Identifying Optimal Blood Pressure for Cerebral Autoregulation in Neonatal Hypoxic Ischemic Encephalopathy

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Background: Neonatal hypoxic ischemic encephalopathy (HIE) causes severe neurologic injuries. Cerebral autoregulation maintains relatively constant cerebral blood flow despite variations in blood pressure and protects the brain from pressure-passive blood flow. Little is known about the optimal blood pressure ranges that support autoregulation in neonates. Hemodynamic instability and sub-optimal blood pressure management may compromise autoregulation and risk further ischemia. We propose a novel method of autoregulation monitoring with near-infrared spectroscopy (NIRS) that can identify optimal mean arterial blood pressure (MAP) ranges that support autoregulation. We present preliminary results of an ongoing pilot study.

Methods: In an observational pilot study in a tertiary level NICU, term infants with HIE had autoregulation monitoring with the cerebral oximetry index (COx) during therapeutic hypothermia, rewarming, and normothermia. COx was continuously calculated by a correlation coefficient between MAP and cerebral oximetry with a bedside computer and ICM+ software. COx is a continuous variable that ranges from -1 to +1. Negative or near-zero COx represents functional autoregulation. When autoregulation becomes impaired with hypotension, COx becomes increasingly more positive. Mean values of COx were sorted into 5-mmHg bins of MAP. The optimal MAP with most robust autoregulatory function was defined as the 5-mmHg bin of MAP with an identifiable COx nadir. (Fig. 1a, 1b) Infants received standard brain MRIs after completion of rewarming.

Results: Thirteen infants were enrolled in the study. Mean Apgar scores at 1, 5, and 10 minutes were 3 (±2), 4 (±2), and 6 (±2), respectively. Cord blood gas pH was 7.00 (±0.08). Autoregulation monitoring with COx identified an optimal MAP range with optimal autoregulation in 8/13 (62%) infants during hypothermia, 7/12 (58%) infants during rewarming, and 8/11 (73%) infants during normothermia. Optimal MAP was 55 (±10) mmHg during hypothermia, 50 (±9) mmHg during rewarming, and 53 (±8) mmHg during normothermia. During hypothermia and rewarming, some infants spent a greater percentage of time with blood pressure that deviated >5 mmHg from the optimal MAP range. (Fig. 1c) Brain MRIs obtained on day of life 10 (±3) showed abnormalities in 10 infants (77%).

Discussion: Cerebral autoregulation can be continuously monitored with the NIRS-derived index COx. Autoregulation monitoring with NIRS can enable clinicians to identify and target optimal blood pressure ranges to support autoregulation. This is particularly relevant during periods of greater hemodynamic variability, such as during hypothermia and rewarming. This technique is easy to use and interpret, and promises to be a bedside tool to guide neuroprotective hemodynamic management in critically ill infants with hypoxic brain injuries.

References
Figure 1. (A) Mean arterial blood pressure (MAP) recording during 24h of therapeutic hypothermia in a neonatal patient with HIE. (B) The cerebral oximetry index (COx) was most negative at the MAP bin of 60 mmHg. Therefore, this patient's "optimal MAP" where autoregulation was most robust occurred at MAP 60 mmHg. (C) In patients with an identifiable optimal MAP, more time was spent with blood pressure outside the optimal MAP range during hypothermia and rewarming.