Masimo Cerebral State Monitoring and Detection of Delirium in Hospitalized Patients

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Introduction

- Delirium continues to be undetected among hospitalized patients
- Resulting in increased complications, length of stay, and mortality/morbidity
- Current screening tools, Confusion Assessment Method (CAM) have limited validity in busy clinical settings[1]
- Electroencephalography (EEG) capable of detecting delirium (i.e. generalized slowing) but limited by availability and resources[2]
- Cerebral State Monitors (CSMs) record limited channel processed EEG, can serve as an accessible and objective screening tool for delirium
- Previously shown that visual data from CSMs can detect delirium, but unable to analyze raw EEG data due to device limitations[3]

Methods

Study Objective:
- To test if raw EEG data obtained from a Masimo CSM can improve upon CAM screening in detection of delirium in 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 10 minutes with eyes closed

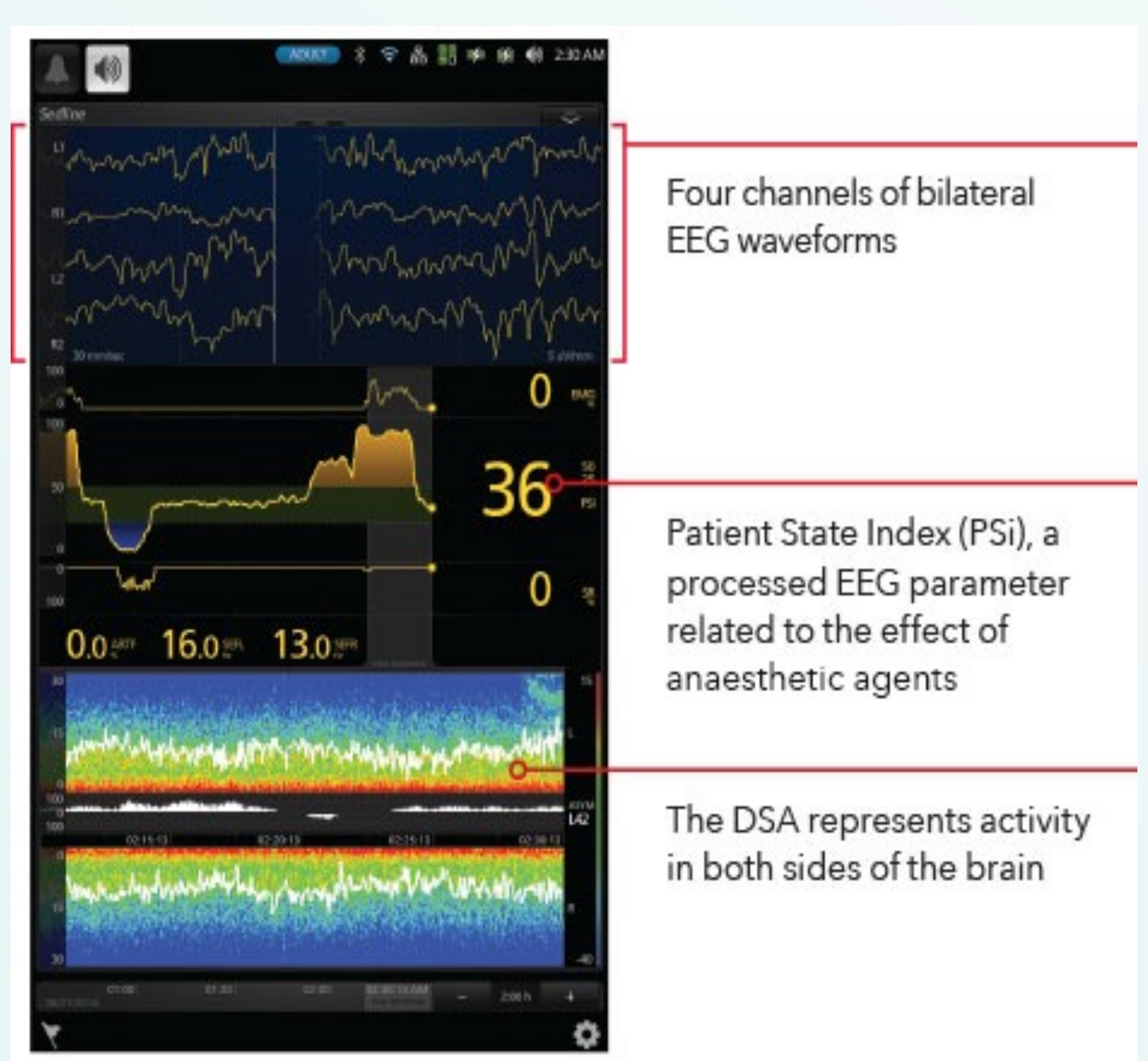


Figure 1. Masimo Cerebral State Monitor Display

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
- Mean Frequency band power ratios (i.e. low/high alpha/theta, alpha/delta, theta/delta)
- Using Mann Whitney U 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

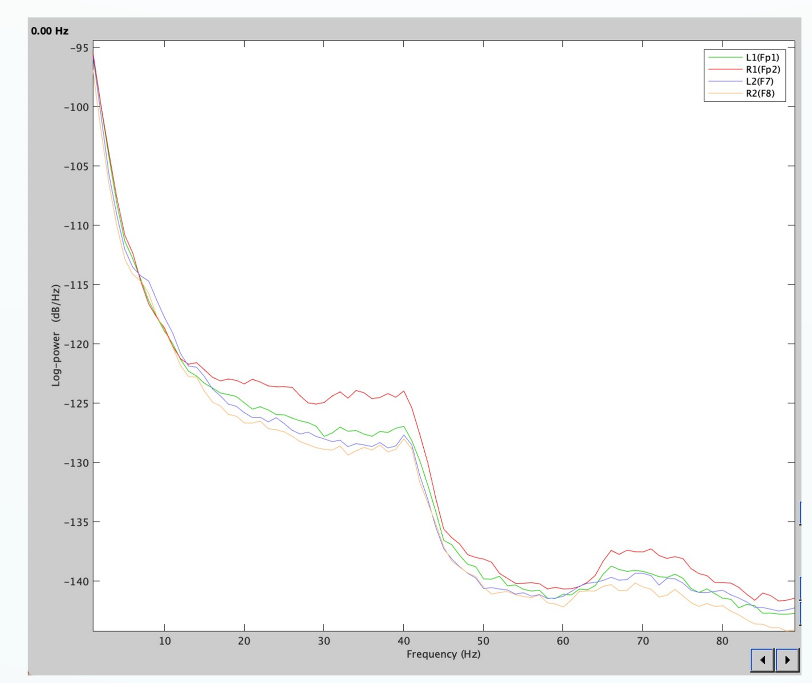


Figure 2. Example of frequency spectrogram generated from raw EEG Data

Results

- Sample of 33 participants (20 non-delirious, 13 delirious)
- 3D-CAM did differentiate between delirious and non-delirious participants (Fisher's Exact T-test, p=.013), but had sensitivity of 53.85% and specificity of 90%

	Non-Delirious	Delirious	Total	Sig
3D-CAM -	18	6	24	
3D- CAM +	2	7	9	
Total	20	13	33	.013

*Fisher's Exact T-test (2-tailed)

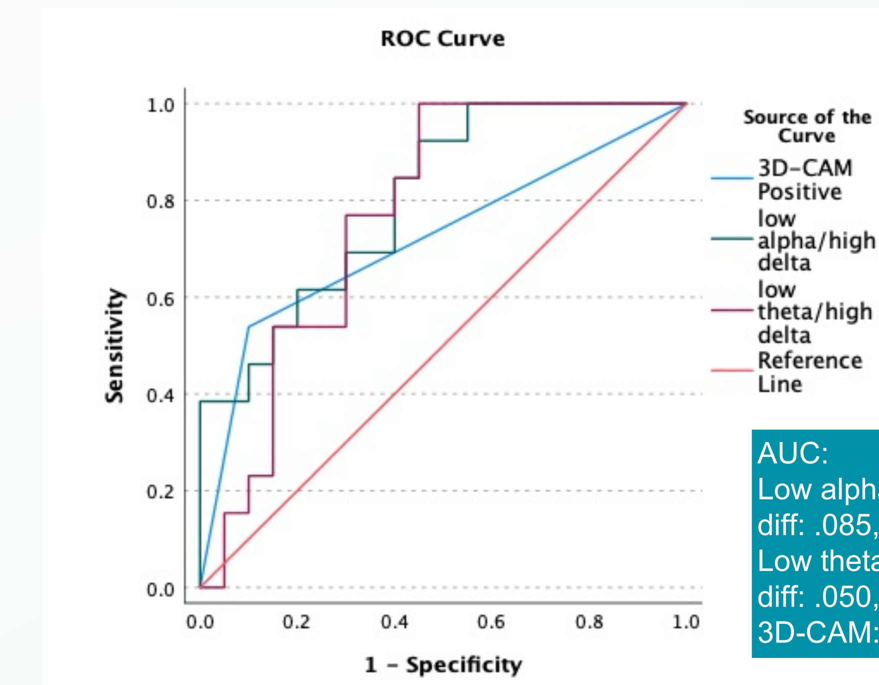
- **Low alpha/high delta**, and **low theta/high delta** remained significantly associated with delirium after Bonferroni Correction (**p=.002**, **p=.002**)

EEG Variables	Delirious	Mean	T-value	DF	Sig
Low alpha/high delta	No	1.338	3.398	27.570	.002
	Yes	0.631			
Low theta/high delta	No	2.332	3.363	30.037	.002
	Yes	1.133			

*Channel Average results shown here

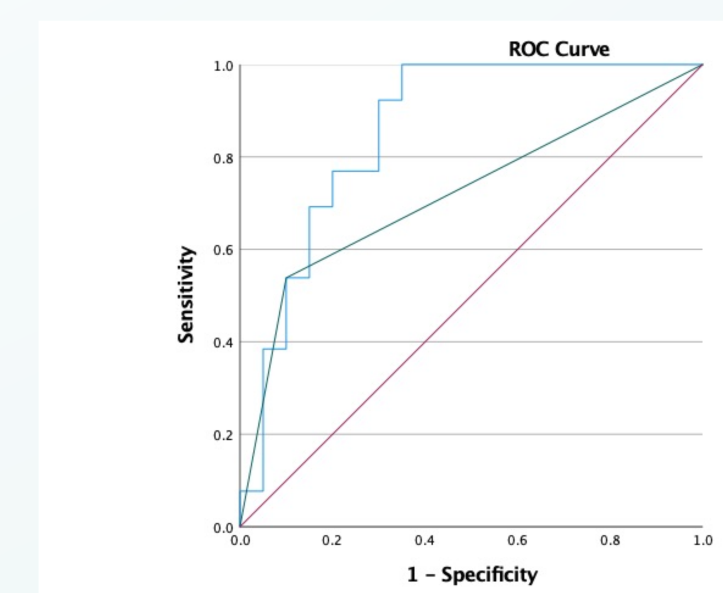
Results

- On AUC, **Low alpha/high delta**, and **low theta/high delta** did not outperform 3D-CAM



AUC:
Low alpha/high delta: .804, AUC diff: .085, p=.428
Low theta/high delta: .769, AUC diff: .050, p=.679
3D-CAM: .719

- On exploratory analysis of other channels, **high delta**, which was significantly associated with delirium **(p=.023)** on average of 4 channels but did not survive multiple corrections, was significantly associated with delirium and survived for multiple corrections on Channel L2 **(p=.002)**
- On further ROC Analysis, high delta did not significantly out-perform 3D-CAM



AUC:
High Delta: .858
3D-CAM: .719
AUC diff: .138
p=.213

EEG Variables	Delirious	Mean	T-Value	DF	Sig
High delta	No	0.218	-3.471	21.088	.002
	Yes	0.401			

Discussion

- Preliminary results consistent with EEG findings in delirium, which reflect decrease in alpha power with increase in theta and delta power
- Incomplete overlap in EEG variables between current and previous findings, which revealed low theta/delta significantly associated with delirium in a non-neurological sub-set[3]
- May reflect a significant improvement in precision in our current analytic methods (using raw EEG data as opposed to visual analysis of colored density spectral arrays)[3]
- While low alpha/high delta and low theta/high delta were significantly associated with delirium after multiple corrections, did not outperform 3D-CAM
- High delta, appears crucial to detecting delirium, as less susceptible to artifact than alpha. Did not survive multiple corrections on average of all channels but analysis of Channel L2 reveals potential as biomarker for delirium
- Recognizing that our small sample size could be skewed by outlying data and underpowered to survive multiple corrections for certain EEG variables
- Future Directions include enrolling more participants to validate early findings

References
1. Ryan K, Leonard M, Guerin S, Donnelly S, Conroy M, Meagher D. Validation of the confusion assessment method in the palliative care setting. *Palliat Med*. 2009;23:40-45.
2. Romano J, Engel GL. Psychologic and Physiologic Considerations of Delirium. *Med Clin North Am*. 1944;28:629-638.
3. Luo A, Muraida S, Pinchotti D, Richardson E, Ye E, Hollingsworth B, Win A, Myers O, Langsjoen J, Valles E, Zolyomi A, Quinn DK. Bispectral Index Monitoring With Density Spectral Array for Delirium Detection. J Acad Consult Liaison Psychiatry. 2021 May-Jun;62(3):318-329.

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