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Continuous Popliteal Sciatic Blocks: Does Varying Perineural Catheter Location Relative to the Sciatic Bifurcation Influence Block Effects? A Dual-Center, Randomized, Subject-Masked, Controlled Clinical Trial

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BACKGROUND: Multiple studies have demonstrated that, for single-injection popliteal sciatic nerve blocks, block characteristics are dependent upon local anesthetic injection relative to the sciatic nerve bifurcation. In contrast, this relation remains unexamined for continuous popliteal sciatic nerve blocks. We, therefore, tested the hypothesis that postoperative analgesia is improved with the perineural catheter tip at the level of the bifurcation compared with 5 cm proximal to the bifurcation.

METHODS: Preoperatively, subjects having moderately painful foot or ankle surgery were randomly assigned to receive an ultrasound-guided subepimyseal perineural catheter inserted either at or 5 cm proximal to the sciatic nerve bifurcation. Subjects received a single injection of mepivacaine 1.5% either via the insertion needle preoperatively or the perineural catheter postoperatively, followed by an infusion of ropivacaine 0.2% (6 mL/h basal, 4 mL bolus, and 30-min lockout) for the study duration. The primary end point was the average pain measured on a numeric rating scale (0–10) in the 3 hours before a data collection telephone call the morning after surgery.

RESULTS: The average numeric rating scale of subjects with a catheter inserted at the sciatic nerve bifurcation (n = 64) was a median (10th, 25th to 75th, and 90th quartiles) of 3.0 (0.0, 2.4–5.0, and 7.0) vs 2.0 (0.0, 1.0–4.0, and 5.0) for subjects with a catheter inserted proximal to the bifurcation (n = 64; P = 0.008). Similarly, maximum pain scores were greater in the group at the bifurcation: 6.0 (3.0, 4.4–8.0, and 9.0) vs 5.0 (0.0, 3.0–8.0, and 10.0) (P = 0.019). Differences between the groups for catheter insertion time, opioid rescue dose, degree of numbness in the foot/toes, catheter dislodgement, and fluid leakage did not reach statistical significance.

CONCLUSIONS: For continuous popliteal sciatic nerve blocks, a catheter inserted 5 cm proximal to the sciatic nerve bifurcation provides superior postoperative analgesia in subjects having moderately painful foot or ankle surgery compared with catheters located at the bifurcation. This is in marked contrast with single-injection popliteal sciatic nerve blocks for which benefits are afforded to local anesthetic injection distal, rather than proximal, to the bifurcation. (Anesth Analg 2016;122:1689–95)

Continuous popliteal sciatic nerve blocks provide postoperative analgesia after surgical procedures of the foot and ankle. The sciatic nerve courses down the posterior thigh and bifurcates just above or within the popliteal fossa into 2 branches: the tibial and common peroneal nerves. Cadaver studies have confirmed the location of this bifurcation to range from approximately 0 to 11 cm proximal to popliteal crease, most commonly 5 to 7 cm above the crease. Using ultrasound guidance, practitioners can target a precise location along the sciatic nerve relative to the sciatic bifurcation for deposition of local anesthetic.

Previous randomized studies document that depositing an initial bolus of local anesthetic via a needle distal to the sciatic bifurcation—compared with proximal to the bifurcation—results in decreased time to onset of sensory and motor block and at times an increased surgical-quality block success rate. This suggests that deposition of local anesthetic at various locations along the sciatic nerve can influence block characteristics. However, findings from studies involving single-injection nerve blocks have not always been replicated when investigated in relation to continuous peripheral nerve blocks. Whether the perineural catheter location relative to the sciatic nerve bifurcation influences

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Reprints will not be available from the authors.

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the quality of analgesia provided by a postoperative peri-
nearal local anesthetic infusion remains unexamined.

We, therefore, conducted this dual-center, randomized, 
subject-masked, controlled, parallel-arm clinical trial to test
the hypothesis that during a continuous popliteal sciatic
nerve block, postoperative analgesia will be improved with
the perineural catheter tip at the level of the sciatic nerve
bifurcation compared with when the catheter tip is 5 cm
cephalad/proximal to the bifurcation. The primary end
point was the average pain measured on a numeric rating
scale (NRS: 0–10) in the 3 hours before a data collection tele-
phone call the morning after surgery.

METHODS
Enrollment
This study adhered to Good Clinical Practice quality stan-
dards and ethical guidelines defined by the Declaration of
Helsinki. It was prospectively registered at ClinicalTrials.
gov (NCT01229696) before enrollment initiation. Study pro-
tocol approval as well as data and safety oversight was con-
ducted by the University of California San Diego IRB (San
Diego, California). Written informed consent was obtained
from all participating subjects.

Enrollment was offered preoperatively to adults (age ≥18
years) undergoing moderately painful unilateral foot and
ankle surgery with a preplanned popliteal sciatic perineu-
rnal catheter for postoperative analgesia. Exclusion criteria
included any neurologic deficit of the operative extremity,
chronic opioid use (daily use of 20 mg oxycodone equiva-
 lent or more for >4 weeks), surgery outside the sciatic and
saphenous nerve distributions, history of opioid abuse,
inability to communicate with the investigators, pregnancy,
and incarceration. The study was conducted at Hillcrest
(San Diego, California) and Thornton (La Jolla, California)
hospitals, both academic institutions associated with the
University of California San Diego Medical Center.

Perineural Catheter Insertion
Subjects were positioned prone with a towel rolled under
the ankle to slightly flex the knee. Standard monitors were
applied, and oxygen was given by facemask at a rate of 8 L/
min. IV midazolam (1–2 mg) and fentanyl (50–100 μg) were
administered, titrating for anxiolysis and analgesia with
verbal responsiveness maintained at all times. Catheters
were placed by regional anesthesia fellows or residents
under the direct supervision of an attending regional anes-
thesiologist or by the attending themselves.

The sciatic nerve bifurcation was identified by using a
13-6 MHz 38-mm linear array ultrasound transducer
(M-Turbo; SonoSite, Bothell, WA) in the short-axis view. The
bifurcation was defined as the most proximal point at which
the tibial and common peroneal nerves had separated. Both
the sciatic nerve bifurcation and the area 5 cm proximal to
the bifurcation were scanned and identified. Randomization
was performed only if both sites were determined to be
acceptable for catheter insertion. Allocation to 1 of 2 treat-
ments was achieved by using computer-generated lists in
blocks of 8 with a 1:1 ratio, stratified for treatment center.
Treatment allocation was concealed by using consecutively
numbered, sealed, opaque envelopes that were opened
only after confirmation by ultrasound that either insertion
site would be acceptable. Treatment allocation was to 1 of
2 groups: (1) at the sciatic nerve bifurcation or (2) 5 cm
proximal to the sciatic nerve bifurcation. For subjects within
the latter treatment group, the preferred insertion point was
5 cm proximal to the bifurcation but could be inserted up to
8 cm proximal to the bifurcation if the sciatic nerve image
was superior in the 5- to 8-cm range. Treatment group
assignment was masked to subjects, but not to investigators.

The site was cleaned with chlorhexidine gluconate/isopro-
pyl alcohol solution, a sterile fenestrated drape applied, and
a skin wheal raised using 1% lidocaine. A 17-gauge nonslius-
ulated Tuohy needle was directed to a subepineurial extrapara-
nearal location using an in-plane technique under real-time
ultrasound guidance, as described in detail previously. Final
needle tip positioning was superficial to the paraneurium and
depth to the epimysium of the surrounding muscles.

Injectate was administered via the needle to achieve cir-
cumferential spread, ensuring that there was no subpara-
nearal or extraepimysial spread. Injectate contents were
determined by surgeon’s preference: if a postoperative
neurologic check in the recovery room was planned, the
injectate consisted of normal saline (20 mL); if no neuro-
logic examination was anticipated, the injectate consisted of
mepivacaine 1.5% with epinephrine 5 to 10 μg/mL (40 mL).

A 19-gauge catheter (FlexTip Plus; Teleflex/Arrow
International, Research Triangle Park, NC) was inserted
1 cm beyond the needle tip, with the Tuohy needle still under
ultrasound visualization. The needle was then withdrawn
2 cm over the stationary catheter. The needle was held sta-
tionary, and 2 to 3 cm of catheter was inserted to create slack
between the nerve and skin exit point. Finally, the needle
was withdrawn over the remaining catheter. The injection
port was attached to the catheter, and a small bolus of air
(0.5 mL) was injected through the perineural catheter under
ultrasound visualization to assess catheter tip location.
The catheter was secured with sterile liquid adhesive, an occlu-
sive dressing, and an anchoring device. The time for catheter
insertion was measured from the time the Tuohy needle first
touched the subject until it was completely withdrawn with-
out reinsertion. For subjects who received a local anesthetic
bolus, sensory and motor block onset was determined within
15 minutes after the mepivacaine injection. Sensory onset
was determined on the plantar aspect of the foot (toes when
a cast was present) and was deemed positive with decreased
sensation to light touch from before the local anesthetic bolus.
Motor block was determined with plantar flexion (flexion of
the toes when a cast was present) and was deemed positive
with decreased force from before the local anesthetic bolus.
Also noted was any saphenous nerve block administration
(ropivacaine 0.5% with epinephrine 5–10 μg/mL).

Intraoperative Protocol
For subjects with a preoperative mepivacaine bolus, their
popliteal sciatic block usually provided the primary anes-
thetic for the surgical procedure. Sedation or a general
anesthetic was permitted, and additional boluses of mepi-
vacaine 1.5% and epinephrine could be administered via
the catheter, if needed, if a postoperative neurologic exami-
nation was not planned.
Postoperative Protocol
For subjects who received normal saline preoperatively, a neurologic check was performed by the surgeon postoperatively. A local anesthetic bolus was subsequently administered via the catheter that was identical to subjects who had a preoperative bolus via the needle (mepivacaine 1.5%/w with epinephrine 5–10 μg/mL, 40 mL). A successful catheter insertion was defined as sensory and motor block onset in both major terminal nerve distributions within the 15 minutes after the local anesthetic injection (for both pre- and postoperative local anesthetic administration). In case of failure, the patient was removed from further study.

A ropivacaine 0.2% perineural infusion was initiated (basal rate 6 mL/h; patient-controlled bolus of 4 mL; 30-minute lockout) and continued at least through the data collection telephone call the morning after surgery (described under End Points section below). Unacceptable pain remaining 20 minutes after a patient-controlled bolus dose was treated with oral oxycodone (5–10 mg) and/or IV morphine (2–4 mg).

End Points
Subjects were contacted via telephone at 10:00 the morning after surgery to collect information regarding study outcome measures for both inpatients and outpatients (exception: inpatient opioid consumption was collected from medical records). The primary end point was prospectively designated as the average pain in the 3 hours before the data collection telephone call as measured on the NRS. High-quality published evidence suggests that rating pain within 24 hours corresponds well to averaged momentary assessments but that patients begin to inflate recalled pain relative to averaged momentary assessments beyond several days. Secondary end points included the maximum pain within the previous 3 hours as measured using the NRS as well as the opioid consumption (measured in morphine IV equivalents) since recovery room discharge, fluid leakage at the catheter insertion site, and the degree of numbness in the foot/toes (reported on a Likert 0–10 scale: 0 = normal sensation; 10 = insensate).

Statistical Analysis
To calculate a sample size, we focused on our primary hypothesis that during a continuous popliteal sciatic nerve block, postoperative analgesia will be improved with the perineural catheter tip at the level of the sciatic nerve bifurcation compared with when the catheter tip is 5 cm cephalad/proximal to the bifurcation. The primary end point was the average pain in the 3 hours before a data collection telephone call the morning after surgery, measured with the NRS. A previously published clinical trial using an insertion technique, equipment, and postoperative infusion similar to the current protocol revealed the mean average pain score of 3.8 on the NRS and an SD of 2.6 the day after foot/ankle surgery. On the basis of these data, we expected an SD of 2.5 for the NRS mean of average pain on postoperative day 1, and given a 2-sided type I error protection of 0.05 and power of 0.8, we prospectively calculated that approximately 65 subjects in each treatment arm were required to detect a difference between treatment group mean of 1.25 (the IRB approved a total of 150 enrollees to account for dropouts).

Normality of distribution was determined using the Shapiro-Wilk normality test (Prism 6; GraphPad, San Diego, CA). For normally distributed data, comparisons for parametric and nonparametric data were tested using the t test or Mann-Whitney test and presented as mean (SD) or median (interquartile range), respectively. Nominal data were analyzed by using the Pearson χ² test. P value <0.05 was considered significant. Significant findings in secondary outcomes should be viewed as suggestive, requiring confirmation in a future trial before considering them as definitive.

RESULTS
Of the 136 subjects enrolled (Fig. 1), 1 was found to have an exclusion criterion before randomization (neuropathy involving the surgical extremity), and in 5 others, the location 5 to 8 cm above the bifurcation was judged inferior to the bifurcation site because of poor imaging of the sciatic nerve. The remaining 130 subjects were randomly assigned to 1 of the 2 treatment groups (Tables 1 and 2), and all but 1 (proximal to bifurcation without sensory/motor changes after bolus) had a catheter inserted successfully per protocol. Within the operating room, 1 subject (at bifurcation) had his surgery cancelled because of electrocardiogram changes unrelated to the perineural catheter insertion (subject was to receive mepivacaine bolus after surgery). The remaining 128 subjects completed the study (64 in each treatment group).

Primary End Point
The average NRS of subjects with a catheter inserted at the sciatic nerve bifurcation was a median (10th, 25th to 75th, and 90th quartiles) of 3.0 (0.0, 2.4–5.0, and 7.0) vs 2.0 (0.0, 1.0–4.0, and 5.0) for subjects with a catheter inserted proximal to the bifurcation (P = 0.008; Fig. 2).

Secondary End Points
Similarly, the proximal group reported lower “maximum” pain scores (Fig. 2). The proximal group also required a lower total opioid rescue dose although this difference did not reach statistical significance (P = 0.097; Fig. 3). There were no clinically relevant or statistically significant differences between the treatment groups for any other secondary end point (Table 3).

Protocol Violation
The original study protocol specified assessing both sleep disturbances and satisfaction with analgesia, as reflected on the ClinicalTrials.gov registry. However, these outcome measures were inadvertently excluded from the case report forms, and therefore, the data were not collected as originally intended.

DISCUSSION
This dual-center, randomized, subject-masked, controlled, parallel-arm clinical trial demonstrates that, for continuous popliteal sciatic nerve blocks, a catheter inserted 5 cm proximal to the sciatic nerve bifurcation—compared with at the bifurcation—provides superior postoperative analgesia in
Catheter Location Relative to the Sciatic Nerve Bifurcation

This is in marked contrast with single-injection popliteal sciatic nerve blocks for which benefits are afforded to local anesthetic injection below the bifurcation. The etiology of these differing results for single-injection versus continuous peripheral nerve blocks remains unknown, and we can only speculate on possible explanations.

One possible explanation involves the paraneural compartment. The sciatic nerve is surrounded by a paraneural sheath, which continues distal to the sciatic bifurcation. Superficial to this sheath is the subepimyselial perineural space, and deep to the sheath is a thin layer of fat and the perineurium of the sciatic and terminal nerves, which is often difficult to differentiate with ultrasound from the subepimyselial space superficial to the paraneurium (at least until the space itself is distended with fluid). Local anesthetic injected superficial to the paraneurium within the subepimysial space—as done in the current study—has to pass through the paraneurium and epineurium to reach the nerve fibers. In contrast, local anesthetic injected deep to the paraneurium must diffuse across only the epineurium, and at an equivalent volume, the paraneural sheath will essentially retain the local anesthetic close to the nerve in this relatively small subparaneural space, resulting in a spread over a longer length of nerve.

Three clinical trials that found benefits to an injection just distal to the bifurcation were published before knowledge of the importance of the paraneural sheath was widespread within the regional anesthesia community, as evidenced by the fact that none of the 3

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**Table 1. Subject Characteristics**

<table>
<thead>
<tr>
<th></th>
<th>At bifurcation (n = 65)</th>
<th>Proximal to bifurcation (n = 65)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>47 (16)</td>
<td>47 (17)</td>
</tr>
<tr>
<td>Sex (female), n (%)</td>
<td>35 (55)</td>
<td>34 (53)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>171 (10)</td>
<td>171 (10)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>81 (17)</td>
<td>81 (15)</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>27.6 (4.8)</td>
<td>27.3 (4.3)</td>
</tr>
</tbody>
</table>

Values are reported as mean (SD) or number (%) of subjects.

**Table 2. Primary Surgical Procedures**

<table>
<thead>
<tr>
<th></th>
<th>At bifurcation (n = 65)</th>
<th>Proximal to bifurcation (n = 65)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achilles tendon repair</td>
<td>8 (12)</td>
<td>7 (11)</td>
</tr>
<tr>
<td>Ankle arthroplasty or ORIF</td>
<td>14 (22)</td>
<td>12 (18)</td>
</tr>
<tr>
<td>Arthrodesis or fusion</td>
<td>7 (11)</td>
<td>8 (12)</td>
</tr>
<tr>
<td>Arthroscopy, synovectomy, and/or debridement</td>
<td>6 (9)</td>
<td>6 (9)</td>
</tr>
<tr>
<td>Foot osteotomy or ORIF</td>
<td>14 (22)</td>
<td>16 (25)</td>
</tr>
<tr>
<td>Hallux valgus repair</td>
<td>10 (15)</td>
<td>12 (18)</td>
</tr>
<tr>
<td>Ligament or tendon repair</td>
<td>6 (9)</td>
<td>4 (6)</td>
</tr>
</tbody>
</table>

Values are reported as number of subjects (%).

ORIF = open reduction, internal fixation.

Percentages do not add to 100% because of a rounding error.
mentioned differentiating between injections superficial and deep to the paraneurial sheath within their Methods sections. It is possible that injections proximal to the sciatic bifurcation in these studies had a lower incidence of subparaneurial injection than the injections below the bifurcation, resulting in the differing results between the 2 locations. In this hypothetical scenario, the location of injection above or below the bifurcation might be less relevant than the positioning of the needle tip relative to the paraneurial sheath. Indeed, a subsequent investigation purposefully injecting local anesthetic deep to the paraneurial sheath for blocks both at or distal to the bifurcation reported equivalent outcomes for the 2 locations.

In the current study, the initial injection (whether saline or local anesthetic) via the Tuohy needle for both locations relative to the bifurcation was purposefully subepimyseal (superficial to the paraneurium).

However, these suppositions would only explain why catheters of the current study inserted at the bifurcation did not result in superior analgesia compared with those located 5 cm proximal to the bifurcation, in contrast to similar single-injection block studies. Importantly, they do not explain our finding of superior analgesia found with proximal catheter insertion. One possible explanation for our results is a difference in internal structure—or internal architecture (the connective tissue component)—of the sciatic nerve above and at the bifurcation, resulting in differing degrees of local anesthetic penetration. Similarly, the subepimyseal space above the bifurcation may provide a more hospitable pocket to hold and/or spread low volumes of catheter infusate adjacent to the nerve. Extending this concept, it is possible that the physical properties of the sciatic nerve at the bifurcation require a greater volume, concentration, or mass of local anesthetic for equivalent efficacy. There are undoubtedly many additional possible explanations for the differing results found between single-injection and continuous peripheral nerve blocks, and this area of investigation requires further examination.

**Study Limitations**

Although the subjects of this investigation were masked to treatment group assignment, investigators were aware of the randomization results. In addition, the results apply only to the specific local anesthetic type, concentration, volume, and rate of the current study. As noted previously, all injections via the Tuohy needle and perineural catheters were located superficial to the paraneurium, within the subepimyseal space, and introduction of local anesthetic either through a needle or catheter into the space deep to the paraneurium would probably influence the outcomes.

Furthermore, we evaluated only one 3-hour period the morning after surgery, and although the difference between groups was statistically significant, a 1-point decrease (33%) on the NRS from a median of 3 to 2 remains of questionable clinical significance.

Although both treatment groups received identical portable electronic infusion pumps and programmable settings (basal rate, bolus dose, and lockout period), the actual number of doses self-administered by each subject is unavailable. Consequently, the possibility remains that subjects assigned to the proximal group self-administered more bolus doses, resulting in a higher delivered mass of ropivacaine. Finally, we do not have data assessing both sleep disturbances and satisfaction with analgesia as these variables were inadvertently excluded from the case report forms.
Table 3. Postrandomization End Points

<table>
<thead>
<tr>
<th>End Point</th>
<th>At bifurcation (n = 64)*</th>
<th>Proximal to bifurcation (n = 64)*</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local anesthetic injected preoperatively, n (%)</td>
<td>58 (91)</td>
<td>56 (88)</td>
<td>0.59</td>
</tr>
<tr>
<td>Catheter placement time (min)</td>
<td>4 (3–5)</td>
<td>5 (4–6)</td>
<td>0.07</td>
</tr>
<tr>
<td>Time last bolus until 10:00 postoperative day 1 (h)</td>
<td>24 (21–26)</td>
<td>24 (22–26)</td>
<td>0.25</td>
</tr>
<tr>
<td>Saphenous nerve block administered, n (%)</td>
<td>37 (58)</td>
<td>33 (52)</td>
<td>0.54</td>
</tr>
<tr>
<td>Outpatient, n (%)</td>
<td>56 (88)</td>
<td>55 (86)</td>
<td>0.80</td>
</tr>
<tr>
<td>Numbness in foot/toes (0–10 scale)*</td>
<td>5.0 (0.0–7.0)</td>
<td>5.0 (3.0–8.0)</td>
<td>0.42</td>
</tr>
<tr>
<td>Leakage at the catheter site, n (%)</td>
<td>10 (16)</td>
<td>11 (17)</td>
<td>0.75</td>
</tr>
</tbody>
</table>

Values are reported as number (%) of subjects or median (interquartile).

*One subject randomized to each treatment group was excluded from the analysis (1 failed catheter insertion and 1 cancelled surgery).

In conclusion, for continuous popliteal sciatic nerve blocks, a catheter inserted 5 cm proximal to the sciatic nerve bifurcation provides superior postoperative analgesia in subjects having moderately painful foot or ankle surgery compared with catheters located at the bifurcation.

DISCLOSURES

Name: Amanda M. Monahan, MD.
Contribution: This author helped conduct the study and write the manuscript.
Attestation: Amanda M. Monahan approved the final manuscript.
Name: Sarah J. Madison, MD.
Contribution: This author helped conduct the study and write the manuscript.
Attestation: Sarah J. Madison approved the final manuscript.
Name: Vanessa J. Loland, MD.
Contribution: This author helped develop the protocol, conduct the study, and write the manuscript.
Attestation: Vanessa J. Loland approved the final manuscript.
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Contribution: This author helped conduct the study and write the manuscript.
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Contribution: This author provided the data analysis and helped write the manuscript.
Attestation: Michael C. Donohue approved the final manuscript.
Name: Scott T. Nomura, BS.
Contribution: This author helped write the manuscript.
Attestation: Scott T. Nomura approved the final manuscript.
Name: Cindy H. Wen, BS.
Contribution: This author helped conduct the study and write the manuscript. In addition, she has seen the original study data.
Attestation: Cindy H. Wen approved the final manuscript.
Name: Brian M. Ilfeld, MD, MS (Clinical Investigation).
Contribution: This author designed the original study, secured appropriate funding, has seen the original study data, reviewed the analysis of the data, approved the final manuscript, and is the author responsible for archiving the study files.
Attestation: Brian M. Ilfeld approved the final manuscript.
This manuscript was handled by: Terese T. Horlocker, MD.

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REFERENCES

7. McCartney CJ, Duggan E, Apatu E. Should we add clonidine to local anesthetic for peripheral nerve blockade? A qualitative
8. Singelyn FJ, Gouverneur JM, Robert A. A minimum dose of clonidine added to mepivacaine prolongs the duration of anesthesia and analgesia after axillary brachial plexus block. Anesth Analg 1996;83:1046–50