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ELECTROENCEPHALOGRAPHY DURING OUT-OF-HOSPITAL CARDIOPULMONARY RESUSCITATION

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☐ **Abstract—Background: At the present time there is no parameter that can estimate the quality of cerebral perfusion and possible success of cerebral resuscitation during advanced cardiac life support (ACLS) efforts. In recent years, various attempts have been made to use electroencephalography (EEG)-based cerebral neuromonitoring to assess the effectiveness of cardiopulmonary resuscitation (CPR). Objectives: The Cerebral State Monitor M3 (Danmeter A/S, Odense, Denmark) is a portable, single-channel EEG monitor that provides the user with different EEG-based parameters and the raw waveform EEG to measure cerebral activity. Case Report: We report two cases of out-of-hospital CPR with single-channel EEG monitoring conducted parallel to ACLS with external chest compressions. We demonstrate an artifact in waveform EEG recordings that is caused by the external chest compressions, and that leads to a miscalculation of the Burst Suppression Ratio and Cerebral State Index. Conclusion: These cases suggest that digitally processed EEG-monitoring is not a useful tool during CPR.** © 2012 Elsevier Inc.

☐ **Keywords—advanced cardiac life support (ACLS); brain ischemia; cardiopulmonary resuscitation (CPR); external chest compression; EEG monitoring**

INTRODUCTION

At the present time, there is no parameter that can reliably estimate the quality of cerebral perfusion during advanced cardiac life support (ACLS) efforts on-scene (1). In the last few years, various attempts have been described to use electroencephalography (EEG)-based cerebral neuromonitoring to assess the effectiveness of cardiopulmonary resuscitation (CPR) with internal as well as external chest compressions (2–10).

The Cerebral State Monitor M3 (CSM; Danmeter A/S, Odense, Denmark) is a portable, single-channel, continuous EEG monitor providing the user with several digitally processed parameters, as well as the raw waveform EEG. The Burst Suppression ratio (BS%) is the percentage of time periods of very low EEG activity; a high value is related to severe encephalopathy, drug-induced coma, or cerebral hypoperfusion. The Cerebral State Index (CSI) is a non-dimensional index scaled between 0 and 100 that corresponds to level of consciousness, used for the assessment of depth of sedation during anesthesia (11,12). Furthermore, there are reports suggesting that the CSI can objectively observe the increase of electrical brain activity after optimal and sustained chest compressions during resuscitation maneuvers (2,3).

We present two cases to demonstrate the changes of CSI, BS%, and the EEG waveform seen during out-of-hospital CPR with external manual chest compressions. The CSM was carried along by an emergency physician on an emergency ambulance based within an urban inner-city area.

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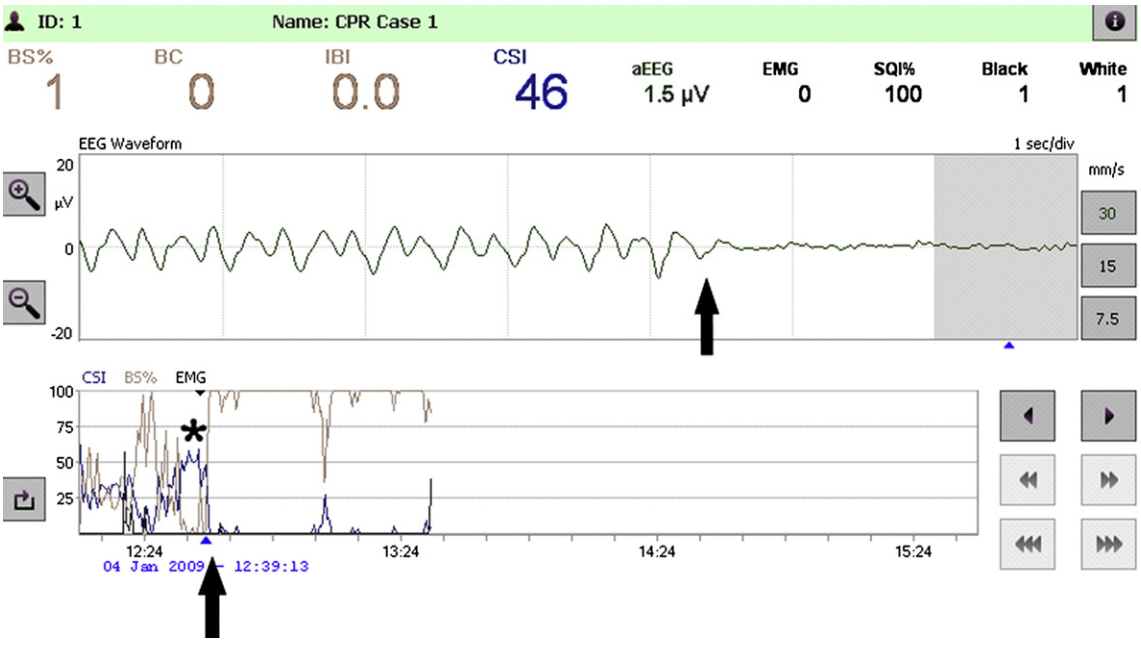

Figure 1. Offline review of the electroencephalogram (EEG) recording during cardiopulmonary resuscitation in case 1 at the moment when chest compressions were discontinued. The spontaneous waveform EEG over a time period of 7 s is shown in the upper graph. The trends of the Cerebral State Index (CSI, blue line) and Burst Suppression Ratio (BS%, brown line) are shown in the bottom graph. Note the maximum of CSI of 54 (*) and the decrease after cessation of chest compressions marked with the arrow (↑) beneath the bottom graph.

CASE REPORT

Case 1

A 37-year-old woman had a witnessed cardiac arrest at her home. EEG recordings were started upon arrival of the anesthesiologist-manned rescue ambulance, parallel to the initiation of ACLS, according to the International Liaison Committee on Resuscitation (ILCOR) Guidelines. After successful CPR, the patient was mechanically ventilated and transferred to the nearest hospital.

EEG recordings were analyzed off-line and compared with the recorded CPR efforts. The waveform EEG clearly showed a rhythmical artifact caused by the external chest compressions. The CSI increased until it reached a maximum of 54, but immediately dropped to zero when chest compressions were discontinued after restoration of spontaneous circulation (ROSC). The BS % ranged between 100% and 0%, but was measured 100% after ROSC due to the isoelectric EEG. Nevertheless, 99% of the recording time was free of alarm signals by the EEG monitoring device and there was no artifact detected by the device. Figure 1 shows the artifact from external chest compressions in the waveform EEG at the moment when chest compressions were stopped after ROSC, followed by the isoelectric EEG in the upper graph. The trends of BS% and CSI are displayed in the bottom graph. In the subsequent clinical course, the patient did not awaken, but stayed in a vegetative state.

Case 2

A 66-year-old man was found unconscious in his home and CPR was performed following the ILCOR Guidelines. Because ROSC could not be achieved, ACLS efforts were abandoned after 30 min of CPR while the electrocardiogram showed persistent asystole.

EEG recordings were initiated upon arrival of the emergency team and, similar to Case 1, the CSI increased during CPR maneuvers to a maximum of 60 but dropped to 0 after the cessation of CPR efforts. The BS% ranged between 0% and 39% during CPR and was calculated at 100% when chest compressions were stopped. Once again, there was no artifact detected by the device for 99% of the recording time. Figure 2 shows the artifact from chest compressions in the EEG waveform in the upper window at the time when CPR efforts were abandoned, and the progression of CSI and BS% during this unsuccessful CPR is shown in the graph below. When the artifact from chest compressions disappears, the isoelectric EEG is clearly visible.

DISCUSSION

The mechanical artifact caused by the external chest compressions created a misinterpretation by the device, which consecutively led to a falsely low BS% and a rise in the CSI up to a maximum of 60. The increase of the CSI