A Comparison of Ultrasound-Guided and Landmark-Based Approaches to Saphenous Nerve Blockade: A Prospective, Controlled, Blinded, Crossover Trial

Michael L. Kent, MD, Robert J. Hackworth, MD, Robert. H. Riffenburgh, PhD, Julie L. Kaesberg, MD, David C. Asseff, MD, Eugenio Lujan, MD, and John M. Corey, MD

BACKGROUND: Blockade of the saphenous nerve is often used for surgeries below the knee. Depending on the approach, success rates vary widely ranging from 33% to 88%. In this prospective volunteer study, we compared 2 ultrasound-guided techniques, the modified vastus medialis and perifemoral saphenous nerve block with a below the knee field block.

METHODS: Twenty volunteer adults, in a single-blinded, crossover, prospective trial underwent 3 different saphenous nerve blocks. The primary endpoint of block success was loss of sensation in the distal two-thirds distribution of the saphenous nerve. Secondary variables included time to perform the block, time to sensory loss, pain during block, and motor weakness.

RESULTS: Compared with the below the knee field block success rate (30%), both the modified vastus medialis and perifemoral techniques had significantly higher success rates (80%, difference 50% with confidence interval [CI], 23%–77%, P = 0.009, and 100%, difference 70% with CI, 41%–91%, P < 0.001, respectively). However, the difference when comparing the perifemoral ultrasound technique against the modified vastus medialis ultrasound technique did not show significance (difference 20% with CI, −7% to 49%, P = 0.125). Also, no statistical differences were found with the other variables measured, except the perifemoral technique showed faster block performance times than below the knee field block (P = 0.007).

CONCLUSION: In our prospective study, we have demonstrated that ultrasound-guided above the knee saphenous nerve blocks have higher success rates than a below the knee field block and are easily performed in a short amount of time.

ANESTHESIA & ANALGESIA

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The saphenous nerve is the terminal sensory branch of the femoral nerve. It provides innervation to the skin overlying the medial, anteromedial, and posteromedial parts of the lower leg. This innervation stretches from the cephalad portion of the knee to the level of the medial malleolus. Blockade of the saphenous nerve is essential for surgeries that involve the medial aspect of the foot or ankle where a regional technique is preferred.1–3 Numerous approaches for saphenous nerve blockade have been described using landmarks, nerve stimulation, and ultrasound.4–11 Recent ultrasound approaches have never been compared in prospective clinical trials and have not been compared with commonly used nonultrasound techniques.

This study compared the success of 3 approaches to saphenous nerve blockade: 2 ultrasound-guided regional techniques (the modified vastus medialis and perifemoral approach)8 and a commonly used nonultrasound-guided technique (the below the knee field block).10 We hypothesized that both ultrasound techniques would display a higher success rate when compared with the below the knee field block. Our secondary clinical hypothesis was that there would be no significant difference in success between ultrasound groups.

METHODS

After receiving the Naval Medical Center San Diego’s IRB approval, written informed consent was obtained from all participants for this single-blinded, crossover, prospective trial. Twenty healthy ASA physical status I or II adult male volunteers were recruited. Exclusion criteria included age younger than 18 years, non-English speaking, history of chronic pain syndromes, central or peripheral neuropathies, relative contraindications to regional anesthesia, allergy to local anesthetics, thyroid disease, significant cardiopulmonary disease, and not eligible for care at the treating military hospital. Enrollment was voluntary and participants acknowledged that withdrawal of participation was optional at any time.

All participants received a series of 3 saphenous nerve blocks separated by a minimum of 7 days. All blocks were conducted by the same investigator (JMC). Block sequence for each participant was determined by a computerized random number generator. The lower extremity (left or right) to be blocked alternated with each successive procedure. All procedures were performed in the designated block area with appropriate monitoring in the supine position. No sedation was provided.
When ultrasound guidance was to be used, either an M-turbo (Sonosite, Bothell, WA) or Logiq E (GE Healthcare, San Francisco, CA) ultrasound machine with a corresponding linear 6 to 13 MHz probe was used. After skin preparation with 2% chlorhexidine in 70% isopropyl alcohol, the skin and subcutaneous tissue were anesthetized with approximately 3 mL of 1% lidocaine with bicarbonate. A 22-gauge 4-inch Tuohy needle was guided to the targeted location in plane with the ultrasound probe. All blocks were performed with 10 mL of 1.5% lidocaine without epinephrine. A blinded investigator assessed saphenous nerve blockade. Assessment was performed at 1-minute intervals over the first 20 minutes with complete loss of sensation to pinprick chosen as the successful end point. The distribution of saphenous innervation was divided into thirds as depicted in Figure 1 similar to De Mey et al.6 Other data recorded included time to conduct block, pain during procedure using a visual analog scale (0 mm, “no pain”; 100 mm, “pain as bad as it could be”), time until sensory loss, and lower extremity muscle strength using hip/knee flexion along with foot flexion/extension and eversion/inversion. Muscle strength was assessed via a standard 0 to 5 scale where 0/5 = no muscle contraction and 5/5 = normal strength. Muscle strength was assessed at either the end of 20 minutes or when complete loss of sensation was achieved.

**Descriptions of the Different Techniques**

For the modified vastus medialis approach, which is a small modification of the technique described by Krombach and Gray,11 we used the relationship of the saphenous nerve running in the fascial plane between the vastus medialis and sartorius. This technique does not use direct visualization of the saphenous nerve or surrounding vascular landmarks (i.e., the geniculate branch of the femoral artery). Patients were placed in a supine position, and a linear ultrasound probe was placed perpendicular to the long axis of the extremity on the anteromedial aspect of the thigh approximately 5 to 10 cm above the knee. After identification of the femur and the vastus medialis, the probe was moved medially and posterior until the medial fascial edge of the vastus medialis and the sartorius fascia were visible (Figs. 2 and 3). After negative aspiration, ultrasonography was used to ensure adequate spread of local anesthetic in the fascial plane of those 2 muscle groups.

The below the knee field block and the ultrasound-guided perifemoral method were conducted as previously described8,12 (Figs. 4 and 5).

**Statistical Analyses**

**Sample Size Considerations**

To estimate minimum required sample size, we adopted a conservative approach. Not having found a sample size estimation method for the case of matched (paired) multinomial independent variables with binary outcomes for \( n \) subjects, we treated the design as unmatched, yet retained a total of \( n \) subjects (rather than \( 3n \)). We used Thompson’s...
sample size method for multinomial proportions with $\alpha = 0.05$ for the 3-way comparison and $\alpha/3 = 0.017$ for the three 2-way comparisons, consistent with our use of the Bonferroni correction for the type I error. The proportion successful was taken as 0.30 (Thompson $\pi_i$) from the medical literature. We wanted to detect a difference in proportion success from the assumed 0.30 of between 0.25 and 0.30, therefore used the midpoint of 0.275 (Thompson $d_i$). The solution yielded a required 19.2, rounded to $n = 20$ subjects.

Statistical analysis was performed by hand calculation augmented by Stata 12.0 (Stata Corporation, College Station, TX). The primary end point of block success was loss of sensation in the distal two-thirds distribution of the saphenous nerve in the same fashion as De Mey et al. Because the data were matched (repeated for the various blocks on the same subject), we tested for differences in success rates among all 3 procedures simultaneously using Cochran Q statistic on a 2 × 3 contingency table. We then tested each possible comparison of 2 types of block success was loss of sensation in the distal two-thirds distribution of the saphenous nerve in the same fashion as De Mey et al. Because the data were matched (repeated for the various blocks on the same subject), we tested for differences in success rates among all 3 procedures simultaneously using Cochran Q statistic on a 2 × 3 contingency table. We then tested each possible comparison of 2 types of block success was loss of sensation in the distal two-thirds distribution of the saphenous nerve in the same fashion as De Mey et al. Because the data were matched (repeated for the various blocks on the same subject), we tested for differences in success rates among all 3 procedures simultaneously using Cochran Q statistic on a 2 × 3 contingency table.

RESULTS

Compared with the below the knee field block success rate (30%), both the modified vastus medialis and perifemoral techniques had significantly higher success rates (80%, difference 50% with CI, 23%–77%, $P = 0.009$, and 100%, difference 70% with CI, 41%–91%, $P < 0.001$, respectively; Tables 1 and 2). However, the difference when comparing the perifemoral ultrasound technique against the modified vastus medialis ultrasound technique did not show significance (difference 20% with CI, –7% to 49%, $P = 0.125$; Table 2).

All volunteers demonstrated 5/5 motor strength pre- and postblockade and reported no difficulty with ambulation postprocedure. Statistical comparison among time of block performance, time to block completion, and visual analog pain scale scores demonstrated no significant differences, except

<table>
<thead>
<tr>
<th>Table 1. Success of Sensory Loss for Each Block</th>
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<tbody>
<tr>
<td>Success</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>Block failure</td>
</tr>
<tr>
<td>Block success</td>
</tr>
</tbody>
</table>

*Successful block was defined as loss of sensory sensation to the distal two-thirds of the area measured (Fig. 1).
that the perifemoral technique took less time to place than the below the knee field block (Tables 3 and 4). In addition, the modified vastus medialis approach is significantly more variable than the perifemoral approach or the below the knee field block with time to place, and the perifemoral approach is significantly less variable than the modified vastus medialis approach or below the knee field block (Table 5). No adverse events were noted, and all patients regained full sensation to the tested area within 24 hours after the procedure.

**DISCUSSION**

In the present study, 2 ultrasound-guided techniques (modified vastus medialis and perifemoral) for saphenous blockade were superior to a nonultrasound-guided below the knee field technique. Furthermore, no significant difference in efficacy was found between the ultrasound-guided techniques (modified vastus medialis versus perifemoral). Our success of saphenous blockade (30%) with the below the knee field method was similar to that reported by De Mey et al. However, as noted in previous articles, there is a varying success rate (35%–70%) for this technique which speaks to the unreliability of its use. Our 2 ultrasound techniques, while slightly modified compared with published ultrasound descriptions, displayed similar high levels of success (80%—modified vastus medialis, 100%—perifemoral). While the superiority of both ultrasound techniques to the commonly used below the knee field method was not surprising based on previous observational success rates, the lack of statistical difference between ultrasound groups was notable.

### Table 2. Comparisons of Between-Technique Group Differences in Success Rates

<table>
<thead>
<tr>
<th>Technique success rate comparison</th>
<th>Difference in proportions</th>
<th>98.3% Confidence interval on proportion difference</th>
<th>P value of test on proportion difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modified vastus medialis (80%) versus perifemoral (100%)</td>
<td>0.2</td>
<td>−0.075 to 0.486</td>
<td>0.125</td>
</tr>
<tr>
<td>Modified vastus medialis (80%) versus below the knee field block (30%)</td>
<td>0.5</td>
<td>0.233–0.767</td>
<td>0.009a</td>
</tr>
<tr>
<td>Perifemoral (100%) versus below the knee field block (30%)</td>
<td>0.7</td>
<td>0.410–0.906</td>
<td>&lt;0.001a</td>
</tr>
<tr>
<td>Modified vastus medialis versus perifemoral versus below the knee field block</td>
<td>—</td>
<td>—</td>
<td>&lt;0.001c</td>
</tr>
</tbody>
</table>

Pairwise comparisons using McNemar test require P < 0.05/3 = 0.017 to be considered significant. Binomial confidence intervals are similarly corrected. The Cochran Q test on differences among the 3 techniques simultaneously yielded P < 0.001, highly significant.

aBonferroni corrected confidence intervals calculated by the Clopper-Pearson method.

bSignificant at 0.05/3 = 0.017 (Bonferroni corrected).

cSignificant at 0.05.

### Table 3. Means for Time to Block Completion, Time Until Sensory Block, and Procedural Pain Score (Visual Analog Scale)

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Technique</th>
<th>Modified vastus medialis</th>
<th>Perifemoral</th>
<th>Below the knee field block</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block placement (min)</td>
<td>4.3</td>
<td>3.0</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>Sensory loss (min)</td>
<td>7.7 (n = 16)</td>
<td>5.9 (n = 20)</td>
<td>10.0 (n = 6)</td>
<td></td>
</tr>
<tr>
<td>Pain score decrease (mm)</td>
<td>11.2</td>
<td>8.8</td>
<td>16.0</td>
<td></td>
</tr>
</tbody>
</table>

### Table 4. Medians (Md), Bonferroni-Corrected (98.3%) Confidence Intervals (CIs), and Significance (P) Values for Pairwise Wilcoxon Signed-Rank Comparisons of Time to Block Completion, Time to Complete Sensory Blockade, and Procedural Pain Score (Visual Analog Scale)

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Modified vastus medialis versus perifemoral</th>
<th>Below the knee field block versus modified vastus medialis</th>
<th>Below the knee field block versus perifemoral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block placement (min)</td>
<td>0.05</td>
<td>0.59</td>
<td>0.61</td>
</tr>
<tr>
<td>Sensory loss (min)</td>
<td>2.00 (n = 16)</td>
<td>5.00 (n = 5)</td>
<td>6.00 (n = 6)</td>
</tr>
<tr>
<td>Pain score difference (mm)</td>
<td>−1.00</td>
<td>−1.00</td>
<td>2.50</td>
</tr>
</tbody>
</table>

*Significant at 0.05/3 = 0.017 (Bonferroni correction).

### Table 5. Significance (P) Values from Variance Ratio Tests on Pairwise Procedure Comparisons

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Var (modified vastus medialis) versus var (perifemoral)</th>
<th>Var (below the knee field block) versus var (modified vastus medialis)</th>
<th>Var (below the knee field block) versus var (perifemoral)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block placement (min)</td>
<td>&lt; 0.001a</td>
<td>&lt; 0.001a</td>
<td>0.171</td>
</tr>
<tr>
<td>Sensory loss (min)</td>
<td>0.279 (n = 16/20)</td>
<td>0.161 (n = 16/6)</td>
<td>0.405 (n = 20/6)</td>
</tr>
<tr>
<td>Pain score decrease (mm)</td>
<td>0.002a</td>
<td>0.972</td>
<td>0.002a</td>
</tr>
</tbody>
</table>

*Significant at 0.05/3 = 0.017 (Bonferroni correction).

Var = variance.
results provide the first prospective comparison of these 2 ultrasound techniques that are widely used.

The lack of significant difference between ultrasound groups may indicate certain clinically important considerations. For our modified vastus medialis approach (distal to the adductor canal), we relied on the relationship of the saphenous nerve within the fascial plane between the sartorius and vastus medialis. While numerous authors have described saphenous nerve blockade dependent upon geniculate artery definition, such a landmark can be difficult to find for the novice ultrasonographer.7,9 However, this technique may be more difficult in an obese patient population where fine ultrasound definition of the sartorius and vastus medialis may be harder to achieve. A particular benefit of this technique is that the patient may remain in the prone position with concurrent sciatic blockade without the need for turning as was also demonstrated by Horn et al.7 Our perifemoral approach (proximal to the adductor canal) displays ease of landmark identification (i.e., femoral artery and easily identifiable muscle bellies) and may serve as an ideal approach for the less experienced ultrasonographer, or in people with larger body habitus.

In all groups, we found no weakness in hip flexion or knee extension in any patient who received a complete sensory block. This indeed has important implications as a recent article by Ilfeld et al.18 demonstrated an increased fall risk postoperatively in patients with a continuous femoral nerve catheter. Theoretically, the concern for motor blockade would be primarily with the perifemoral approach where the saphenous, infrapatellar, and the nerve to the vastus medialis run together. Furthermore, one may choose a technique similar to our modified vastus medialis approach if concerned about avoiding any vastus medialis weakness because it is performed distal to the adductor canal away from vastus medialis innervation. While Davis et al.19 claim proximal spread is possible and thus the concern for proximal motor blockade, 30 mL dye was injected, where we used only 10 cc local anesthetic. Indeed, weakness may occur with larger volumes which may cause significant proximal spread. However, we have not noticed quadriceps weakness in our experience with 10 mL or less of local anesthetic.

One limitation of our study was the end point of loss of sensation instead of postoperative analgesia. While our measure of loss of sensation to pinprick is common after nerve blockade, a more accurate measure would be measures of postoperative analgesia after foot and ankle surgery. Furthermore, our study did not include obese patients where such ultrasound techniques are theorized to assist in nerve blockade due to difficult landmarks. Additionally, our patient population in this study consisted of healthy physically fit subjects in whom subtle changes in muscle strength may not have been detected. Finally, our study was not specifically designed to demonstrate equivalence between the 2 ultrasound techniques.

In summary, we compared 3 techniques of saphenous nerve blockade (2 ultrasound-guided and a commonly performed landmarked-based technique). Success rates in modified vastus medialis and perifemoral showed no significant difference, but both were significantly more successful than below the knee field block. While we discovered no decrement in motor strength, future studies powered to measure such indices are required.

DISCLOSURES
Name: Michael L. Kent, MD.
Contribution: This author helped design and conduct the study, analyze the data, and write the manuscript.
Attestation: Michael L. Kent has seen the original study data, reviewed the analysis of the data, and approved the final manuscript.

Name: Robert J. Hackworth, MD.
Contribution: This author helped design the study, analyze the data, and write the manuscript.
Attestation: Robert J. Hackworth has seen the original study data, reviewed the analysis of the data, and approved the final manuscript.

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Contribution: This author helped design the study, analyze the data, and write the manuscript.
Attestation: RH Riffenburgh has seen the original study data, reviewed the analysis of the data, and approved the final manuscript.

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Attestation: Julie L. Kaesberg has seen the original study data, reviewed the analysis of the data, and approved the final manuscript.

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Contribution: This author helped design the study and analyze the data.
Attestation: David C. Asseff has seen the original study data, reviewed the analysis of the data, and approved the final manuscript.

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Contribution: This author helped design the study and analyze the data.
Attestation: Eugenio Lujan has seen the original study data, reviewed the analysis of the data, and approved the final manuscript.

Name: John M. Corey, MD.
Contribution: This author helped design and conduct the study, analyze the data, and write the manuscript.
Attestation: John M. Corey has seen the original study data, reviewed the analysis of the data, and approved the final manuscript.

This manuscript was handled by: Terese T. Horlocker, MD.

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