Long-Axis Ultrasound Imaging of the Nerves and Advancement of Perineural Catheters Under Direct Vision: A Preliminary Report of Four Cases

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Background and Objectives: Ultrasound allows visualization of in plane needle insertion toward a nerve and the perineural spread of local anesthetic (LA) solution. However, advancement and final positioning of perineural catheters is difficult to visualize. We assessed the feasibility of long axis nerve scans for controlling perineural catheter placement.

Methods: Four orthopedic patients scheduled for continuous peripheral nerve blocks (interscalene, femoral, midfemoral sciatic, and popliteal sciatic), had perineural catheters inserted under ultrasound guidance. After obtaining adequate short axis images of the target nerves, the high frequency linear transducer was rotated 90° to obtain long axis views. An 18-gauge epidural Tuohy needle was inserted tangentially to the nerve and the correct tip position was confirmed visually by small volume injections of LA. A rigid epidural catheter was inserted under the transducer's long plane and advanced into the desired perineural position. LA was then injected through the catheter and the spread was confirmed both on long axis and short axis scans.

Results: The catheters were captured on the long axis scans in all 4 patients, both exiting the needle tip, and during further advancement. They remained in situ for 3 to 5 days providing adequate postoperative analgesia and were removed uneventfully.

Conclusions: This short case series suggests that long axis imaging of the nerve, the needle, and the catheter allows visualization of a catheter's advancement. Using to-and-fro movements, and slight rotation the needle's bevel, the catheter may be maneuvered under the ultrasound beam, which facilitates correct positioning. *Reg Anesth Pain Med 2008;33:477-482.*

Key Words: Ultrasonography, Continuous nerve block, Peripheral nerve catheter, Regional anesthesia.

Continuous peripheral nerve blocks provide excellent analgesia after painful orthopedic surgery.[1] However, the correct perineural placement of the catheter is still a challenge for the anesthesiologist. Ultrasound (US) scans of the nerves on their short axis (SAX) facilitate their identification and allow observation of the circumferential spread of local anesthetic (LA) boluses. The insertion needles are adequately imaged using the in plane (IP) technique. However, most perineural catheter insertions are either "blind,"[2] or facilitated by continuous electrical stimulation through the catheter.[3] Movements of the surrounding tissues and injections of LA or small volumes of air to verify catheter position have also been reported,[4,5] but neither allows continuous visual control of the catheter's advancement. This preliminary report describes 4 successful continuous nerve blocks, where long axis nerve scans (LAX) and IP needle and catheter insertion technique allowed visualization of both the catheter advancement, and the longitudinal perineural spread of LA injected through the catheter.

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Methods

Illustrative Cases

Informed consent to publish these data was obtained from the patients and/or guardians prior to

Fig 1. The ultrasound-guided catheter insertion in the right interscalene space in case 1. Patient is supine. The probe is positioned parallel to the scalene muscles. Caud, caudad; Ceph, cephalad.

submission of this manuscript. The equipment used in all patients were: LOGIQe portable US scanner (GE Medical Systems, Wuxi, China) with a 5 to 13 MHz broadband linear transducer (12L-RS), and an epidural ProSet containing an 18-gauge graduated Tuohy needle and a Perifix ONE epidural catheter (B. Braun Medical, Melsungen, Germany). In the first 3 patients the LAX images of the nerves were clear. In the fourth patient, who had popliteal sciatic nerve block, the initial image of the nerve was verified by electrical stimulation through a 22-gauge, 50 mm long, insulated cannula (Stimuplex D, B. Braun Medical) before insertion of the Touhy needle. In all 4 patients, the correct perineural position of the tip of Tuohy needle was confirmed by injection of a few mL of 0.75% ropivacaine, which also opened and dilated perineural spaces. The catheters were advanced under direct vision into the final position using to-and-fro movements. Their advancement alongside the nerves was facilitated by rotating the Tuohy needle. None of the catheters curled back or coiled, although it was not always possible to advance catheters strictly superficial to the target, so that both the catheter and the nerve were in the transducer's plane. In such cases the transducer was slightly tilted and/or rotated to follow the catheter and tilted/rotated back to assess its deviation from the nerve.

Case 1. A 38-year-old male cyclist hit by a motor vehicle sustained traumatic right glenohumeral joint luxation and clavicular fracture. The shoulder was repositioned in the emergency room under US-guided SAX out of plane, single shot interscalene block with 20 mL of 2% mepivacaine. After computed tomography scan, and exclusion of major internal injuries, he was scheduled for open rotator cuff repair and reinsertion of the suprascapularis muscle. LAX scan of the right interscalene space was performed under light sedation in supine position. A linear transducer was positioned between the scalene muscles as distally as allowed by the clavicle in an almost frontal plane (Fig 1). This improved visibility of the cleft between the scalene muscles and the nerves. An 18-gauge Tuohy needle was inserted through the middle scalene muscle. The images of needle, catheter, and C5 root were clear. C6 and C7 roots were also visible but less clearly (Fig 2). The catheter was advanced under direct vision circa 4 cm beyond the needle tip tangentially to the nerves, and adjacent to C5 and C6 roots. Thirty mL of ropivacaine 0.75% was injected through the catheter. The insertion procedures took 15 minutes. Adequate LA spread was visualized on both LAX and SAX scans. During surgery the patient did not require further analgesics. He woke up without shoulder pain and was still able to move his fingers. In the first 18 postoperative hours he obtained good pain relief (Visual Analogue Scale

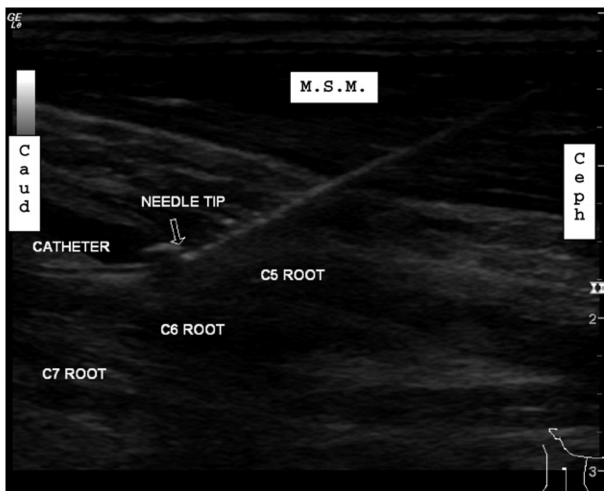

Fig 2. Long axis scan of the interscalene block in case number 1. The needle tip is posterior and adjacent to the inferior border of C5 root. The catheter is being advanced caudally between C5 and C6 roots. C7 root visibility is poorer because it is not completely in plane. Caud, caudad; Ceph, cephalad; M.S.M., middle scalene muscle.

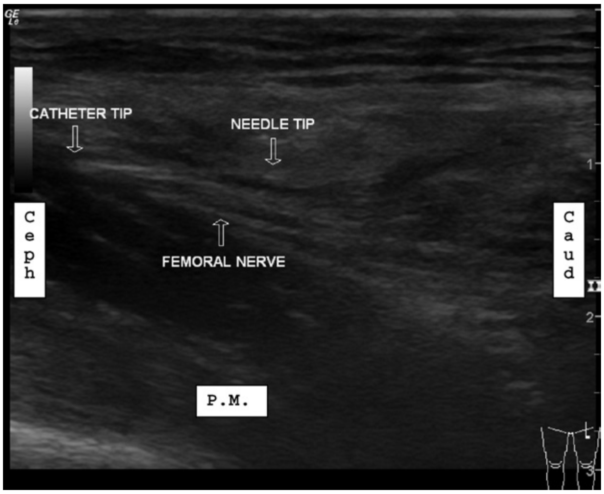

Fig 3. The tip of the Tuohy needle and the catheter emerging from it in case 2. The needle shaft and the femoral nerve are not completely in-plane. Catheter deviates medially to the nerve. LA injected during a diagnostic single-shot block is visible as a hypoechoic area below the catheter tip. Caud, caudad; Ceph, cephalad; P.M., pectineus muscle.

[VAS] ≤ 30/100), with continuous infusion of 0.2% ropivacaine 6 mL/h, and 2 nurses administered boluses of 10 mL 0.25% bupivacaine. After that, the infusion was stopped by the surgeon to check shoulder movements. Within 3 hours VAS increased to 80/100, and after a new bolus of bupivacaine the infusion was reinstated. The catheter was removed uneventfully on the fourth postoperative day.

Case 2. A 19-year-old male with posttraumatic osteomyelitis of the left distal femur was referred from another hospital for removal of the intramedullary nail and external femoral shaft fixation. His daily analgesic medication consisted of 60 mg of oxycodone, 150 mg of diclofenac, and 4 g of paracetamol. He was scheduled for general anesthesia (GA) and peripheral nerve block/blocks. To determine the extent of pain reduction after a femoral nerve block alone, a diagnostic US-guided femoral nerve block (SAX) using 10 mL of 2% lignocaine was performed first. A linear probe was placed parallel and circa 2 to 3 cm distal to the inguinal ligament in an oblique axial plane to obtain the SAX view of the nerve. A 22-gauge, 5 cm long needle was inserted in plane from the superior-lateral to the inferior-medial position under the transducer through the fascia lata and the fascia iliaca. Lignocaine was injected just below the nerve. Ten minutes after LA injection the VAS scores (0-100) were reduced from 55 to 15 mm. The patient was anesthetized with propofol and remifentanil. After preparation of the inguinal area the LAX image of the nerve was obtained just distal to the ligament. A Tuohy needle was inserted 5 to 6 cm from the inguinal crease in a cephalad, medial, and slightly dorsal direction. The femoral nerve, the LA below it, the needle tip, and the emerging catheter were visualized (Fig 3). The catheter was advanced circa 7 cm beyond the needle tip, ending inferiolateral to the nerve, just proximal to the inguinal ligament. The advancement was followed visually. The insertion procedures took 20 minutes. Fifteen mL of 0.75% ropivacaine was injected through the catheter. The perineural spread of LA was verified by SAX scan at the level of the inguinal ligament. Postoperatively the patient reported mild pain in the operated leg. He received 0.2% ropivacaine infusion 6 mL/hour for 3 days, continuing oral treatment with oxycodone and paracetamol. The infusion was terminated because of weakness of the quadriceps muscle, which interfered with mobilization. His VAS scores at rest varied between 20 and 40 mm.

Case 3. A 12-year-old immature (21 kg) and mentally retarded girl suffering from cerebral palsy was scheduled for corrective osteotomies of a left clubfoot under GA and continuous midfemoral sciatic nerve block. After induction of GA with propofol and 0.05 mg of fentanyl, the patient was turned into prone position. The sciatic nerve was easily visualized on the SAX scan, 5 to 6 cm distal to the inferior border of the gluteus maximus muscle. The transducer was rotated 90 degrees and the LAX image of the nerve was obtained. The Tuohy needle was inserted tangentially in a cephalad direction under the distal border and in plane of the transducer (Fig 4). After the injection of 4 mL of 0.5% ropivacaine to confirm perineural spread, the cath-

Fig 4. Position of the transducer in midfemoral approach to the sciatic nerve in case 3. Tuohy needle inserted in-plane with a catheter emerging from it.

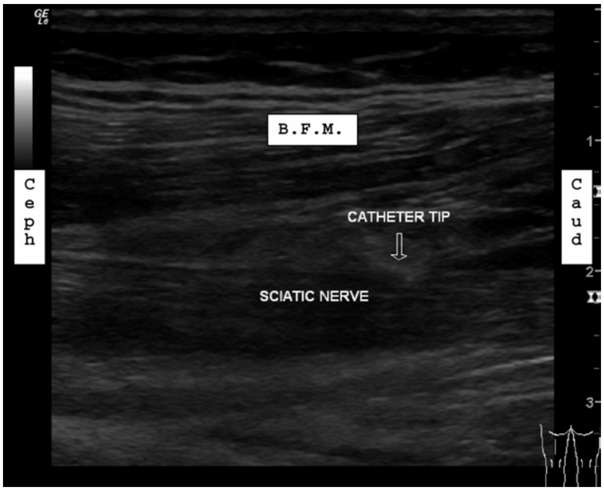

Fig 5. Long axis scan of the midfemoral area in case 3 showing the catheter tip adjacent to the sciatic nerve. Local anesthetic (LA), which was injected through the needle, is seen as a hazy, hypoechoic area spreading above and below the nerve. The catheter is advancing through the LA pool superficial to the nerve. B.F.M., biceps femoris muscle; Caud, caudad; Ceph, cephalad.

eter was advanced circa 4 to 5 cm superficial to the nerve (Fig 5). The insertion procedure took 12 minutes. An additional 8 mL of ropivacaine was injected through the catheter, and the spread was visualized with LAX and SAX scans. During anesthesia, which took 95 minutes, the patient remained unresponsive to surgical stimuli. There was a gradual slow increase in pulse rate and blood pressure, which normalized after removal of the femoral tourniquet. The awakening and recovery were slow, but quiet. Postoperatively the patient received continuous infusion of 0.2% ropivacaine 4 mL/h for 5 days. During this time she did not cry excessively, ate and drank normally, and did not receive any opioids. The parents described her behavior as usual.

Case 4. A 15-year-old female outpatient weighing 45 kg was scheduled for elective correction of a right hallux valgus under GA and continuous popliteal sciatic nerve block. After induction of GA with propofol and 0.1 mg of fentanyl, the patient was turned into a prone position. The SAX image of the sciatic nerve in the right popliteal triangle was obtained first. Nerve position on the LAX scan was verified by electrical stimulation. The perineural catheter was advanced superficially to the nerve 5 to 6 cm beyond the needle tip. Twenty mL of 0.75% ropivacaine was then injected through the catheter. The longitudinal LA spread is visualized in Figure 6, which shows the catheter surrounded by LA and freely floating in the LA pool 4 to 6 mm superficial to the sciatic nerve. The procedure took 25 minutes. After securing the catheter, the patient was turned supine and the saphenous nerve was visualized on the SAX scan superficial to the medial condyle of the tibia. This nerve was blocked with 4 mL of 0.5% bupivacaine using the IP technique. During ensuing surgery the patient remained cardiovascularly stable and unresponsive to surgical stimuli. Postoperatively she received continuous infusion of 0.2% ropivacaine 5 mL/h, and patient-controlled boluses of 5 mL with a lock-out of 60 minutes. She had a secondary analgesia failure 12 hours postoperatively, which was corrected by administering an additional bolus of 10 mL 0.25% bupivacaine through the catheter. The infusion rate was increased to 6 mL/h and the lock-out time shortened to 30 minutes. She was released home with the pump and was comfortable during the next 4 days. All 4 patients were followed for 1 month. No complications were observed.

Discussion

This preliminary report of US-guided perineural catheter insertions in 4 patients indicates that LAX nerve scans and IP insertion of both the needle and the catheter may allow real time visual control of catheter advancement in superficial locations. Using to-and-fro movements and slight rotation of the needle's bevel, the catheter may be maneuvered under the ultrasound beam, which facilitates correct positioning. The technique may be useful even in already anesthetized nerves, e.g., after diagnostic blocks.

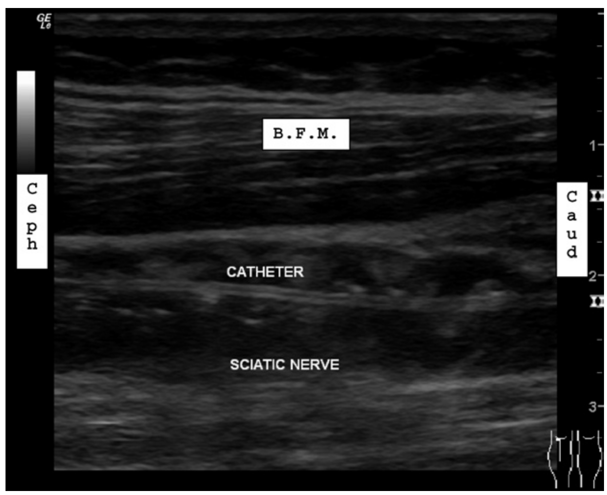

Fig 6. Position of the popliteal catheter in case 4 after the final injection of local anesthetic (LA). Sciatic nerve is seen at the bottom of the screen. The catheter is floating in the LA, 4 to 6 mm superficial to the nerve. B.F.M., biceps femoris muscle; Caud, caudad; Ceph, cephalad.

Most regional anesthesiologists that use ultrasound for peripheral blocks scan the nerves transversally. This technique helps to locate the nerves in the surrounding anatomical structures. For the single-shot blocks, the blocking needle may then be inserted perpendicular to the nerve, under the transducer's long axis, so called in plane technique, which allows visualization of the entire needle shaft, and of the circumferential LA spread. However, in a continuous block the needle is usually inserted tangentially to the nerve to facilitate the perineural advancement of the catheter. SAX nerve scans give only limited information about the needle tip, which approaches the nerve tangentially, e.g., in a cephalad or a caudad direction. Besides, good images of the perineural catheters are difficult to obtain on the SAX scans.[6] Therefore, most anesthesiologists insert these catheters blindly,[2] advance them for a very short distance past the needle tip and observe tissue displacement,[4] inject minute volumes of air,[5] or abandon the US scan and use stimulating catheters.[3] LAX scans of the nerve/nerves are also more difficult to interpret and may need confirmation by nerve stimulation. However, once the target nerve is identified, both the needle and the catheter can be inserted in the transducer's long plane, which allows visualization of both the needle tip and the catheter emerging from it. To our knowledge this is a first report showing clear LAX images of perineural catheters.

Besides LAX scans and IP needle and catheter insertion, other factors might have helped us to obtain good US images of the catheters. All blocked nerves were located superficially, within 1 to 3 cm depth. The yellow Perifix ONE catheter used by us is more rigid and less translucent than polyamide epidural catheters, which was advantageous during the advancement. Patients 1 and 2 had US-guided single-shot blocks before catheter insertions, which dilated the perineural spaces. After initial injections of LA through the needle to confirm correct spread, all 4 catheters were gliding alongside the nerves without kinking or curling back. LAX scan cannot prevent catheters from kinking or curling, but should show a stop of forward advancement.

The main difficulty encountered during catheter insertion was to maintain all 3 structures: nerve, needle, and catheter, in plane. A beam of linear transducer is only 1 mm thick and the catheters were not always advancing strictly superficial to the nerve. Therefore, after obtaining the first images of catheters emerging from the needle tip, the ultrasonic beam followed the catheters' advancement. Imaging of the needle shaft was no longer needed. If, during the advancement, the nerve image became unclear, the transducer was slightly tilted or rotated and the nerve image reacquired to assess the catheter's deviation from plane. It was then carefully withdrawn inside the needle, which was first rotated, then slightly repositioned before a new attempt. However, these maneuvers were only necessary in the patient having a femoral block, where the catheter deviated laterally and inferiorly to the nerve during advancement toward the inguinal ligament. This block had the longest procedural time – 25 minutes. During both sciatic blocks, the catheters were followed in plane 8 to 10 cm past the needle tip and then drawn back to the final position 4 and 7 cm alongside the nerves. Both were advanced superficially to the nerves. The sciatic nerve has a much larger diameter than an epidural catheter and is surrounded by loose perineural tissue, so even small deviations away from transducer's plane did not result in a loss of nerve image. In the lower extremity blocks, the needle was held in place by the tissues, so one hand of the anesthesiologist held the transducer and the other advanced the catheter. In the patient having an interscalene block, the needle had to be stabilized by an additional hand during catheter advancement.

LAX scan allows only limited assessment of perineural LA spread. It shows longitudinal spread superficial and deep to the nerve/nerves. Lateral and medial LA spread can be imaged only by tilting the transducer. This assessment is difficult and imprecise. Hence, after demonstrating the initial longitudinal spread of LA, the anesthesiologist should rotate the transducer back to SAX imaging, to verify the circumferential spread during further injection, and then follow the nerve course proximally and distally, checking the length of this spread. Either technique alone does not adequately demonstrate a sufficient LA spread.

Limitations of this report are the small number of patients, superficial nerve locations, and the experience of the attending anesthesiologist. Our 4 patients were either adolescents or young adults. Their body habitus was either normal or slim and therefore not comparable with the standard population of often elderly and overweight patients. The blocks were superficial, the needles were thick (18 gauge), and inserted at sharp angles ($<30°$) to the transducer plane. Needle visibility deteriorates rapidly with a steeper angle,[7,8] which characterizes deeper blocks. A recently published needle test[9] concluded that very few needles are adequately imaged at a 45° angle. All catheters were inserted almost perpendicular to the ultrasonic beam, which improved their visibility. The anesthesiologist performing the blocks avoided errors of a novice such as: sidedness correlation, fatigue, inability to recognize LA maldistribution, etc.[10] All these factors have undoubtedly improved efficacy of the method, and reduced its broad clinical applicability.

The technique may be further improved by using a stimulating Tuohy needle and either a rectangular or an oval hole in the sterile draping. The identification of a nerve on a LAX scan may be difficult. This was the case in our patient number 4, who had a popliteal sciatic block. Stimulation through the Tuohy needle could verify tip position and eliminate the additional puncture by the Stimuplex needle. The diameter of standard circular opening was too small to follow both the needle and the catheter with a linear transducer. A rectangular or oval hole in the draping, placed longitudinally over the nerve, would allow continuous transducer alignment with the catheter tip during the advancement, without lifting the draping.

In conclusion, this case series suggests that LAX ultrasound imaging of the peripheral nerves and IP catheter insertion technique may allow visual control of the advancement of perineural catheters, facilitating their placement. Further studies, e.g., comparisons of LAX and SAX scan-guided catheters in large groups of patients with regard to efficiency, success, and complication rates, are necessary to establish the clinical relevance of our findings.

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