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The Journal of Education in Perioperative Medicine

Letter to the Editors

Spectrograms—Need for Increased Training and Accessibility

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To the Editor:

With the goal of improving patient safety, the Anesthesia Patient Safety Foundation published a statement that enhances existing monitoring.[1] Recognizing the risk of awareness when using total intravenous anesthesia, especially when combined with neuromuscular agents, the Anesthesia Patient Safety Foundation now recommends using an encephalogram (EEG)-based monitor of unconsciousness during these procedures. This is the first time a recommendation has been made for using a depth of anesthesia monitor in the United States.

The EEG changes systematically in relation to the dose of anesthetic drugs.[2] The unprocessed EEG is challenging and time-consuming for the average anesthesiologist to analyze. Consequently, the most readily available, well-studied, and widely used depth monitors are based on *processed* EEG analysis. A variety of parameters is extracted from the EEG, and derived indices, such as the bispectral index (Covidien, Boulder, CO) and patient state index (PSI; Masimo, Irvine, CA), are widely used in the United States. These indices are easy to read and understand; they provide a number (scale of 0 to 100) that tracks the level of consciousness, with 100 corresponding to being completely awake, and 0 corresponding to profound unconsciousness or an isoelectric EEG.[3,4] The patient is deemed appropriately anesthetized when the bispectral index is between 40 to 60 or the PSI is between 25 and 50.[5]

Unfortunately, the derived indices have several issues. They do not ensure that awareness is prevented,[6] they may be less reliable in extremes of age,[7] and they assume the same index value reflects the same level of unconsciousness for all anesthetics.[8]

There has been increasing interest in using the numerous other parameters that can be extracted from the EEG. For instance, the compressed spectral array, or spectrogram, is a three-dimensional representation of the EEG, plotting power by frequency by time. The density spectral array is a two-dimensional version of the spectrogram.[9,10] The spectrogram and density spectral array show different characteristic patterns depending on the drug used and give more detailed and accurate assessments of the patient's depth of anesthetic than the derived indices. Consequently, neurophysiology experts advocate the training of anesthesiologists to read and interpret these complex recordings.[8]

Some institutions possess depth of anesthesia monitors that combine derived indices with the spectrogram. Our institution uses such a device (Root, Masimo, Irvine, CA), which shows the unprocessed EEG, the PSI, and the density spectral array. These devices have the goal of providing the anesthesiologist with more information; why not use multiple derived parameters instead of one, after all? However, even for the anesthesiologist who has taken the time to learn and understand density spectral arrays, confusion may occur when the derived indices do not correlate with the density spectral array. Two examples from our institution are shown (Figures 1 and 2). In these situations, the trained anesthesiologist should follow the more sensitive density spectral array, but lacking this specialized training, an anesthesiologist may resort to relying on the PSI, potentially leading to a very different anesthetic.

We concur with the Anesthesia Patient Safety Foundation's recommendations for using some form of EEG monitoring with total intravenous anesthesia and additionally advocate their use with inhaled anesthetics. While many institutions have bispectral index or PSI monitors, we anticipate that spectrograms will become more prevalent in the operating room. Consequently, it will become imperative that anesthesiologists are educated in interpreting density spectral arrays. Additionally, we advocate that anesthesiology residency programs incorporate training and aim for mastery of the necessary clinical skill of spectrogram interpretation before graduation.

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Funding/Financial Disclosures: *None*

Conflicts of interest: *None*

In Reply

We appreciate this letter from Brook and Lambert calling for increased training of Anesthesiology residents in density spectral array interpretation. While derived indices have been broadly adopted and taught for evaluating the depth of anesthesia, we likely have more to learn from the study of density spectral array and its role in both better evaluating depth of anesthesia as well as uncovering strategies to mitigate perioperative delirium and perhaps even postoperative cognitive dysfunction. For example, Hesse and colleagues in 2019 published their research describing how emergence trajectories on electroencephalography were associated with delirium in the post anesthesia care unit. Having these devices and additional electroencephalography-related monitoring in academic operating rooms and teaching residents in the more complex interpretation of the information therein is an important next step in the proliferation of the research needed to address these serious perioperative complications.

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Figure 1. *Unprocessed electroencephalography shows low-frequency waves and a spectral edge frequency is 5.5 to 5.8 Hz, indicating that the patient is overanesthetized. However, the patient state index reads 54, which suggests that the patient is possibly underanesthetized and would need additional anesthesia. This elderly patient was undergoing emergent laparotomy with sevoflurane at a minimum alveolar concentration ranging from 0.6 to 1.3.*

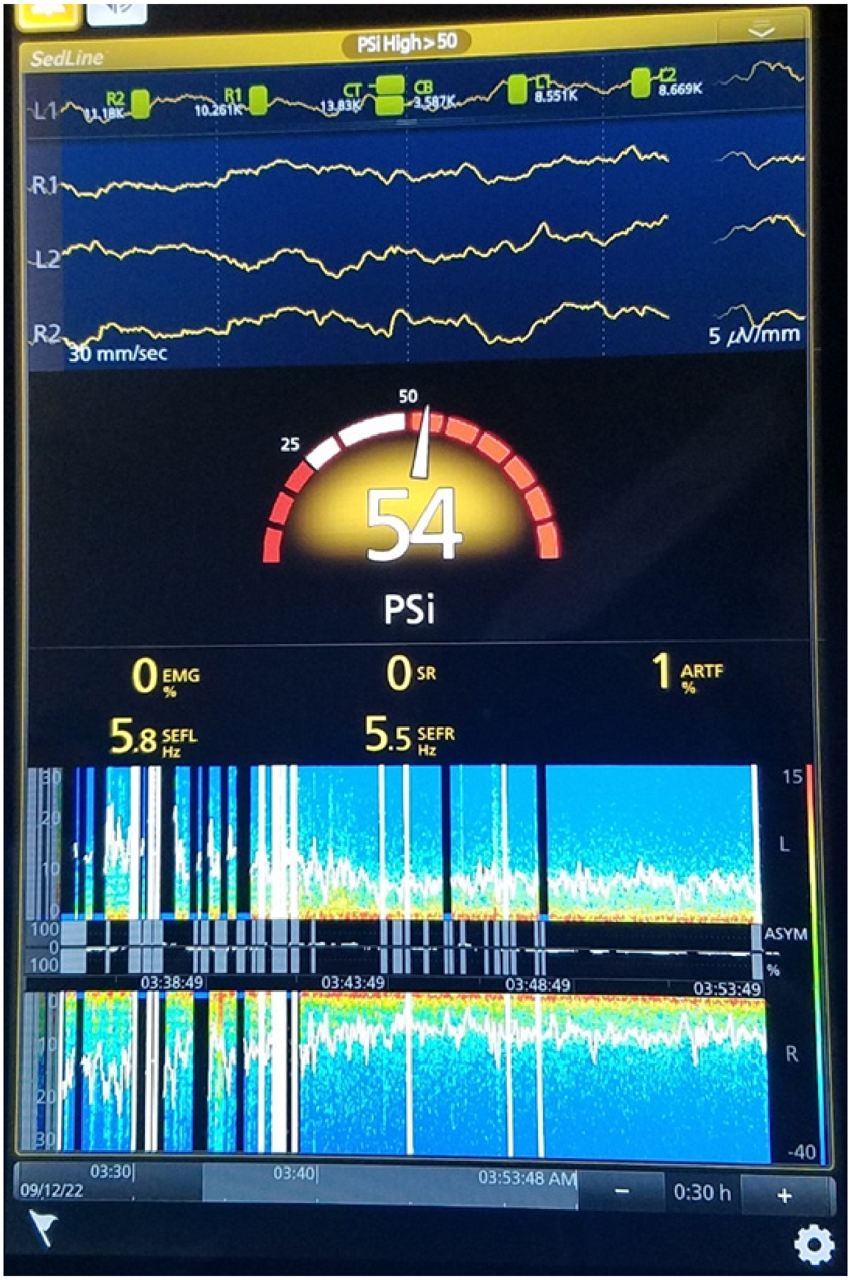

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Figure 2. *Unprocessed electroencephalography shows slow delta and alpha waves and a spectral edge frequency of 10.3 to 12 Hz, indicating that the patient is appropriately anesthetized. However, the patient state index reads 18, which suggests that the patient is overanesthetized. This young-adult was undergoing urgent open reduction internal fixation of a mandibular fracture with sevoflurane.*