Evaluation of point-of-care thumb-size bispectral electroencephalography device to quantify delirium severity and predict mortality

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Background

We have developed the bispectral electroencephalography (BSEEG) method for detection of delirium and prediction of poor outcomes.

Aims

To improve the BSEEG method by introducing a new EEG device.

Method

In a prospective cohort study, EEG data were obtained and BSEEG scores were calculated. BSEEG scores were filtered on the basis of standard deviation (s.d.) values to exclude signals with high noise. Both non-filtered and s.d.-filtered BSEEG scores were analysed. BSEEG scores were compared with the results of three delirium screening scales: the Confusion Assessment Method for the Intensive Care Unit (CAM-ICU), the Delirium Rating Scale-Revised-98 (DRS) and the Delirium Observation Screening Scale (DOSS). Additionally, the 365-day mortalities and the length of stay (LOS) in the hospital were analysed.

Results

We enrolled 279 elderly participants and obtained 620 BSEEG recordings; 142 participants were categorised as BSEEG-positive,

reflecting slower EEG activity. BSEEG scores were higher in the CAM-ICU-positive group than in the CAM-ICU-negative group. There were significant correlations between BSEEG scores and scores on the DRS and the DOSS. The mortality rate of the BSEEG-positive group was significantly higher than that of the BSEEG-negative group. The LOS of the BSEEG-positive group was longer compared with that of the BSEEG-negative group. BSEEG scores after s.d. filtering showed stronger correlations with delirium screening scores and more significant prediction of mortality.

Conclusions

We confirmed the usefulness of the BSEEG method for detection of delirium and of delirium severity, and prediction of patient outcomes with a new EEG device.

Keywords

Delirium; electroencephalography; bispectral EEG (BSEEG); delirium rating scales; mortality.

Copyright and usage

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Delirium has been a social burden among elderly in-patients owing to the significantly poor outcomes related to it. Delirium is very common in older adult in-patients, especially those with dementia. It occurs in up to 50% of patients admitted to general internal medicine wards, 15–53% who are undergoing post-operative recovery and 70–87% who are in intensive care units (ICUs).[1,2] Delirium is a strong predictor of poor patient outcomes such as increased mortality rates, length of stay (LOS) in hospital and institutionalisation after discharge.[3] However, delirium is less likely to be treated because it is difficult to diagnose.[4] Early identification of delirium can prompt medical workups and lead to capturing underlying medical problems, but proper detection of delirium has been a challenge. Although many useful tools for screening and detecting delirium using various questionnaire-style instruments have been developed,[5] their subjective nature makes it difficult to precisely identify changes in mental status, especially when administered by different healthcare professionals. These questionnaires are also extensive, making it difficult for busy hospital staff to administer them several times each day. Owing to these challenges, it has been shown that tools of this type have suboptimal sensitivity (38–47%) when used in busy clinical settings such as the ICU.[6,7] Without effective and efficient tools for early detection, delirium remains seriously underdiagnosed and undertreated.[1,3,8] Therefore, there is a need for a more objective and efficient device for delirium detection.

Delirium is characterised by low-frequency brain wave signals, and electroencephalography (EEG) can be used to detect such

signals.[9–11] We have developed a novel bispectral EEG (BSEEG) system that utilises only two EEG channels and can be easily applied by non-experts. Our novel EEG algorithm was found to detect delirium and reported promising data in general medicine settings, the emergency room, in electroconvulsive therapy patients and in lipopolysaccharide-induced delirium in rodents.[12–16] Although our previously published data using the original BSEEG device has shown its effectiveness in detecting delirium, our previous data did not report the level of correlation between delirium severity and the BSEEG score. Also, the device used had some limitations. For example, it did not have the ability to show a calculated BSEEG score at the bedside. Thus, the EEG recording had to be analysed at a later time in order to obtain a BSEEG score. In busy clinical settings, these additional steps would be unrealistic to implement as a routine procedure. For this reason, we have introduced a new device with the ability to send a wireless signal so that the BSEEG score can be calculated and displayed at the bedside, enabling its use as a point-of-care device.

Aims

Our aim in this study was to determine whether the BSEEG score can show delirium severity in a dose-dependent manner. We also aimed to demonstrate that our new device could and would replicate our previous findings in the detection of delirium, as well as predicting outcomes, including mortality and hospital LOS, as our original device did.[12–14] In addition, we have continued to pursue our

interest in ways to improve the performance of the BSEEG method in the detection of delirium and the prediction of outcomes. The noise in EEG signals has presented challenges, so an additional aim was to investigate the effect of additional filtering by excluding EEG data with higher noise.

Method

Study design

This is a prospective cohort study to test the effectiveness of BSEEG in detecting delirium and predicting patient mortality using a new, small (thumb-sized) EEG device. The human participant protocol for this research study was approved by the University of Iowa Institutional Review Board. This study conforms to the provisions of the Declaration of Helsinki.

Setting and participants

We recruited participants between 55 and 99 years old at the University of Iowa Hospitals and Clinics (UIHC) between January and November 2019.

All participants were enrolled after admission to the UIHC or an emergency room visit. Because the study included patients with delirium, not all participants had the capacity to consent. We determined whether patients were able to consent to participate at the time of enrolment. Participants with the capacity to consent did so themselves; when participants were not able to consent, their legally authorised representative provided signed approval on their behalf.

The recruitment process and overall protocol for this study followed the same structure as our previous studies.[13,14] Further details are described in the supplementary material available at https://doi.org/10.1192/bjp.2021.101.

Clinical data collection and case definition

Clinical data, including the Confusion Assessment Method for the Intensive Care Unit (CAM-ICU),[17] the Delirium Rating Scale-Revised-98 (DRS)[18] and the Delirium Observation Screening Score (DOSS),[19] were collected as described in previous papers.[12–14] We defined delirium status by a CAM-ICU-positive score, DRS score ≥18, DOSS score ≥3, or clinical documentation of delirium. Additional details are described in the supplementary material.

BSEEG data collection and score calculation

We used a portable, thumb-sized EEG device (ZA, ProAssist, Osaka, Japan) (supplementary Fig. 1(a)) to collect brain signals. EEG recordings were conducted at the same time as the clinical scale assessment. Signals were obtained from the two-lead montage Fp1–A1 for 3 min (supplementary Fig. 1(b)). A study team member interacted with the participants during the assessments to make sure that patients were not asleep during recording. The EEG sampling rate was 128 Hz. Raw EEG signals were processed and BSEEG score was calculated as a power ratio of low frequency (3 Hz) to high frequency (10 Hz) as described previously.[12–14,20] Further details are described in the supplementary material.

Standard deviation filtering and first BSEEG extraction

Because a BSEEG score with high s.d. suggests excess noise during the EEG recording, we employed additional filtering for EEG data by limiting signals to those with low s.d. values (s.d. filtering). The cut-off s.d. value was 0.18/0.19. We also extracted BSEEG scores from the first assessment day (first BSEEG) for survival analysis. We divided the study participants into two groups: (a) a BSEEG-positive group (BSEEG score ≥1.40, reflecting slower EEG activity on relative spectral density) and (b) a BSEEG-negative group (BSEEG score ≤1.39, reflecting faster EEG activity on relative spectral density)[13] (supplementary Table).

Assessment of mortality and LOS in hospital

All-cause mortality data were obtained from each patient's hospital records and obituary records as previously reported.[13,14,21] Hospital LOS data were collected by reviewing hospital records.

Statistical analysis

To compare the relationships between BSEEG and each delirium screening scale, all obtained BSEEG data were analysed. The BSEEG scores of the CAM-ICU-positive group and CAM-ICU-negative group were compared using Mann–Whitney U-tests. The receiver operating characteristic (ROC) curve and the area under the curve (AUC) were also used to analyse the relationship between BSEEG score and CAM-ICU results. The most optimised sensitivity and specificity were calculated. To compare the correlation between the BSEEG score and the DRS score, as well as the BSEEG and the DOSS scores, we performed Spearman's rank correlation. We also divided data into three groups based on the mortality risks associated with DRS and DOSS scores identified in our previous study: DRS = 0–3, 4–9 and ≥10; and DOSS = 0, 1–2 and ≥3.[21] The BSEEG scores of the three groups were compared using the Kruskal–Wallis test and Mann–Whitney U-test with Holm correction. The data are presented with scatter plots, medians and interquartile ranges. For outcome analysis, we used only the first BSEEG scores. This was to avoid potential bias from those who stayed longer in hospital and had more EEG recordings, and thus had more random chance to show higher BSEEG scores. Kaplan–Meier survival curves were used for visual presentation of time to death, and log-rank statistics were used to assess significance of difference in 365-day mortality. The hazard ratio (HR) for mortality was computed using Cox proportional hazards regression analyses. Age, gender, delirium status and severity of illness as quantified with the Charlson Comorbidity Index (CCI)[22] were added as covariates in the regression analyses. The association between mortality and BSEEG scores was illustrated by comparing two survival functions for BSEEG-positive and BSEEG-negative groups, as well as three survival functions for high-BSEEG, medium-BSEEG, and low-BSEEG groups. Finally, we conducted a subgroup analysis combining clinical delirium and BSEEG categories to show their mortality. Mann–Whitney U-tests were also used for the comparison of LOS between the BSEEG-positive group and the BSEEG-negative group. Corrected P-values <0.05 were considered significant. All analyses were performed with R software, version 4.0.2 for Windows.

Results

Participant demographics

We enrolled 279 participants. The average patient age was 71.2 years (s.d. = 9.0), 47.3% of the participants were female and 93.2% were non-Hispanic White. Among the 279 participants, 93 (33.3%) were identified as delirious and 186 (66.7%) were judged not to have delirium (supplementary Table). In total, 620 EEG recordings were available for analysis. On average, each participant had 2.2 recordings.
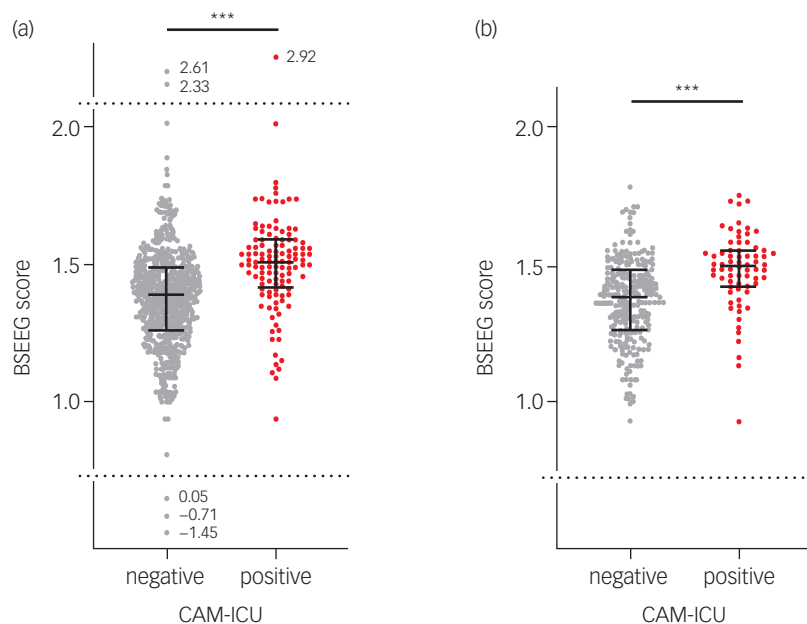
Fig. 1 Comparison of bispectral electroencephalography (BSEEG) scores between CAM-ICU-negative groups and CAM-ICU-positive groups (a) for all data and (b) after s.d. filtering. CAM-ICU, Confusion Assessment Method for the Intensive Care Unit.

Correlation between BSEEG score and delirium screening scales

BSEEG and CAM-ICU

The BSEEG and CAM-ICU were measured 612 consecutive times. When the BSEEG scores were compared between CAM-ICU-negative groups and CAM-ICU-positive groups, the median BSEEG scores were 1.39 and 1.51 respectively ($P < 0.001$) (Fig. 1(a)). The AUC from the ROC curve was 0.71 (95% CI 0.66–0.76). The optimised sensitivity and specificity were 0.69 and 0.67 respectively (supplementary Fig. 2(a)). After s.d. filtering, similar results were observed (median BSEEG score of 1.39 (CAM-ICU-negative) and 1.51 (CAM-ICU-positive), $P < 0.001$) (Fig. 1(b)). The AUC from the ROC curve was 0.72 (95% CI 0.65–0.79). The optimised sensitivity and specificity were 0.70 and 0.67 respectively (supplementary Fig. 2(b)).

BSEEG and DRS

There were 607 times when the BSEEG and DRS were measured consecutively. We tested the BSEEG and DRS scores for correlation and the Spearman's rank correlation coefficient was 0.26 ($P < 0.001$) (Fig. 2(a)). When the BSEEG scores after s.d. filtering were analysed, the correlation coefficient increased to 0.34 ($P < 0.001$) (Fig. 2(b)). When we compared the BSEEG scores for the three groups divided on the basis of DRS scores of 0–3, 4–9 and ≥10,[21] there were significant differences in the scores among the three groups ($P < 0.001$). The BSEEG score increased along with the DRS score (Fig. 2(c)). These differences were observed more clearly when s.d.-filtered BSEEG scores were analysed (Fig. 2(d)).

BSEEG and DOSS

The BSEEG and DOSS were measured 374 times consecutively. When the BSEEG and DOSS scores were tested for correlation, Spearman's rank correlation coefficient was 0.24 ($P < 0.001$) (Fig. 3(a)). After s.d. filtering, the correlation coefficient increased to 0.28 ($P < 0.001$) (Fig. 3(b)). Comparing the BSEEG scores for the three groups divided on the basis of DOSS scores of 0, 1–2 and ≥3, there were no significant differences in BSEEG scores

between the DOSS = 0 group and the DOSS = 1–2 group or between the DOSS = 1–2 group and the DOSS ≥3 group. However, the BSEEG scores of the DOSS ≥3 group were significantly higher than those of DOSS = 0 group (Fig. 3(c)). A similar tendency was observed when s.d.-filtered BSEEG scores were analysed (Fig. 3(d)).

Mortality prediction

Two-group comparison

We tested to verify whether the first BSEEG score obtained using the new device could be used to predict 365-day mortality, replicating our previous data.[13] We looked at data from 279 participants with available mortality data. Mortality data for our 279 participants data confirmed that the BSEEG-positive group experienced higher mortality than the BSEEG-negative group (22.6 v. 9.1%, $P = 0.004$; log-rank analysis) (Fig. 4(a)). When we analysed participant mortality over 365 days controlling for age, gender and CCI score, the HR based on the two BSEEG groups (high versus low) was 2.36 (95% CI 1.20–4.65; $P = 0.013$). Even after control for clinical delirium status in addition to age, gender and CCI score, the HR based on the BSEEG groups remained significant, at 2.28 (95% CI 1.14–4.57; $P = 0.020$). Next, we analysed the s.d.-filtered first BSEEG data of 154 participants. The performance of mortality prediction improved when only s.d.-filtered first BSEEG scores were used. The BSEEG-positive group experienced higher mortality than the BSEEG-negative group (21.7 v. 4.4%, $P = 0.006$; log-rank analysis) (Fig. 4(b)). Analysing participant mortality controlling for age, gender and CCI score, the HR based on the two BSEEG groups was 4.56 (95% CI 1.32–15.62; $P = 0.016$). After controlling for clinical delirium status, in addition to age, gender and CCI score, the HR based on the BSEEG groups was 4.82 (95% CI 1.38–16.80; $P = 0.014$).

Dose-dependent increase in mortality by three-group comparison

Next, the participants were divided into three groups based on BSEEG score: high BSEEG, medium BSEEG, and low BSEEG. The low-BSEEG group tended to show a higher chance of survival
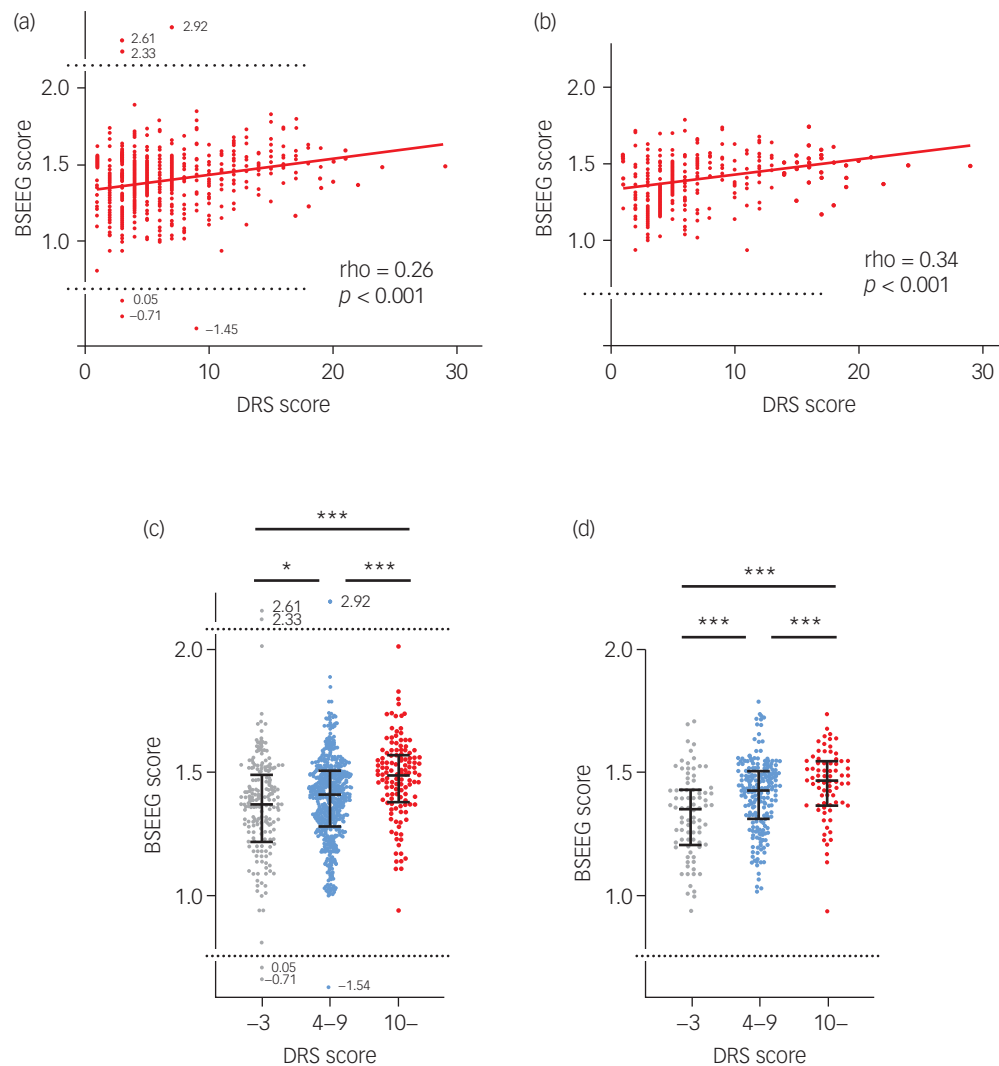
Fig. 2 Correlation between bispectral electroencephalography (BSEEG) scores and Delirium Rating Scale-Revised-98 (DRS) scores. (a) All data. (b) Data after s.d. filtering. (c) All BSEEG scores grouped by DRS scores. (d) s.d.-filtered BSEEG scores grouped by DRS scores.

(90.9%) than the medium-BSEEG (84.6%) and high-BSEEG groups (78.4%) (Fig. 4(c)). When we analysed participant mortality within 365 days controlling for age, gender, and CCI score, the association between the BSEEG grouping and mortality did not remain significant (HR = 1.29, 95% CI 0.85–2.00; $P = 0.23$). After controlling for clinical delirium status, in addition to age, gender and CCI score, the HR based on the BSEEG groups was 1.23 (95% CI 0.80–1.90; $P = 0.34$). When we limited our data to only s.d.-filtered BSEEG scores, analysis of the mortality rate showed a more distinct association between BSEEG score and mortality in a dose-dependent manner, indicating that a higher BSEEG score is associated with an increased risk for mortality (Fig. 4(d)). When we analysed participant mortality rates using this subset of participants, controlling for age, gender and CCI score, the HR based on the three BSEEG groups was 2.17 (95% CI 1.08–4.35; $P = 0.029$). Even after controlling for patients' clinical delirium status, in addition to age, gender and CCI score, the HR based on the three BSEEG groups remained significant at 2.29 (95% CI 1.11–4.71; $P = 0.024$).

Subgroup survival analysis based on BSEEG and delirium diagnosis

We divided participants into four groups on the basis of their first BSEEG scores and clinical status of delirium (present or absent). BSEEG-positive participants with delirium showed the highest

mortality rate. In contrast, BSEEG-negative participants without delirium showed the lowest mortality rate. Of note, BSEEG-positive participants without delirium had higher mortality rates than BSEEG-negative participants with delirium (Fig. 4(e)). Next, we analysed s.d.-filtered first BSEEG data. The mortality of the BSEEG-positive participants with delirium was nearly the same as that of BSEEG-positive participants without delirium. Similarly, the mortality of the BSEEG-negative participants with delirium was almost the same as that of the BSEEG-negative participants without delirium (Fig. 4(f)).

LOS in hospital

Hospital LOS in the BSEEG-positive group was significantly longer than in the BSEEG-negative group (median LOS: 4 v. 7 days, $P = 0.032$) (supplementary Fig. 3). The difference in LOS remained the same after s.d. filtering (median LOS: 4 v. 7 days, $P = 0.047$) (supplementary Fig. 3).

Discussion

In the present study, we investigated whether our new device could provide high-quality BSEEG signals to quantify delirium severity in participants who were at a higher risk of poor outcomes, such as
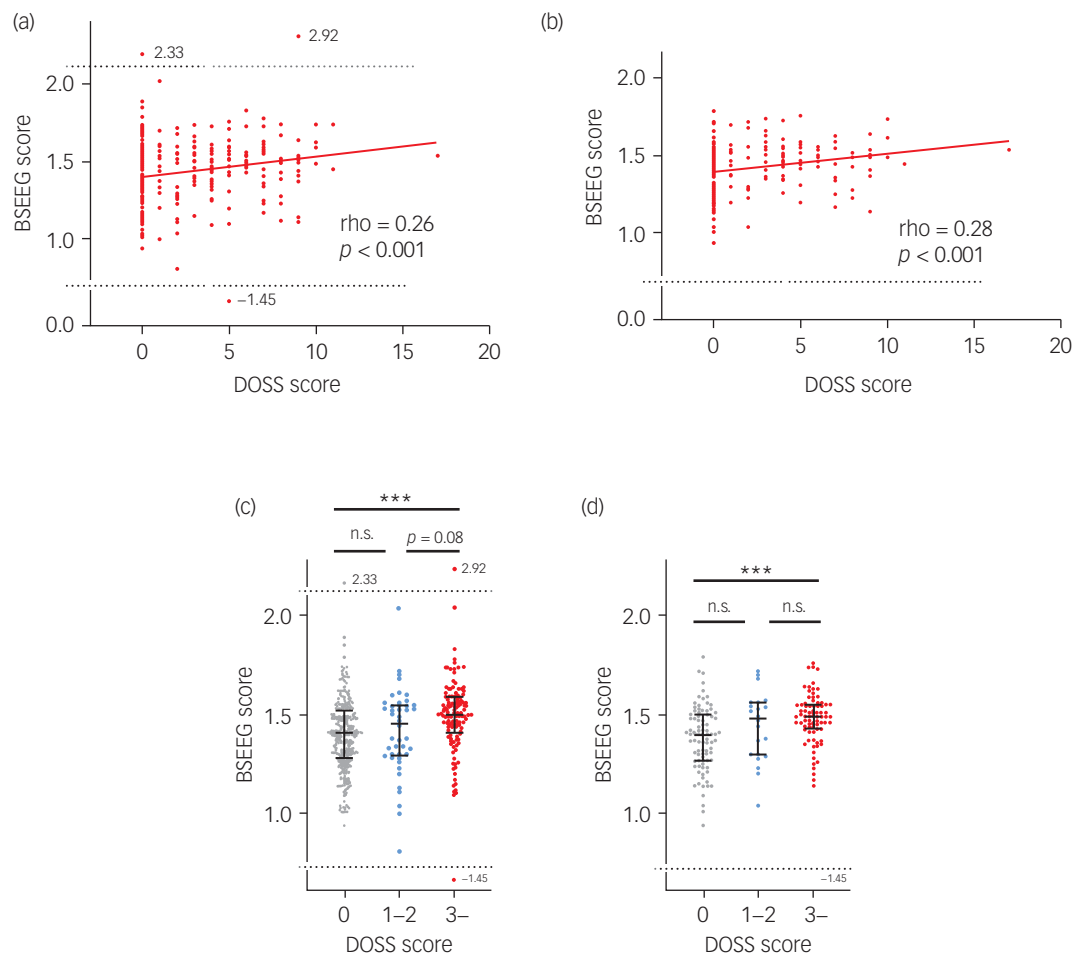
Fig. 3 Correlation between bispectral electroencephalography (BSEEG) scores and Delirium Observation Screening Scale (DOSS) scores. (a) All data. (b) Data after s.d. filtering. (c) All BSEEG scores grouped by DOSS scores. (d) s.d.-filtered BSEEG scores grouped by DOSS scores.

mortality and/or extended LOS. We also investigated whether s.d. filtering could improve performance of the BSEEG method.

Identifying delirium and its severity

In our earlier study, we demonstrated that the BSEEG method could differentiate delirium-positive and delirium-negative cases.[12] In this current study, high BSEEG score was related to CAM-ICU-positive status (Fig. 1 and supplementary Fig. 2). Furthermore, our present data validate the significant association between BSEEG scores and delirium severity measured by commonly used clinical assessment tools. We demonstrated that the BSEEG scores were correlated with DRS scores and DOSS scores (Figs 2(a), 2(b), 3(a) and 3(b)). And when participants were divided into three groups on the basis of the mortality risks associated with their DRS or DOSS scores,[21] the BSEEG scores increased along with the raised DRS or DOSS score in a score-dependent manner (Figs 2(c), 2(d), 3(c) and 3(d)). These results suggest that the BSEEG score can reflect the presence and severity of delirium.

Predicting mortality and LOS

The data presented here demonstrate that the BSEEG score is significantly associated with mortality among older hospital in-patients (Fig. 4(a) and (b)). It was also revealed that long-term mortality rates went up accordingly as the BSEEG score increased (Fig. 4(c) and (d)). Additionally, we showed that participants with a high BSEEG score stayed in hospital for a longer duration

(supplementary Fig. 3). These results replicated and confirmed our previous BSEEG approach and established the reliability of this method.[13] Importantly, the BSEEG scores used to assess the association with mortality and LOS were from the very first EEG recordings conducted at the time of study enrolment. These initial EEG recordings were often within 24 h of admission to the hospital, suggesting that a single BSEEG score obtained from patients shortly after their arrival at hospital can and should be used to predict their outcomes. Such essential, vital and fundamental information would be extremely useful in a clinical setting to provide the opportunity for early and prompt intervention, with the potential to ameliorate poor outcomes and improve survival rates.

The new BSEEG method and device

In a recent fascinating publication describing work by Kimchi et al, it was demonstrated that EEG slowing detected by traditional EEG recording was associated with the presence of delirium. Their data also suggested that generalised EEG slowing, which was a composite measure defined as the presence of either generalised theta or generalised delta waves, was correlated with delirium severity.[23] They demonstrated that patients with EEG slowing had poor outcomes, including increased LOS in hospital and increased rates of in-hospital mortality. Interestingly, they showed that rates of in-hospital mortality for patients with EEG slowing were high even if they were not diagnosed with delirium. Those data on detection of delirium, proportionality to delirium severity and association with poor outcomes based on EEG slowing are consistent with
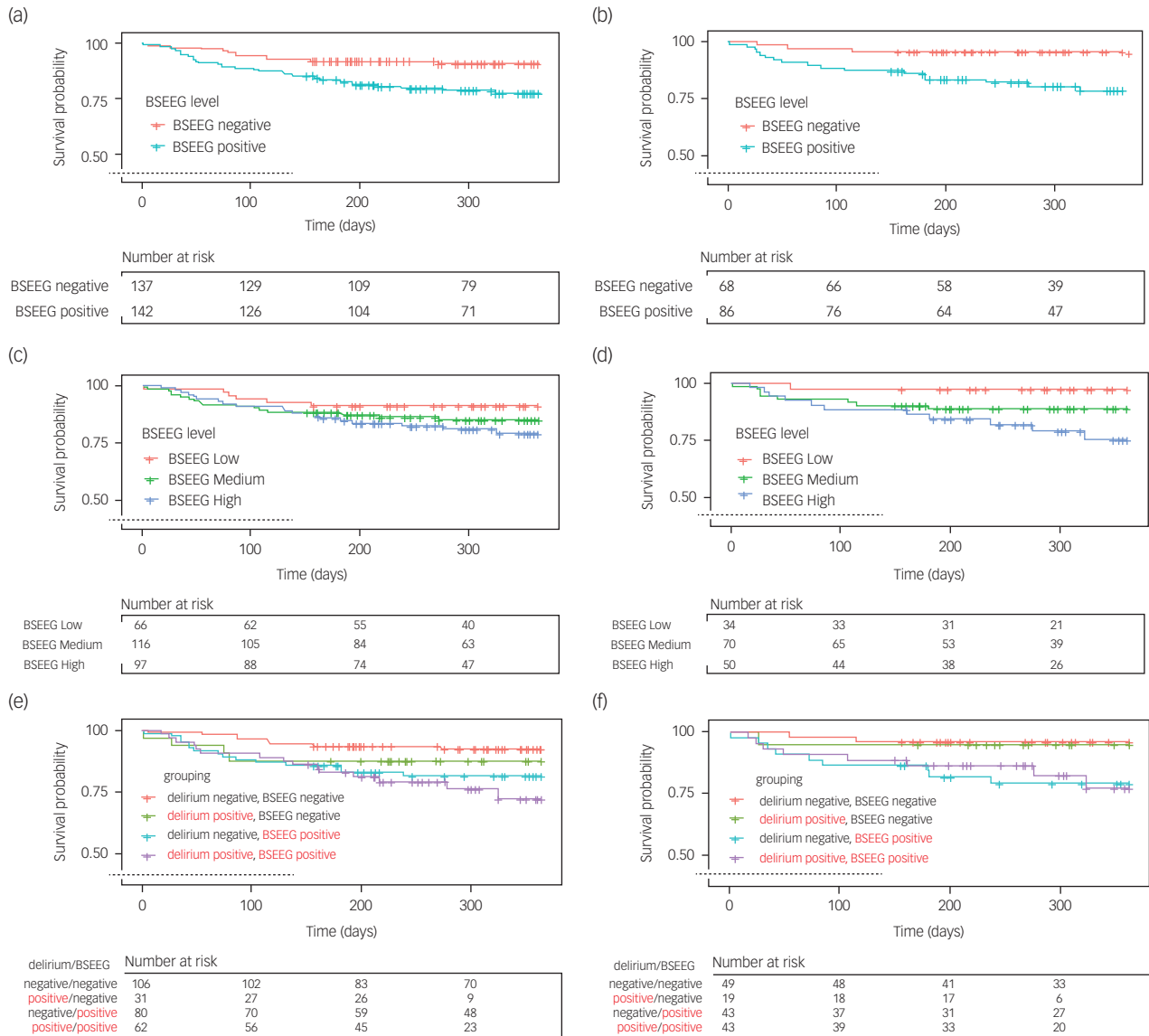
Fig. 4 Kaplan–Meier cumulative survival curve over 365 days based on (a) two-group comparison of all bispectral electroencephalography (BSEEG) scores, (b) two-group comparison of s.d.-filtered BSEEG scores, (c) three-group comparison of all BSEEG scores, (d) three-group comparison of s.d.-filtered BSEEG scores, (e) subgroup comparison of all BSEEG scores, and (f) subgroup comparison of s.d.-filtered BSEEG scores.

our data based on the BSEEG method.[23] Because their results corroborate the results of our previous and present studies,[12–14] their data from traditional multichannel EEG supports the validity of our BSEEG method with the limited electrodes (just two leads in the present report) using our BSEEG algorithm. Moreover, the user-friendly BSEEG method has additional advantages. An EEG device used in this study is thumb-size with only two electrodes, and has the capacity to send EEG signals wirelessly so that BSEEG scores can potentially be calculated and displayed at the bedside. With objective scoring calculated by the BSEEG algorithm, it does not require expert EEG evaluation and can avoid potential delays in assessment. These advantages would make it easy to apply the BSEEG method in clinical settings.

BSEEG scores versus clinical diagnosis an an outcome predictor

Accumulated evidence suggests that patients with delirium have a higher mortality risk.[24,25] However, our previous studies and our present subgroup analysis results verify that long-term poor outcome was predicted more significantly by BSEEG scores than by clinical diagnosis of delirium (Fig. 4(e)).[13,14] Remarkably, subgrouping survival analysis using the s.d.-filtered BSEEG scores indicated that long-term mortality was predicted almost exclusively by BSEEG scores, regardless of the clinical status of delirium (Fig. 4(f)). These results suggests that a higher BSEEG score was stronger predictor of long-term mortality than clinically identifiable symptoms of delirium. There are two possible reasons for this. First, BSEEG could identify patients with brain dysfunction but without clinically diagnosable delirium. Our previous study demonstrated that even patients with only mild symptoms of delirium, that may not be diagnosed as delirium, had high mortality risk.[21] The BSEEG method might be able to capture such individuals with 'subthreshold delirium'. Second, BSEEG may measure something different from clinical delirium. The BSEEG method likely measures more generic brain dysfunction, rather than brain dysfunction that is specific only to delirium. It is possible, however, that not all patients with brain dysfunction captured by BSEEG express symptoms of

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delirium as a phenotype. Our data suggest that the BSEEG method can detect many delirious patients and can quantify their delirium severity with reasonably accuracy. In addition to detection of what is called delirium, our data indicate that this BSEEG method may have independent prognostic significance. Further investigation using this BSEEG method is needed to make clear what is happening in participants with a high BSEEG score but without clinical symptoms of delirium, and it might lead to better understanding of delirium and its pathophysiology.

The signal-processing algorithm

We showed that s.d. filtering could improve performance of the BSEEG method. This is a practical but important step in developing BSEEG as a reliable clinical tool. We tested several methods to improve our signal-processing algorithm to seek the best performance. For example, we previously showed that a topological data analysis (TDA) approach improved delirium detection by BSEEG.[15] However, TDA is computationally intensive and is harder to implement in a point-of-care device to be used at the bedside. Another approach we applied is s.d. filtering. There were several outliers with relatively high s.d., indicating that BSEEG data with high s.d. contain more noise. The use of s.d. filtering is a reasonably simple yet effective way of improving the performance of delirium detection as presented here. However, it was necessary to exclude much of the BSEEG data based on s.d. to increase performance. Approximately 45% of BSEEG scores were filtered out on the basis of high s.d.. For the device to be successfully implemented in a clinical setting, it is important that each individual score is reliable, so that detection of delirium and prediction of poor outcomes can be made promptly, followed by appropriate interventions. One way to achieve this goal is to implement s.d. filtering in the algorithm so that the EEG recording continues until optimal EEG signals under a certain s.d. cut-off value are obtained. We are actively planning to update our algorithm accordingly with this approach.

Limitations and further research

There are several limitations in this study. First, we obtained BSEEG scores at the time of enrolment, but there was no intervention initiated on the basis of BSEEG results. The next important step would be to obtain BSEEG scores, use this information to identify high-risk patients, intervene promptly and assess how early intervention modifies patient outcomes. Second, as mentioned above, s.d. filtering to exclude data was required to achieve better performance in this cohort. The technical challenges from a hardware standpoint need to be surmounted for further development of this approach. Third, this study was conducted in a single institution and more than 93% of study participants were non-Hispanic White. Thus, generalisability requires confirmation in a more diverse ethnic population. Nonetheless, the findings have been replicated repeatedly and consistently with hundreds of patients at UIHC over the past several years.

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Supplementary material

Supplementary material is available online at https://doi.org/10.1192/bjp.2021.101.

Data availability

The data that support the findings of this study are available from the corresponding author (G.S.) on reasonable request.

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Author contributions

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Declaration of interest

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EXTRA CONTENT ONLINE

Extra

In Beckett's words, by Beckett's thoughts: a narrative on ageing

João Martins-Correia ⓘ

Samuel Beckett, Nobel Prize winner in literature in 1969, is one of the central names of 20th century Modernism. Beckett's artistic movement was deeply influenced by the deconstructionist atmosphere of the post-war period and is undeniably marked by the minimalist exploration of words as well as the separation from the traditional novel format.

Malloy (1951), *Malone Meurt* (1951) and *L'Innommable* (1953) form the post-war trilogy and support what was the author's greatest period of literary creation. Despite the lack of any associated logical sequence, each novel being a departure and destination in itself, they share a solid common ground: the progressive breakdown of the characters and the concept of human mortality.

In *Malone Meurt*, Malone appears as an institutionalised old man, stuck in a room, reduced to the limits of the bed and the rigidity of his own body; the world is reached only through the words he writes, and it is with them that he is entertained until the arrival of death. The entire narrative is marked by an inviolable feeling of death. The announcement is made at the start, in the title of the work.

Time is moved by the taste of words, entertained in tales, in stories, in lost memories. The creation of an inventory of belongings, which Malone imagines for himself, cradles the passage of time and is in line with the narrator's visible state of weakness, unable to accurately recall his goods in the absence of fateful calculations. Through the stories, traces of an indelible separation emerge between the facts announced by Malone, part of his elaborated fictional world, and his own past, indistinctly remembered. It is thus the portrait of a narrative amalgamation, an unstable game of blurred distinction between the act of narrating and being narrated.

Perceptual changes are consistently portrayed at the pace of the construction of the narrative, expressed not only as a translation of the fragility expectedly found in someone who lives his last days, with deficits in attention, memory and temporal perception, but also as symptomatic of a global loss of the sense of understanding of reality and of relations established with the world. *Malone Meurt* is a novel of vague phrases, wrapped in contradictions, associated with a certain degree of inconsistency and marked, at times, by an almost impenetrability: a complex labyrinth of both language and mind, collapsing together, bringing death and decay.