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Confirmation of Caudal Needle Placement Using Nerve Stimulation

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Background: **The study was designed to examine a new method of confirming proper caudal needle placement using nerve stimulation.**

Methods: **Thirty-two pediatric patients were studied. A 22-gauge insulated needle was inserted into the caudal canal *via* the sacral notch until a "pop" was felt. The needle placement was classified as correct or incorrect depending upon the presence or absence of anal sphincter contraction (S2–S4) to electrical simulation (1 to 10 mA).**

Results: **Three patients were excluded, two because they inadvertently received neuromuscular blockers and one because the patient's anatomy precluded any attempt at a caudal block. The sensitivity and specificity of the test were both 100% in predicting clinical outcomes of the caudal block. Six patients had a negative stimulation test after the first attempt to place the needle. Four of these went on to receive a second attempt of needle insertion after a subcutaneous bulge or resistance to local anesthetic injection were observed. Following needle reinsertion, positive stimulation tests were elicited. These patients received the local anesthetic injection with ease and had good analgesia postoperatively. No attempt was made to reinsert the needle in the remaining two patients with a negative stimulation test, as they did not show subcutaneous bulge or resistance upon injection. These patients had poor analgesia postoperatively. The positive predictive value of the test was greater than the presence of a "pop" alone ($P < 0.05$) but not significantly different ($P = 0.492$) over the presence of "pop" and easy injection.**

Conclusion: **This test may be used as a teaching and adjuvant tool in performing caudal block. (Key words: Caudal block; epidural stimulation.)**

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CAUDAL epidural anesthesia is useful when anesthesia of the sacral and lumbar dermatomes is needed. The key to successful caudal anesthesia relies on the proper placement of a needle in the epidural space. The most common way to identify the caudal epidural space is detecting a characteristic "give" or "pop" upon penetration of the sacrococcygeal membrane. Final confirmation of proper needle placement can be made only after observing the clinical effect of injection of medication. However, this clinical effect may take many minutes depending on the type of medication injected. To our knowledge, there is no practical technique that allows for verification of proper needle placement prior to local anesthetic injection. Since identification of the caudal epidural space can be difficult (up to 25% failure rate)[1] even in experienced hands, the development of an easy and reliable objective method that enables rapid confirmation of proper needle placement is desirable.

In clinical anesthesia practice, spinal cord stimulation techniques for the treatment of chronic pain and electrical stimulation methods for localizing peripheral nerves have been used for decades.[2,3] However, electrical stimulation has never been described to identify entry into the epidural space until two recent clinical trials.[4,5] These studies demonstrated that this new test is an objective and reliable way to confirm entry into the epidural space. A positive motor response to low current electrical stimulation confirms proper epidural location. A negative response suggests placement outside the epidural space. Based on previous data, positive and negative test criteria were developed. The purpose of this study was to examine the reliability and practicality of applying this test to confirm the correct placement of a caudal needle.

Materials and Methods

After ethics committee approval and written informed consent from patients' parents, 32 consecutive pediatric patients (American Society of Anesthesiologists physical status I or II) who had already agreed to receive caudal

Table 1. Criteria for Positive and Negative Test

Testing conditions: ensuring the subject has not received any local anesthetic *via* caudal needle or neuromuscular blocker prior to the testing
Positive criteria
(1) The current needed should be within 1 to 10 mA and motor activity/twitch response in the anal sphincter (S2–S4)
(2) The motor response should be unchanged in term of strength or location regardless of placement of the anode grounding electrode.*
Negative criteria
(1) If the current needed is less than 1 mA, it is likely to be subarachnoid placement or directly against a nerve root.*
(2) The needle is not in the caudal epidural space and is likely posterior to the sacrococcygeal membrance (*i.e.*, subcutaneous): If the subject does not respond at all, or If the subject responds to a higher current (*i.e.*, >8 mA) and the motor response changes in term of strength or location with repositioning of the anode grounding electrode.

Modified From Tsui *et al.*[4]

* Criteria are based on observation for lumbar and thoracic epidural placement from the previous study.

anesthesia were studied. These patients presented for minor urological and general surgery procedures below the umbilicus.

Caudal anesthesia was performed after the induction of general anesthesia with inhalational or intravenous agents without neuromuscular blockers. The caudal blocks were then performed by anesthesiologists who were blinded to the results of the stimulation tests. Patients were turned to the lateral position and the sacral hiatus was identified using the bony landmarks of the sacrum. A 22-gauge 2-1/8 insulated needle (Stimplex, Becton Dickinson, Franklin Lakes, NJ) was inserted perpendicularly to the skin and advanced until a "give" or "pop" was felt as the needle penetrated the sacrococcygeal membrane. After the anesthesiologist was satisfied with the needle placement, a separate investigator connected a nerve stimulator (Dakmed model 750 digital, Buffalo, NY) to the 22-gauge insulated needle. The negative lead of the nerve stimulator was attached to the metal hub of the needle. The nerve stimulator frequency was set to 1 Hz. The output current was gradually increased from zero until motor activity or twitch response in the anal sphincter (S2–S4) was visible. Depending on the observed positive or negative response to low-current simulation (1 to 10 mA), the needle placement was then considered to be correct or incorrect according to the test criteria (table 1).[4,5]

Unaware of the stimulation results, the attending anesthesiologist then proceeded with injection. After the absence of blood or cerebrospinal fluid was assured, 1 ml/kg of bupivacaine 0.25% was injected in small incremental doses. Any clinical signs of subcutaneous bulging or tissue resistance upon injection of local anesthetics were considered to indicate an unsuccessful caudal block with improper needle placement. Finally, the caudal block was determined clinically to be successful or unsuccessful based on whether or not opioid was required postoperatively, as judged by the anesthesiologist who performed the caudal block.

Table 2. Comparison of New Test with Outcome of Blocks

Stimulation	Caudal Successful	Caudal Unsuccessful	Total
Positive	23	0	23
Negative	0	6*	6
Total	23	6	29

Sensitivity and specificity of the new test = 100%; positive and negative predictive value = 100%.

* Four patients underwent second attempt (see table 3).

Statistical Analysis

Fisher exact test was used to compare the positive predictive value between the new test and the standard method (*i.e.*, "pop" alone and "pop" and easy injection). Differences among predictive values were considered statistically significant when $P < 0.05$. The lower 95% confidence limit of sensitivity and specificity was calculated using a formula $\sqrt[n]{(0.05)}$, where n indicates the number of patients.[6]

Results

Thirty-two patients aged 1 month to 9.5 yr were studied. Three patients were excluded from the study (two inadvertently received neuromuscular blockers and one patient's anatomy precluded any attempt at a caudal block). Tables 2 and 3 summarize the comparison of this

Table 3. Outcome of Blocks

	Caudal Successful	Caudal Unsuccessful	Predictive Value (%)
"Pop" present	23	6	79.3
"Pop" present and easy injection	27	2	93.1
Positive stimulation	27	0	100*

* Fisher's exact test (new test *vs.* "pop": $P = 0.024$; new test *vs.* "pop" and easy injection: $P = 0.492$).

Table 4. Profile of Six Patients with a Negative Stimulation Test after the First Attempt to Place the Needle

Age (mo)	1st Attempt Test Result	Clinical Assessment	2nd Attempt Test Result	Clinical Assessment
18	Negative (11 mA; back muscle twitch)	Resistance upon injection	Positive (3.0 mA)	Easy injection, good postoperative pain relief
17	Negative (14 mA; back muscle twitch)	Bugling upon injection	Positive (4.0 mA)	Easy injection, good postoperative pain relief
6	Negative (12 mA; back muscle twitch)	Resistance upon injection	Positive (2 mA)	Easy injection, good postoperative pain relief
22	Negative (14 mA; back muscle twitch)	Bugling upon injection	Positive (6 mA)	Easy injection, good postoperative pain relief
6	Negative (16 mA; back muscle twitch)	Easy injection, no bugling	No attempt	Poor postoperative pain relief
1	Negative (15 mA; back muscle twitch)	Easy injection, no bugling	No attempt	Poor postoperative pain relief

test with the clinical assessment for the remaining 29 patients. There were 23 positive and 6 negative results from the stimulation test after the first attempt to place the caudal needle. Four patients had a second placement attempt as improper needle position was suggested by clinical signs of subcutaneous bulging or tissue resistance upon injection of local anesthetics (table 4). All these patients had good postoperative analgesia without opioids. No attempt was made to reinsert the caudal needle for the remaining two patients with negative stimulation tests as they did not have any clinical signs of improper needle placement. These patients were found to have poor analgesia such that intravenous morphine was given postoperatively in the recovery room. The current needed to produce a positive test was 1.8 to 8.6 mA with an average of 3.78 mA in 27 positive tests (23 after the first attempt and 4 after the second attempt). For the six negative tests (four became positive upon reinsertion of the needle), patients exhibited local (*i.e.*, deltoid and back) muscle contraction at a current range from 11 to 16 mA (average, 13.7 mA). These negative tests were confirmed by observing relocation of the local muscle contraction following repositioning of the anode electrode over the deltoid muscle on the other side. Two patients whose needle placements were found to be in an epidural vein (as demonstrated by blood aspiration) showed positive motor responses at 3.9 mA and 4 mA, respectively. The needles were withdrawn slowly until no further blood could be aspirated. After the absence of blood aspiration was assured, local anesthetic was injected as positive motor response was still present in both cases. Both these patients had good postoperative analgesia.

Discussion

Spinal cord stimulation has been used as a safe means of long-term pain control for many years.[2,7] However, the use of low-current epidural stimulation to confirm the location of the epidural space was only recently demonstrated.[4,5] In these clinical trials, a low-current stimulation technique appeared to provide favorable results in confirming lumbar and thoracic epidural catheter placement at the time of insertion for obstetric and postoperative patients. None of the patients studied experienced any discomfort or side effects from the stimulation test. Since the milliamperage used in the previously described test is within the safety range used for patients with chronic pain, it was anticipated that the risk of a brief electrical stimulation used in the test would be less than the risk of long-term epidural stimulation used in chronic pain management. The technique described here is based on the same concept of epidural stimulation and applied to confirm caudal needle placement by applying electrical stimulation through an insulated needle into the caudal epidural space. Even though the safety of this new test applied to the caudal space is untested, it is speculated that the risk of this test would be similar to the one applied to the thoracic or lumbar epidural region.

In pediatric patients, central (epidural, spinal, or caudal) and peripheral blocks are commonly performed

under sedation or general anesthesia for ease of administration and practical reasons.[8,9] However, paresthesia, an early warning sign preceding permanent neurologic injury, cannot be elicited in anesthetized patients.[8,9] Thus, controversy still exists as to the practice of placing a central block in a patient under heavy sedation or general anesthesia as it entails the danger of neurological complications. Hence, any warning sign available as an alternative to paresthesia is desirable when placing a central block in an anesthetized patient.

In performing regional anesthesia, it has been suggested that the use of a peripheral nerve stimulator may reduce the chance for nerve injury, as the needle does not actually have to contact the nerve to produce a motor response.[10] However, no study has definitively proven a reduction of nerve damage by using a nerve stimulator. Using a peripheral nerve stimulator, it is generally agreed that a motor response with a current less than 0.5 mA is considered an indication of the needle being close enough to the nerve to obtain an effective block.[3] Because the intended milliamperage (1–10 mA) used in this test is greater than 0.5 mA, it is hypothesized that any abnormally low-current (< 1 mA) motor response may provide an early warning of the risk of contacting the nerve root or entering the subarachnoid space when performing a central block. In our previous study,[4] the observation of a case of subarachnoid catheter placement with 0.4 mA and proximity of the catheter tip to the nerve root with 0.5 mA were consistent with such a hypothesis. Another relevant observation was documented in a case report, in which an acute transient total spinal block and a permanent neurologic deficit occurred after a nerve stimulator–guided interscalene brachial plexus block performed during general anesthesia.[11] In this case, the complications from inadvertent intrathecal and intraneural local anesthetic injection also occurred at low current (0.2 mA). Conversely, these findings suggest the potential application of the test as an alterative warning sign (< 1 mA) in the situation when paresthesias cannot be obtained. However, it is important to note that this potential application remains unproven from this study as neither low-current (< 1 mA) warning signs nor neurologic complications occurred in our patients.

In clinical practice, accurate caudal needle positioning depends on the "pop" as the sacrococcygeal membrane is pierced during needle insertion. The lack of subcutaneous bulging or resistance upon injection of local anesthetic are also important signs of proper needle placement. Other tests such as the "whoosh" test have been described.[1] This is claimed to be more reliable than the "pop" of the sacrococcygeal membrane.[12] However, eliciting the "whoosh" may cause venous air embolism following the use of 2.5 ml of air for this test.[13]

Tables 2 and 3 show acceptable values for this new test used to confirm caudal needle placement. The sensitivity and specificity were both 100%. Of the 29 patients studied, there were no false-positive or -negative results. All patients with positive tests experienced good analgesia in the postoperative period. Two patients with negative tests had poor analgesia from the caudal blocks. As shown in table 4, six patients showed a negative result after the first attempt. Four underwent a second block as the first attempt showed clinical signs (subcutaneous bulging or resistance upon local anesthetic injection) of improper placement. Upon reinsertion of the needles, all of these patients received the full dose of local anesthetic injection after lack of subcutaneous bulging or resistance upon local injection. Positive tests were elicited in all four patients after the second attempt of caudal needle placement. Postoperatively, these patients had good analgesia. Since the remaining two patients did not show any signs of subcutaneous bulging or resistance upon injection, no reinsertion attempt of the needle was made. These patients were found to have poor postoperative analgesia and required opioids.

Based on these observations (table 3), a positive stimulation test is a better indication of correct needle placement than the presence of a "pop" of the sacrococcygeal ligament alone ($P < 0.05$). Although the positive predictive value of the stimulation test was greater than the presence of "pop" and easy injection, it was found to be not statistically significantly different ($P = 0.492$). This may be a reflection of the small number of patients in the study and a larger study will be required to show a statistically significant difference. These findings require cautious interpretation because of the small number of patients studied to date.[6,14] Even if perfect sensitivity (100%) is observed, as in this study, the 95% lower confidence limit is approximately 50% when correctly detecting six of six patients with needle misplacement. Likewise, even with precise specificity (100%) as found in this study, the 95% lower confidence limit is also only around 90% when accurately identifying 23 of 23 patients without needle misplacement.

All of the attending anesthesiologists were blinded to the stimulation test results with the exception of those from the two patients whose needles were found to be in epidural veins (as demonstrated by blood aspiration). In these patients, the needle was withdrawn slowly until

no further blood could be aspirated. After the absence of blood aspiration was assured, local anesthetic was injected only after a positive motor response was still present. In both cases, the patient had good postoperative analgesia. Strictly speaking, the anesthesiologists should have remained blinded to the stimulation test results for the study purposes. On these occasions, we elected to provide the stimulation test results for ethical reasons, to assist the attending anesthesiologists in managing these patients. Otherwise, the anesthesiologists would have removed the needles and required a second attempt. Although the interpretation of this new test with intravascular epidural catheter placement was discussed in a previous report,[5] the application of this new test in detecting caudal needle intravascular placement was not evaluated and remains unanswered by this study.

We have found this stimulation test easy to perform. Because this test relies only on the objective observation of motor movement, it appears to be suitable for testing in a wide variety of patient groups, varying from conscious and oriented individuals to unconscious patients and those not capable of verbal communications. As the test can be performed with one of the commonly available insulated needles, it can be readily applied in routine practice as an adjuvant technique to improve the success rate of caudal anesthesia and as a useful teaching tool in a clinical setting. Nevertheless, there is no substitute for practical experience coupled with a sound knowledge of the anatomy of the sacrum in performing successful caudal blocks.

There are modifications that can be made to the design of the needle used here to improve the existing insulated needle, specifically for caudal block. First, the needle was relatively dull to penetrate the sacrococcygeal membrane and therefore could be sharper for ease of insertion. Second, a stylet should be added to minimize the risk of introducing dermal elements into epidural space.[8] Because an insulated sheathed needle is required for this test, this may increase the overall cost of the caudal block depending on the market value of the needle. Thus, the cost and benefit of using this technique in caudal block should be considered case by case.

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