anesthesiologists; BMI, Body mass index. *Include wash out, total synovectomy, excision of plica, condroplasty, micro-fracture (two cases), and fixation of osteochondritis dissecans lesion. In the former two cases, a femoral catheter was inserted after operation

<table>
<thead>
<tr>
<th>Age (yr) [median (range)]</th>
<th>37.5 (18–81)</th>
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<tbody>
<tr>
<td>Gender male/female [n (%)]</td>
<td>41 (79)/11 (21)</td>
</tr>
<tr>
<td>ASA class I/II/III [n (%)]</td>
<td>42 (81)/8(15)/2(4)</td>
</tr>
<tr>
<td>BMI (kg m$^{-2}$) [mean (SD)]</td>
<td>27.3 (4)</td>
</tr>
<tr>
<td>Surgeries [n (%)]</td>
<td>Partial or total meniscectomy 33 (63%) \n Meniscus repair (include in-out repair) 12 (23%) \n Others 7 (14%)*</td>
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</tbody>
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**Fig 1** Patients’ responses to different lidocaine concentrations. The horizontal line is the calculated minimum concentration of lidocaine providing successful femoral block in 90% of patients (MEAC$_{90}$); error bars represent 95% CI.

**Table 2** Clinical assessment in relation to lidocaine concentration in patients with negative response

<table>
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<th>Lidocaine concentration</th>
<th>Assessment</th>
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<tbody>
<tr>
<td>Three patients 0.8%, 1%, 0.8%</td>
<td>Had neither grade II sensory nor motor block</td>
</tr>
<tr>
<td>Three patients 0.9% (81 yr), 0.8%, 0.7%</td>
<td>Had grade II sensory but not motor block</td>
</tr>
<tr>
<td>One patient 0.9% (71 yr)</td>
<td>Grade II sensory and motor blocks were achieved within 10 min, but they fade within 45 min (before surgery start)</td>
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A decrease in the volume injected can significantly decrease the LA dose. US-guidance allows precise perineural LA placement and, therefore, reduces the effective LA volume. A very low volume of LA (0.1 ml mm⁻² nerve surface area) was reported to produce successful blocks of different nerves. However, these results have just been obtained by highly professional sonographic anaesthetists. The other way to decrease the LA dose is to decrease its concentration; but, over-diluted LA may result in unsuccessful block in a high percentage of patients. The biased-coin design up–down sequential method allows direct estimation of the MEAC at any quantile.

The MEAC of lidocaine required to block the femoral nerve, to our knowledge, has not yet been studied. Usually, lidocaine 2% is used to block the femoral nerve. However, lidocaine 1.1% was also reported to produce a successful femoral nerve block when a large volume (30 ml) was used. The use of US-guidance in the current study has allowed a further decrease in lidocaine concentration even when smaller volumes (15 ml) were used. Contrary to our result, lidocaine 0.95%, used for US-guided axillary block, was not associated with a motor block in 50% of patients.

In general, the MEAC can be affected by many factors, including LA type, the volume injected, the use of adjuvant, the nerve to be blocked, the block level, and theoretically, the localizing technique. Our results suggested that the MEAC may also be affected by age. Adding epinephrine to lidocaine potentiates its effect and decreases its peak plasma level. However, epinephrine prolongs the anaesthetic duration of lidocaine significantly, and hence, a femoral nerve block lasts up to 5 h. This effect is not desirable in outpatient surgeries. All blocks were performed by a single anaesthetist and most of the patients studied were middle-aged. This may limit the general application of the results. The injected volume (15 ml) used in this study was not the minimum effective volume; therefore, using a smaller volume may or may not be effective. Although the tourniquet was inflated in three patients with no pain, the reliability of the estimated MEAC₉₀ to prevent the tourniquet pain cannot be confirmed.

Conclusion

Perineural injection of 15 ml of lidocaine 0.93% w/v under the US guidance could provide a successful femoral nerve block in 90% of patients.

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Declaration of interest

None declared.

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