CORRESPONDENCE

False negative electrical epidural stimulation test due to the excessive impedance of a saline bridge

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To the Editor,

The epidural stimulation test (EST) can predict successful neuraxial analgesia by confirming the location of the epidural catheter tip.¹ Over the past 20 years, this technique's effectiveness has been confirmed in multiple studies; however, concerns about its reliability in clinical practice settings persist.² In particular, its negative predictive value has been called into question as failed tests (inability to generate adequate current) and false negatives (no muscular twitches despite expected current) have been anecdotally reported and are often interpreted with ambiguity. Contrasting the reliability of the EST in clinical trials, we hypothesize that these failures may be due to important electrical current considerations easily overlooked by practitioners unfamiliar with the test. Recently, we encountered a series of false negative results. Upon reviewing the configuration of the EST assembly, we discovered that some clinicians had placed extension tubing between the electrode and the epidural catheter (Figure). Thus, we performed an *in vitro* study to validate whether the addition of this extension (i.e., a “saline bridge”) could yield a failed EST.

We compared the impedance between a wire-reinforced epidural catheter (Perifix, B. Braun, Bethlehem, PA, USA) connected directly to the Arrow-Johans Electrocardiography (ECG) adapter (Teleflex, Morrisville, NC, USA) with the same epidural catheter with a saline-filled tubing extension (Statlock Epidural Stabilization Device, BD, Franklin Lakes, NJ, USA). We found that

even a short saline bridge added enough circuit impedance that the 95 V stimulator (Braun HNS 12, Bethlehem, PA, USA) could deliver no more than 1 mA regardless of the pulse-width applied. According to Ohm's law,³ this suggested that the added saline extension significantly increased the impedance of the circuit. With such high impedance, most commercially available nerve stimulators would not be able to generate sufficient amperage (2–15 mA)⁴ to produce a positive motor response. Hence, we caution anesthesiologists against using extension tubing during an EST. We also noticed that any air within the system similarly made it impossible to deliver sufficient current, and that air bubbles tended to coalesce within the ECG adapter. Care is needed to ensure that the system is free of air bubbles before an EST is performed. While other variations of the system were tested (different techniques for connecting the anode to the ECG adapter, exchanging catheter clamps, and testing different lengths of epidural catheters), none of them had as significant an effect on the impedance of the system as the presence of a saline extension or air did.

Importantly, even properly placed epidural catheters with appropriate impedance can still yield false negatives if inadequate electrical charges (i.e., product of voltage, current, and time) are applied. Most nerve stimulators allow users to set the current while some also allow users to set the pulse-width (time). The maximum voltage can vary significantly between devices. It should be noted that a pulse-width of 0.1 msec will provide significantly less charge than a pulse-width of 1.0 msec at the same current and voltage. Accordingly, the range of current expected to produce a muscular twitch may need to be adjusted based on the pulse-width. Higher current will be needed to produce a twitch at a pulse-width of 0.1 msec than at 1.0 msec.⁵ We also noted that nerve stimulators have different

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Figure The maximum amperage delivery with HNS 12 (Braun, Bethlehem, PA, USA) stimulator. The measurements were performed five times. The mean (with 95% confidence intervals) maximum amperage that the stimulator could generate with (black diamond) and without (red square) a saline bridge extension are plotted.

ways of alerting the clinician that the set current is not being delivered despite the application of maximum voltage (due to too much impedance). If this is missed, a failed test could easily be interpreted as a negative one. We recommend that clinicians familiarize themselves with their nerve stimulator and choose a device and settings that can produce adequate charges.

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