Cerebral Blood Flow Velocities in Newborn Infants with Perinatal Asphyxia
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Abstract:

The cerebrovascular hemodynamic alteration in asphyxia and intraventricular hemorrhage in newborn infants were determined by monitoring the pulsatile flow changes in the anterior cerebral arteries using Doppler ultrasound. The pulsatility index measurements, which were calculated from the recorded changes in Doppler frequency shifts, were obtained in four groups of newborn infants, each comprising 20, with the following diagnoses: Group I normal term, Group II asphyxia, Group III IVH, Group IV asymptomatic preterm. There was no significant difference between the PI values of groups I and IV. Compared to normal term infants, those diagnosed as having asphyxia had significantly lower PI measurements and those with IVH had significantly higher PI values. The low PI values in asphyxia and prior to the onset of IVH indicate vasodilatation and decreased resistance to blood flow. In IVH, the high PI values denote the opposite.

Abbreviations: PI = Pulsatility index; S = Mean systolic amplitude; D = mean diastolic amplitude; CBF = Cerebral blood flow; IVH = Intraventricular hemorrhage; AGA = Appropriate for gestational age.

Introduction:

Neonatal asphyxia and intracerebral-intraventricular hemorrhage are both associated with high morbidity and mortality. Intracerebral-intraventricular hemorrhage remains a poorly understood condition despite the many studies designed to explain its etiology. Based on neonatal brain perfusion studies, it has been suggested that IVH results from the transmission of elevated arterial pressure into the thin-walled capillaries in the germinal matrix. The proposed pathogenesis has generated some controversy since the major pathologic findings demonstrated by other investigators involved the cerebral venous system.

To have a better understanding of asphyxia and IVH, we applied the transcutaneous Doppler technique to evaluate infants with these disorders. Through the anterior fontanel of the newborn infant, it is possible to study the pulsatile flow in the anterior cerebral arteries. Since these arteries are located intracranially, the changes in the flow velocity/time profile are indicative of alterations in the neonatal cerebrovascular circulation. The objective of our study is to determine the usefulness of the technique for diagnosis of asphyxia and IC-IVH and to define the associated cerebrovascular hemodynamics alterations in neonatal IC-IVH, testing the hypothesis that hyperperfusion precedes IVH.

Subjects and Methods:

The study comprised 4 groups of newborn infants, each consisted of 20 infants from both sexes. Group I comprised normal term AGA infants born after uncomplicated pregnancy and delivery. Group II comprised 20 term AGA infants with asphyxia. They all had a one minute Apgar score of 5 or less and all required resuscitation by intermittent positive pressure ventilation. Group III included 20 preterm AGA infants with IVH confirmed by ultrasonographic examination. Group IV included 20 normal preterm AGA newborn infants with no IVH as confirmed by ultrasonographic examination.

A bi-directional Doppler flow was used. The ultrasonic transducer, having a natural frequency of 5 MHz. The bi-directional probe was placed on the anterior fontanel and directed toward either anterior cerebral artery as it coursed along the longitudinal fissure.

From the recorded changes in Doppler frequency shifts, the mean systolic amplitude and the mean diastolic amplitude were determined. The pulsatility index (PI) was calculated for both the right and left sides using the formula PI = (S-D)/S. This formula was adapted from Pourcelot's index of resistance. We preferred to use this formula rather than that of Gosling (PI = (S-D)/M) where M is the mean velocity. Computation of PI was preferred than only recording the velocity since peak frequency shifts may vary with probe placements.
Results:

The PI values are shown in Table I. The measurements obtained from the right side did not differ significantly from those obtained from the left side. There was no significant difference between the PI values of groups I (normal term) and IV (normal preterm). The infants with asphyxia (group II) had significantly lower PI values than did normal term infants (group I) \( (p < 0.001) \). Infants with IVH (group III) had significantly higher PI values than asymptomatic preterm infants (group IV) \( (p < 0.001) \).

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<tr>
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<th>Group I (term)</th>
<th>Group II (asphyxia)</th>
<th>Group III (IVH)</th>
<th>Group IV (preterm)</th>
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<td>n</td>
<td>20</td>
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<td>20</td>
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<tr>
<td>Mean PI</td>
<td>0.76</td>
<td>0.59</td>
<td>0.96</td>
<td>0.74</td>
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<tr>
<td>SD</td>
<td>0.16</td>
<td>0.13</td>
<td>0.08</td>
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<td>t-test</td>
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<td>Gp I Vs Gp IV, ( t=0.41 )</td>
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<td>Gp I Vs Gp II, ( t=3.7^* )</td>
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<td>Gp I Vs Gp III, ( t=5^* )</td>
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* Significant \( p<0.05 \)

Discussion:

The transcutaneous Doppler technique is currently utilized in adults for diagnosis of peripheral vascular disease and cerebrovascular disorders. In obstetrics McCallum et al. have studied flow velocity patterns obtained from the umbilical arteries to complement the routine biophysical monitoring. They observed in fetuses of diabetic mothers that zero forward flow velocity during diastole appeared to have important prognostic significance. In children, the Doppler technique is sued mainly for blood pressure measurements and cardiac diagnosis. It has not been previously frequently applied to the diagnosis of neonatal asphyxia and IVH.

The cerebral Doppler flow velocity profile differs from that of the peripheral circulation because of the low resistance of the cerebrovascular bed. Under normal conditions, a forward or advancing diastolic flow is recorded from the anterior cerebral arteries, similar to the tracings obtained from the internal carotid arteries. The calculated PI values in our study actually denote the degree of resistance to CBF. A low PI, therefore refers to a decreased resistance, where a high PI implies increased resistance.

Compared to normal term infants, the forward diastolic flow velocities recorded in infants with asphyxia were significantly higher, accounting for the lower calculated PI values. The increased diastolic amplitude indicates vasodilatation, most likely the result of hypoxia, acidosis or hypercarbia; the biochemical changes of asphyxia. Recent data in experimental animals show that CBF increases significantly with acidosis and hypercarbia.

In IVH, the flow velocity pattern in most instances showed a zero diastolic amplitude i.e. vasoconstriction. Arterial vasospasm within the area of hemorrhage and at distal arterial branches has not been previously associated with neonatal IVH but is well recognized in adults with intracranial hemorrhage. The vascular hemodynamic alterations need to be correlated with other clinical variables such as systemic arterial pressure changes, blood gas values and the site and the degree of intracranial hemorrhage. If vasospasm proves to be a consistent finding, it could have important prognostic implications in terms of the effects of hypoxemia on survival and the long-term neurologic outcome of infants with IVH. Moreover, the pharmacologic prevention and treatment of this complication should be explored.

Another observation, which is quite disturbing, is the persistence of vasodilatation after recovery from asphyxia or hypoxia. This persistent vasodilatation may be explained by the impairment of autoregulation of CBF. With continuing vasodilatation, CBF may increase to excessive levels resulting in rupture of the thin-walled capillaries and veins in the subependymal region of the grey-white matter.
the choroid plexus. It appears that cerebral hyperperfusion is an important factor in the pathogenesis of neonatal IVH. In the treatment of shock or metabolic acidosis in infants with respiratory distress, the slow administration of plasma expanders and hyperosmolar solutions might help to prevent a sudden increase in circulating volume, cerebral hyperperfusion and IVH.\(^{(19)}\)

References:
