Comparison of electrode technologies for portable EEG monitoring

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Abstract— This paper presents a comparison of novel and versatile EEG electrode technologies for use in a rapid, portable and low-cost EEG monitoring system in neonatal intensive care units in resource limited settings. Several designs incorporating wet and dry components are compared. It is shown that high quality EEG is achievable using dry electrode setups.

I. INTRODUCTION

Neonatal brain injuries are a serious concern for clinicians and parents [1]. Continuous electroencephalography (EEG) monitoring remains the only method to accurately detect all brain abnormalities. However, EEG equipment is expensive and substantial training is required to acquire and interpret EEG signals. In critical cases, vital time is lost due to the complexity of preparing the patient for EEG monitoring [2]. A rapid, low-cost solution for assessing brain health in newborns in all healthcare settings is urgently required. This paper focuses on the sensor design component of a low-density channel acquisition system for portable EEG recording with minimal patient preparation. In particular, this work assesses the practicality and quality of dry, no-preparation electrodes versus the wet EEG setup, which requires the use of abrasive and conductive creams to acquire accurate EEG.

II. METHODOLOGY

In this work, the comparison was performed among the Ambu Neuroline 700 electrodes which represent the current gold standard of neonatal EEG acquisition, Cognionics Flex sensors which are designed to push hair aside in order to establish a good contact with scalp, and micro-needle array electrodes which penetrate the stratum corneum layer [3]. The electrodes were compared in dry and wet conditions, with the latter achieved with the usage of NuPrep abrasive cream and the Ten20 conductive gel. In order to compare the performance of the electrodes, the alpha rhythm (8-13 Hz) in the EEG acquired from occipital region, was quantified. The alpha rhythm is present when visual processing is not being completed by the brain. The test subject was asked to keep the eyes open for 30 seconds and then close their eyes for 30 seconds and repeat. The results were obtained using the OpenBCI V3-32bit board for amplification and digital conversion. Each EEG segment was filtered between 0.5 and 40 Hz and segmented into 2s epochs with 25% overlap between epochs. The short-time Fourier transform was applied to each epoch resulting in spectral distributions from which the power in the alpha band was calculated. The test was repeated twice on a healthy adult, and the mean values were used for comparison.

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III. RESULTS & DISCUSSION

Fig 1 presents the mean spectral envelope with the eyes open and eyes closed along with the 95% confidence intervals for each tested electrode. The percentage increase in the alpha band power is also computed. It can be seen that apart from the Ambu Dry, all other electrode setups result in statistically significant difference in the alpha-band powers. Among the dry electrode setups, the microneedle electrode achieves the highest gain in the alpha band power, which is comparable to the gold standard (Ambu Wet). These results confirm that a dry system can be used without degradation in EEG quality and represent a positive step towards the development of a portable neonatal brain stethoscope for rapid sound-based assessment of neonatal brain health [4].

REFERENCES