Is There a Better Timing for Frontal Electroencephalogram Alpha Band Power Quantification to Predict Delirium After Cardiac Surgery?

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There is currently a growing body of clinical research indicating that lower intraoperative α-band power, a component of the electroencephalogram (EEG) spectrum, might be a predictor of postoperative delirium (POD).[1–5] However, practical questions still need to be answered before effectively using intraoperative α-band power to predict delirium. More specifically, it is not clear how much the timing of EEG recording and the type of surgery influence the predictability of intraoperative α-band power.

In a previous study, we showed that a lower intraoperative frontal α-band power measured 30 minutes after the induction of anesthesia, but before surgical skin incision, was associated with a higher incidence of POD in elective cardiac surgery.[4] However, one could argue that quantifying intraoperative α-band power before initiation of cardiopulmonary bypass (CPB) and aortic clamping might not take into account the specific impact of these surgical phases on the risk of developing POD.

The aim of this study was to determine the most suitable timing to quantify intraoperative EEG α–band power to identify cardiac surgery patients at risk of POD and potentially initiate subsequent preventive strategies. We hypothesized that the "post-induction" period would already be efficient in this matter.

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METHODS

This preplanned secondary analysis is part of a prospective observational trial evaluating perioperative predictors of POD.[4,6] The study protocol was approved by the "Comité d'Ethique Hospitalo-Facultaire des Cliniques Universitaires Saint-Luc" (B403201837550, Brussels, Belgium—chairman Pr. J-M Maloteaux) on September 2018 and registered on ClinicalTrials.gov (NCT03706989) before starting patients inclusion. Written informed consent was obtained from all patients, according to the Declaration of Helsinki.

From May 2019 to December 2021, 220 adult patients who underwent their first elective cardiac surgery with CPB were included. Preoperative (2 minutes) and intraoperative (5 minutes) EEG recordings were collected using a 32-channel BioSemi ActiveTwo recording system (BioSemi B.V., Amsterdam, the Netherlands): preoperatively eyes-closed (T0), 30 minutes after the induction of anesthesia but before surgical incision (T1), before aortic cannulation (T2), during CPB (T3) and after chest closure (T4). Maintenance of anesthesia with sevoflurane was systematically guided by a NeuroSENSE depth-of-anesthesia monitor (NeuroWave Systems Inc) to avoid any intraoperative episode of burst suppression, and administration of ketamine was prohibited as per study protocol. After surgery, patients were screened for POD by trained nurses using the Confusion Assessment Method for Intensive Care Unit 3 times a day while in Intensive Care, then the Confusion Assessment Method in the ward 2 times a day until discharge from the hospital. Considering the fluctuating course of POD, a chart review was systematically performed by the research staff checking for any notifications suggesting an episode of POD.

Spectral analyses were performed using MATLAB and focused on frontal mean α-band power (8–12 Hz).[4] Power values were converted into dB and expressed

as means ± standard deviation (SD). Comparisons of continuous variables between patients with and without POD were performed by Mann-Whitney *U* test or Student *t* test, depending on normality assumption. Comparisons between categorical variables were performed by χ^2 test. The effect of mean α-band power at each time-point on the occurrence of POD was evaluated using univariable logistic regression analyses.

RESULTS

Clinical and perioperative EEG data are detailed in the Table. Sixty-five (29.5%) patients experienced POD. Delirious patients were significantly older (median [interquartile range {IQR}], 74 years [64–79] vs 67 years [59–74]; $P < .001$) and had significantly higher EuroSCORE (European System for Cardiac Operative Risk Evaluation) II scores (median [IQR], 2.4 % [1.3–4.0] vs 1.5 % [0.9–2.5]; $P < .001$). CPB time was significantly longer in patients with POD (mean ± SD, 112 ± 40 minutes vs 99 ± 33 minutes; $P = .015$).

Patients who developed POD presented significantly lower mean α-band power at the 4 intraoperative time-points of EEG recordings (T1–T4; Table). Conversely, there was no statistically significant difference between both groups in preinduction eyes-closed frontal EEG mean α-band power.

Univariable logistic regression analyses showed that mean α-band power "30 minutes after the induction of anesthesia," even though the surgery had not yet started, was effectively a relevant timing in identifying patients at risk of POD (odds ratio [95% confidence interval {CI}], 0.85 [0.78–0.92]), in comparison with other selected surgical time-points, such as "before aortic cannulation" (odds ratio [95% CI], 0.88 [0.82–0.94]), "during CPB" (odds ratio [95% CI], 0.87 [0.81–0.93]) or "after chest closure" (odds ratio [95% CI], 0.87 [0.81–0.93]), which were each significantly associated with POD.

DISCUSSION

Our results showed that frontal mean α-band power 30 minutes after the induction of anesthesia was significantly lower in patients who experienced delirium and continued to be significantly lower until the end of surgery. Moreover, a lower mean α-band power after the induction of anesthesia predicted POD, although α-band power at each measured intraoperative time-point was significantly associated with the occurrence of POD.

These findings suggest that the physiologic changes associated with cardiac surgery and CPB do not appear to influence the relationship between frontal mean α-band power under general anesthesia and POD. Moreover, in light of our results, one

Table. Demographics, Comorbidities and Perioperative EEG and Clinical Data in Patients With and Without Postoperative Delirium

	Nondelirious patients (n = 155)	Delirious patients (n = 65)	*P*-value
Preoperative data			
Age, y	67 (59–74)	74 (64–79)	<.001*[a]
Sex, male	128 (82.6)	52 (80.0)	.651[c]
Body mass index, kg/m^2	27.7 (25.4–30.0)	28.2 (25.1–30.0)	.507[a]
EuroSCORE II, %	1.5 (0.9–2.5)	2.4 (1.3–4.0)	<.001*[a]
Mini-mental state examination,/30	29 (27–29)	28 (26–29)	.047*
Preoperative mean α-band power (T0), dB	–16.74 ± 4.42	–17.61 ± 4.21	.178[b]
Intraoperative data			
Intraoperative mean α-band power, dB			
Postinduction of anesthesia (T1)	–11.59 ± 3.37	–14.03 ± 4.61	<.001*[b]
Before aortic cannulation (T2)	–12.48 ± 3.76	–14.67 ± 4.76	.001*[b]
During cardiopulmonary bypass (T3)	–12.03 ± 3.65	–14.45 ± 4.86	.001*[b]
After chest closure (T4)	–13.08 ± 4.03	–15.74 ± 4.77	<.001*[b]
Type of surgery			.180*[c]
Isolated CABG	74 (47.7)	26 (40.0)	
Single non-CABG	35 (22.6)	10 (15.4)	
2 interventions	30 (19.4)	20 (30.8)	
3 interventions or more	16 (10.3)	9 (13.8)	
Surgical time, min	226 ± 57	238 ± 60	.170[b]
Cardiopulmonary bypass time, min	99 ± 33	112 ± 40	.015*[b]
Postoperative data			
Mechanical ventilation time, h	7.3 ± 3.4 (n=152)	9.8 ± 6.6	.005*[b]
Peak of serum troponin, pg/mL	737 ± 655	972 ± 1153	.126[b]
Intensive care unit length of stay, d	2 ± 1	4 ± 3	.004*[b]
Hospital length of stay, d	8 (7–9)	8 (7–11)	.006*[a]

Continuous variables are expressed as means ± SD or as medians (interquartile ranges). Categorical variables are expressed as numbers (percentages). Number of patients with available data are mentioned between brackets.

Abbreviations: CABG: coronary artery bypass grafting; EEG, electroencephalogram; EuroSCORE, European System for Cardiac Operative Risk Evaluation.

* $P < .05$. *P*-values refer to group comparisons by

[a]Mann-Whitney *U* test;

[b]Student *t* test;

[c]χ^2 test.

could reasonably hypothesize that quantifying frontal mean α-band power as soon as after the induction of anesthesia could be a suitable marker of brain vulnerability, regardless of the type of surgery. However, this hypothesis needs to be confirmed in further trials including different types of surgeries. It also suggests that the higher incidence of POD in cardiac surgery might not only be related to the procedure but also to the patients' predisposing comorbidities, which would make them more vulnerable to postoperative cognitive complications than other patients. Delirious patients in our cohort had lower scores at their preoperative cognitive evaluation.[4,6] This association between lower intraoperative α-band power and preexisting cognitive impairment has already been published.[7,8] Likewise, lower intraoperative frontal α-band power has also been independently associated with a greater comorbidities' load in cardiac surgery patients during general anesthesia maintained with isoflurane.[9]

Additionally, our results indicate that a unique frontal EEG recording of few minutes, without any artifact or suppression epochs, is sufficient for evaluation. This strategy would allow time to initiate preventive strategies (adaptation of intraoperative drugs and dosages, enhancement of delirium risk status among postoperative health care teams), whenever appropriate.[10]

In summary, we showed that, in cardiac surgery with CPB, POD can be predicted by quantifying frontal mean α-band power at any time-point during the procedure, giving the anesthesiologist the opportunity to perform it at the most suitable timing for each case, the sooner, the better. ■

DISCLOSURES

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