The point-of-care EEG for delirium detection in the emergency department

Delirium is an advanced clinical state of brain failure commonly seen in the acute care setting. The frequency of delirium in the Emergency Department (ED) is reported as 8–17% among elderly patients, which increases to 25–44% in the inpatient setting [1,2]. The presence of delirium leads to significant increases in mortality and morbidity [1]. The challenge with diagnosing delirium is that the condition continues to be underdiagnosed. A study in the ED reported 80% of the miss rate by using clinical gestalt [3]. Bedside cognitive assessment tools have been reported to provide high sensitivity and specificity but have not been routinely used in many EDs.

The screening for delirium is important to stratifying risks and optimizing treatment approaches. The EEG signals characteristic of delirium is diffuse slow wave, which is seen in all 20 leads, showing the increased ratio of low frequency over high frequency [2]. The simplification of lead placement allows non-experts to apply only two channels (Bispectral EEG) to measure the ratios. In this study, we propose the introduction of a BSEEG to diagnose delirium in the ED.

This prospective pilot study took place from 2016 to 2017 in the single academic ED. Data collection was planned before the use of the index test (BSEEG), and the reference standard was set as the clinical and cognitive assessment of delirium. Institutional Review Board approval was obtained before the initiation of the study.

The study's population was drawn from a convenience series of patients 65 years of age or older who presented to the ED and were admitted to the hospital. Patients with a Glasgow Coma Scale (GCS) of less than 8 or those with agitation were excluded. We also excluded patients who were incapable of making decisions and their legal representatives were not present.

Our trained research staff used standardized questionnaires and data abstraction forms to record the clinical characteristics of each patient as well as Confusion Assessment Method (CAM)-ICU, Delirium Rating Scale (DRS), and BSEEG findings. A handheld EEG device was used in the ED, and a trained physician research fellow (KY) instructed ED research assistants on cognitive assessment tools and the application of EEG, data saving, and observed actual patient enrollment at the beginning for a month and ongoing basis. The EEG data were stored on a hard drive and analyzed by an analyst who was blinded to the clinical information (JC).

We defined clinical impression or admission diagnosis of delirium, positive CAM-ICU, and those with DRS-R-98 more than 18 as the reference standard [4]. The rationale for using the composite outcome was due to the high rate of missed diagnoses of delirium by clinical assessments alone [3]. The EEG finding of the diffuse slowing wave, which was defined by the ratio of low-to-high frequency brain activity and we developed the BSEEG index to measure the ratios.

Diagnostic characteristics were described in the receiver operator curve (ROC) to distinguish delirious from nondelirious subjects based on the clinical diagnosis, the cognitive assessment consistent with delirium, and the finding of the diffuse slowing wave in the EEG.

We approached a total of 101 patients who presented to our ED from October 2016 to April 2017. Among them, 49 patients consented to participate in the study (Fig. 1). A total of 48 patients had clinical information and BSEEG data during hospitalization (Table 1). A total of nine (9/48 = 18.8%) patients were found to have delirium.

The BSEEG index was shown in Table 1. The BSEEG index had an Area Under the Curve of 0.91 at the cutoff of 1.45 and yielded a sensitivity of 88.9% (95% CI 50.7–99.4), a specificity of 92.3% (95% CI 78.0–98.0), a positive likelihood ratio of 11.6 (95% CI 3.8–35.1), and a negative likelihood of 0.12 (95% CI 0.02–0.77). Also, the cutoff of 1.36 yielded the sensitivity of 100% (95% CI 60–100%).

Our study has several limitations. First, the study was not blinded, and it is possible that our finding was affected by observation bias. Second, a small sample size led to wide confidence intervals and affected the precision of the findings. Third, we likely had a significant rate of recruitment bias. Fourth, the study's results may not be generalizable to other practice settings, such as the outpatient clinic, inpatient and intensive care unit.

The diagnostic characteristics of the BSEEG yielded a moderate sensitivity and specificity. We reported similar study finding from our inpatient data [7]. The diagnosis of delirium often requires a resource-intensive cognitive assessment tool, such as the DRS [4]. CAM-ICU administered by health care provider has been reported as a valid screening tool for delirium in the ED with a high specificity but a moderate sensitivity [5,6].

In conclusion, this pilot study demonstrated that the BSEEG could be used to distinguish between delirious and nondelirious patients. Further research is necessary to develop an algorithm to translate BSEEG into real-time data.

Funding information

This study was funded by the University of Iowa Department of Emergency Medicine Seed Grant.

Author contributions

SL, KY, JC and GS developed the hypothesis and study design. SL did the statistical analysis. SL wrote the first and successive drafts of the manuscript. All authors contributed to study concept and design, analysis and interpretation of data, and drafting or critical revision of the manuscript for important intellectual content or additionally to data acquisition. SL and GS obtained funding for the study. SL, KY had full access to the data and take responsibility for the integrity of the data and the accuracy of the data analysis. SL is the guarantor.

Declaration of interest statement

Gen Shinozaki and John Cromwell are co-founders of Predelix Medical LLC. Gen Shinozaki and John Cromwell are the only authors with a conflict of interest.

Sangil Lee, MD, MS
Department of Emergency Medicine, University of Iowa Carver College of Medicine, United States of America
Corresponding author at: 0094 RCP, 200 Hawkins Dr., Iowa City, IA 52242, United States of America.
E-mail address: sangil-lee@uiowa.edu.

Kumi Yuki, MD
Department of Family Medicine and Psychiatry, University of Iowa Carver College of Medicine, United States of America

Aubrey Chan, MD, PhD
Department of Medicine and Psychiatry, University of Iowa Carver College of Medicine, United States of America

Abbreviations: BSEEG, Bispectral electroencephalography; DRS, Delirium rating scale; CAM, Confusion assessment method; PSD, Power spectral density; SD, Standard

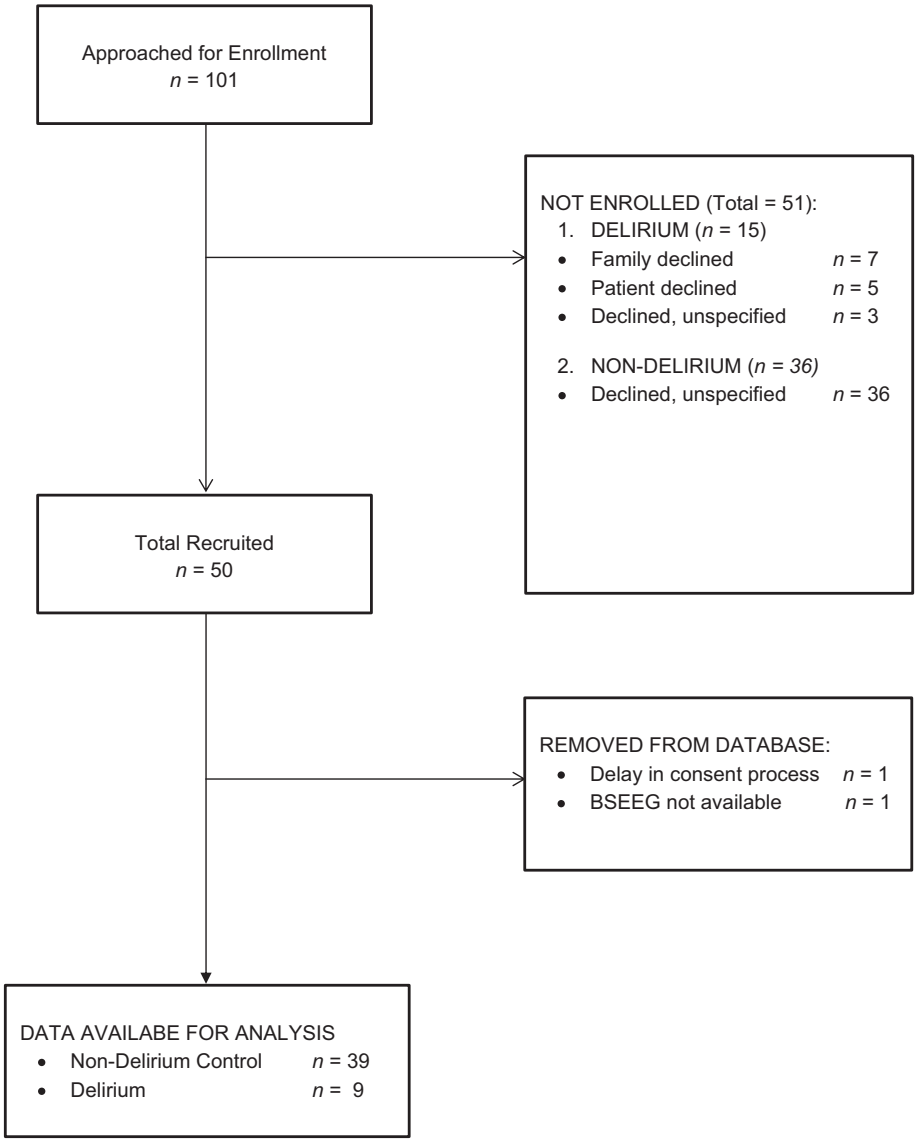

Fig. 1. Flowchart of the patient selection.

Table 1
Demographics of patients.

	Non-delirium ($N = 39$)	Delirium ($N = 9$)
Median age in years (IQR)	77 (70–87)	71 (67.5–77.5)
Female (%)	25 (64)	3 (33.3)
Delirium Rating Scale (SD)	6.2 (3.0)	17.7 (5.2)
BSEEG index (SD)	1.36 (0.08)	1.48 (0.06)

IQR: Inter-quartile range.

John Cromwell, MD
Department of Surgery, University of Iowa Carver College of Medicine, United States of America

Gen Shinozaki, MD, MSc
Department of Psychiatry, University of Iowa Carver College of Medicine, United States of America

https://doi.org/10.1016/j.ajem.2018.10.004

References

[1] Han JH, Wilson A, Ely EW. Delirium in the older emergency department patient: a quiet epidemic. Emerg Med Clin North Am 2010;28:611–31.
[2] Adhikari S, Fiorello A. Emergency ultrasound fellowship training: a novel team-based approach. Ann Emerg Med 2013;62:S80.
[3] Lewis LM, Miller DK, Morley JE, Nork MJ, Lasater LC. Unrecognized delirium in ED geriatric patients. Am J Emerg Med 1995;13:142–5.
[4] Trzepacz PT, Mittal D, Torres R, Kanary K, Norton J, Jimerson N. Validation of the Delirium Rating Scale-revised-98: comparison with the delirium rating scale and the cognitive test for delirium. J Neuropsychiatry Clin Neurosci 2001;13:229–42.
[5] Han JH, Wilson A, Vasilevskis EE, et al. Diagnosing delirium in older emergency department patients: validity and reliability of the delirium triage screen and the brief confusion assessment method. Ann Emerg Med 2013;62:457–65.
[6] Han JH, Wilson A, Graves AJ, et al. Validation of the confusion assessment method for the intensive care unit in older emergency department patients. Acad Emerg Med 2014;21:180–7.
[7] Shinozaki G, Weckmann, Lee, et al. Delirium detection by a novel bispectral EEG device in general hospital. Psychiatry Clin Neurosci 2018 Sep 24 PMID: 30246448.