EARLY POSTNATAL CHANGES IN THE SUPERIOR MESENTERIC ARTERY BLOOD FLOW PARAMETERS IN LATE PRETERM NEWBORNS – A PILOT STUDY

Lenka Kocvarova L., Lucanova L., Zibolenova J., Paulusova E., Matasova K.

Department of Neonatology, Jessenius Faculty of Medicine, Comenius University and University Hospital in Martin, Slovak Republic

A b s t r a c t

Significant hemodynamic changes happen in the abdominal region at the moment of birth and during the first week of life in premature newborns. The aim of the study was to assess early postnatal changes of Doppler sonographic blood flow parameters in the superior mesenteric artery (SMA) occurring during the first three days of life in *late preterm* infants. 10 infants were enrolled into the prospective study. Abdominal blood flow velocities (ABFV) in the SMA were obtained at the age of 2, 24 and 72 hours (h), before feeding. Screening parameters included the peak systolic velocity (PSV), end-diastolic velocity (EDV), time-averaged mean velocity (TAMV). Doppler indices (DI) - resistance index (RI) and pulsatility index (PI) were calculated. EDV changed significantly from 2 h to 24 h [-13.08 cm/s (-20.46 – -9.34) to 12.79 cm/s (11.83 – 24.72); $p < 0.01$] with a further statistically insignificant increase within 72 h [12.79 cm/s (11.83 – 24.72) to 17.90 cm/s (16.93 – 19.25)]. The EDV values were negative in 9 out of l0 neonates at 2 h of age. The SMA PSV showed a daily increase from 2 h to 72 h. The ABFV and characteristics of vascular resistance (DI) in the SMA change significantly in near term infants within the first 3 days. At 2 h of age a negative blood flow and elevated parameters characterizing vascular resistance were documented in the superior mesenteric artery.

Key words: late-preterm newborn, superior mesenteric artery, splanchnic circulation, Doppler ultrasonography

INTRODUCTION

According to the statistics of the U.S., preterm birth rate accounts for 11.99 % of all births. *Late preterm* children is a vulnerable group of premature infants born between 34th and 36th weeks of gestation and comprise the bulk of all preterm births (71 % in 2010) (1). Although these infants fare better than those born before 34 weeks of gestation, they experience substantially increased morbidity and mortality compared with neonates born after 37 weeks of gestation (2). *Late preterm* newborns are at risk for clinical complications related to prematurity, including respiratory distress syndrome, temperature instability, hypoglycemia, feeding problems, hyperbilirubinemia and acute bilirubin encephalopathy, infection and gastrointestinal complications (3).

Under physiological conditions, the gastrointestinal tract receives about 20 – 25 % of the total cardiac output. The superior mesenteric artery (SMA) supplies the small bowel and parts of the colon and originates only 1.5 to 2 cm below the celiac trunk (4,5). Regulation and characteristics of the intestinal blood flow in the early perinatal period in preterm infants is not completely understood. A progressive increase in the SMA abdominal blood flow velocities (ABFV) was documented from birth and throughout the first week and month of life in preterm babies (6,8). Based on the results of the scientific studies, it is assumed that the rate of the early postnatal SMA ABFV increase may be of clinical significance. Pathological blood flow parameters in the SMA already present on the first day of life or after the first feeding, can help to predict intestinal motility and difficulties in later enteral feeding of premature infants (9,10). And, moreover, a high-resistance pattern of blood flow velocity in the SMA on the first day of life in preterm neonates was associated with an increased risk of developing necrotizing enterocolitis (NEC) (11). There are only limited data about

A d d r e s s f o r c o r r e s p o n d e n c e :
Lenka Kočvarová, MD, Clinic of Neonatology, University Hospital Martin, Kollarova Str. N. 2, 036 59 Martin, Slovak Republic
Phone: ++421/4203641; e-mail: lenka.kocvarova@gmail.com

intestinal blood flow velocity changes after birth in near term newborns. Comprehensive knowledge would help to decrease the gastrointestinal morbidity and feeding intolerance in such premature infants. The main purpose of this investigation was to evaluate early postnatal hemodynamic changes in the splanchnic circulation in *late preterm* neonates.

METHODS

Informed consent was obtained from parents of each enrolled infant and the study protocol and consent forms were approved by the Ethical Committee of the Jessenius Faculty of Medicine (EK 1187/2012). The study group consisted of 10 healthy *late preterm* infants born after uncomplicated pregnancies. Late preterm birth was defined as a delivery between 34 $^{0/7}$ and 36 $^{6/7}$ weeks of gestation. All patients included in the study had uncomplicated postnatal adaptation and none of them suffered from respiratory, infectious or gastrointestinal complications. All the conditions which could alter the SMA ABFV were eliminated (i. e. phototherapy, ventilatory support, various pharmacologic agents, umbilical arterial catheterization).

An ALOKA alpha 10 machine (Tokyo, Japan) with a 7.5-MHz linear Doppler probe was used to measure the peak systolic velocity (PSV), end-diastolic velocity (EDV), time-averaged mean velocity (TAMV) in the SMA at the age of 2, 24 and 72 hours. The examinations were performed preprandially – approximately 2 hours after the last feeding. The neonates were in the supine position, and the probe was placed on the mid abdomen above the umbilicus, in the sagittal plane. Color flow imaging was used for identification of the SMA, in the locality where the SMA is leaving from the abdominal aorta. The sample volume was measured about 5 mm distally from the origin of the SMA by using a pulse-wave Doppler mode. An angle correction of ≤ 30º was used when necessary. The SMA blood flow parameters were obtained from minimally 5 homogenous consecutive blood flow wave patterns. Three sets of measurements were realized. Doppler indices (DI) were calculated using standard formulas for resistance index and pulsatility index: RI = (PSV-EDV)/PSV; PI = (PSV – EDV)/TAMV. Comparisons of the ABFV and DI for several time points were statistically analyzed. Friedmann's Test was used for the analysis, P values < 0.05 were considered significant.

RESULTS

10 infants (7 female and 3 male infants) were enrolled into the study. Mean gestational age was 35.5 weeks, all infants were appropriate for gestational age, mean birth weight was 2493 g. None of the subjects developed significant feeding intolerance or NEC during hospitalization. The postnatal changes in the SMA perfusion over time documented in this study are shown in Tab. 1.

Table 1. Abdominal blood flow velocities and Doppler indices in the superior mesenteric artery in 10 late preterm newborns measured at the ages of 2, 4, and 6 h. Variables are expressed as median (interquartile range). p total is a level of significance of the Friedmann test; p (1 - 2), p (2 - 3), p (1 - 3) are the significance levels of pairwise comparisons between the first and the second measurement, the second and the third measurement, and the first and the third measurement, respectively. Peak systolic velocity (PSV), end-diastolic velocity (EDV), resistance index (RI), pulsatility index (PI), time-averaged mean velocity (TAMV).

	2 hours			24 hours			72 hours			
	Percentiles			Percentiles			Percentiles			
	50^{th}	(25^{th} – 75^{th})	p (2 – 24)	50^{th}	(25^{th} – 75^{th})	p(24-72)	50^{th}	(25^{th} – 75^{th})	p (2 -72)	p total
PSV	72.69	(54.43 – 107.36)		93.92	(61.32 – 121.61)		113.77	(66.24 – 124.81)		0.273
EDV	-13.08	(-20.46 – -9.34)	0.011	12.79	(11.83 – 24.72)	1	17.90	(16.93 – 19.25)	<0.001	<0.001
RI	1.21	(1.10 – 1.22)	0.002	0.81	(0.77 – 0.84)	1	0.82	(0.78 – 0.85)	0.002	0.001
PI	4.91	(2.73 – 5.63)	0.022	1.85	(1.61 – 2.23)	12.99	1.95	(1.65 – 2.18)	0.022	0.008
TAMV	15.61	(12.86 – 19.82)	0.221	34.45	(20.62 – 53.01)	0.221	33.37	(23.34 – 51.38)	<0.001	0.002

DISCUSSION

In the present study we assessed the relationship between ABFV and characteristics of vascular resistance in association with the increasing postnatal age. An increase in abdominal perfusion was found characterized by an ABFV increase, associated with a decrease in vascular resistance. These changes are caused by the effort of neonatal gastrointestinal tract to provide sufficient blood flow and oxygen delivery for intense gut metabolism after birth.

The EDV values were negative in 9 out of 10 neonates at 2 h of age, one infant had zero EDV. In fact, it reflects that there is only a very low or absent flow in the SMA and the gut blood supply is limited. Our results are in agreement with the previous results published by Matasova *et al.* (12) who reported negative values in 46 out of 50 term infants and by Paulusova *et al.* (13) who reported negative values in 13 out of 15 term infants. As this phenomenon was detected in majority of healthy children, it is considered to be physiological and can be explained as a ductal steal phenomenon due to the left-to-right shunt via persistent ductus arteriosus Botalli (PDA) (12). As in the studies mentioned above (12, 13), the PDA was not evaluated in this study, as the babies were hemodynamically stable (therefore a presence of hemodynamically significant PDA was not supposed) and the PDA was expected to be physiologically open at 2 h of age and closed at 3 days of age in all of the newborns. This assumption was based on Martinussen's study findings (14). The main function of steal phenomenon in the SMA is probably the effort to supply the blood to the neonatal vital organs such as brain, heart, adrenal glands and liver. There is only a little chance of adequate feeding immediately after birth, so that the gastrointestinal tract's digestive function may be attenuated within the first 2 hours after birth. The SMA blood flow can be used as a mechanism to the DAB compensation (13). According to the report by Matasova *et al.*, neg-

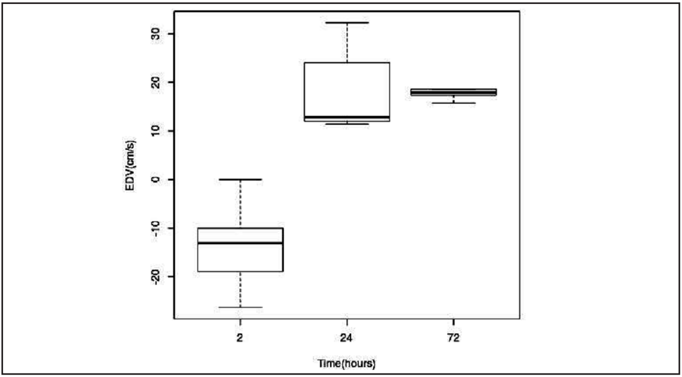

Fig. 1. Postnatal changes of end-diastolic velocity (EDV). Mean EDV measured at 2, 24 and 72 h after delivery.

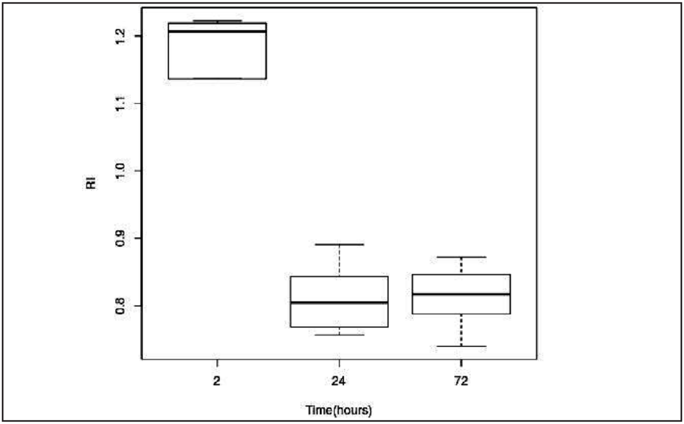

Fig. 2. Postnatal changes of resistance index (RI). Mean RI measured at 2, 24 and 72 h after delivery.

ative EDV values are associated with an increased end organ vascular resistance, characterized by high RI (7). The recently reported elevated RI values at 2 h also support the statement (Fig. 1 and 2). All EDV measurements were positive at the time points of 24 h and 72 h, and these findings are similar to those reported by other authors (12,13,14). EDV changed significantly from 2 h to 24 h with a further statistically insignificant increase to 72 h. These results are similar with those reported by Papacci *et al.* who measured in infants born between 33 - 36 gestational weeks. Papacci and colleagues also reported positive EDV values in all *late preterm* infants at the day of age 3, 7, 14, 21 and 28 (6).

PSV values showed a daily increase in the SMA, but the increase was statistically insignificant (Tab. 1). Significant increases in the SMA PSV were documented by Matasova *et al.* (2011) in the group of term infants, although the measured PSV values were lower than in the presented *late preterm* infants (24 *vs.*72 h: 62.5 *vs.* 82.2 cm/s; $p < 0.001$) (12). TAMV values in the SMA changed significantly over time. This is similar to the Papacci's report showing a progressive significant daily increase of TAMV values in preterm infants. The values were in contrast to the term infants' characteristics, which remained stable during the first week of life (6).

The Doppler indices reflect vascular resistance. An inverse correlation between RI and arterial blood flow has been proved (12). In the presented study a significant decrease in RI and PI values occurred between 2 h to 24 h and also between 2 h and 72 h. This change was associated with a significant increase in EDV and improvement of intestinal perfusion (Fig. 1 and 2). Murdoch *et al.* found a positive correlation between gestational age at birth and the SMA PI on the first day of life. Premature neonates tend to have lower values of Doppler indices indicating their lower vascular resistance (11). If an increased resistance pattern in the SMA of preterm infants on the first day of life is documented, an increased risk of NEC development must be considered (11).

The increases in PSV and EDV and the decreases in RI and PI presented in this study characterize the changes in mesenteric perfusion during the first 3 days of life. Papacci *et al.* reported that the ABFV values in near term infants change during the first month of life and on the 28th day of life they are nearly the same as the values in term babies (6). Not only the closure of DAB may be associated with the ABFV improvement, but also the initiation of enteral feeding plays a role in those changes. The most important factors related to postprandial increase of the SMA blood flow velocity include feeding volume, feeding interval and meal composition (12).

In conclusion, this study provides physiological values of abdominal blood flow velocities and of Doppler indices in the superior mesenteric artery in *late preterm* infants. The presented data contribute to a comprehensive knowledge on early postnatal changes in the mesenteric circulation.

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Acknowledgements:
The work was supported by the ITMS project 26220120036 Centre of excellence for perinatology research ("*Dobudovanie Centra excelentnosti pre perinatologický výskum*" CEPV II) which is co-financed from the European Union sources. The study was also supported by the Comenius University Grant (Grant UK) No. 121/2013.

Received: April, 2, 2013
Accepted: April, 19, 2013