HHS Public Access

Author manuscript

Pediatr Crit Care Med. Author manuscript; available in PMC 2016 June 01.

Published in final edited form as:

Pediatr Crit Care Med. 2015 June ; 16(5): 486–487. doi:10.1097/PCC.0000000000000369.

Seizure detection in the pediatric intensive care unit: can we "see" seizures better in color?

Yi-Chen Lai, MD

Texas Children's Hospital, Pediatric Critical Care Medicine 6621 Fannin WT6-006, Houston, Texas 77030, (832) 826-6230, ylai@bcm.tmc.edu

Keywords

color density spectral array; electroencephalography; electrographic seizures; quantitative EEG; pediatric intensive care unit

Seizures and status epilepticus represent common neurological findings in the critical care unit. Continuous electroencephalographic (cEEG) studies have revealed the prevalence of electrographic seizures and status epilepticus ranging from 19% to 42%; at least a 1/3 or more of the seizure events do not exhibit overt clinical signs of seizure activities (1–3). Therefore, cEEG potentially could provide real-time bedside monitoring and early electrographic seizure detection, allowing timely intervention that may result in improved outcome. Unfortunately there exist several obstacles that limit the widespread use and monitoring potential of cEEG in a critical care unit. The interpretation of cEEG currently depends on the retrospective, visual review by a qualified neurophysiologist, a process that requires additional expertise, is time-consuming and negates the benefit of real-time seizure detection. In order to facilitate the interpretation of prolonged cEEG recordings, quantitative EEG modalities have been developed to mathematically transform large amount of raw, multi-channel cEEG data into time-compressed, reduced-channel graphical displays highlighting significant electrographic events (4).

In this issue Topjian and colleagues (5) investigated the sensitivity and reliability of color density spectral array (CDSA), a quantitative EEG modality, in detecting electrographic seizures by the pediatric critical care providers. They demonstrated that the pediatric critical care providers with varying experience level could retrospectively identify electrographic seizures based on cEEG-derived CDSA images with reasonable accuracy and reliability following brief training. Compared with previous studies on the use of CDSA by neurophysiologists (6, 7), Topjian's study demonstrated similar accuracy and reliability by the critical care providers. Together, these findings suggest that cEEG-derived CDSA may serve as a useful adjunct for the critical care providers to detect electrographic seizures in the intensive care unit. Early CDSA application has focused on facilitating the interpretation of prolonged sleep recordings (8, 9). This article represents only the third study of this modality for the detection of electrographic seizures.

Increasingly, the use of cEEG has been proposed as part of multimodal monitoring of the injured brain in the critical care units (10); however, timely seizure identification is paramount to achieve full cEEG monitoring potential. Although quantitative EEG modalities

may facilitate the interpretation of cEEG, their utilization has not been widely adopted by neurology or critical care. The application of amplitude-integrated EEG for the assessment and prognosis of neonatal hypoxic-ischemic encephalopathy and prematurity perhaps represents the most common indication for quantitative EEG in critical care medicine (11, 12). The sensitivity of amplitude-integrated EEG in detecting neonatal electrographic seizures ranges widely from 40% to 80% (13, 14). Direct comparison between amplitude-integrated EEG and CDSA has shown comparable sensitivity (81.5% vs. 83.3%) of detecting pediatric seizures by the neurophysiologists in a testing environment (7), suggesting that either modality may be suitable for the pediatric intensive care units. Amplitude-integrated EEG often requires the purchase of additional equipment and provides information regarding only the amplitude of a single EEG channel. In contrast, CDSA images can be directly derived from the standard EEG machine and provides information regarding the amplitude and frequency of 8 EEG channels. Therefore, CDSA displays more content and possibly can be adapted more readily for clinical practice as compared with amplitude-integrated EEG.

Although Topjian and colleagues have demonstrated the utility of CDSA in the retrospective identification of electrographic seizures by the pediatric critical care providers, several key issues remain to be explored. The crux of utilizing bedside quantitative EEG is to improve the accuracy and time to seizure detection. Whether CDSA can fulfill these goals in the clinical setting is currently unknown. To date, there have been no studies investigating the accuracy and reliability of CDSA for seizure detection in real life application. The inter-rater reliability of CDSA ranges widely from 58%–72% in this study, while others have reported similar ranges (6, 7). Whether the inter-rater reliability can improve with increased training and experience remains to be examined. Most importantly, CDSA and other quantitative EEG modalities still require providers' constant vigilance to visually review the recordings; therefore, the time to seizure detection by CDSA may not differ significantly from the current practice utilizing cEEG.

Nevertheless, this study represents an important first step to evaluate the utility of CDSA for the timely and reliable seizure detection in the critical care units. Here Topjian and colleagues demonstrate reasonable accuracy and reliability in a testing environment with minimum training. CDSA possesses several theoretical advantages over amplitude-integrated EEG. Studies of real time application ultimately will determine the true monitoring potential of CDSA in the critical care units.

Acknowledgments

Copyright form disclosures: Dr. Lai's institution received grant support from the National Institutes of Health.

References

1. Topjian AA, Gutierrez-Colina AM, Sanchez SM, et al. Electrographic status epilepticus is associated with mortality and worse short-term outcome in critically ill children. Crit Care Med. 2013; 41(1):215–223. [PubMed: 23164815]
2. Claassen J, Mayer SA, Kowalski RG, et al. Detection of electrographic seizures with continuous EEG monitoring in critically ill patients. Neurology. 2004; 62(10):1743–1748. [PubMed: 15159471]

3. Williams K, Jarrar R, Buchhalter J. Continuous video-EEG monitoring in pediatric intensive care units. Epilepsia. 2011; 52(6):1130–1136. [PubMed: 21671924]

4. Scheuer ML, Wilson SB. Data analysis for continuous EEG monitoring in the ICU: seeing the forest and the trees. J Clin Neurophysiol. 2004; 21(5):353–378. [PubMed: 15592009]

5. Topjian AA, Fry M, Jawad AF, et al. Detection of Electrographic Seizures by Critical Care Providers Using Color Density Spectral Array After Cardiac Arrest is Feasible. Pediatr Crit Care Med. 2015 in press.

6. Pensirikul AD, Beslow LA, Kessler SK, et al. Density spectral array for seizure identification in critically ill children. J Clin Neurophysiol. 2013; 30(4):371–375. [PubMed: 23912575]

7. Stewart CP, Otsubo H, Ochi A, et al. Seizure identification in the ICU using quantitative EEG displays. Neurology. 2010; 75(17):1501–1508. [PubMed: 20861452]

8. Salinsky M, Goins S, Sutula T, et al. Comparison of sleep staging by polygraph and color density spectral array. Sleep. 1988; 11(2):131–138. [PubMed: 3381054]

9. Salinsky M, Sutula T, Roscoe D. Representation of sleep stages by color density spectral array. Electroencephalography and clinical neurophysiology. 1987; 66(6):579–582. [PubMed: 2438123]

10. Kurtz P, Hanafy KA, Claassen J. Continuous EEG monitoring: is it ready for prime time? Curr Opin Crit Care. 2009; 15(2):99–109. [PubMed: 19578320]

11. al Naqeeb N, Edwards AD, Cowan FM, et al. Assessment of neonatal encephalopathy by amplitude-integrated electroencephalography. Pediatrics. 1999; 103(6 Pt 1):1263–1271. [PubMed: 10353940]

12. Klebermass K, Olischar M, Waldhoer T, et al. Amplitude-integrated EEG pattern predicts further outcome in preterm infants. Pediatr Res. 2011; 70(1):102–108. [PubMed: 21436758]

13. Toet MC, van der Meij W, de Vries LS, et al. Comparison between simultaneously recorded amplitude integrated electroencephalogram (cerebral function monitor) and standard electroencephalogram in neonates. Pediatrics. 2002; 109(5):772–779. [PubMed: 11986435]

14. Shellhaas RA, Soaita AI, Clancy RR. Sensitivity of amplitude-integrated electroencephalography for neonatal seizure detection. Pediatrics. 2007; 120(4):770–777. [PubMed: 17908764]