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Accurately determining accuracy

We read with great interest the review article by Hilber *et al.*,[1] which summarized the reliability of epidural waveform analysis (EWA) as a confirmatory adjunct for epidural blocks. Unfortunately, key elements pertaining to pooled calculation of sensitivity/specificity, etiology of false positive waveforms, criteria for trial inclusion, and assessment of bias require further clarification.

Ideally, EWA should increase the specificity of LOR without impacting its sensitivity. Pragmatically, the sensitivity of EWA may be affected by the conduit used for transduction (rigid needle *vs.* compliant catheter).[2] In other words, epidural waveforms incur an increased risk of dampening through epidural catheters compared to needles. Consequently, the indiscriminate pooling of trials by Hilber *et al*. analyzing waveforms obtained through needles and catheters constitutes a potential methodological shortcoming.

In their review article, the authors attribute false positive waveforms to arterial or subarachnoid locations of the needle (or catheter) tip.[1] This appears illogical, as no operator would perform EWA with blood or cerebrospinal fluid flowing back through the needle or catheter. A more logical explanation for false positive waveforms stems the "reference test". For instance, Leurcharusmee *et al*.[3] initially reported a 4% incidence of false positive waveforms with an ice test performed 10 minutes after the local anesthetic bolus. Subsequently, the same research team found a 2% rate of false positive waveforms when the ice test was conducted at 15 minutes. This explanation is also compatible with the 0%-incidence of false positive waveforms reported by Lennox *et al*. and de Medicis *et al*., as both authors delayed the assessment of their epidural blocks until the postoperative period.[2, 4]

The inclusion of three trials by Hilber *et al*.[1] may be methodologically problematic. In the study by Ghia *et al.*,[5] EWA was performed at an undetermined postoperative timeframe thereby making it difficult to distinguish between primary epidural failure (non-epidural LOR mistaken for the epidural space) and secondary failure (*i.e.*, epidural catheter dislodgment). The small study by Sebbag *et al.*[6] (N.=10) exists only as a letter to the editor and thus does not fulfill the authors' predefined inclusion criteria. Finally, in Gong's trial,[7] it is debatable the dichotomic nature of the selected reference test (possibility of conducting surgery under different levels of sedation).

In terms of risk of bias and applicability analysis, Hilber *et al*.[1] should provide readers with a QUADAS 2 Risk of Bias Summary, which would expose individual risks for each trial. As it stands, the Risk of Bias Graph conveys the impression of similar quality amongst studies analyzed, independently of heterogeneity.

In summary, EWA constitutes an invaluable adjunct for epidural analgesia and, in our center, have become routine for thoracic epidural blocks. Although EWA constitutes a fertile terrain for review, any review article must clearly establish the difference between needle and catheter waveform transduction, understand the genesis of false positive waveforms, abide by its own inclusion criteria, and clearly expose any risk of bias to readers.

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Accuracy studies accurately read

Aliste *et al.*[1] in response to our systematic review[2] state that "pooling of trials analyzing waveforms obtained through needles and catheters constitutes a potential methodological shortcoming." We absolutely agree with this. We mentioned even more causes of heterogeneity among the studies of our review, *e.g.* the various tests to assess clinical efficacy. Consequently, we had written: "Given this heterogeneity we decided ... not to calculate aggregate sensitivities or aggregate specificities."

Another issue raised are the reasons for a false-positive reference test. The authors attribute false positive findings (*i.e.* presence of an epidural wave form but a not functioning epidural) to the timing of the reference test. They quote the studies by Lennox *et al.*[3] and de Medicis *et al.*[4] who had not had false positive cases. However, there were other studies (Al Aamri *et al.*,[5] Gong *et al.*[6]) in our systematic review which did have false positive findings. We conclude from our review that there is no 100% of correct positioning, even after confirmation with EWA. We doubt that there will be any diagnostic test without false positive and without false negative readings.

The authors comment on the trial by Ghia *et al.*[7] saying that it would be "difficult to distinguish between primary … and secondary failure." We absolutely agree and this is why we had written in our discussion: "In some of the studies … the epidural wave signal was obtained through the epidural catheter. Wave form monitoring through the catheter would allow for analyzing the reasons of a secondary catheter failure…"

Another statement of the authors refers to the inclusion of the study by Sebbag *et al.*[8] We defined clear inclusion criteria (prospective observational or randomized controlled trials) and exclusion criteria (retrospective studies, reviews, comments, editorials, case reports, studies of children, studies of chronic pain conditions) but letters or short communications were not to be excluded. We feel that a systematic review should be as inclusive as possible and it would have been a deviation from our protocol as well as a methodological flaw to exclude the study by Sebbag *et al*.[8] Moreover, as we had stated in our protocol, we had contacted the corresponding author of this letter so that we could get additional information, similar to that that would have been presented in a full paper.

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