Cerebral Blood-Flow Velocity During the First Five Days of Life of Asphyxiated and Healthy Infants

C. Zuhal **ERDEM**[1], Ceyda **ACUN**[2], L. Oktay **ERDEM**[1], Süreyya **ÖZBEK**[3], Ege **SÜZER**[4]

[1] Karaelmas University Faculty of Medicine, Department of Radiology, [2]Department of Pediatrics, Zonguldak, Turkey
[3] Ege University Faculty of Medicine, Department of Radiology, İzmir, Turkey
[4] SSK Tepecik Training Hospital, Department of Radiology, İzmir, Turkey

Abstract

Objective: In order to evaluate the cerebral blood flow velocity in asphyxiated newborns, to compare these values with the healthy newborns and to find out the most important parameter which supports the diagnosis of asphyxia.

Materials and Methods: Peak systolic velocity and end diastolic velocity were measured by the duplex Doppler ultrasonography in the anterior and median cerebral arteries in 60 asphyxiated and 50 healty term infants in the first five days of life. Resistive index and pulsatility index values were calculated. T test and Mann-Whitney test was used for statistical analysis to compare asphy xiated and healthy infants.

Results: Resistive index values were lower in measured vessels in the asphyxiated infants compared with controls. When asphyxiated infants and control group were compared according to ages of infants, blood flow velocities, resistive index and pulsatility index of anterior and median cerebral artery were found to be statistically different ($p<0.05$).

Conclusion: Duplex Doppler ultrasonography measurements may differ significantly in the asphyxiated infants. Therefore, we consider that duplex Doppler ultrasonography may be a useful modality in the diagnosis and follow-up of asphyxiated infants.

Key words: perinatal asphyxia, Doppler ultrasonography

Özet

Asfiksili ve Sağlıklı İnfantlarda Yaşamın İlk 5 Gününde Serebral Kan Akımı Hız Değerleri

Amaç: Asfiksili ve sağlıklı yenidoğanlarda serebral kan akımı değerlerini bularak karşılaştırmak ve asfiksi tanısını destekleyen önemli bir parametre edinmek.

Materyal ve Metot: Dupleks Doppler ultrasonografi ile yaşamın ilk 5 gününde termde doğan 60 asfiksili ve 50 sağlıklı yenidoğanda ön ve orta serebral arterlerden end-diyastolik ve pik sistolik hız ve rezistif indeks ve Pulsatilite indeks değerleri ölçüldü. Asfiksili ve sağlıklı infantların Doppler ölçümlerini karşılaştırmak için T-test ve Mann-Whitney U test kullanıldı.

Sonuçlar: Ölçüm yapılan damarlardan elde edilen rezistif indeks değerleri, asfiktik grupta kontrol grubuna göre anlamlı olarak düşüktür. İnfantların yaşlarına göre karşılaştırıldığında akım hızı değerleri, rezistif indeks ve pulsatilite indeks değerlerinde anlamlı farklılık saptanmıştır.

Tartışma: Dupleks Doppler ultrasonografi ölçümleri asfiktik infantlarda kontrol grubuna göre farklı olabilir. Bu nedenle dupleks Doppler ultrasonografinin asfiktik infantların tanı ve izleminde yararlı bir modalite olabileceği kanısındayız.

Anahtar sözcükler: perinatal asfiksi, Doppler ultrasonografi

Corresponding Author: Dr. Zuhal Erdem
Karaelmas Üniversitesi Tıp Fakültesi Radyoloji AD,
67100, Kozlu, Zonguldak, Türkiye
Tel: +90-372-2610169
Faks: +90-372-2610155
E-posta: sunarerdem@yahoo.com

Table. Comparison of daily values of the mean, minimum and maximum RI values in the anterior cerebral (ACA) and middle cerebral artery (MCA) between the study groups.

	ASPHYXIA					CONTROL				
	N	ACARI		MCARI		N	ACARI		MCARI	
		Mean	Median (Max-Min)	Mean	Median (Max-Min)		Mean	Median (Max-Min)	Mean	Median (Max-Min)
First day	16	0.57	0.58 (0.52-0.62)	0.58	0.59 (0.54-0.62)	13	0.71 (0.63-0.81)	0.71	0.73	0.72 (0.67-0.83)
Second day	11	0.54	0.59 (0.41-0.61)	0.55	0.58 (0.44-0.61)	9	0.69 (0.69-0.72)	0.70	0.71	0.71 (0.70-0.74)
Third day	12	0.55	0.58 (0.42-0.62)	0.56	0.58 (0.44-0.62)	11	0.71 (0.63-0.81)	0.71	0.73	0.72 (0.67-0.83)
Fourth day	12	0.55	0.56 (0.44-0.61)	0.57	0.57 (0.54-0.61)	9	0.68 (0.65-0.75)	0.67	0.70	0.70 (0.63-0.76)
Fifth day	9	0.57	0.60 (0.45-0.62)	0.57	0.60 (0.46-0.62)	8	0.68 (0.65-0.70)	0.69	0.70	0.70 (0.67-0.74)

N: Number of cases.
ACARI: Anterior cerebral artery resistance index.
MCARI: Middle cerebral artery resistance index.

Introduction

Neonatal asphyxia causing hypoxic-ischaemic encephalopathy (HIE) frequently results in the chronic handicapping conditions of cerebral palsy, mental retardation, learning disabilities and epilepsy (1). The pathogenesis of HIE after perinatal asphyxia in term infants is not completely understood, but impaired energy metabolism and disturbed cerebral circulation seem to play a key role in causing brain damage (2).

A diagnosis of intrapartum fetal asphyxia can be provided by blood-gas and acid-base assessments of umblical vein and artery blood at delivery (3). But no specific test excludes or confirms a diagnosis of HIE. The diagnosis is based on history and physical examination. The neurologic injury in perinatal asphyxia has a characteristic course over time. Signs of injury are nonspesific at birth and most indicators take from hours to days before they become manifest (4).

Doppler ultrasonography is a non-invasive method, which allows repeated and safe assessment of neonatal cerebral hemodynamics and shows consistent changes in cerebral blood flow (CBF) velocities in infants with intrapartum asphyxia (5-7).

In this study, we investigated CBF velocities, resistive index (RI) and pulsatility index (PI) in asphyxiated and healthy infants in the first five days of life.

Materials and Methods

This study is performed in SSK Tepecik Training Hospital between 1996 and 1997 and Zonguldak Karaelmas University Faculty of Medicine Hospital between 2000 and 2001. A prospective study was performed on 50 healthy term and 60 asphyxiated term neonates in the first five day of life. Perinatal asphyxia defined as Apgar scores <5 at the 1st minute and <5 at 5th minute of life. Healthy infants defined as Apgar scores >7 at the 1st and 5th minutes of life (8). Infants with major or multiple minor malformations, systemic infections or haemolytic disease were excluded.

Cerebral blood flow velocity recordings were made by color duplex Doppler scanner (Model SSA-270 with 3.75 MHz pulsed wave and 5 MHz imaging crystal, Toshiba, Japan and Model EUB-525 with 3.5 MHz pulsed wave and 5 MHz imaging crystal, Hitachi, Japan). The high-pass filter, used to remove low frequency noise (i.e. vessel wall movement) was set at the level of 50-100 Hz.

Recordings of CBF velocities were made in the supine position 30-60 minutes after feeding. Observations were made when the infants was in the quiet state, eyes closed and with no gross body movements.

Anterior cerebral artery was visualized in the sagittal plane through the anterior fontanel and the signals were recorded from the point midway between the inferior-most border of the corpus callosum and the vessel's origin from the circle of Willisi. Middle cerebral artery was visualized through the temporal bone in the region above the zygomatic arch in the fold of the temporal lobe from the straight mid-portion of the artery (9). The angle correction was performed and the angle was always less than 60°. The data reported represent the average of three determinations. The resistance index (RI)

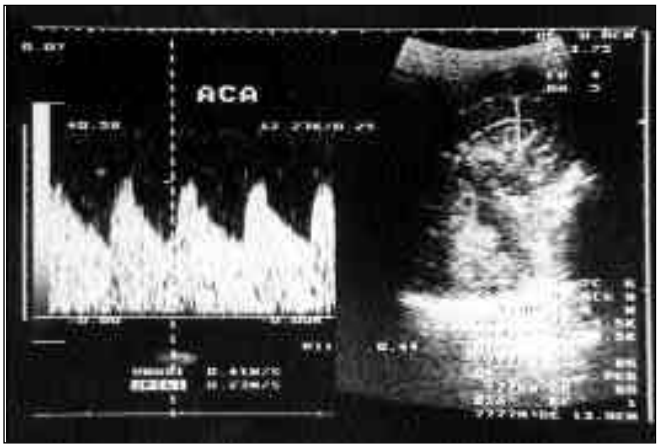

Figure 1. Transcranial duplex Doppler ultrasonography demonstrating a low resistance pattern of the anterior cerebral artery (ACA) in an asphyxiated infant.

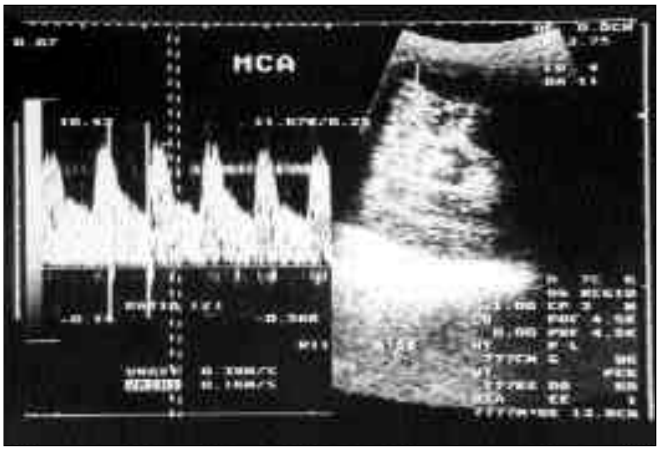

Figure 2. Transcranial duplex Doppler ultrasonography demonstrating a low resistance pattern of the middle cerebral artery (MCA) in an asphyxiated infant.

was calculated according to formula RI=(S-D)/S, and the pulsatility index PI=(S-D)/TAV (time avarage velocity).

T test and Mann-Whitney U test was used for statistical analysis to compare asphyxiated and healty infants. P values of <0.05 were considered statistically significiant.

Results

In asphyxiated neonates gestational age was 39.65±1.17 weeks, in healthy neonates gestational age was 39.60±1.08 weeks. There was no statisticaly significiant difference between the groups (p>0.05).

Asphyxiated and control groups were compared with systolic and end-diastolic peak flow velocities, RI, PI values in anterior and middle cerebral arteries in the first five days of life**.** There was statisticaly significant difference (p<0.05) between the groups in anterior cerebral artery end diastolic flow velocity in the first and fourth days, anterior cerebral artery pulsatility index in the first four days,anterior cerebral artery resistance index in the first five days, middle cerebral artery end diastolic flow velocity in the first, fourth and fifth days, middle cerebral artery peak systolic flow velocity in the fourth day, median cerebral artery pulsatility index in the first, thirth and fourth days, middle cerebral artery resistance index in the first five days.

Resistive index values were lower in measured vessels in the asphyxiated infants compared with controls (Figure 1-2). We determined that RI values of anterior and middle cerebral arteries were 0.63-0.83 in healthy infants and 0.41-0.62 in asphyxiated infants in the first five days of life. Numbers of asphyxiated and healthy neonates and the mean, minimum, maximum RI values for each vessel interrogated are listed on Table.

Discussion

HIE is an important cause of permanent damage to central nervous system cells, which may result in neonatal death or which may be manifest later as cerebral palsy or mental deficiency. The symptoms of HIE develop over the first days of life and exact clinical assessment is complicated as the babies are usually mechanically ventilated and/or sedated. Its prevention and treatment are those of the basic conditions that cause it; death and disability may sometimes be prevented through symptomatic treatment with oxygen or artificial respiration and the correction of associated multiorgan system dysfunction (10). Early recognition of the hypoxic-ischaemic injury is important in guiding management during those critical first days (11).

Imaging findings on ultrasonography (11,12), computed tomography scan (13) or magnetic resonance spectroscopy (14) may be normal despite anoxic injury, if performed on the first day after injury. Neurophysiological methods (somatosensory evoked potentials, visual evoked potentials, cerebral function monitoring) (12) and near-infrared spectroscopy (15) have proved predictive also during the first hours after asphyxic insult, but are not avalaible in all centres. Doppler ultrasonography is a non-invasive method, which allows repeated and safe assessment of neonatal cerebral hemodynamics and shows consistent changes in CBF velocities in infants with intrapartum asphyxia (5-7).

The overbundant cerebral blood-flow relative to the metabolic needs of the brain tissue, so called “luxury-perfusion”, was described by Lassen et al (16). The mechanisms of such luxury cerebral perfusion following ischaemic brain injury are still unclear, although in fetal sheep it is mediated in part by nitric oxide production (17). Neuronal disruption causing a release of vasoactive substances, such as adenosine and lactate, or liberation of excitatory aminoacids, such as glutamate and aspartate (18), irreversibl cerebral vascular injury and complete loss of tone in resistance vessels, may play a role in the pathogenesis (6, 7).

Infants with lower birth gestational ages had lower blood flow velocities (19). The follow velocities of small for dates infants increase more rapidly than do appropriate for dates infants. The maturation of the intracranial vessels may be determinated by gestational age. The most significiant variable was gestational age (20). For this reason, we paid attention in order not to be a significiant difference in gestational age between the groups.

Bada et al. (21), first work in Doppler ultrasonography in neonates showed an initial RI in asphyxia, especially in newborn infants who later developed intracranial hemorrhage. Archer et al. (5) first investigated 36 survivors of intrapartum asphyxia who had undergone intracranial Doppler ultrasonography in the first week of life and they found decrease of the RI. Daneman et al (22) also reported the results of Doppler studies in intracranial vessels in 21 asphyxiated infants. They found an increase in diastolic flow and lowering of the RI to be the usual initial response detectable on day 1. In the same manner, most of Doppler ultrasonography works have shown that high CBF velocities (2,11,13) and low RI, PI velocities (5,11,21,23) in asphyxiated neonates in the first week of life. But, in these studies, CBF, RI and PI velocities were not compared in order to support diagnosis of asphyxiated neonates. In our study, there was statistically significiant difference between the asphyxiated and control groups only in resistive index values which were evaluated in the first five days of life in both anterior cerebral artery and middle cerebral artery.

Having found normal RI values with the doppler method, the clinician can confidently reassure parents that their baby has little risk of death or handicap (5). Seibert et al. (24) reported that mean RI values of the intracranial arteries in term infants were 0.75± 0.10 during the first 24 hours of life. Allison et al. (25) reported that mean RI values of the intracranial arteries in term infants were 0.72± 0.057 during the first 24 hours of life. Stark et al. (11) were established initial RI values ranged 0.23- 0.59 in the 16 neonates with history asphyxia in the first day of life. Archer et al. (5) found no normal infant ever had a value of 0.55 or below during the first five days of life. In our study we determinated that RI values were 0.63- 0.83 in healthy infants and 0.41- 0.62 in asphyxiated infants in the first five days of life. There were studies in order to evaluate the normal RI values in the first day of life, but there were very few studies which present normal RI values between the second and fifth day of life. In spite of the number of the cases in our study was low it is valuable as it shows the normal RI values in healthy neonates in the first five days of life.

Duplex Doppler ultrasonography measurements may differ significantly in the asphyxiated infants. Therefore, we consider that duplex Doppler ultrasonography may be an important modality in the dignosis and follow-up of asphyxiated infants. However, this subject requires more studies.

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