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Accuracy of seizure identification by critical care providers using quantitative EEG displays

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Accuracy of seizure identification by critical care providers using quantitative electroencephalography displays

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Introduction

- Non-convulsive seizures are common in the critically ill
  - Detectable only by electroencephalography (EEG)
- Continuous EEG in ICU is interpreted intermittently
  - Delays between seizure recognition & treatment
- Quantitative EEG (QEEG) can simplify interpretation
  - Color Density Spectral Array (CDSA)
  - Amplitude-integrated EEG (aEEG)
- Limited data on utility of QEEG in the hands of critical care providers in pediatric ICU

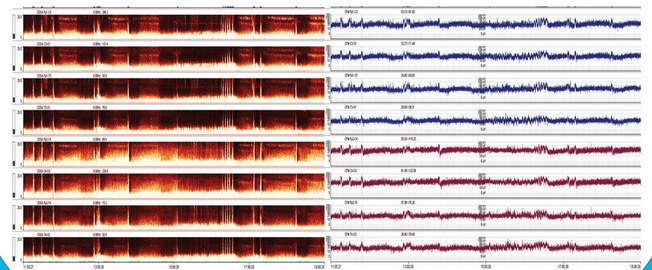
Objectives

1. To evaluate the accuracy of CDSA and aEEG for seizure detection in the hands of critical care providers
2. To identify the factors that influence the performance when using CDSA and aEEG

Methods

- Participants: Three volunteers each from 4 groups: ICU Fellows, ICU Nurses, Neurophysiologists and EEG Technologists
- cEEG from critically ill children aged 1 month–18 years
- Gold standard: Seizures confirmed by review of the raw cEEG by a board-certified neurophysiologist
- Participants underwent 2h of formal QEEG training
- Performed supervised review of 27 cEEG recordings with only CDSA and aEEG displays visible (Figure 1)

Figure 1: Representative CDSA and aEEG displays



Stewart et al., Neurology 2010.

Methods

- Asked to mark all events suspected to be seizures
- No access to raw EEG or clinical data
- Sensitivity: Proportion of seizures marked compared to the gold standard review of raw EEG
- False positive rate: Number of events marked 'off' seizures per 24 hours of recording
- Performance across groups compared using mixed model, pairwise comparison and nested model analysis
- Mean square error attributable to different determinants of performance calculated

Results

1. Critical care providers performed as well as neurophysiologists at seizure identification using both CDSA and aEEG (Table 1, Figure 2)
2. ICU Fellows and ICU nurses had similar performance:
   i. Median sensitivity ranged from 82.4%–88.2% for CDSA and 73.1%–83.8% for aEEG
   ii. FPR ranged from 7.1–7.7 for CDSA and 2.8–4.2 falsely marked seizures per 24h for aEEG

Figure 2: Performance of CDSA and aEEG across groups

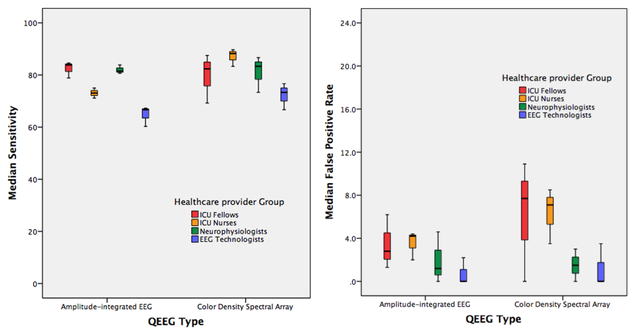


Table 1: Performance of CDSA and aEEG across groups

Group	CDSA, median (IQR*)		aEEG, median (IQR*)	
	Sensitivity (%)	FPR (per 24h)	Sensitivity (%)	FPR (per 24h)
ICU Fellows	82.4 (75.8 – 84.9)	7.7 (3.9 – 9.3)	83.8 (81.3 – 84.2)	2.8 (2.1 – 4.5)
ICU Nurses	88.2 (85.8 – 89)	7.1 (5.3 – 7.8)	73.1 (72.1 – 74.0)	4.2 (3.1 – 4.3)
Neurophysiologists	83.3 (78.3- 85)	1.5 (0.8 – 2.3)	81.5 (81.1- 82.7)	1.2 (0.6- 2.9)
EEG Technologists	73.3 (70.0 -75.0)	0 (0 – 1.8)	66.7 (63.5 – 67)	0 (0 -1.1)

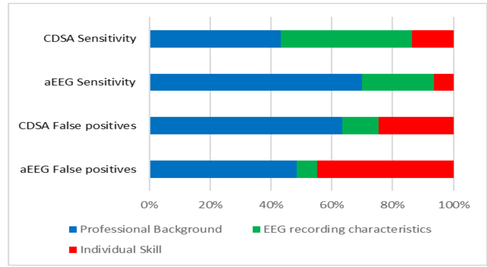
* IQR calculated by Tukey's Hinges method

FPR: False Positive Rate

Results

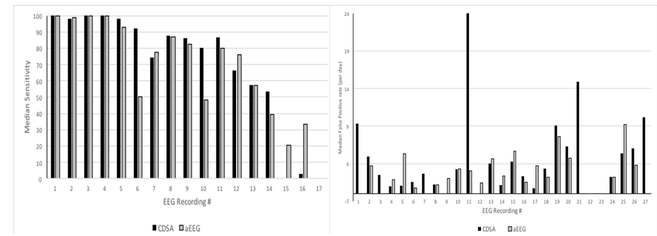
3. Across inter-professional groups, (Figure 3)
   i. Sensitivity was more consistent using CDSA
   ii. False positive rate was more consistent using aEEG

Figure 3: Determinants of performance for CDSA and aEEG



4. However, performance varied across individual EEG recordings for both CDSA and aEEG (Figure 4)

Figure 4: Sensitivity & false positive rates by EEG recordings



Conclusions

1. Critical care providers can identify seizures as well as neurophysiologists using CDSA & aEEG displays
   - Our results confirm and extend previously published work in critically ill adults & children by Swisher et al., Dericioglu et al. and Topjian et al.
2. Both CDSA and aEEG have strengths & weaknesses
3. Some cEEG recordings present challenges irrespective of professional background
4. Although accuracy with CDSA & aEEG is not as good as raw EEG, use of these tools by critical care providers could result in more timely seizure detection
5. In clinical practice, suspected seizures identified by critical care providers should be confirmed by neurophysiologists