Neonatal cerebrovascular autoregulation

Because infants are exquisitely sensitive to changes in cerebral blood flow (CBF), both hypoperfusion and hyperperfusion can cause significant neurologic injury.

Rhee et al. reviewed neonate pressure autoregulation and autoregulation monitoring techniques with a focus on brain protection. Current clinical therapies have failed to fully prevent permanent brain injuries in neonates. Adjuvant treatments that support and optimize autoregulation may improve neurologic outcomes [1].

Very low birth weight (VLBW) preterm infants are at risk for impaired cerebral autoregulation with pressure passive blood flow. Fluctuations in cerebral perfusion may occur in infants with a hemodynamically significant patent ductus arteriosus (hsPDA), especially during ductal closure.

A prospective observational study enrolled 28 VLBW infants with an hsPDA diagnosed by echocardiography and 12 control VLBW infants without an hsPDA. Near-infrared spectroscopy cerebral monitoring was applied during conservative treatment, indomethacin treatment, or surgical ligation. A cerebral pressure passivity index (PPI) was calculated, and PPI differences were compared using a mixed-effects regression model. Cranial ultrasound and magnetic resonance imaging data were also assessed.

Infants with surgically ligated hsPDAs were more likely to have had a greater PPI within 2 hours following ligation than were those treated with conservative management (P=.04) or indomethacin (P=.0007). These differences resolved by 6 hours after treatment.

Cerebral autoregulation was better preserved after indomethacin treatment of an hsPDA compared with surgical ligation. Infants requiring surgical hsPDA ligation may be at increased risk for cerebral pressure passivity in the 6 hours following surgery [2].

The sick newborn infant is vulnerable to brain injury and impaired cerebral autoregulation is thought to contribute to this. Coherent averaging is a method of measuring the dynamic cerebral autoregulatory response that is particularly suitable for neonates. We used this method in combination with a measure of the gradient of the cerebral blood flow velocity (CBFV) response following transient blood pressure (BP) peaks to study dynamic autoregulation in infants undergoing intensive care. Term and preterm infants at high risk of neurologic injury were compared with a control group of infants, also undergoing intensive care. Simultaneous video-EEG, CBFV (using transcranial Doppler), and arterial blood pressure measurements were obtained intermittently during a study period of at least 2 h. Cerebral autoregulatory response curves were constructed for high risk and control groups. Intact cerebral autoregulation produces a characteristic response consisting of a brief period when CBFV follows arterial blood pressure but quickly returns to baseline value. An impaired autoregulatory response shows CBFV mirroring the arterial blood pressure curve closely. Thirteen high-risk infants, who also had seizures (10 term and 3 preterm) and 12 control infants (6 term and 6 preterm) were studied. Autoregulation was absent in high-risk term and preterm infants. It was also absent in preterm control infants. Term, neurologically healthy infants undergoing intensive care have an intact autoregulatory response. The constant passive response seen in high-risk infants may reflect the severity of the underlying neurologic disease [3].

Cerebral blood flow velocity was measured with Doppler ultrasonography in one middle cerebral artery for 5-minute periods in 33 babies of gestational age < 33 weeks admitted to a neonatal intensive care unit. Two methods of evaluating autoregulation were developed. The first used linear regression analysis of blood flow velocity on blood pressure. Records were classified as showing loss of autoregulation if the regression slope was greater than a critical value. A minimum change in mean arterial blood pressure of 5 mm Hg and a critical slope of 1.5%/mm Hg were found to be adequate criteria for the classification of records by the regression method. The second method used coherent averaging, a technique similar to that used in recording evoked potentials. Spontaneous transient increases in blood pressure were automatically detected, and the instant corresponding to its maximum rate of rise was used to synchronize averages of the blood pressure and blood velocity transients. The resulting coherent averages were classified into two groups based on the morphology of the cerebral blood flow velocity average.

Whereas the regression method allowed the classification of only 51 of 106 records, the coherent average method classified 101 of 106 (95.3%) of the records available. For 51 records that were classified by both methods, there was agreement in 42 cases (82.3%). The coherent average of all records classified as having an active autoregulation showed cerebral blood flow velocity returning to baseline much earlier than blood pressure, suggesting that autoregulation was taking place within 1 to 2 seconds. This pattern was absent in records in which autoregulation was classified as absent.

Computerized coherent averaging of the cerebral blood flow velocity response to spontaneous blood pressure transients offers a promising new method for noninvasive bedside assessment of autoregulation in patients undergoing intensive care. The time course for autoregulation, when present, is in agreement with that reported in adults [4].

The low frequency cerebral blood flow velocity (CBFV) oscillations in neonates are commonly attributed to an under-dampened immature linear type cerebral autoregulation, and the 'instability' is regarded as causative for periventricular intraventricular hemorrhage/periventricular leukomalacia. In contrast, oscillations susceptible to frequency entrainment are a fundamental part of the stable function of non-linear control systems. To classify the autoregulation an observational study was done on the relationship between CBFV oscillations, heart rate variability, and artificial ventilation. In 10 preterm neonates (gestational age 26 to 35 weeks) we serially Doppler traced arterial CBFV continuously for 12 minutes between days 1 and 49 of life. The individual time series of CBFV and heart rate were subjected to spectral analysis. Forty six of 47 tracings showed significant low frequency CBFV oscillations. Low frequency heart rate oscillations were not a prerequisite thereof. All patients with < 30% of total power in the low frequency band of CBFV oscillations were on the ventilator. Three of them demonstrated a shift of spectral power from low frequency to a frequency equal or harmonic to the ventilator rate indicating entrainment. The findings of CBFV oscillations combined with entrainment classify the autoregulation as a non-linear system. It is suggested that entrainment by periodic high amplitude stimuli might challenge the regulatory capacity to its limits thus increasing the risk for cerebral damage [5].

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