A Systematic Comparison of Depth of Hypnosis Indices during Intravenous and Volatile Anesthesia by Electroencephalogram Replay

Authors: Christian L. Petersen¹, Zachary Katz¹, Matthias Görges², Nicholas West¹, Guy A. Dumont³, J. Mark Ansermino¹
¹ Dept of Anesthesiology, Pharmacology & Therapeutics, ² Pediatric Anesthesia Research Team, Child and Family Research Institute, and ³ Dept of Electrical and Computer Engineering, University of British Columbia, Vancouver, BC, Canada

Background: Commercially available Depth of Hypnosis (DoH) monitors are based on the processing of electroencephalography (EEG) data. Each manufacturer uses different signal processing algorithms, and for most monitors the details of implementation are not fully disclosed. Little is known about how these DoH indices compare with respect to bias and noise, or if the choice of anesthetic agent affects the output.

Objective: Differences between DoH monitor indices were investigated by replaying previously-recorded EEG to a DoH monitor through a simulator [1] that mimics the impedance of the patient forehead and delivers electrical signals to the monitor’s electrodes.

Methods: Approval for secondary use of EEG data, collected under previous studies, was obtained from our Research Ethics Board. EEG data was taken from 24 patients, who had undergone general anesthesia using either a volatile anesthetic with desflurane (DES) plus fentanyl, or Total Intravenous Anesthesia (TIVA) with propofol and remifentanil. This data had been recorded at 16 bit resolution and 256 Hz sampling rate with a NeuroSENSE (WAV; NeuroWave Systems Inc., Cleveland Heights, OH) monitor. The collected data was replayed to two other DoH monitors: BIS (BIS; Covidien, Mansfield, MA) and M-Entropy (ENT; GE Healthcare, Little Chalfont, Bucks., UK). The resulting indices were compared, using Bland-Altman analysis (Fig. 1a), and evaluated with respect to bias and root mean square error (RMS).

Results: A total of 40,241 DoH samples were analyzed at a rate of 0.2 Hz. Of these 47% were DES anesthetics, and the rest TIVA. For each combination of monitor (WAV, BIS, ENT) and anesthetic (DES, TIVA), the calculated bias was too small to be of clinical relevance (-1.1–1.1 points), but the RMS error large (7.3–12 points) (Fig. 1b). The DES and TIVA results were similar.

Conclusions: The large RMS errors suggest that there may be prolonged periods with significant deviations between the three DoH monitor readings [2]. We plan to expand this analysis to include more than 300 additional cases and to investigate the monitor differences during specific phases of anesthesia. This work was supported in part by the STA 2015 Fresenius Award.
Figure 1: Comparison between WAV, BIS and ENT monitors. Example Bland-Altman (a) and overall bias/RMS (b).
