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EDITORIAL (INVITED)

Cerebral response to obstructive apnea: the times they are a-changin'

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The response of the human brain to obstructive respiration during sleep is dynamic and is likely dependent on several different factors. The neural response, at least that measurable by surface electroencephalography (EEG), seems to be most in adults, less in children, and least in infants [1, 2]. This blunted arousal response to apnea in infants and children may act to protect the developing brain from the ill-effects of arousal. In this month's issue of *Sleep and Breathing*, Yang et al. further explore the arousal response of the childhood brain to obstructive respiratory events by using EEG spectral analysis [3]. The authors analyzed EEG before, during, and after respiratory events with spectral analysis, comparing events with and without association to EEG cortical arousal. While events associated with cortical arousal expectedly showed a decrease in delta and theta power, no such decrease was observed with events without obvious arousal. This study importantly confirms prior findings of decreased arousal response to apnea in the pediatric population. Furthermore, it provides reassurance that careful human scoring of EEG arousal is likely sufficient.

It is important to note that these results differ from the findings of Gozal et al. in 2000 [4]. This group looked at the EEG response in pediatric obstructive sleep apnea to respiratory events occurring during rapid eye movement (REM) sleep. They found that delta power was highest before and after respiratory events and lowest during an obstructive event, differing from the results of the Yang study. There are important differences in design between the two studies which may account for the divergent findings. Gozal looked only at events during REM sleep, while Yang combined respiratory events that occurred during REM and non-rapid eye movement (NREM) sleep; furthermore, Gozal used children ages 2 to 8 years, while the Yang study included children between 7 and 12 years. The latter difference is likely the most significant as the adolescent brain shows a decreased delta power spectrum compared to the toddler's [5]. In this way, the younger brain may have more delta pressure and be more likely to increase delta power in response to a stimulus external to the brain, in this case, apnea.

The difference seen in these two studies highlights the need for additional research in the neural EEG response to obstructive respirations across multiple age groups. In the absence of obvious arousal response, does this increased delta power, in response to apnea, gradually disappear with age? And if so, does this happen in both REM and NREM sleep? These are some questions that are important to answer. Yet, there are other factors that likely affect the arousal response to apnea other than age, some examples being gender, sleep debt, duration of sleep up to the point of the event, and likely, a host of undetermined genetic factors [6]. Perhaps as one ages and the delta power decreases, these genetic factors more strongly predict arousability than age does.

One other important point to mention when considering the EEG response to respiratory obstruction is the means by which the cerebral response is being measured. EEG can be a powerful clinical tool giving care providers information regarding arousal state. It is amazing to think that this technology has been used for almost a century and, still,

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without much modification to the method, is the gold standard to determine vigilance state [7]. Although a powerful tool, it is undoubtedly a crude measure of cerebral activity. Using EEG to characterize the cerebral arousal response to obstructive respiration is a good start and the lessons learned from such study are important. However, further investigation with more sensitive measures will be needed in future studies to clarify this important and interesting question.

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