Validation of Cerebral State Monitor Frequency Power Ratios for Detection of Delirium

Alexander Robles[1], Robert DeBurlo[1], Savannah Salazer[1], Justine Yang MD[2], Samuel MacDonald MD[2], Alice Luo MD[3], Davin K. Quinn MD[2]

[1]University of New Mexico School of Medicine, Albuquerque, NM
[2]Department of Psychiatry and Behavioral Sciences, University of New Mexico School of Medicine, Albuquerque, NM
[3]Department of Psychiatry and Behavioral Sciences, Memorial Sloan Kettering Cancer Center, New York, NY

Introduction

- Delirium continues to be undetected among hospitalized patients, resulting in increased complications, length of stay, and mortality/morbidity
- Current screening tools such as the Confusion Assessment Method (CAM) have limited validity in busy clinical settings[1]
- Electroencephalography (EEG) is capable of detecting delirium (i.e. generalized slowing) but is limited by availability of specialized equipment and staff[2]
- Cerebral State Monitors (CSMs) are portable devices that record limited channel processed EEG, and can distinguish delirious and nondelirious patients with high sensitivity and specificity[3]
- Our group has shown that visual and raw EEG data from CSMs can distinguish delirious from nondelirious patients using a FDA-approved Masimo CSM, but was not able to outperform 3D-CAM.

Methods

Study Objective:
- To test if raw EEG data obtained from a Masimo CSM can improve upon 3D-CAM screening in detection of delirium in a larger sample of hospitalized patients

Study Design:
- Recruited participants from hospitalized patients at University of New Mexico Hospital (UNM), who received psychiatric consultation and clinical evaluation for delirium according to DSM-V criteria

Data Collection:
- Participants underwent 3D-CAM Screening prior to Masimo CSM monitoring for 5 minutes with eyes closed

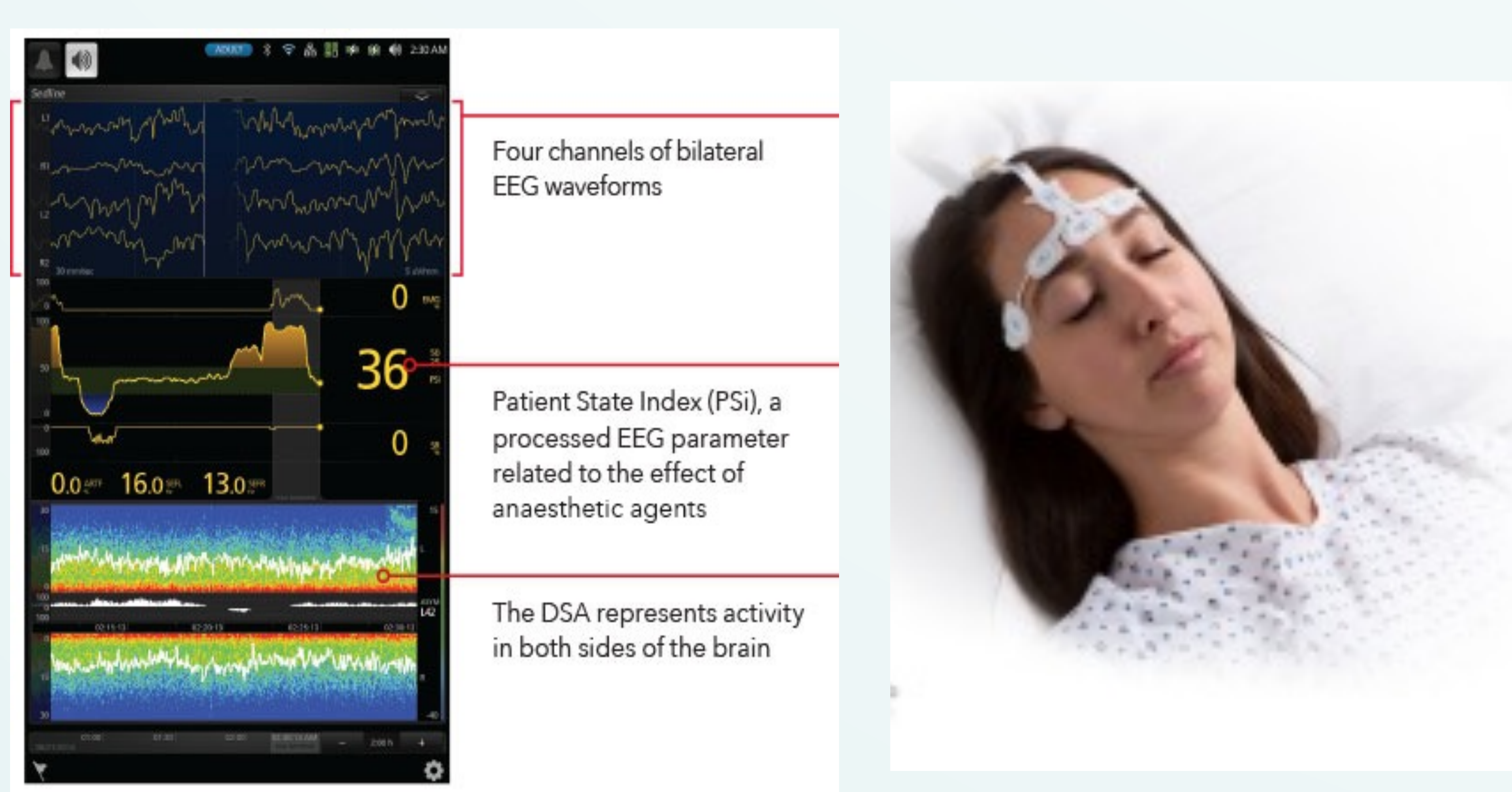


Figure 1. Masimo Cerebral State Monitor Display. www.investor.masimo.com

Methods

Data Analysis:
- Downloaded four-channel frontotemporal raw EEG data into EDF format
- Generated frequency spectrograms with a MAT-LAB Based Program, Brainstorm
- Power values in each channel were extracted from each spectrogram for frequency bands (low/high theta, delta, alpha, and beta) and averaged over all four channels
- Mean Frequency band power ratios (i.e. low/high alpha/theta, alpha/delta, theta/delta) were calculated.
- Using independent samples t-tests, EEG variables were compared between the 2 groups to assess for significant association with delirium
- AUC was calculated for significant EEG variables that survived multiple corrections
- Fisher's Exact Test was used to assess for 3D-CAM Accuracy

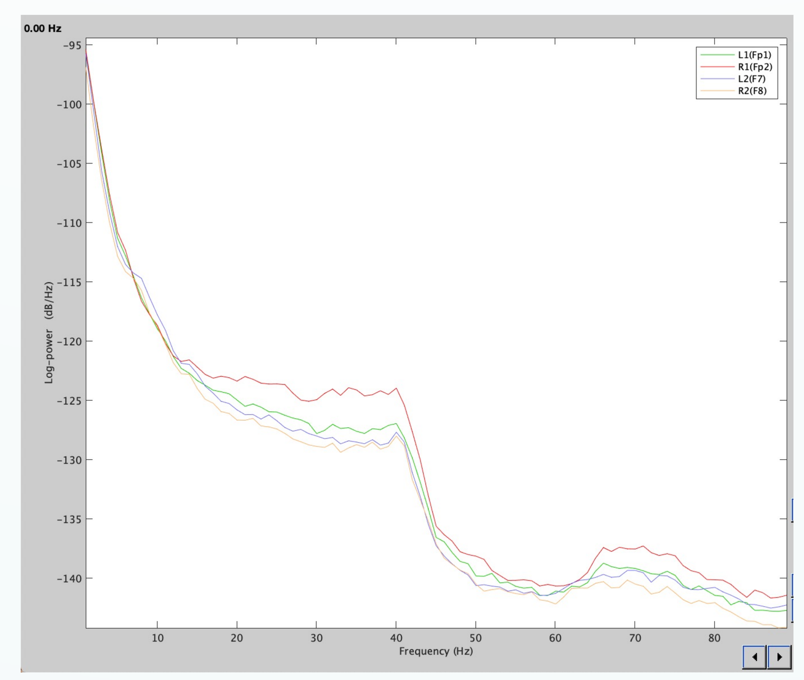


Figure 2. Example of frequency spectrogram generated from raw EEG Data

Results

- Sample of 75 participants (52 non-delirious, 23 delirious)
- 3D-CAM did differentiate between delirious and non-delirious participants (Fisher's Exact T-test, 2-tailed, p<.001), with sensitivity of 83.3% and specificity of 55.6%, and AUC of 0.711.

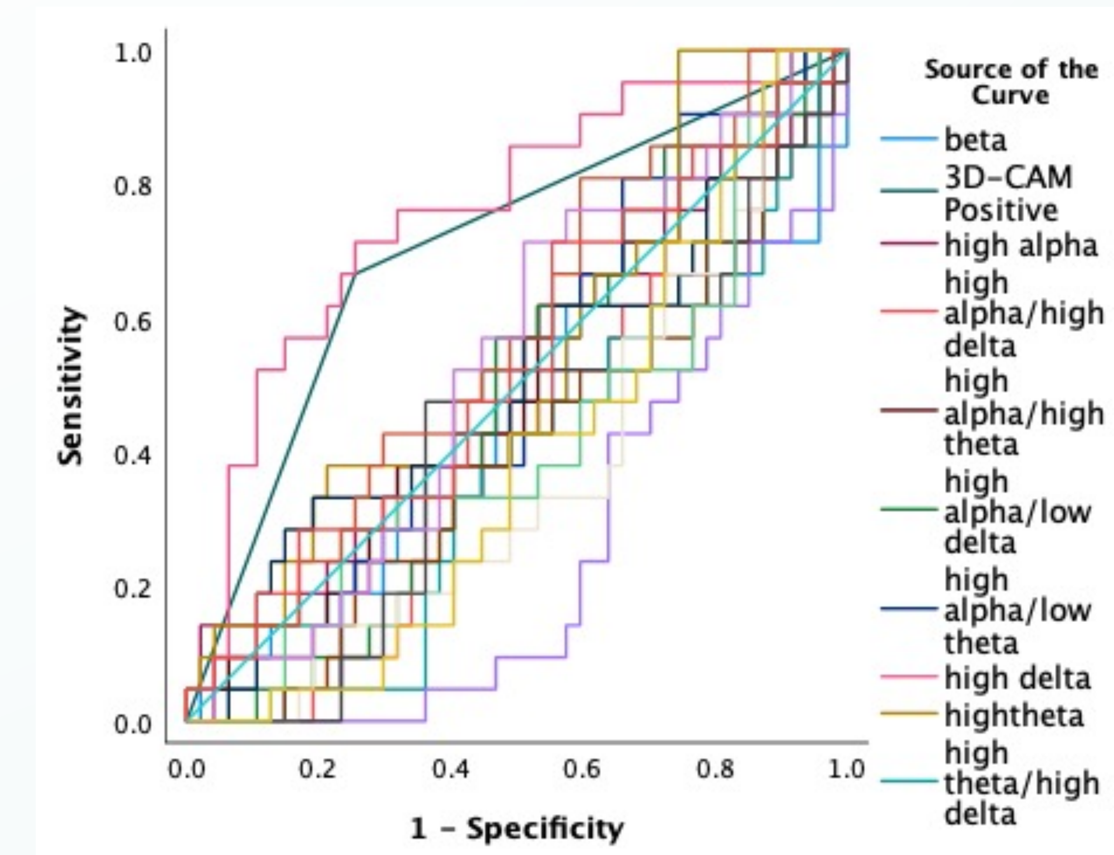
	Non-Delirious	Delirious	Total	Sig
3D-CAM -	40	8	48	
3D- CAM +	12	15	27	
Total	52	23	75	<.001

- Low theta/high delta power ratio averaged across all channels was significantly associated with delirium (t(65) = 1.76, p = .04, Cohen's d = 1.1). After Bonferroni correction for multiple comparisons (0.05/19) this was no longer significant.
- In individual channels, high delta, low theta/high delta, and low alpha/high delta were significantly different between delirious and nondelirious:

Channel	Variable	t	df	Sig	d
L1	*Low theta/high delta*	*2.51*	*68.2*	*.014*	*1.1*
L2	*High delta*	*-3.19*	*32.9*	***.002***	*-0.89*
L2	*Low theta/high delta*	*2.08*	*58.1*	*.04*	*1.2*
R2	*High delta*	*-2.25*	*35.2*	*.03*	*0.13*
R2	*Low alpha/high delta*	*3.68*	*63.9*	***<.001***	*0.73*
R2	*Low theta/high delta*	*2.14*	*51.1*	*.04*	*1.2*

Results

- On receiver-operator curve analysis (ROC), **low alpha/high delta** and **high delta** both outperform 3D-CAM, but the areas under the curve (AUC) for both are not statistically significant from 3D-CAM (both p > .5).



AUC:
3D-CAM: .706
Low alpha/high delta: .744
High delta: .753

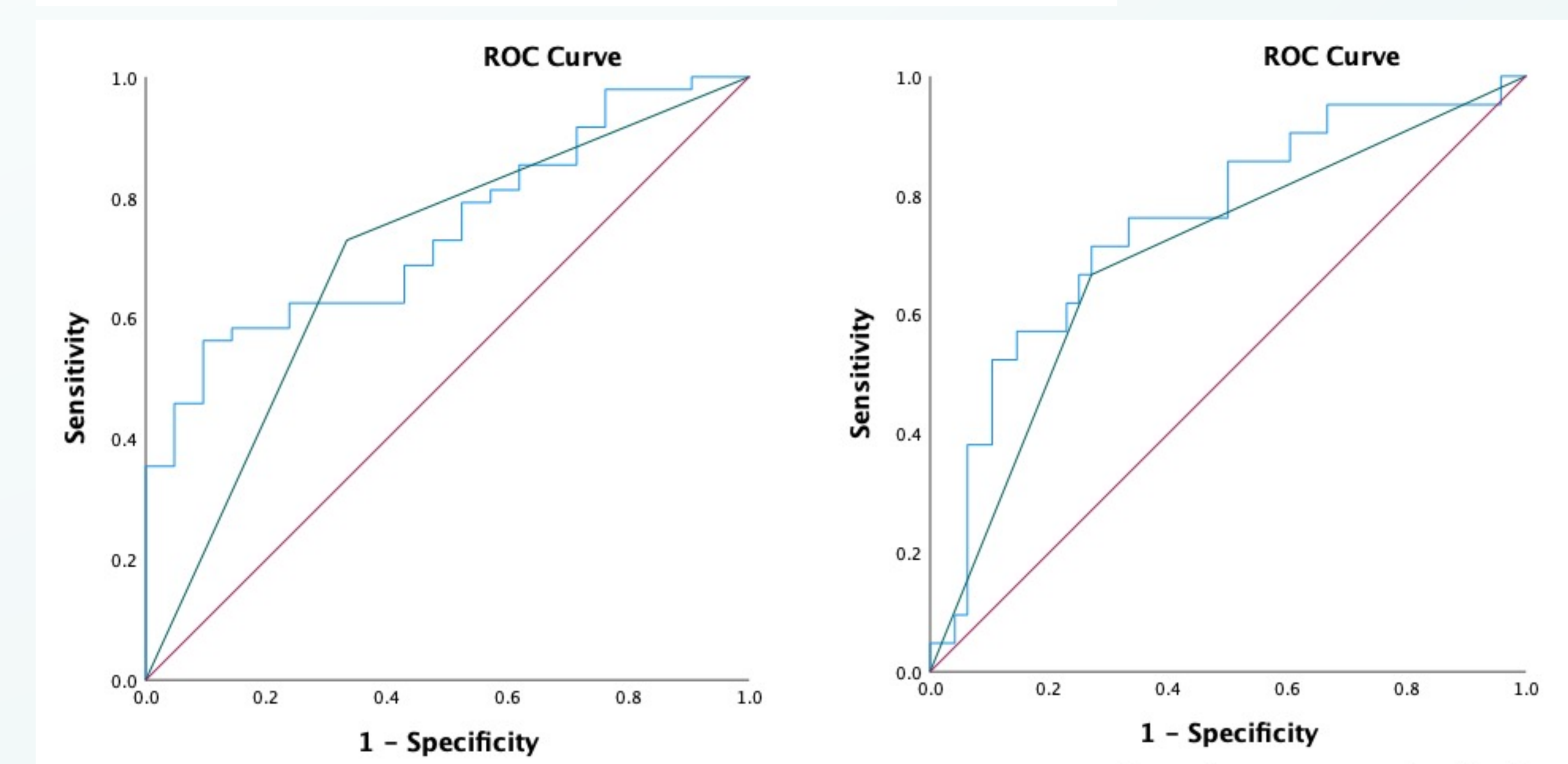


Figure 3. ROC curves of all band power (top), low alpha/high delta (lower left) and high delta (lower right)

Discussion

- These results are consistent with previous EEG findings in delirium, which reflect decrease in alpha power with increase in theta and delta power.
- These results highlight the importance that loss of alpha power may have and increased power in the high delta frequency band can identify delirium, and update the findings from our group previously, which focused on low theta/high delta ratio.
- Findings appear to be more robust in temporal leads rather than frontal leads, suggesting distance to cortex and muscle artifact may be relevant considerations.
- However, at this time these EEG biomarkers do not outperform 3D-CAM. Further study involves gathering more participants and exploring whether combined EEG variables (e.g., high delta + low alpha/high delta) have better predictive ability.
- Strengths include use of a FDA-approved CSM and widely available computational software and methods. Limitations include small sample size, leading to possible skewing by outlying data and underpowered to survive multiple corrections for EEG analysis.

References
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