

Continuous Sedation Monitoring in Critically Ill Patients Using the WAV_{CNS} Index

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Introduction: Achieving appropriate sedation in the intensive care unit (ICU) is challenging, as both over- and under-sedation are detrimental^{1,2}. Current strategies involve sedation scoring systems such as the Richmond Agitation Sedation Scale (RASS)⁴. These scales rely on patient response to a stimulus, and are hence insensitive to change for deeper levels of sedation⁵. Furthermore, scoring is intermittent leading to prolonged periods of unmeasured sedation depth. Several processed electroencephalography (pEEG) monitors have been developed to continuously measure depth of hypnosis during general anesthesia⁶. In the ICU, correlation between bispectral index (BIS) and sedation scales has been low, and is negatively affected by muscle activity, a known confounder in BIS monitoring⁷. Thus far, no pEEG monitor is routinely used in the ICU¹. The aim of this observational pilot study was to assess the feasibility of using the NeuroSENSE monitor (NeuroWave, Cleveland, USA⁶) WAV_{CNS} index in the ICU. We hypothesized the WAV_{CNS} can distinguish between consciousness (RASS goal ≥ -2) and unconsciousness (RASS goal ≤ -3).

Method: With Research Ethics Board approval, adults admitted to the ICU on continuous propofol sedation with ventilator support were screened for eligibility. Informed consent was deferred to the substitute decision maker, and obtained post-hoc from participants if possible. WAV_{CNS} values were obtained from the NeuroSENSE, to which clinicians were blinded. Bedside ICU nurses performed RASS assessments every 4 hours or more frequently when clinically indicated, and the sedation regimen was adapted to clinical need. Propofol infusion rates and RASS scores were recorded manually. Participants were monitored for duration of their propofol infusion, up to 24hrs.

Results: Of 93 ICU patients screened, 47 patients were ineligible due to neurological diagnoses, and 16 were weaned off propofol within the first hour. In 21 cases, sensor placement was deemed impractical (due to facial bandaging, diaphoresis, etc), and consent could not be obtained for 9 cases. Sixteen patients were included in the analysis (mean age 59 ±12 years, 12 male, monitoring time 14.0 ±7.7 hrs). Only 3 cases consistently had RASS scores equivalent to

their sedation goals during the study period. These cases had the deepest sedation goals (i.e. RASS ≤-4).

Table 1. WAV_{CNS} indices grouped by RASS goal

	WAV _{CNS} minimum	WAV _{CNS} maximum	WAV _{CNS} median	WAV _{CNS} MAE	BSR maximum
Conscious (n=7) <i>RASS goal ≥ -2</i>	35 [29, 40]	95 [94, 95]	57 [54, 66]	8.6 [7.0, 11]	1.3 [0.15, 3.4]
Unconscious (n=6) <i>RASS goal ≤ -3</i>	29 [22, 35]	81 [78, 87]	48 [42, 62]	4.3 [4.2, 6.2]	11 [7.4, 18]

Values are median [IQR], from 4hr intervals (standard time between RASS assessments). RASS goal was not documented for 2 cases (excluded). (MAE: median absolute error; RASS: Richmond Agitation Sedation Scale; BSR: burst suppression ratio)

The remaining 13 cases were frequently scored higher or lower than their RASS goals. Overall, in the 4 hour intervals between scheduled RASS assessments, those who were lightly sedated showed higher, but more variable, WAV_{CNS} indices, and less burst suppression than those who were deeply sedated [Table 1].

Conclusion: The use of pEEG monitoring in the ICU is challenging due to a high prevalence of neurological diagnoses and impracticality of placing sensors. However, these preliminary results reflect sedation inadequacy obtained using current methods. RASS scores were more stable in deeply sedated patients. However, unconscious patients had a higher prevalence of burst suppression, a sign of overly-deep sedation, which has been associated with an increased risk of delirium⁸. The variability in WAV_{CNS} values between RASS assessments highlights the limitations of the RASS as a stand-alone measure of sedation levels, and suggests a potential benefit of adjunct continuous brain monitoring.

References: [1] Crit Care Med 2013;41:278–80.[2] Curr Opin Crit Care 2011;17:43–9.[3] Anesth Analg 2011;112:1202–11.[4] Am J Respir Crit Care Med 2002;166:1338–44.[5] Crit care 2000;4:217–25.[6] J Clin Monit Comput 2011;25:81–7.[7] Br J Anaesth 2015;115:i95–103.[8] BMC Anesthesiol 2015;15:61.