Slow-wave correlates of anesthesia-induced unconsciousness in infants

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Video Abstract

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Abstract

How humans lose consciousness under anesthesia is a bit of a mystery, but that's especially true in the case of young infants. Scientists have known that in adults, fast alpha-wave frequencies in the electroencephalogram, or EEG, appear when someone undergoes anesthesia and loses consciousness. But that doesn't happen in infants younger than about 4 months. So, how do young infants lose consciousness? Because awake infants do show slow delta-wave frequencies, a team at the University of Cambridge and Harvard Medical School and Boston Children's Hospital decided to investigate those waves. Now, in a new article in the journal Anesthesiology, the researchers report that infants lost slow-wave synchronization—or "functional connectivity"—between the frontal and parietal regions of their brains when they underwent anesthesia. There is evidence that during anesthesia, the adult brain reorganizes itself into a less complex configuration with more segregation between functional systems. For this reason, the team hypothesized that infant brain networks would also become less complex and more fragmented. To find out, the group took EEG recordings from 20 infants under the age of four months who were anesthetized with the volatile anesthetic sevoflurane for elective surgery. Comparing the recordings during surgery and as the babies emerged from anesthesia, the group then looked for brain-network changes using graph theory, modeling pairwise relations between different brain areas. They found that functional connectivity was lower during anesthesia relative to emergence. Similarly, modularity, a measure of brain segregation, was higher. This indicates that during anesthesia, infant brain networks become more fragmented. Slow-wave delta frequencies also demonstrated less overall complexity—specifically, reduced richness of connectivity across the entire brain. The findings suggest that in infants, as in adults, anesthesia-induced unconsciousness is driven by dramatic synchronization changes. In particular, the frontoparietal regions lost connectivity with other parts of the brain, including the posterior cingulate – which may explain how infants become unconscious during anesthesia. The results add to physicians' understanding of how very young infants lose consciousness, and may be valuable clinically. Connectivity changes in delta oscillations, detected through careful monitoring of EEG data in the pediatric OR, thus may serve as an indicator of anesthetic depth in infants. Future studies with a larger cohort might allow researchers to investigate whether these preliminary findings can be confirmed, as well as the role of anesthetic concentrations and variability among individuals.