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COLOR DOPPLER EVALUATION OF THE INFLUENCE OF TYPE OF DELIVERY, SEX, POSTNATAL AGE AND TIME POST FEEDING ON FULL TERM HEALTHY NEWBORNS CEREBRAL BLOOD FLOW

Carlos Alberto Aranha[1], Henrique Manoel Lederman[2], Conceição A.M. Segre[3]

Abstract – **Objective:** The purpose of this study was to evaluate with Color Doppler the influence of type of delivery, sex, postnatal age and time post feeding on full term healthy newborns cerebral blood flow. **Method:** 50 newborns were studied. The Doppler parameters, peak-systolic velocity, end-diastolic velocity, mean velocity, pulsatility index and resistance index, were measured in the anterior cerebral artery, middle cerebral artery, posterior cerebral artery, and basilar artery. The data were compared and analyzed by statistical tests. Informed consent was obtained from all parents, and the study was approved by institutional ethical committee and review board. **Results:** We observed not statistically significant differences on cerebral blood flow Doppler parameters in relation to type of delivery, sex, postnatal age and feeding in full term healthy newborns. **Conclusion:** We believe that the knowledge of these cerebral hemodynamic profile of newborns in the first days of life can contribute in an accurate interpretation of cranial Doppler abnormal findings when pathologic flow velocities are analyzed.

KEY WORDS: color Doppler, ultrasonography, cerebral arteries, newborn, blood flow velocity, delivery, sex postnatal age, time post feeding.

Doppler colorido na avaliação da influência do tipo de parto, sexo, idade pós-natal e tempo pós-mamada no fluxo sanguíneo cerebral em recém-nascidos a termo e saudáveis

Resumo – **Objetivo:** O objetivo deste estudo foi avaliar com Doppler colorido a influência do tipo de parto, sexo, idade pós-natal e tempo pós-mamada no fluxo sanguíneo cerebral de recém-nascidos a termo e saudáveis. **Método:** Foram estudados 50 recém-nascidos. A Dopplervelocimetria foi obtida nas artérias cerebral anterior, cerebral média, cerebral posterior e basilar. Os parâmetros foram comparados e analisados pelos testes estatísticos Esta pesquisa foi aprovada pela comissão ética e de pós-graduação das instituições e o consentimento informado dos pais foi obtido em todos os casos. **Resultados:** Não observamos diferenças estatísticamente significativas na Dopplervelocimetria do fluxo sanguíneo cerebral em relação ao tipo de parto, sexo, idade pós-natal e tempo pós-mamada dos recém-nascidos normais e saudáveis estudados. **Conclusão:** Acreditamos que o conhecimento deste perfil hemodinâmico do fluxo sanguíneo cerebral de recém-nascidos nos primeiros dias de vida possa contribuir para uma acurada interpretação dos achados do Doppler cerebral quando alterações patológicas de velocidade do fluxo sanguíneo forem analisadas.

PALAVRAS CHAVE: Doppler colorido, ultra-sonografia, artérias cerebrais, recém-nascido, velocidade de fluxo sanguíneo, parto, sexo, idade, pós-natal, tempo pós-mamada.

Departamento de Diagnóstico por Imagem da Escola Paulista de Medicina da Universidade Federal de São Paulo, São Paulo SP, Brazil: [1]Pós-Graduando em Radiologia Clínica e Ciências Radiológicas; [2]Professor Titular; [3]Livre Docente em Neonatologia pela UNIFESP, Escola Paulista de Medicina. Coordenadora do Curso de Pós-Graduação em Perinatologia do Hospital Israelita Albert Einstein, São Paulo SP, Brasil.

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Dr. Carlos Alberto Aranha – Departamento de Diagnóstico por Imagem da EPM / UNIFESP / Setor de Pós-Graduação - Rua Napoleão de Barros 800 / 1º Subsolo - 04024-002 São Paulo SP - Brasil. E-mail: drcarlosaranha@hotmail.com

It is well known that many cerebral diseases in neonates are of circulatory origin and that fluctuations in cerebral perfusion have been recognized as a major causal factor in the pathogenesis of hemorrhagic and ischemic lesions in the preterm infant. Lou, et al.[1], in their pioneering studies using the 133 Xenon clearance technique, first suggested that some critically ill infants might have a pressure-passive cerebral circulation, thus allowing abrupt changes in arterial blood pressure to be transmitted directly to the brain microvasculature, then infants with impaired regulation in the first 72h of life have a significantly greater incidence of hemorrhagic and ischemic lesions.

Bada, et al.[2] in 1979, was the first investigator to use Doppler ultrasonography in neonates and demonstrated changes in cerebral blood flow velocity (CBFV) and in resistance index (RI) in asphyxiated neonates, particularly in newborn infants who developed intracranial hemorrhage.

Many studies have reported the normal values of CBFV and RI in asymptomatic both preterm and term neonates during the first days of life[3-5]. The CBFV in term healthy newborns increased with increasing gestational age, postnatal age and birthweight, and the RI increased significantly with increasing gestational age[6-8]. However, limited information is available regarding influence of other factors such as type of delivery, sex, postnatal age and feeding on CBFV, RI and pulsatitility index (PI) in neonates.

The purpose of this study was to evaluate with color Doppler the influence of type of delivery, sex, postnatal age and time post feeding on full term healthy newborns cerebral blood flow between 12h and 72h of life.

METHOD

This study was performed in the Department of Diagnostic Imaging of Paulista School of Medicine of Federal University of São Paulo, Brazil, as part of a thesis of postgraduate medical course by first investigator.

We evaluated 50 full term healthy neonates (n=50) that were born at Hospital Albert Einstein, São Paulo, Brazil, with Apgar score 9 and 10 at 5 minutes of life, gestational age between 37 to 41 weeks (mean 38.94 SD±0.87 weeks), birthweight 2.665 to 4.170 grams (mean 3.359 SD±385.30 grams). 37 newborns were born by caesarean section and 13 were born vaginally (normal labor), 23 was male and 27 female, 12 with postnatal age from 12 to 24h (mean 22h), 26 from 24–48h (mean 41h) and 12 from 48–72h of life (mean 66h), 17 newborns were examined 1h after feeding, 24 after 2h and 9 after 3h . All infants were fed three hourly with their mothers'breast milk.

Gestational age was determined according to the mother's obstetric history, date of last menstruation and confirmed by

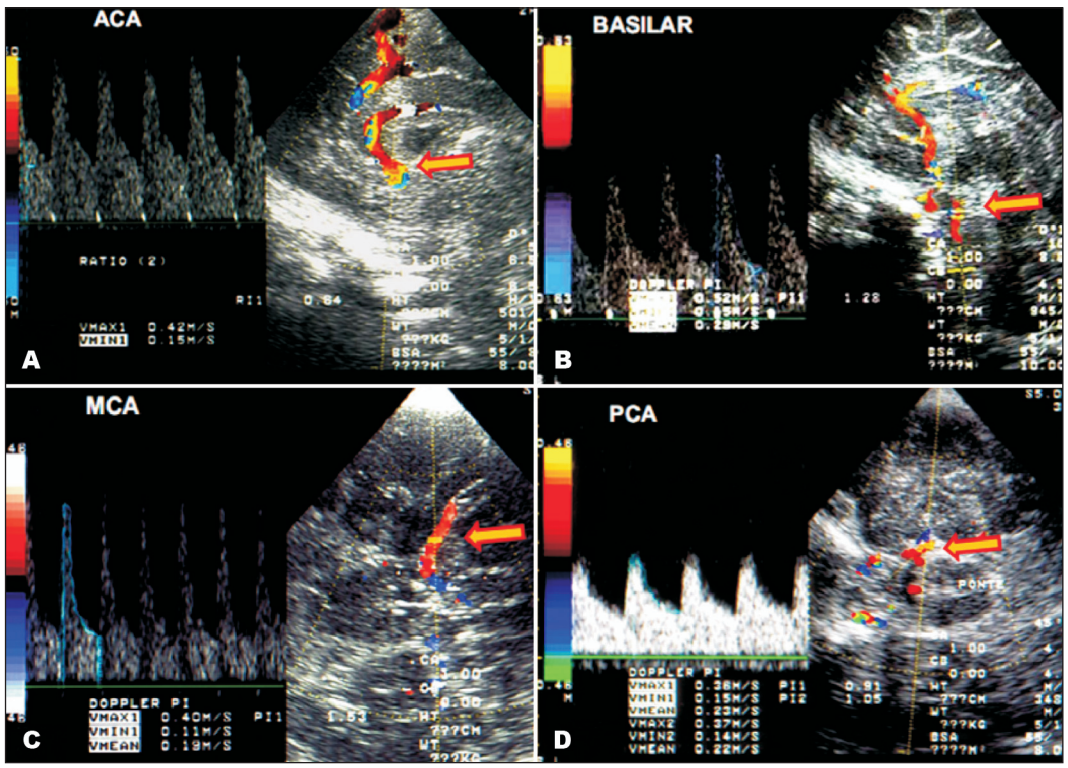

Fig 1. [A] Midline sagittal uplex Doppler scan through anterior fontanel showing on the right the color image of anterior cerebral artery (arrow) and on the left the spectral curve, and in [B] basilar artery (arrow). [C] Transaxial Duplex Doppler scan through temporal bone showing on the right the color image of M1 segment of middle cerebral artery (arrow) and on the left the spectral curve and in [D] posterior cerebral artery (arrow).

somatic physical and neurological examination of the newborn, using the Capurro method. All infants were healthy and hemodynamically stable with normal heart rate, mean arterial blood pressure, pCO2, pO2 and hematocrit.

The newborns were investigated by computer sonography with color Doppler, Acuson 128 XP/10 (Mountain View, USA) and Toshiba SSH-140-A, (Nasu, Japan) with sectorial probes apropriated for neonate head. The transducer created the gray-scale image at a frequency between 5.0 MHz to 7.0 MHz and Doppler at a frequency at 5.0 MHz. The deep of image was set 10 cm, sample volume was set 1 mm or 2 mm, and the color sensitivity and frame rate were optimized. The high-pass filter, used to remove low frequency noise from vessel wall movement, was set at the level of 50–100 Hz. All infants were examined under criterious technical conditions in supine position when the infants was in the quiet state and eyes closed to avoid influence of ambient lighting, and with no gross body movements.

Informed consent was obtained from at least one parent, and the study was approved by both institutional ethical committee and review board.

We evaluated the right or left anterior cerebral artery (ACA), the left middle cerebral artery (LMCA), the right middle cerebral artery (RMCA), the left posterior cerebral artery (LPCA), the right posterior cerebral artery(RPCA) and the basilar artery(BA). The ACA and BA were approached through the anterior fontanel on the sagittal plane and its blood flow velocity was determined at the proximal part of these vessels. The MCA and PCA arteries were approached through the temporal bone in the region above the zygomatic arch in both side. We insonated all vessels between 0 to 45 degrees and the angle correction was made when necessary (Fig 1A, B, C, D).

The CBFV measurements were obtained by cursor and automatic Fourier transform analysis from regular blood flow wave patterns over at least 4 cardiac cycles with good clear signals of spectral curve and in each artery we measured the following Doppler parameters, peak-systolic velocity (PSV), end-diastolic velocity (EDV), mean velocity, the area under the curve (MV), pulsatility index (PI) and resistance index (RI).

The RI, first described by Pourcelot[9] is a blood-flow velocity waveform index, calculated by formula: RI=(PSV –EDV)/EDV, where PSV is the peak systolic velocity, EDV is the minimum forward diastolic velocity in unidirectional flow or the maximum negative velocity in diastolic flow reversal. The majority of investigators use RI as a indicative of cerebrovascular resistance because it minimizes the effect of transducer placement and can be easily obtained without velocity signal calibration[6].

The pulsatility index, PI, is an arterial blood-flow velocity waveform index designed by Gosling, et al.[10], to quantify the pulsatility or oscillations of the waveform. Different definitions of this simplified PI may be found in the literature, but the following formula is commonly used: PI=(PSV–EDV)/MV where PSV is the peak systolic velocity, EDV is the end diastolic velocity or

Table 1. Median, mean and SD of blood flow parameters in all arteries of our study population of 50 full term healthy newborns. Friedman teste demonstrated significant differences between the cerebral blood flow velocities, PI and RI, p<0.001.

		RMCA	LMCA	ACA	BA	RPCA	LPCA	p	Friedman test
PSV	Median	48	46	44.5	35.5	27	29	<0.001*	MCA (R=L) › ACA › BA › PCA (R=L)
	Mean	48.18	47.64	44.4	36.62	28.72	28.08		
	DP	9.09	10.37	7.42	7.98	8.25	7.29		
	n	50	50	50	50	50	50		
EDF	Median	14.5	14.5	16	12	11	10	<0.001*	MCA (R=L) = ACA › BA › PCA (R=L)
	Mean	15.08	15.14	15.4	12.66	10.64	10.46		
	DP	4.83	4.3	3.69	3.54	3.33	2.87		
	n	50	50	50	50	50	50		
MV	Median	26	27	26.5	22	17	17	<0.001*	MCA (R=L) = ACA › BA › PCA (R=L)
	Mean	26.48	26.4	26.14	21.74	17.74	17.04		
	DP	6.47	6.56	4.76	5.24	5.54	4.52		
	n	50	50	50	50	50	50		
PI	Median	1.24	1.26	1.09	1.09	1.05	1.03	<0.001*	MCA (R=L) › ACA = BA › PCA (R=L)
	Mean	1.29	1.25	1.12	1.12	1.04	1.04		
	DP	0.27	0.23	0.21	0.21	0.21	0.16		
	n	50	50	50	50	50	50		
RI	Median	0.68	0.68	0.65	0.65	0.63	0.63	<0.001*	MCA (R=L) › ACA = BA › PCA (R=L)
	Mean	0.69	0.68	0.65	0.65	0.62	0.62		
	DP	0.07	0.06	0.07	0.06	0.07	0.05		
	n	50	50	50	50	50	50		

RMCA: right middle cerebral artery; LMCA: left middle cerebral artery; ACA: anterior cerebral artery; BA: basilar artery; RPCA: right posterior cerebral artery; LPCA: left posterior cerebral artery; PSV: peak systolic velocity; EDV: end diastolic velocity; MV: mean velocity; PI: pulsatility index; RI: resistance index; n: number of cases.

Table 2. Mean and medians of cerebral blood flow velocities (cm/s), PI and RI in relation to type of delivery. Mann-Whitney test (p>0.05).

Type of delivery		ACA-PSV	ACA-EDV	ACA-MV	ACA-PI	ACA-RI
Caesarean section (n=37)	Mean	45.59	15.22	26.57	1.16	0.66
	Median	46	16	27	1.11	0.66
Normal labor (n=13)	Mean	41	15.92	24.92	1.03	0.61
	Median	41	16	24	1	0.6
		RMCA-PSV	RMCA-EDV	RMCA-MV	RMCA-PI	RMCA-RI
Caesarean section (n=37)	Mean	48.97	15.11	26.57	1.32	0.69
	Median	48	14	26	1.25	0.69
Normal labor (n=13)	Mean	45.92	15	26.23	1.21	0.67
	Median	49	15	26	1.23	0.66
		LMCA-PSV	LMCA-EDV	LMCA-MV	LMCA-PI	LMCA-RI
Caesarean section (n=37)	Mean	48.81	15.08	26.65	1.28	0.69
	Median	48	15	27	1.28	0.68
Normal labor (n=13)	Mean	44.31	15.31	25.69	1.16	0.66
	Median	44	14	27	1.15	0.66
		RPCA-PSV	RPCA-EDV	RPCA-MV	RPCA-PI	RPCA-RI
Caesarean section (n=37)	Mean	29.19	10.84	18.03	1.03	0.62
	Median	27	11	17	1.04	0.63
Normal labor (n=13)	Mean	27.38	10.08	16.92	1.05	0.62
	Median	27	11	18	1.05	0.63
		LPCA-PSV	LPCA-EDV	LPCA-MV	LPCA-PI	LPCA-RI
Caesarean section (n=37)	Mean	28.3	10.32	17.03	1.05	0.63
	Median	30	10	17	1.06	0.63
Normal labor (n=13)	Mean	27.46	10.85	17.08	0.98	0.6
	Median	27	10	16	0.94	0.6
		BA-PSV	BA-EDV	BA-MV	BA-PI	BA-RI
Caesarean section (n=37)	Mean	37.92	12.84	22.16	1.15	0.66
	Median	37	12	22	1.14	0.66
Normal labor (n=13)	Mean	32.92	12.15	20.54	1.04	0.63
	Median	32	11	19	1	0.64

RMCA: right middle cerebral artery; LMCA: left middle cerebral artery; ACA: anterior cerebral artery; BA: basilar artery; RPCA: right posterior cerebral artery; LPCA: left posterior cerebral artery; PSV: peak systolic velocity; EDV: end diastolic velocity; MV: mean velocity; PI: pulsatility index; RI: resistance index; n: number of cases.

minimum forward diastolic velocity in unidirectional flow or the maximum negative velocity in diastolic flow reversal, and MV is the area under velocity curve or velocity averaged.

Statistical analysis

The values were estimated and the relationship between these Doppler blood flow parameters and clinical factors of newborns were analyzed by statistical tests, using the software SPSS, inc. version 16.0. Data are expressed as median, mean and SD of cerebral blood flow parameters in all arteries studied. Differences in cerebral blood flow parameters between medians in the ACA, MCA, PCA and BA were assessed by Friedman test and Wilcoxon test. Comparison between medians were analyzed using Mann-Whitney test and Kruskal-Wallis test. The probability, $p<0.05$ was considered statistically significant.

RESULTS

Our results demontrated that in normal clinical conditions there were differents CBFV, RI and PI between the cerebral arteries, with higher values of PSV in MCA, following by ACA, BA and PCA. Statistically significant differences were found in these parameters, showing regional differences in cerebral blood flow, that was significantly lower in the occipital region than in the frontal and parietal regions. Friedman test, $p<0.001$. However, we found that there was no significant diferences in CBFV, PI and RI between the right and left MCA and also between right and left PCA, $p>0.05$.

The values of CBFV, PI and RI, with medians, means and SDs of our study population of 50 full term healthy newborns are demonstrated in Table 1.

Table 3. Mean and medians of cerebral blood flow velocities (cm/s), PI and RI in all cerebral arteries in relation to sex of newborn. Mann-Whitney test (p>0.05).

Sex of newborn		ACA-PSV	ACA-EDV	ACA-MV	ACA-PI	ACA-RI
Female (n=27)	Mean	44.93	15.3	26.22	1.14	0.65
	Median	47	16	27	1.1	0.65
Male (n=23)	Mean	43.78	15.52	26.04	1.1	0.64
	Median	44	16	25	1.06	0.65
		RMCA-PSV	RMCA-EDV	RMCA-MV	RMCA-PI	RMCA-RI
Female (n=27)	Mean	50.37	15.07	27.52	1.31	0.7
	Median	49	15	26	1.26	0.69
Male (n=23)	Mean	45.61	15.09	25.26	1.26	0.67
	Median	45	14	25	1.23	0.66
		LMCA-PSV	LMCA-EDV	LMCA-MV	LMCA-PI	LMCA-RI
Female (n=27)	Mean	48.81	14.96	26.85	1.27	0.69
	Median	47	15	27	1.3	0.68
Male (n=23)	Mean	46.26	15.35	25.87	1.23	0.67
	Median	44	14	27	1.22	0.67
		RPCA-PSV	RPCA-EDV	RPCA-MV	RPCA-PI	RPCA-RI
Female (n=27)	Mean	29.04	10.67	17.93	1.04	0.63
	Median	27	12	18	1.07	0.63
Male (n=23)	Mean	28.35	10.61	17.52	1.04	0.62
	Median	27	11	17	1	0.63
		LPCA-PSV	LPCA-EDV	LPCA-MV	LPCA-PI	LPCA-RI
Female (n=27)	Mean	28.7	10.26	17.37	1.07	0.64
	Median	30	10	18	1.11	0.64
Male (n=23)	Mean	27.35	10.7	16.65	1	0.6
	Median	28	10	16	1	0.61
		BA-PSV	BA-EDV	BA-MV	BA-PI	BA-RI
Female (n=27)	Mean	36.89	12.67	22.19	1.11	0.65
	Median	36	12	22	1.04	0.65
Male (n=23)	Mean	36.3	12.65	21.22	1.13	0.65
	Median	35	11	19	1.15	0.65

RMCA: right middle cerebral artery; LMCA: left middle cerebral artery; ACA: anterior cerebral artery; BA: basilar artery; RPCA: right posterior cerebral artery; LPCA: left posterior cerebral artery; PSV: peak systolic velocity; EDV: end diastolic velocity; MV: mean velocity; PI: pulsatility index; RI: resistance index; n: number of cases.

When analized the CBF parameters in comparison with type of delivery, we observed not statistically significant differences. Mann-Whitney test, p>0.05 (Table 2).

When we studied the CBF parameters in comparision with sex of newborn, we observed not statistically significant differences on CBFV, PI and RI. Mann-Whitney test, p>0.05 (Table 3).

Not statistically significant differences were found in CBFV, RI and PI in relation to postnatal age of 50 full term newborns between 12h and 72h of life. Kruskal-Kallis test, p>0.05 (Table 4, Fig 2).

In relation to influence of feeding, the results also demonstrated not statistically significant differences in CBFV, RI and PI with increasing the time after feeding from 1h to 3h. Kruskal-Kallis test, p>0.05 (Table 5, Fig 3).

DISCUSSION

Imaging modalities, as a ultrasonography, computed tomography or magnetic resonance may be normal in newborn if performed on the first day after brain anoxic injury. Neurophysiological methods, somatosensory evoked potentials, visual evoked potentials, cerebral function monitoring and near-infrared spectroscopy have proved good predictive value also during the first hours after asphyxic insult, but are not available in all centres[11,12].

Color Doppler ultrasonography (CDUS) is a non-invasive imaging modality, which allows a early evaluation of newborn at bedside, repeated and safe assessment of neonatal cerebral blood flow[13].

We think that is one of the first CDUS study of the influence of type of delivery, sex, postnatal age and time

Table 4. Mean and medians of cerebral blood flow velocities (cm/s), PI and RI in all arteries studied in relation to postnatal age of newborn. Kruskal-Kallis test (p>0.05).

Postnatal age (hours)			n	ACA-PSV	ACA-EDV	ACA-MV	ACA-PI	ACA-RI
12 < 24h	Mean	22h	12	46.25	16.17	27.58	1.1	0.64
	Median	24h		44.5	16	26	1.1	0.67
24 < 48h	Mean	41h	26	42.73	14.96	25.23	1.12	0.65
	Median	48h		43.5	16	24.5	1.05	0.64
48 < 72h	Mean	66h	12	46.17	15.58	26.67	1.16	0.66
	Median	72h		48	14.5	17	1.16	0.68
				RMCA-PSV	RMCA-EDV	RMCA-MV	RMCA-PI	RMCA-RI
12 < 24h	Mean	22h	12	50	15	27.5	1.32	0.7
	Median	24h		47	14.5	27.5	1.3	0.72
24 < 48h	Mean	41h	26	47.69	15.27	26.73	1.24	0.68
	Median	48h		47.5	15	26	1.22	0.66
48 < 72h	Mean	66h	12	47.42	14.75	24.92	1.37	0.69
	Median	72h		50	14	25	1.34	0.69
				LMCA-PSV	LMCA-EDV	LMCA-MV	LMCA-PI	LMCA-RI
12 < 24h	Mean	22h	12	46.92	14.33	25.25	1.31	0.69
	Median	24h		46	15.5	27	1.3	0.68
24 < 48h	Mean	41h	26	45.81	14.42	25.5	1.25	0.68
	Median	48h		44.5	14	25.5	1.23	0.68
48 < 72h	Mean	66h	12	52.33	17.5	29.5	1.2	0.66
	Median	72h		57	16.5	30.5	1.21	0.65
				RPCA-PSV	RPCA-EDV	RPCA-MV	RPCA-PI	RPCA-RI
12 < 24h	Mean	22h	12	30.92	10.58	18.42	1.13	0.66
	Median	24h		31	11	17	1.13	0.66
24 < 48h	Mean	41h	26	27.12	10.23	16.81	1.02	0.62
	Median	48h		26	11	17	1.02	0.63
48 < 72h	Mean	66h	12	30	11.58	19.08	0.99	0.61
	Median	72h		27.5	11	17	0.98	0.61
				LPCA-PSV	LPCA-EDV	LPCA-MV	LPCA-PI	LPCA-RI
12 < 24h	Mean	22h	12	27	9.83	16.17	1.05	0.62
	Median	24h		30	10	17.5	1.11	0.64
24 < 48h	Mean	41h	26	29.15	10.85	17.77	1.04	0.62
	Median	48h		29	10	17	1.06	0.63
48 < 72h	Mean	66h	12	26.83	10.25	16.33	1.02	0.62
	Median	72h		25	9.5	15.5	1	0.61
				BA-PSV	BA-EDV	BA-MV	BA-PI	BA-RI
12 < 24h	Mean	22h	12	38.92	12.83	22.92	1.15	0.66
	Median	24h		37.5	11.5	22.5	1.15	0.67
24 < 48h	Mean	41h	26	35.42	12.62	21.38	1.08	0.64
	Median	48h		34	12	22	1.02	0.65
48 < 72h	Mean	66h	12	36.92	12.58	21.33	1.19	0.66
	Median	72h		35.5	12	20	1.13	0.65

RMCA: right middle cerebral artery; LMCA: left middle cerebral artery; ACA: anterior cerebral artery; BA: basilar artery; RPCA: right posterior cerebral artery; LPCA: left posterior cerebral artery; PSV: peak systolic velocity; EDV: end diastolic velocity; MV: mean velocity; PI: pulsatility index; RI: resistance index; n: number of cases.

post feeding on full term healthy newborns cerebral blood flow.

Hansen et al.[14] demonstrated a linear correlation between cerebral blood flow (CBF) and area under the velocity curve (mean velocity, MV) measured by radionuclide-labeled microspheres in piglets, and that Doppler blood flow velocity could be used to provide a noninvasive estimate of CBF in neonates. Other experimental research in lambs have demonstrated that Doppler blood flow estimates and mean blood flow velocities correlate

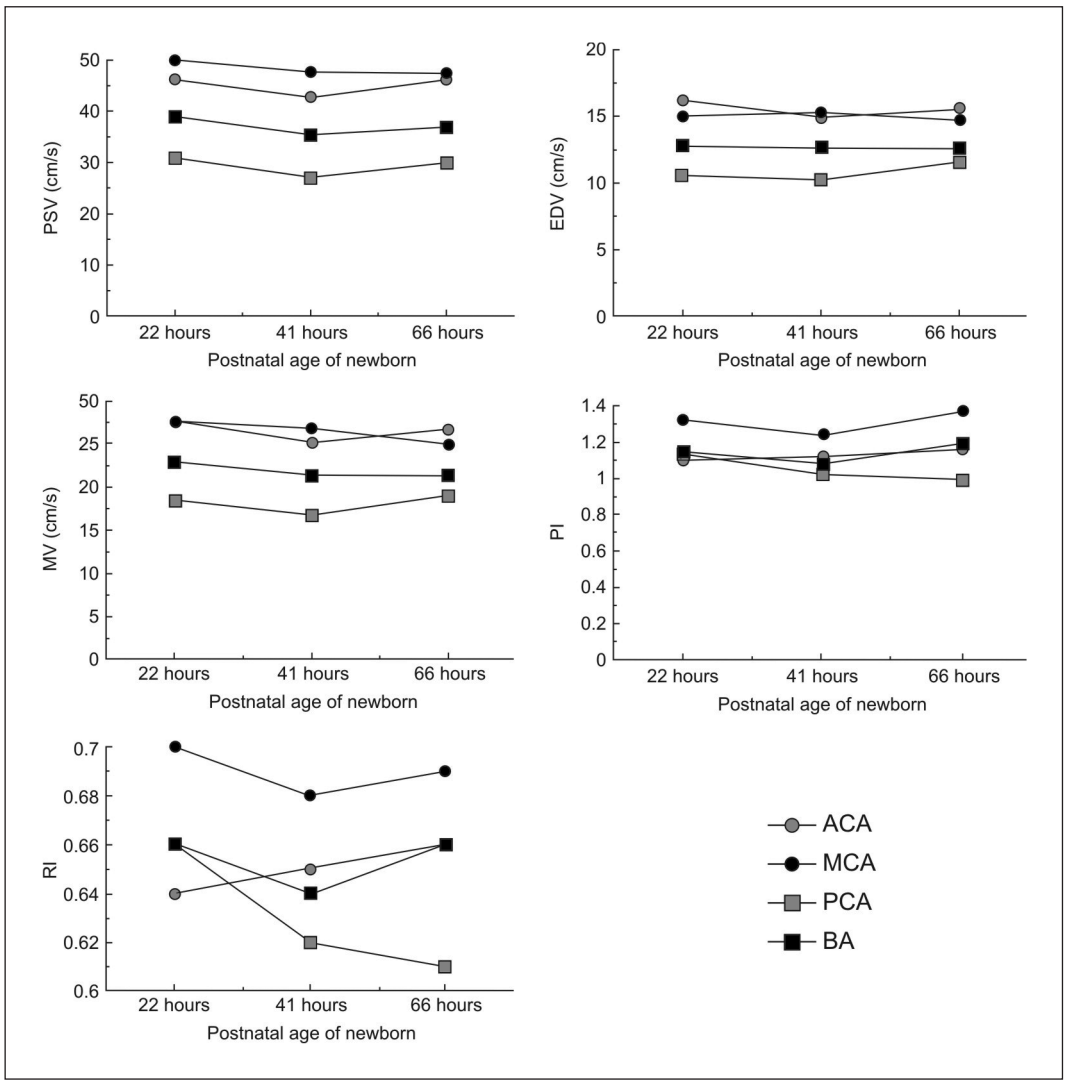

Fig 2. Graph of correlation between postnatal age of newborn and peak systolic velocity (PSV); MV: mean velocity; EDV: end diastolic velocity; PI: pulsatility index; RI: resitance index.

well with changes in CBF and allow a significant improvement in accuracy over instantaneous velocity or RI measurements isolated, and that RI correlated well with brain perfusion pressure but correlated weakly with cerebrovascular resistance and is not a good predictor of changes in cerebral blood flow[15].

Seibert et al.[16] studied the CBFV and RI in the anterior cerebral artery, middle cerebral artery and carotid artery in 57 healthy neonates and reported that average RI for healthy newborns was 0.75±0.10 during the first 24h of life, and that was a wide variation of normal and an overlap between normal and abnormal values.

In neonate with asphyxia RI is frequently low due to increase diastolic blood flow, but also can be higher if there is associated cerebral edema, hemorrhage, patent ductus arteriosus, cardiac ischemia due to decreased cerebral perfusing pressure rather than from increase of cerebral vascular impedance. There is a direct linear correlation between RI and increased of intracranial pressure particularly when associated a subdural efusion and hydrocephalus[17,18].

Stark et al.[19] were established initial RI values ranged 0.23–0.59 in 16 neonates with history asphyxia in the first day of life. Archer et al.[20] found no normal infant ever had a value of 0. 55 or below during the first five days of life.

Recently, Swarup et al.[21] described that blood flow velocity was lower and more variable in the left compared to the right middle cerebral artery on first day of life in premature infants, and speculate that this difference could be due to the associated ductus arteriosus patency. Pezzati et al.[6] and Bokiniec et al.[8], reported that there was no difference in CBFV in both brain hemispheres in healthy term neonates. Assis, et al.[13] described no significant difference in RI between right and left ACA and MCA

Table 5. Mean and medians of cerebral blood flow velocities (cm/s), PI and RI in all cerebral arteries studied in relation to time after feeding of newborn. Kruskal-Kallis test (p>0.05).

Time after feeding (hour)		n	ACA-PSV	ACA-EDV	ACA-MV	ACA-PI	ACA-RI
Mean	1h	17	43.65	14.71	25.65	1.13	0.66
Median			43	16	25	1.06	0.65
Mean	2h	24	44.13	15.04	25.71	1.14	0.66
Median			45.5	15.5	26.5	1.14	0.66
Mean	3h	9	46.56	17.67	28.22	1.05	0.62
Median			47	16	27	0.97	0.63
Time after feeding (hour)		n	RMCA-PSV	RMCA-EDV	RMCA-MV	RMCA-PI	RMCA-RI
Mean	1h	17	48.06	14.18	25.76	1.36	0.7
Median			47	16	27	1.33	0.7
Mean	2h	24	46.63	14.5	25.5	1.29	0.69
Median			47.5	14	25	1.23	0.68
Mean	3h	9	52.56	18.33	30.44	1.16	0.65
Median			52	17	30	1.16	0.66
Time after feeding (hour)		n	LMCA-PSV	LMCA-EDV	LMCA-MV	LMCA-PI	LMCA-RI
Mean	1h	17	49.76	15.41	27.35	1.27	0.69
Median			49	14	27	1.3	0.69
Mean	2h	24	45.63	14.42	25.08	1.26	0.68
Median			44	15	25.5	1.27	0.67
Mean	3h	9	49	16.56	28.11	1.19	0.66
Median			51	14	28	1.18	0.67
Time after feeding (hour)		n	RPCA-PSV	RPCA-EDV	RPCA-MV	RPCA-PI	RPCA-RI
Mean	1h	17	29.94	11.18	18.88	1	0.62
Median			27	12	18	1	0.61
Mean	2h	24	28	10	16.83	1.09	0.64
Median			27	10	16.5	1.09	0.64
Mean	3h	9	28.33	11.33	18	0.96	0.6
Median			27	12	19	1	0.61
Time after feeding (hour)		n	LPCA-PSV	LPCA-EDV	LPCA-MV	LPCA-PI	LPCA-RI
Mean	1h	17	29.65	11	18	1.04	0.62
Median			30	10	17	1	0.63
Mean	2h	24	26.17	9.71	15.79	1.04	0.62
Median			27.5	10	16	1.06	0.63
Mean	3h	9	30.22	11.44	18.56	1.01	0.62
Median			31	11	18	1	0.62
Time after feeding (hour)		n	BA-PSV	BA-EDV	BA-MV	BA-PI	BA-RI
Mean	1h	17	36	12.65	21.24	1.14	0.65
Median			35	12	20	1	0.66
Mean	2h	24	36.17	12.46	21.58	1.1	0.65
Median			35	12	22	1.05	0.65
Mean	3h	9	39	13.22	23.11	1.13	0.66
Median			38	13	24	1.14	0.65

RMCA: right middle cerebral artery; LMCA: left middle cerebral artery; ACA: anterior cerebral artery; BA: basilar artery; RPCA: right posterior cerebral artery; LPCA: left posterior cerebral artery; PSV: peak systolic velocity; EDV: end diastolic velocity; MV: mean velocity; PI: pulsatility index; RI: resistance index; n: number of cases.

in a group of 45 preterm healthy newborns. Our results demonstrated that the CBFV, PI and RI were significantly more higher in MCA than ACA, and more than PCA, showing regional difference of CBF, but there was no significant difference in CBFV, PI and RI between right and left MCA and between right and left PCA, demonstrating that there was no vascular dominant hemisphere in full term healthy newborns.

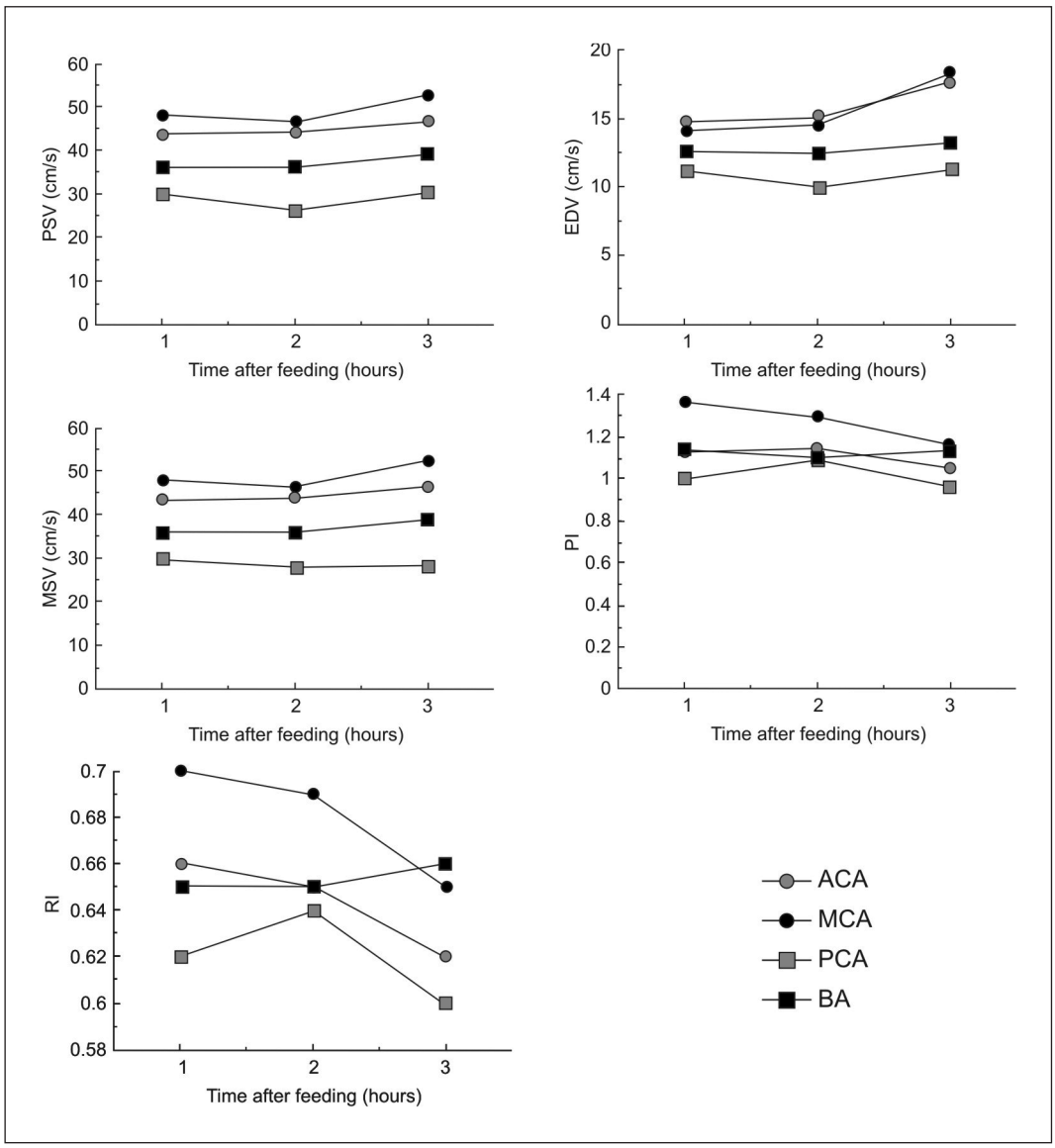

Fig 3. Graph of correlation between time after feeding of newborn and peak systolic velocity (PSV); MV: mean velocity; EDV: end diastolic velocity; PI: pulsatility index; RI: resitance index.

Baytur et al.[22] studied 43 healthy term neonates who were delivered vaginally (n=20) and by caesarean section (n=23), using Doppler ultrasound in middle cerebral artery and venous cerebral transverse sinus before delivery, and 1h and 24h after birth and observed that mode of delivery does not affect cerebral blood velocities. We observed similar findings in our study. The CBFV, PI and RI not changed significantly with the type of delivery.

Newborns males are more sensitive to brain injury and have higher morbidity and mortality than newborns females. Researches aiming at explaining the vulnerability in male infants has been intensified in the last years, and exposure to circulating sex steroids, that are potent hormones that exert a wide spectrum of influences on developing fetal organs is felt to be a chief contributor to this phenomenon[23].

Kehrer et al.[24], studied quantitative measurement of cerebral blood flow volume performed by sonographic flowmetry of both internal carotid and vertebral arteries in healthy preterm and term infants in order to delineate the physiological characteristics of brain perfusion and they found no difference in cerebral blood flow volume between the sexes. In our study we demonstrated similar findings, the CBFV, PI and RI not changed significantly with the sex of newborn.

Usually, in term healthy newborns in the first days of life, the CBFV increase with increasing gestational age, postnatal age and birthweight, and RI increase with in-

creasing gestational age. Studies has shown that there was no correlation between the mean blood pressure and mean blood flow velocity in cerebral arteries, and that this change is likely to represent a normal adaptive response of the cerebral circulation to postnatal life, when the efficiency of the CBF autoregulatory response in general improved with increasing age and maturity of the brain[6,25]. In the 50 full term healthy newborns studied between 12h and 72h of life, the results showed not statistically differences on CBFV, PI and RI.

In relation to influence of feeding on CBF, Nelle et al.[26] using a transcranial Doppler ultrasound in preterm infants reported that bolus feeding provokes a considerable early decrease in CBFV in first 5 to 11 minutes after feeding with prefeeding values reached after 17 minutes.

Coombs[27]and Badaró-Marques et al.[28] reported that enteral feeding induces a significant and progressive increase in blood flow velocity in the superior mesenteric artery. Martinussen et al.[29] studied healthy term neonates and described that postprandial increase in superior mesenteric artery mean velocity was not associated with changes in cardiac output and blood pressure;however, a fall in relative mesenteric vascular resistance suggesting regional redistribution of cardiac output, and that middle cerebral artery mean velocity increase was associated with an increase in blood pressure, and also observed that relative fraction of cardiac output to middle cerebral artery increased during the first days of life, suggesting a redistribution of blood flow to the metabolically active organs in the neonatal period.

Temporal changes in cerebral blood flow induced by feeding and postprandial period was investigated in our study by evaluation of newborns in 1h, 2h and 3h after breastfeeding and the results demonstrated not statistically significant differences in the Doppler parameters. The oral feeding leads a vasodilation in the splanchnic area, with elevation of systolic velocity in the superior mesenteric artery and consequent increase of intestinal blood flow. After feeding to maintain constant perfusion of brain, small arteries and arterioles must vasoconstrict during increases in blood pressure to attenuate flow, and vasodilate during decreases in blood pressure, so producing a "autoregulatory plateu". This process occur specially in small resistance vessels, but may occur in vessels as proximal as the circle of Willis. The mechanisms by wich the process takes place may be intrinsic in the arteriolar wall, or be related to changes wich occur in relation to other stimuli such as arterial carbon dioxide tension ($PaCO_2$), oxygen concentration (cO_2), or glucose concentration levels, wich in turn lead to alterations in vascular tone to maintain cerebral blood flow[30].

In conclusion, this cranial color Doppler ultrasonography study in full term healthy newborns with postnatal age between 12h and 72h of life demonstrated that there was not statistically significant differences on CBFV, PI and RI in relation to type of delivery, sex, postnatal age and time post feeding from 1h to 3h . In this context, we believe that the knowledge of this cerebral blood flow profile in the first days of life can contribute to radiologists and pediatricians in an accurate interpretation of the cranial Doppler abnormal findings when pathologic flow velocities are analyzed.

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