Clinical Reports

Detection of subarachnoid and intravascular epidural catheter placement

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Purpose: To report the detection of subarachnoid and intravascular catheter placement using nerve stimulation through an epidural catheter.

Clinical features: Electrical stimulation (1-10 mA) was applied through the catheter. A positive motor response (truncal or limb movement) indicated that the catheter was in the epidural space. Absence of a motor response indicated that it was not. A low milliamperage (< 1 mA) with bilateral response indicated subarachnoid placement. Intravascular catheter placement was indicated by a positive response to the test, which remains at or returns to the baseline levels (i.e. prior to any local anesthetic injection), despite the administration of local anesthetics. In the first patient, the test confirmed subarachnoid catheter placement during attempts at continuous spinal anaesthesia even though CSF could not be aspirated. Bilateral motor response in the legs was observed at 0.2 mA. In the second patient, inadvertent subarachnoid placement was detected during attempted lumbar epidural block by observing bilateral motor response in the legs at 0.3 mA. In the third patient, intravascular placement was suspected and confirmed by failure to obliterate the motor response despite repeated local anesthetic injection.

Conclusion: The new test provides objective information in managing epidural catheters when their position is uncertain.

Objectif : Décrire la détection du positionnement d'un cathéter sous-arachnoïdien et intravasculaire à l'aide de la neurostimulation au moyen d'un cathéter épidural.

Éléments cliniques : La stimulation électrique (1-10 mA) a été appliquée au moyen du cathéter. Une réponse motrice positive (mouvement du tronc ou d'un membre) indiquait que le cathéter était dans l'espace épidural et l'absence de réponse, qu'il n'y était pas. Un faible milliampérage (< 1 mA) et une réponse bilatérale indiquaient un placement sous-arachnoïdien. La position intravasculaire du cathéter était indiquée par une réponse positive au test, laquelle demeurait au niveau de base ou y revenait (c.-à-d., avant toute injection d'anesthésique local), malgré l'administration d'anesthésiques locaux. Chez le premier patient, le test a confirmé le positionnement sous-arachnoïdien du cathéter pendant les essais sous une rachianesthésie continue même si le LCR ne pouvait être aspiré. Une réponse motrice bilatérale a été observée à 0,2 mA. Chez le second patient, un placement sous-arachnoïdien involontaire a été détecté, pendant qu'on tentait un bloc péridural lombaire, en notant une réponse motrice bilatérale aux jambes sous 0,3 mA. Chez le troisième patient, le placement intravasculaire a été soupçonné et confirmé par l'échec à bloquer la réponse motrice malgré l'injection répétée d'anesthésique local.

Conclusion : Le nouveau test fournit une information objective sur la mise en place des cathéters quand leur position est incertaine.

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INADVERTENT subarachnoid or intravascular catheterizations are recognized complications of epidural blockade. Aspiration of the catheter alerts one to the possibility of misplacement of catheters in many cases. However, there are numerous reports of unrecognized subarachnoid and intravascular catheters even after negative aspiration for cerebraospinal fluid (CSF) or blood.[1-3] An epidural test dose (3 ml lidocaine 1.5% with 1:200,000 epinephrine) is traditionally used to detect subarachnoid or intravascular placement.[1] There are many examples of false positive and negatives results associated with the standard epidural test dose.[1-3] The use of low current epidural stimulation to confirm the location of epidural catheters has recently been described.[4-6] In clinical trials involving this new test, it was suggested that this technique might allow one to detect subarachnoid and intravascular placement of epidural catheters. This report describes the successful use of this new test to detect two cases of subarachnoid placement and one case of intravascular catheter placement.

Stimulation test

Using sterile technique, a nerve stimulator (Dakmed model 750 digital, C.R. Bard, Inc., Tewksbury, MA, USA) was connected to the epidural catheter (19G Arrow Flextip plus, Arrow International, Inc., Reading, USA) via an adapter (Johans ECG Adapter, Arrow International, Inc., Reading, USA).[4-6] The epidural catheter (19 G ArrowFlextip Plus, Arrow International, Inc., Reading, USA) and ECG adapter were primed with sterile normal saline(0.2 to 1 ml).The anode lead of the nerve stimulator was connected to an electrode over the deltoid muscle as a grounding site and the cathode to the metal hub of the adapter. The nerve stimulator was set at a frequency of 1 Hz with a pulse width of 200 msec and the current output carefully increased from zero until motor activity was visible in the trunk, abdominal wall or lower extremites. Based on observations from two previous clinical trials, test criteria are summarized in the Table.

Case #1

An 87-yr-old woman was scheduled for elective revision of a total hip prosthesis. The initial surgery was performed under spinal anesthesia. A combined technique (consisting of light general anesthesia and continuous spinal anesthesia) was selected for the revision surgery. With the patient in the sitting position, an epidural catheter was placed and advanced 5 cm into the subarachnoid space at the L_{3-4} interspace. Aspiration of cerebrospinal fluid (CSF) through the catheter was easy. Upon positioning the patient laterally, CSF could no longer be aspirated. Because of the inability to aspirate CSF, the stimulation test was used to confirm the catheter location prior to local anesthetic injection. A bilateral motor response was observed in the legs at 0.2 mA, suggesting subarachnoid placement. General anesthesia was induced and maintained. Bupivacaine 5 mg (0.5%), was injected without resistance into the subarachnoid space after the induction of general anesthesia. The patient remained hemodynamically stable throughout the 90 min operation. Upon completion of surgery the patient was placed in the supine position, CSF was aspirated freely from the catheter. Intrathecal morphine (0.2 mg) was given prior to the removal of the catheter at the end of the case. The patient awoke with good analgesia and remained pain-free until the next day. Subsequent postoperative pain was managed with oral analgesics. The patient was discharged six days later with no signs of postdural puncture headache.

Case #2

A 61-yr-old man was scheduled for elective abdominal aortic aneurysm repair. An epidural catheter was inserted at the T_{10-11} interspace with good loss of resistance to air. However, upon aspirating the catheter, clear fluid was produced and it was evident that the catheter was in the subarachnoid space. The catheter was removed and a second attempt was made at T_{9-10} interspace. Once again, the epidural space was easily identified but fluid dripped slowly from the needle. An epidural catheter was then advanced. Attempts to aspirate fluid from the catheter were negative. Because of the uncertainty about the anatomic location of the epidural catheter, injection of local anesthetic or opioids was deferred. General anesthesia was induced and maintained. The operation was uneventful and lasted for four hours. During the operation, the patient received a total of 30 mg morphine *iv*. The patient awoke and reported discomfort. The patient received a total of 10.5 mg morphine *iv* in the post anesthesia recovery room (PARR) with minimal relief. Attempts to aspirate CSF from the catheter were negative but electrical stimulation revealed a bilateral motor response in the legs at 0.3 mA confirming subarachnoid catheterization. Intrathecal morphine (0.3 mg) was given prior to the removal of the catheter. Within half an hour, the patient was comfortable. Patient controlled analgesia (PCA) using morphine was available as a back up for inadequate pain. The patient remained pain-free and did not use the PCA morphine until eight hours later. The patient was discharged eight days later with no signs of postdural puncture headache.

Case #3

A 27-yr-old primigravida was admitted in labour at term. An epidural catheter was placed at the L_{3-4} interspace with ease. After negative aspiration for blood and CSF, a test dose of 3 ml bupivacaine 0.25% with 1:200,000 epinephrine was given without noticeable heart rate increase. Using 3 ml aliquots, 12 ml bupivacaine 0.25% were injected followed by 12 ml bupivacaine 0.125% but with poor results. Fentanyl 50 μg followed by 10 ml lidocaine 2% was then injected and the patient experienced somewhat better pain control. An infusion of bupivacaine (0.125%) and fentanyl (2.5 $\mu g \cdot ml^{-1}$) was commenced at a rate of 10 $ml \cdot hr^{-1}$. The infusion rate was later increased to 16 $ml \cdot hr^{-1}$ as the patient was still uncomfortable with each contraction. No clear sensory block was observed. The stimulation test was performed and showed a positive lower limb motor response at 5 mA current which suggested possible intravascular catheter placement. An epidural test dose was then given. Within 60 sec, the patient complained of "dizziness" and a metallic taste in her mouth associated with an increased heart rate (from 88 to 110 bpm). Based on these findings, the epidural catheter was determined to be intravascular. Repeat stimulation showed the threshold current remained at 5 mA despite the injection of additional local anesthetic, which is consistent with intravascular placement. The epidural catheter was withdrawn 2 cm. A repeat test dose was administered with a similar increase in heart rate. The epidural catheter was then removed and a small amount of blood was noted at the tip of the catheter. A new epidural catheter was inserted at the L_{2-3} interspace. The stimulation test was again performed resulting in a positive response at 5 mA. An epdiural test dose was then given with a negative response. After five minutes, repeat stimulation test showed a positive response at 8 mA. Twelve millilitres bupivacaine 0.125% were injected and the patient reported good analgesia and sensory changes up to the T_8 dermatome. The patient did well with a continuous infusion of 12 $ml \cdot hr^{-1}$ of a mixture of bupivacaine 0.125% and 2.5 $\mu g \cdot ml^{-1}$ fentanyl. She delivered a healthy infant spontaneously three hours later.

Discussion

We have described successful detection of two cases of subarachnoid catheter placement and a case of intravascular placement using a previous reported electrical stimulation test criteria (Table).[4-6] In the first case, the new test confirmed subarachnoid catheter placement during attempts at continuous spinal anaesthesia even though CSF could not be aspirated. Bilateral motor response in the legs was observed at 0.2 mA. In the second case, inadvertent subarachnoid placement was detected during attempted lumbar epidural block by observing bilateral motor response in the legs at 0.3 mA. In the third case, intravascular placement was suspected and confirmed by failure to obliterate the motor response despite repeated local anesthetic injection.

Anesthesiologists have relied heavily on the epidural catheter aspiration and epidural test dose to rule out subarachnoid or intravascular catheter placements. There are many reports of subarachnoid and intravascular injection following negative aspiration tests.[1-3] This point was illustrated in the first two cases described. In the first patient, despite the free flow of CSF with catheter insertion, aspiration was impossible after placing the patient in the lateral decubitus position. However, aspiration was possible when the patient was placed in the supine position. In the second case, fluid was dripping from the needle yet we were unable to aspirate from the catheter. Since CSF was not freely aspirated from the needle, the anesthesiologist suspected that the fluid issuing from the needle might be CSF from the previous dural tap. Fortunately, the anesthesiologist deferred from injecting any medication at that time. The new test was performed in the PARR and indicated that the catheter was in the subarachnoid space. This finding was confirmed by a remarkable clinical response to a small amount of morphine (0.3 mg). Aspiration for blood was negative in the third patient and intravascular catheterization was suspected using the stimulation test. The epidural test dose also suggested intravascular placement. Failure to aspirate blood from the catheter could be explained by: occlusion of the catheter by clotted blood, proteinaceous material or neural tissue plugging the catheter during negative pressure aspiration, or collapse of the soft epidural catheter during aspiration.

We previously observed a bilateral motor response in the abdomen when we stimulated through an epidural catheter known to be in the subarachnoid

TABLE Simplified guide for confirming of epidural catheter placement (Adapted from Tsui *et al.*, Can J Anaesth 1998; 45: 640–4, and Tsui *et al.*, Reg Anesth Pain Med 1999; 24: 17–23)

Epidural location	*Test result*
Subarachnoid	positive bilateral motor response (<1 mA)
Epidural space	positive motor response (1- 10 mA)
nonintravascular	threshold current increased after local anesthetic injected
intravascular	remain or return to baseline positive motor response(1-10 mA) even after local anesthetic injection
Subcutaneous	negative response

space (positive CSF aspiration).[4] The current required to produce a bilateral motor response on that occasion was 0.4 mA. The large difference in current required to produce a motor response in the two spaces can be explained by enhanced conduction to the nerve roots bilaterally by the CSF in the subarachnoid space. The observation of a low current and bilateral motor response in our first two cases is consistent with such a hypothesis. Both cases demonstrated a bilateral motor response to low current stimulation (<1 mA). In the first case, subarachnoid placement was reconfirmed when CSF was aspirated after repositioning the patient. Furthermore, the patient experienced excellent post-operative pain releif. In the second case, subarachnoid placement was supported by the excellent analgesic response to 0.3 mg morphine. This suggests that the new test may be useful to identify subararchnoid catheter placement when uncertainty exists.

The loss of resistance (LOR) technique is the most common method used to identify the epidural space. Air or saline is used interchangeably to demonstrate loss of resistance. The advantage of using air is that it is a readily available commodity but the disadvantages are that the injection of air in to the subarachnoid space may cause headache, injection intravascularly may cause venous air embolism and air in the epidural space may impair the spread of local anesthetics.[7] Thus, some anesthesiologists recommend LOR to saline as the preferred technique because this technique has not been associated with any of the abovementioned complications. However, one of the major disadvantages of saline LOR[7] is that it introduces fluid into the epidural space, which may cause confusion when a "wet tap" is suspected. This new test objectively allows one to distinguish subarachnoid from epidural placement. Therefore, the origin of fluid issuing from the catheter can be readily identified.

Previous studies[5,6] have shown that repeat injections of local anesthetic into a properly placed epidural catheter results in impairment of nerve conduction and requires a gradual increase in the current to produce a positive motor response. Absence of this phenomenon after repeated doses of local anesthetic suggests that the injected local anesthetic may be rapidly disappearing from the epidural site, as is the case with intravascular placement. Thus, it is hypothesized that the typical characteristics of intravascular catheter placement are a positive response to the new test that remains at or returns to the baseline levels (i.e. prior to any local anesthetic injection) despite the administration of local anesthetics. The findings from the third case are consistent with such a hypothesis. In this case, the patient remained uncomfortable and had no sensory changes despite the injection of significant amounts of local anesthetic into the epidural catheter. The positive response observed from the new test indicated that the catheter was still in the epidural space. Although we did not have a baseline threshold current for comparison, the threshold current of 5 mA suggested that there was minimum amount of local anesthetic remaining in the epidural space even though the local anesthetic injected is as being removed from the epidural space. The most likely explanation for this phenomenon was intravascular placement (local anesthetic enters the systemic circulation). Intravascular placement was later confirmed when typical symptoms and signs of intravascular placement were observed (metallic taste and increased heart rate) following an epidural test dose. After reinsertion of the epidural catheter, the stimulation test was repeated with a positive response at 5 mA. Five minutes after the test dose, a repeat stimulation test showed a positive response at 8 mA. This indicated proper epidural placement. These findings were also confirmed clinically when the patient developed a sensory block up to T_8 level.

In summary, this new test may have potential not only to verify epidural catheter placement but also to investigate suspected subarachnoid or intravascular catheter placement.

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