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A novel combined Electroencephalographic approach for monitoring neurological complications in neonates with Surgically Treated Congenital Heart Disease (CHD)

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BACKGROUND

Neonates with CHD are at high risk for brain function impairment due to both altered prenatal brain development and postoperative surgical risks (1,2). Subclinical seizures were reported in 5–26% of neonates undergoing cardiac surgery (3). Here, we aimed to investigate neurological alterations in terms of postoperative amplitude-integrated EEG (aEEG) signal characteristics and evolution of aEEG patterns across the segments, by using a novel combined approach with conventional EEG (cEEG) and aEEG. Simultaneous recording of the raw cEEG/aEEG provides a good level of sensitivity and allows for better discrimination of artifacts (4).

METHODS

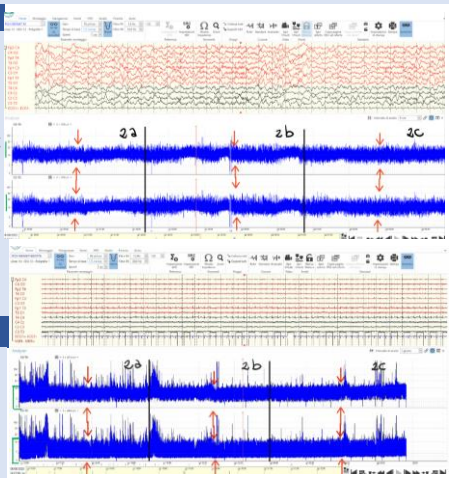
A consecutive cohort of 78 neonates with a diagnosis of CHD was unrolled in our study. All participants underwent a standardized combined cEEG/aEEG monitoring at different three timepoints:

T0: Preoperative VideoEEG/aEEG recording (90–120 minutes);

T1: Postoperative cEEG/aEEG recording within 24–48 hours of surgery (≥11 hours) that we split in three segments: 2A, 2B and 2C (we split the total recording time in the three homogeneous part to observe the evolution);

T2: VideoEEG/aEEG recording 7–10 days post-surgery (90–120 minutes).

We investigated the evolution and variability of aEEG traces in the three segments; the relation between the signal trend in T1 and short-term neurological outcome (alertness, posture, motor function); the correlation between changes in aEEG patterns and surgical complexity (Aristotle BasicScore).



In the pictures above,:, in A a normal S/W pattern, in B a severely altered pattern

RESULTS

A significant association was found between baseline EEG and postoperative aEEG trend ($\chi^2 = 4.10$, p = 0.043). None of the neonates with abnormal baseline EEG improved during postoperative monitoring, whereas 8 of 31 (25.8%) with normal baseline EEG showed improvement across the monitoring thirds. Improving EEG trend was associated with a lower Aristotle Basic Score (8[1]vs.10[2];p=0.040, Figure 4.A). Patients with normal baseline EEG had significantly higher aEEG amplitude ranges in segments 2B (p = 0.004, Figure 4.B) and 2C (p = 0.018, , Figure 4.C). After adjusting for sedative drugs, the difference remained significant in 2C (p = 0.049). Neonates with post-surgical neurological deterioration had narrower amplitude ranges in 2B (p = 0.041, Table 3,Figure 4.D). An amplitude range threshold of 17.5 predicted adverse neurological outcomes with 70.6% sensitivity and 62.9% specificity; a range above 17.5 was associated with a negative predictive value of 81.48% for poor neurological evolution (Table 2, Figure 5).

Table 1. relation between the trend of aEEG monitoring (T1) and Aristole Basic Score

	Trend stabile (media ed intervallo interquartile)	Trend migliorato (media ed intervallo interquartile)
Banda 2A min	4 (2)	3 (1)
Banda 2A maz	24,4 (5)	24 (5)
Banda 2A range	20,3 (5,75)	20,5 (5)
Banda 2B min	4,5 (2)	4,6 (2)
Banda 2B maz	22,8 (5)	26,8 (10)
Banda 2B range	18,4 (4)	22,3 (10)
Banda 2C min	4,2 (2)	4,5 (1)
Banda 2C maz	23,2 (5)	25 (0)
Banda 2C range	19 (4.75)	20,5 (3)
Aristotele Basic Score	10 (4)	8 (3)

Relazione tra trend monitoraggio aEEG entro 24-48 ore dal termine di intervento CHD ed Aristotle s

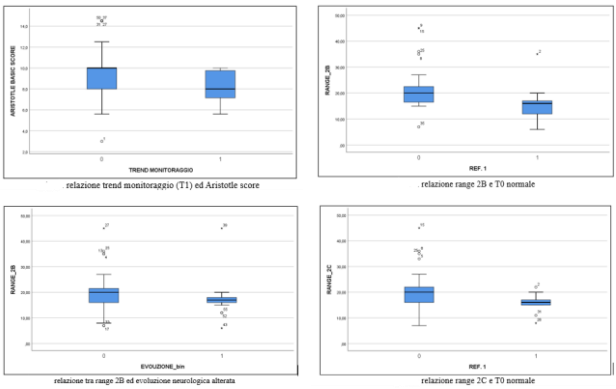


Figure 4. Box plots showing the following differences: A. Aristotele Basic score between neonates with improving EEG trends and not improving EEG trends; B. EEG amplitude in sgments 2B between neonates with normal and abnormal EEG at baseline; C. EEG amplitude in sgments 2B between neonates with normal and abnormal EEG at baseline ; D. Amplitude range in 2B segment in neonates with and without post-surgical deterioration

Table 3. relation between adverse neurological outcome and amplitude range of the segment 2B in T1 -

	Referto 2B Outcome neurologico favorevole (media ed intervallo interquartile)	Referto 2B Outcome neurologico sfavorevole (media ed intervallo interquartile)
Banda 2B min	4,54 (1)	4,53 (2)
Banda 2B maz	24,6 (5)	22,1 (5)
Banda 2B range	20 (6)	17,5 (2,5)

: Relazione tra esito neurologico sfavorevole e range di ampiezza della banda 2B del monitoraggio aEEG entro 24-48 ore dal termine di intervento CHD

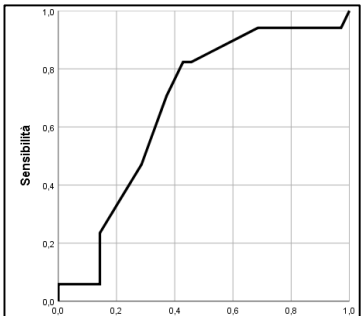


Table 2	
accuracy	65.38%
sensitivity	70.59%
specificity	62.86%
PPV	48.00%
NPV	81.48%

Figure 5. Table 2. ROC curve testing the accuracy of the amplitude range in predicting adverse neurological outcomes

CONCLUSIONS

Our preliminary results suggest that aEEG amplitude range and the trend evolution may be associated with surgical complexity and short-term neurological outcome. Early long-term combined cEEG/aEEG monitoring within 24–48 hours post-surgery may provide relevant prognostic information on neurological trends in neonates with CHD, that can be useful in clinical practice.

REFERENCES

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