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Continuous Peripheral Nerve Blocks With Stimulating Catheters

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Background and Objectives: This study evaluated the efficacy of stimulating catheters used for continuous peripheral nerve blocks as a means of immediate verification and confirmation of correct catheter position.

Methods: This observational study presents our experience with 130 stimulating catheters used in 40 intersternocleidomastoid, 24 axillary, 47 femoral, and 19 lateral midfemoral sciatic nerve blocks. Placement characteristics (amperage, depth of introducer needle or catheter insertion, elicited motor responses), subsequent postoperative analgesia, and catheter position evaluated with the radiopaque dye analysis were all studied.

Results: Except in femoral blocks, characteristics of motor responses elicited (1 Hz, 0,1 ms) by the introducer assembly and catheter differed. The amperage required to elicit motor responses typically was higher with the catheter than with the introducer needle (1.6 [0.2 to 4 mA] *v* 0.5 [0.4 to 1 mA] $P < .0001$). The ability to elicit a motor response with the stimulating catheter correlated with successful clinical anesthesia in 124 cases. Opacified radiography showed no aberrant position in these cases. Three catheters for upper limb block failed to stimulate, provided poor anesthesia, and had radiologic evidence of aberrant position. Even though they failed to stimulate, 3 catheters for sciatic block functioned well, and the opacified radiography showed correct position.

Conclusion: The ability to electrostimulate nerves using an in situ catheter increases success rate in catheter placement for continuous peripheral nerve blocks. Further controlled investigations are necessary to compare this technique with more conventional methods in terms of cost and utility for various peripheral nerve blocks. *Reg Anesth Pain Med 2003;28:83-88.*

Key Words: Catheter, Continuous, Block, Neurostimulation.

The primary goal of continuous peripheral nerve block catheter insertion is placement of the catheter into the perineural space. Verification of correct catheter position is determined by clinical effect following injection of the anesthetic or by opacified radiography. To the best of our knowledge, the stimulating catheter was only recently introduced in peripheral nerve block techniques.[1,2] Catheter stimulation potentially provides another means of verifying placement. In this report, we present our initial experience with stimulating catheters and neurostimulation to verify and confirm correct catheter placement for continuous peripheral nerve block.

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Methods

The study was supported by the University Hospital and approved by the Provincial Ethics Committee. After written informed consent, 130 patients scheduled for limb surgery were given continuous peripheral nerve blocks. Patients with the following clinical criteria were eligible for enrollment in the study: postoperative pain control

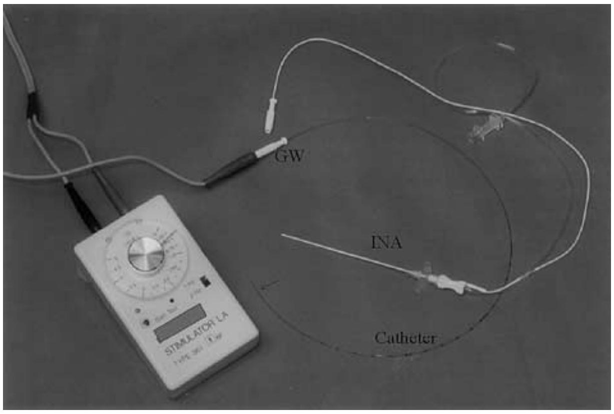

Fig 1. Stimulong set is presented with the introducer needle assembly (INA) and the catheter with the guide wire (GW) protruded (arrow) for stimulation.

after major knee surgery, immediate postoperative physiotherapy, or frequent painful dressing changes involving an operated limb. Exclusion criteria included minor surgery, infection near the site of needle insertion, coagulation disorders, or pre-existing neurologic dysfunction.

Continuous peripheral nerve blocks were performed in conscious and cooperating patients before surgery. We initially used the Stimulong-set (Pajunk, Geisingen, Germany), which was modified to Stimulong Plus in 2001. The former had a guide wire to manipulate in or out for stimulation, whereas the latter has the wire integrated within the catheter (Figs 1 and 2). After skin wheal with 2 mL 1% lidocaine and skin penetration with an 18-gauge needle, the introducer needle assembly was placed using previously described block techniques.[3-6] The nerve stimulator current was initially set at 2 mA (1 Hz, 0.1 ms) and, after initial appropriate motor response was seen, progressively reduced to 0.5 mA or until loss of motor response. After 5 mL normal saline was injected through the needle, the Teflon canula was advanced slightly. Two milliliters normal saline was then injected through the canula to check for possible kinking before threading the stimulating catheter ≥ 3 to 5 cm beyond the canula tip. Stimulation of the catheter was initiated at 0.5 mA and increased to a maximum of 5 mA until the appearance of an appropriate motor response. The current was again reduced and the catheter secured in place by surgical sutures and adhesive. In the absence of a response, the stimulating catheter was removed completely and passage reattempted via the Teflon canula. If the second passage failed to elicit a motor response, the introducer needle assembly was manipulated again (another puncture site or redirection) until the stimulating catheter was passed and an acceptable response was obtained. After 3 attempts to manipulate the introducer needle assembly, the catheter was left in place even if no response was obtained. After insertion of the introducer needle assembly was made deeply through the muscles for lateral midfemoral sciatic block, the catheter was left in place after 1 try, whether there was a response or not.

A bolus of 7.5 mg/mL ropivacaine was given to initiate the block (20 mL for intersternocleidomastoid (ISCM), axillary or sciatic block, and 10 mL for femoral block). General anesthesia was induced and maintained with sevoflurane at end tidal concentration of 1.5%. Radiographs were obtained in the postanesthesia care unit (PACU) after injection of 5 mL contrast (OMNIPAQUE; Iohexol 180, Nycomed Amersham, Paris, France) via the catheter. Radiologic analysis determined the position of the catheter and whether to maintain or remove it. After this precaution, the catheters were connected to a patient-controlled anesthesia (PCA) pump and 2 mg/mL ropivacaine infused at 2 to 5 mL/h. A patient-controlled bolus of local anesthetic (5 mL for ISCM or axillary blocks, 10 mL for femoral or sciatic blocks) could be administered (30-minute lockout). For all patients, rescue analgesia treatment (acetaminophen intravenous [IV] 1,000 mg and morphine subcutaneous [SC] 0.1 mg/kg) was available every 6 hours if needed.

For placement of ISCM catheters, we accepted contraction of deltoid, biceps brachii, or supraspinatus muscles (superior trunk of plexus), contraction of triceps brachii or wrist extension (middle trunk) or contraction of pectoralis, wrist and finger

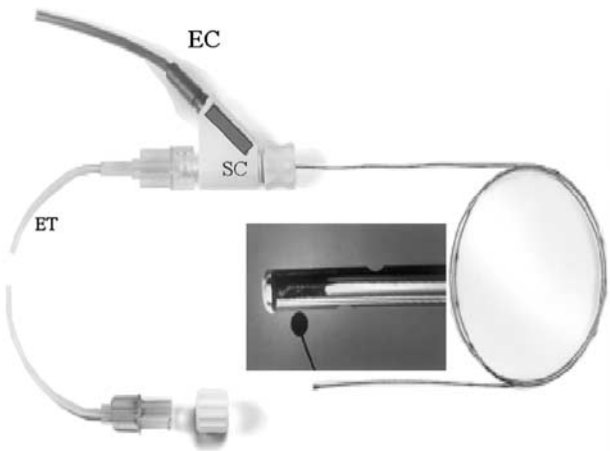

Fig 2. The stimulating catheter, Stimulong Plus, was shown with its screw connector (SC) capable to screw fix the stimulating catheter with integrated wire. The connector accepts an electric cable (EC) and a extention tubing (ET) for infusion. Note zoom view of the golden tip at the end of the new stimulating catheter.

Table 1. Demographic Characteristics

	ISCM Blocks	Axillary Blocks	Femoral Blocks	Sciatic Blocks
Age (yr)	48 (19-86)	35 (18-80)	62 (18-85)	57 (21-78)
Gender (F/M)	16/22	5/18	24/21	10/7
Weight (kg)	68 (50-103)	69 (55-105)	72 (50-125)	67 (50-100)
Height (cm)	168 (155-185)	170 (156-190)	166 (145-190)	160 (146-176)

NOTE. Data expressed in median and (range).
Abbreviation: ISCM, intersternocleidomastoid.

flexion (lateral cord).[7] For axillary catheters, we accepted stimulation of median, ulnar, or radial nerves. For sciatic blocks, dorsi or plantar flexion of the foot was sought and for femoral block, the quadriceps. The motor response, stimulator current, depth of insertion of needle, and catheter were recorded for all blocks.

In the PACU, motor and sensory block were assessed at admission and every 30 minutes using a previously described grading scale.[3,4] Motor block was defined as M_0 (no contraction), M_1 (isometric contraction, but no motion), M_2 (complete motion possible if gravity was not acting), M_3 (complete motion against gravity), M_4 (complete motion against resistance), M_5 (normal). Sensory block was defined as S_0 (no sensation at all), S_1 (sensation but inability to distinguish application of the head or point of a pin), S_2 (sharp tingling and stinging sensation S_3 (localization correct of 2 points within 2 cm distance), and S_4 (normal sensation accurately localized using response to pinpricks). A complete block would thus be graded M_0S_0. Testing was conducted after ISCM block (territories innervated by the axillary, musculocutaneous, radial, and median nerves), after axillary block (musculocutaneous, radial, median, and ulnar nerves), after femoral block (femoral nerve), and after sciatic block (tibial and common peroneal nerves). This examination was repeated during 48 hours, every 4 hours by nurses and twice a day by physiotherapists. The physician investigator verified these examinations twice a day.

Analgesia was assessed using visual analog scoring (VAS = 0 for no pain, VAS = 100 mm for maximum pain). Pain was assessed at rest (VASr) and with manipulation (VASm) as physiotherapy or wound dressing at bed side. Block quality was rated as good (VAS $<$ 30), acceptable (VAS 30-49 mm), or failed (VAS $\geq$ 50 mm). In patients with failed blocks (poor clinical effect, poor opacified image, no stimulation), the catheter was removed and PCA morphine IV prescribed.

Data were expressed in median and (range). T-paired statistics were used.

Results

A total of 130 continuous peripheral nerve blocks was performed including 40 ISCM, 24 axillary, 47 femoral, and 19 lateral midfemoral sciatic nerve blocks. Of these, 28 were performed with the Stimulong Plus set: 7 ISCM, 3 axillary, 10 femoral, and 8 sciatic blocks. Patient demographics are shown for each approach (Table 1).

Motor responses to needle and catheter tip in ISCM, axillary, and sciatic blocks are summarized in Table 2. In contrast to femoral blocks, in brachial plexus and lateral midfemoral sciatic nerve blocks, the motor responses elicited by the needle often differed from those elicited by the catheter. Characteristics of neurostimulation are shown in Table 3. A higher amperage was needed to elicit a response via the catheter than via the needle: 1.6 (0.2

Table 2. Stimulation of Nerve Groups by Needle, Then by Catheter

ISCM Blocks			Axillary Blocks			Sciatic Blocks		
Needle	Catheter	No.	Needle	Catheter	No.	Needle	Catheter	No.
MT	MT	18	Median	MC	4	Tibial	Tibial	8
MT	LC	3	Median	Ulnar	2	Peroneal	Peroneal	6
MT	Radial	1	Median	None	2	Peroneal	None	2
MT	ST	2	Radial	Radial	5	Tibial	None	1
MT	None	1	Radial	Ulnar	1	Tibial	Peroneal	1
ST	ST	5	Radial	MC	1	Peroneal	Tibial	1
LC	LC	9	Ulnar	MC	2	—	—	—
LC	Radial	1	Ulnar	Ulnar	6	—	—	—
—	—	—	Ulnar	Axillary	1	—	—	—

Abbreviations: MT, middle trunk; ST, superior trunk; LC, lateral cord; MC, musculocutaneous; ISCM, intersternocleidomastoid.

Table 3. Neurostimulation Characteristics

	ISCM Blocks	Axillary Blocks	Femoral Blocks	Sciatic Blocks
N-depth (cm)	5 (3-7)	3 (1-5)	5 (2-8)	6 (3-10)
C-depth (cm)	8 (5-12)	8 (6-10)	10 (7-15)	10 (6-15)
N-intensity (mA)	0.6 (0.4-0.8)	0.5 (0.5-0.8)	0.7 (0.4-1)	0.5 (0.4-0.7)
C-intensity (mA)	1.5 (0.2-2.6)	1.5 (0.5-2.5)	2 (0.4-4)	3 (1.5-4)
1 attempt	30	16	20	19
2 attempts	7	6	24	—
3 attempts	2	2 (abandon)	3	—
4 attempts	1 (abandon)	—	—	—

NOTE. Data are expressed in median and (range) for successful catheters and numbers of attempts before elicitation of motor responses or abandonment.

Abbreviations: N, needle; C, catheter; ISCM, intersternocleidomastoid.

to 4) mA *v* 0.5 (0.4 to 1) mA, respectively, $P <$ .0001.

In 20 femoral blocks, the stimulating catheter was very easily threaded ≥ 15 cm, but no elicitation of motor response was found at that depth. Quadriceps contractions were obtained only after withdrawing the catheter to a depth averaging 10 cm. The placement of 27 other catheters achieved acceptable response and was not advanced further.

Intravascular catheterization was recognized by blood drainage in 1 ISCM block. This was initially suspected by elicitation of flexion of the wrist at 0.2 mA via the catheter and persistence of this elicitation after saline injection. The procedure was repeated uneventfully.

In the PACU, examination showed a complete block with a grading M_0S_0 in 127 patients regardless of the technique used. Three catheters failed to produce adequate block: 1 ISCM block in which the stimulating catheter was left in place after 4 unsuccessful tries and 2 axillary blocks in which the stimulating catheter was left in place after 3 tries.

Initial block duration after bolus was 9 (6 to 12) hours in 39 ISCM blocks, 8 (6 to 16) hours in 22 axillary blocks, 6 (4 to 10) hours in 47 femoral blocks, and 10 (8 to 28) hours in 19 sciatic blocks. Before the patient was discharged from the PACU, infusion of 0.2% ropivacaine was started at the following rates: 3 (2 to 4) mL/h in ISCM blocks, 3 (2 to 5) mL/h in axillary blocks, 3 (2 to 5) mL/h in femoral blocks, and 4 (4 to 5) mL/h in sciatic blocks. At these infusion rates, block was maintained at an average of $M_{2\text{-}3}S_{2\text{-}3}$ in targeted nerves. Those nerves originally stimulated by the catheters typically displayed the greatest degree of block.

Analgesia was good in all cases in which a motor response was elicited via the stimulating catheter. Among these patients, the VAS scores in PACU were VASr = 0 (0 to 20) mm and VASm = 0 (0 to 20) mm. In the same patients maintained on a PCA pump, the scores were VASr = 10 (0 to 30) mm and VASm = 30 (0 to 30) mm. Minimal additional analgesic was needed (acetaminophen 3,000 mg per day, orally).

In upper extremity catheters in which no stimulation via the catheter could be elicited (1 ISCM and 2 axillary), the block was ineffective: the VAS scores were VASr > 30 mm, VASm > 50 mm, and rescue analgesia treatment was used. The catheter was removed and the PCA morphine IV was given. In contrast, the 3 sciatic catheters that failed to elicit a motor response achieved good anesthesia (VASr = 10, VASm = 20).

Radiograph analysis of contrast administration via the successful catheters showed a tubular image. In femoral blocks, the images ended half way between the acetubulum and vertebral column. Their orientation was cephalad, medial, and made an angle of approximately 35° with the axis of the spine. Tubular opacifications were also obtained via the catheters placed for brachial plexus or sciatic blocks. The unsuccessful catheters showed an atypical opacified image in the brachial plexus blocks, but not in the sciatic blocks.

No dislodgement of the catheters was noted. The surgeons reported no block-related neuropathy after 3 months follow-up.

Discussion

The ability to elicit motor responses with a stimulating catheter implies that the catheter is adjacent to a nerve and within the perineural space. Logically, this should facilitate the technique of catheter placement by giving a definitive clinical endpoint.

A surprising finding of this study was that the characteristics of motor stimulation with the catheter and introducer needle frequently differed. Several hypotheses can be suggested to explain the increased current requirements during catheter stimulation. The different contacts and distances between nerve and needle (the tip being on the nerve) or catheter (parallel to the nerve) might explain this increased requirement.[8] This is consistent with Coulomb's Law: doubling the distance between nerve and stimulating points will decrease the electrical field strength by the square of the distance, hence the current requirements for stimulation quadruple. Using saline flush to distend the perineural space before catheter passage may also disperse the current density and contribute to increased current requirements. We excluded the role of the electrical characteristics of the needle and catheter by testing 5 needles and stimulating catheters using a multimeter and 2 different peripheral nerve stimulators. No differences were found. During placement, the stimulating catheter migrates to different positions within the perineural compartment thus explaining different motor responses observed when stimulating via the catheter. For example, in axillary blocks, introducer needle stimulation of the median nerve followed by catheter stimulation of the musculocutaneous nerve. Presumably, when the catheter was advanced within the perineural compartment, it contacted a more proximal or distal portion of the plexus. This finding is consistent with earlier observations of successful musculocutaneous nerve block using continuous axillary blocks.[3,9,10] The absence of motor response elicitation in axillary blocks after first insertion probably corresponds to an aberrant position, as noted previously in a radiopaque dye study.[3] Such malpositions are not predicted by the easy passage of the catheter. In the ISCM approach, our experience confirmed our earlier impression[4] that catheter passage is easiest when the introducer needle/canula stimulates the middle trunk of the brachial plexus. From this position, the catheter easily passes into an infraclavicular position.[4] This information may be useful for one wishing to place a supraclavicular block while avoiding diaphragmatic palsy.[11] In practice, infraclavicular placement is confirmed by radiopaque dye analysis or by referring to typical motor responses (e.g., wrist flexion, digit flexion, and pectoral contraction).[7]

During femoral block, easy advancement of the catheter up to 15 cm and the absence of response at this depth is interesting. The ultimate position of the catheter tip when advanced this distance is unclear. Contrast media injection via femoral catheters in our study differed somewhat from previous works,[12-14] by not reaching the roots of the lumbar plexus.[12,14] A possible explanation is that the contrast media was injected around the femoral nerve on its path in a plane anterior to psoas muscle, where its intrapelvic spread was stopped at the point where the path twists into a plane posterior to the psoas.[15] Contrary to a recent study using nonstimulating catheters,[14] we found no aberrant position with stimulating catheters for femoral blocks in our study. We are in full agreement with the authors that easy insertion of a regular catheter does not exclude aberrant placement. We concur that femoral block is a good model to assess the utility of stimulating catheters. In the lateral midfemoral sciatic block, the inability to produce a motor response with the stimulating catheter did not always predict failure. This observation may be explained by the catheter passage in a plane perpendicular to the nerve, allowing the catheter to advance past the nerve, make a 90° turn, and then depart in a large perineural space filled with adipose. Since these catheters functioned well clinically despite their lack of a motor response, questions are raised about the utility and predictive value of a stimulating catheter, particularly with the needle directed perpendicularly to the nerve. However, because all our catheters that produced a motor response functioned well clinically and displayed good opacified images, we believe that successful motor stimulation via the catheter is of predictive value. Thus, actual predictive values need to be determined in future studies, because positive predictive values would justify re-attempts when stimulating catheter placement is technically demanding.

The price for the Stimulong Plus set was 30 Euros, 23 Euros for the Stimulong set, and 21 Euros for the regular set. If reduced failure rates result in reduced catheter set usage and if effectiveness results in reduced anesthetic dosages, difference in acquisition prices might be negated. A comparative controlled study is necessary to address this economic point.

In conclusion, our initial observational experience with the stimulating catheters is encouraging. We speculate that the ability to neurostimulate with a stimulating catheter will increase the success rate of catheter placement. However, randomized, controlled trials are necessary to compare this technique with more conventional ones in terms of costs and utility, and in different approaches to continuous peripheral nerve block.

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