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ARTYKUŁ ORYGINALNY / *ORIGINAL ARTICLE*

Doppler tissue imaging assessment of myocardial velocities and atrioventricular time intervals in term newborn infants during the neonatal period

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Abstract

Background: In both term and premature neonates, changes in the systolic and diastolic function of the left ventricle (LV) and right ventricle (RV) reflect the degree of neonatal myocardial immaturity and the co-existence of foetal circulation as well as the presence of concurrent diseases.

Aim: To evaluate the changes in values of systolic and diastolic LV and RV function using pulse tissue Doppler imaging (TDI) in 20 healthy term newborn infants from birth to the 28th day of life.

Methods: Ventricular peak myocardial velocities were recorded during early diastole (Em wave), atrial contraction (Am wave), and systole (Sm wave). TDI derived atrioventricular (AV) intervals were measured as the period from atrial contraction (Am) to isovolumic contraction (IV), from Am to ventricular systole (Sm), from Sm to the following Am, and from IV to the following Am. The first measurements were taken as soon as possible after birth, the second on the third day, and the final one on the 28th day of life.

Results: The diastolic myocardial velocities recorded in the RV were higher than those in the LV. Statistically significant differences were observed for time intervals in the RV: Am-IV and Am-Sm (day 1–3), $p < 0.02$; IV-Am (day 1–28), $p < 0.005$; Sm-Am (day 1–28), $p < 0.01$. Statistically significant differences for time intervals were also evident in the LV: Am-IV (day 1–28), $p < 0.05$; and for Sm-Am (day 1–28), $p < 0.01$. Mean isovolumetric contraction time (ICT) and isovolumetric relaxation time (IRT) intervals remained stable for all measurements recorded in the RV. However, a statistically significant difference was evident for both ICT and IRT intervals in the LV between days 1 and 28 of life ($p < 0.01$).

Conclusions: 1. Cardiac TDI is feasible in the neonate. 2. In neonates, the diastolic and systolic function recorded in the RV was better than that in the LV. This may reflect the 'persistent' foetal status of this ventricle in the first day of life. 3. The differences observed in conduction times also reflect the haemodynamic changes which occur in the circulatory system of the neonate in the first month of life. 4. Further investigation of a larger population of neonates throughout the whole neonatal period is indicated.

Key words: tissue Doppler, pulsed Doppler, myocardial, newborn, infant

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INTRODUCTION

In both term and premature neonates, changes in the systolic and diastolic function of the left ventricle (LV) and right ventricle (RV) reflect the degree of neonatal myocardial immaturity and the co-existence of foetal circulation as well as the presence of concurrent diseases. The impairment of myocardial systolic and diastolic function accompanies intrauterine and secondary infections, affects premature neonates with bronchopulmonary dysplasia, hypoxia and with intrauterine growth retardation. Not infrequently, it results from diabetic cardiomyopathy and multiple pregnancies. In the aforementioned pathological conditions, impairment of cardiac rhythm may be observed frequently and may be expressed as impaired atrioventricular conduction time (AVCT).

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Having performed a systematic review of the literature, including a review of Medline, Cochrane databases, and during our participation in multiple symposia in the field of neonatology, we did not find any satisfactory papers assessing cardiac function parameters in term or preterm infants. No reference values were available for neonatal cardiac function, thus we decided to perform a study to estimate those parameters.

This paper presents the nature of the changes in the parameters of systolic and diastolic function of the LV and RV based, similarly to the studies reported by other authors [1–4], upon the measurement of myocardial velocity observed during tissue Doppler examination in healthy term newborns during the neonatal period. AVCT was assessed with a spectral tissue Doppler in accordance with reports by Nii et al. [5], and analysed throughout the entire neonatal period i.e. in the first 28 days of life.

The tissue Doppler imaging (TDI) procedure utilises the fact that reflection of the ultrasound wave by the myocardium generates a different signal to that which arises from reflection of the ultrasound wave by the blood flowing through the cardiac chamber. In contrast to the pulse Doppler method, this allows for the assessment of the motility of the cardiac muscle. This procedure utilises the difference in the frequency of the Doppler wave to calculate the velocity of the myocardial wall. The method is based upon the measurement of the signal obtained from the myocardial wall which is characterised by a low velocity and high amplitude. In contrast, conventional Doppler techniques assess the velocity of blood flow by measuring high-frequency, low amplitude signals from small, fast-moving blood cells. One of the parameters assessed by TDI is the maximal velocity of the myocardial wall measured along the long axis of the ventricle. The longitudinal course of the myocardial fibres along this axis is parallel to the ultrasound beam transmitted from the probe placed in the apical region. The determination of myocardial velocity provides for the assessment of the systolic and diastolic function of the LV and RV, measured as the annular motility of the mitral or tricuspid valves.

METHODS

Study group

The examination was performed in 20 healthy, term infants born at 37–41 weeks of gestation (average gestation 39 weeks). The neonates included 12 boys and eight girls. The mean birth weight was 3,376.5 g (min. 2,700 g, max. 4,200 g). The mothers of the neonates had undergone natural births (n = 13) or caesarean sections (n = 7). Neonates were included in the study if they had normal cardiac morphology and if the mother had a normal perinatal history. Parental consent was obtained for all neonates involved in the study, prior to examination. The study was approved by the Ethical Committee of the Medical University of Warsaw. The detailed characteristics of the neonates in terms of selected clinical and electrocardiographic parameters (M-mode and pulsed Doppler) are presented in Table 1.

Tissue Doppler imaging

The examinations were performed using a Philips HD 11XE Ultrasound with a 12 MHz sector probe. Myocardial velocity measurement was performed in parasternal long-axis and apical four-chamber views with colour flow coded tissue Doppler (Fig. 1). The spectral Doppler gate was placed exactly in the central region of the muscle of the LV or RV as appropriate, below the lateral tricuspid or bicuspid annulus, such that the angle of the ultrasound beam did not exceed 30 degrees. The record of the cardiac cycle was viewed on the ultrasound apparatus screen as three waves: systolic wave — Sm (when the cusps of the valve migrate towards the apex); early diastolic wave — Em (when the valve annulus moves away from the apex); and the wave associated with the phase of atrial contraction — Am (Fig. 2). The IV wave reflects the velocity of the myocardium during the isovolumetric contraction. Additionally, the following AVCT were measured: Am-IV (the time closest to the PR interval on ECG) from the beginning of the Am wave (from the onset of the atrial contraction) to the start of the IV wave (the wave which appears during the isovolumic relaxation time [IRT]); Am-Sm time measured from the beginning of the Am wave (from the onset of the atrial contraction) to the start of the Sm wave (the wave which appears during the myocardial contraction in ventricular systole); in pulsed wave Doppler it is similar, although not equal, to the time measured from the A wave in mitral valve Doppler tracing to the beginning of the outflow to the aorta; IV-Am from the beginning of the IV wave to the start of the following Am wave; Sm-Am from the beginning of the Sm wave to the start of the following Am wave (Figs. 3, 4); isovolumetric contraction time (ICT) and IRT. Velocity and myocardial time interval measurements were performed in all neonates three times: the first measurement after birth was made on the first day of life; the second measurement was made on the third day of life prior to discharge home; and the third measurement was made at the conclusion of the neonatal period on the 28th day of life. Four children failed to attend for examination on the 28th day of life. During the electrocardiographic examination, it was possible to obtain a continuous record of the cardiac electrical activity (ECG) in approximately 30% of neonates.

Statistical analysis

Statistical tests were used to analyse the significance of the differences. For analysis of continuous variables, two types of Wilcoxon tests were used. For independent samples Wilcoxon rank-sum tests were used. For analysis of the changes in variables during the neonatal period Wilcoxon signed-range tests were applied. χ^2 or Fisher's exact tests (depending on the

Table 1. Clinical, M-mode, and conventional Doppler echocardiographic data for the study group

	Day 1	Day 3	Day 28	P
No. of patients	20 (12 male, eight female)	20 (12 male, eight female)	16 (eight male, eight female)	
Birth weight [g]		Mean 3,376.5 (minimum 2,700, maximum 4,200)		
Gestational age [weeks]		Mean 39 (minimum 37, maximum 41)		
Heart rate (LV) [bpm]	132 ± 10	121 ± 13	146 ± 14	Day 1–3: NS Day 1–28: < 0.02
Heart rate (RV) [bpm]	129 ± 9	126 ± 14	148 ± 13	Day 1–3: NS Day 1–28: < 0.0002
Fractional shortening [%]	44 ± 16	34 ± 8	36 ± 13	Day 1–3: NS Day 1–28: NS
Transmitral E [cm/s]	53.1 ± 10	47.2 ± 7.8	68.5 ± 15.5	Day 1–3: < 0.05 Day 1–28: < 0.01
Transmitral A [cm/s]	54.4 ± 13.6	50.1 ± 9.5	78.0 ± 21.4	Day 1–3: NS Day 1–28: < 0.01
Transtricuspid E [cm/s]	49.1 ± 11.4	46.9 ± 9.2	63.6 ± 10.3	Day 1–3: NS Day 0–28: < 0.01
Transtricuspid A [cm/s]	58.5 ± 11.0	57.2 ± 9.5	75.8 ± 16.3	Day 1–3: NS Day 1–28: 0.0005
Systolic pressure [mm Hg]	70 ± 11	78 ± 11	86 ± 17	Day 1–3: NS Day 1–28: < 0.05
Diastolic pressure [mm Hg]	37 ± 11	46 ± 11	49 ± 12	Day 1–3: NS Day 1–28: < 0.02
Mean pressure [mm Hg]	48 ± 9	57 ± 9	62 ± 11	Day 1–3: NS Day 1–28: 0.0004

LV — left ventricle; RV — right ventricle

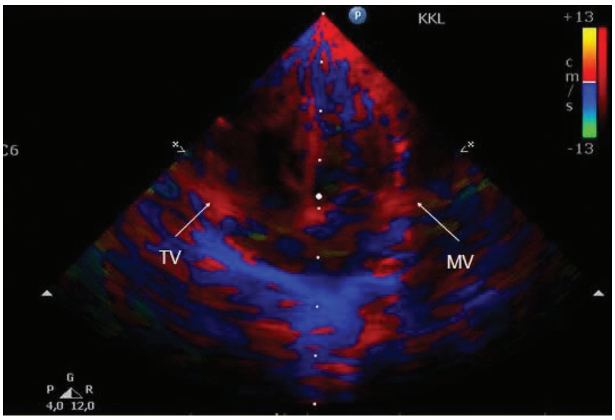

Figure 1. Four-chamber cardiac image, apical projection tissue Doppler; MV — mitral valve; TV — tricuspid valve

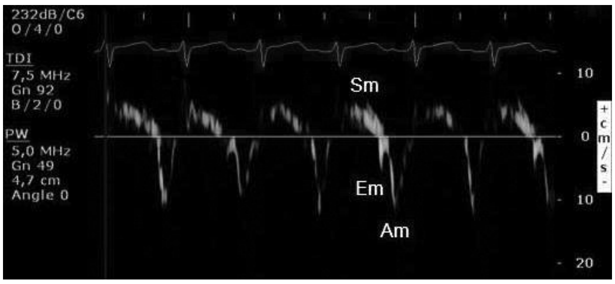

Figure 2. Spectral Doppler record, tissue Doppler (Sm — systolic wave, Am — atrial contraction wave, Em — diastolic wave)

number of cases) were used for analysis of the relationship between quantitative variables. A p value < 0.05 was taken as statistically significant. Calculations were made using the SAS system.

RESULTS

The tissue Doppler figures are presented in Tables 2 and 3.

Values of Em, Am, Sm wave velocity

No statistically significant differences were present between the measurements of the mean velocity of the Em, Am and Sm waves recorded on days 1 and 3 of life for both the RV and LV. However, mean velocities for Em, Am and Sm waves in the RV recorded at the end of the neonatal period (i.e. day

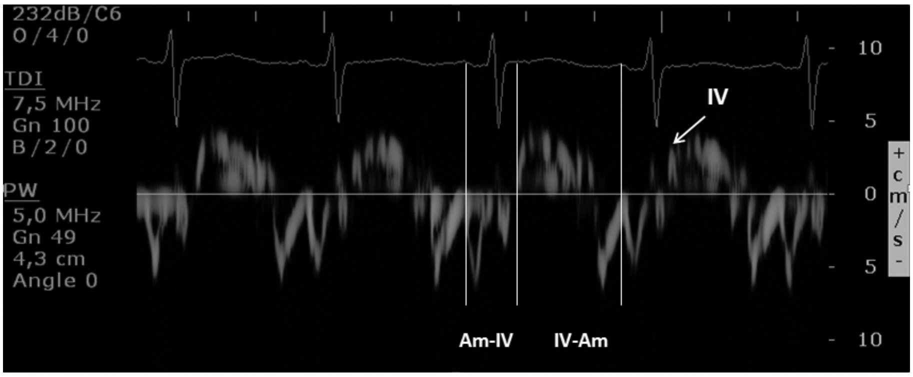

Figure 3. Atrioventricular conduction time measurement plan — spectral Doppler record in the tissue Doppler option (Am-IV and IV-Am times); Am — atrial contraction wave; IV — velocity of myocardium during the isovolumetric contraction

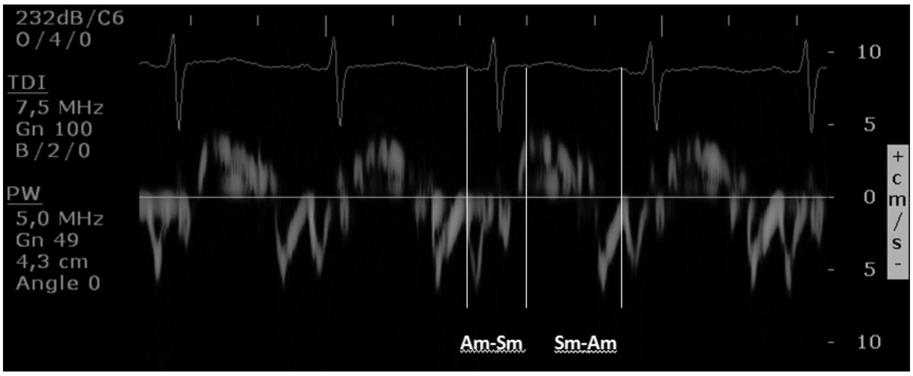

Figure 4. Atrioventricular conduction time measurement plan — spectral Doppler record in the tissue Doppler option (Am-Sm and Sm-Am times); abbreviations as is Figure 2

Table 2. Mean value of velocities of Em wave (early diastole), Am wave (atrial contraction), and Sm wave (systole) for the right (RV) and left (LV) ventricles

TDI [cm/s]	RV (1st day)	RV (3rd day)	RV (28th day)	P	LV (1st day)	LV (3rd day)	LV (28th day)	P
Em	8.70 ± 2.6	8.30 ± 2.2	10.50 ± 3.7	Day 1–3: NS Day 1–28: < 0.05	6.40 ± 1.3	7.00 ± 1.7	8.60 ± 2.6	Day 1–3: NS Day 1–28: < 0.02
Am	10.00 ± 2.6	9.40 ± 1.3	14.50 ± 5.3	Day 1–3: NS Day 1–28: < 0.01	7.50 ± 2.1	6.40 ± 1.5	8.20 ± 2.7	Day 1–3: NS Day 1–28: NS
Sm	7.00 ± 1.3	7.00 ± 1.5	9.70 ± 2.5	Day 1–3: NS Day 1–28: < 0.004	5.20 ± 1.2	5.20 ± 1.1	6.00 ± 1.1	Day 1–3: NS Day 1–28: NS

TDI — tissue Doppler imaging

28 of life) were much higher than those recorded on the first day of life. Furthermore, these differences were statistically significant (Em $p < 0.05$; Am $p < 0.01$; Sm $p < 0.004$). A statistically significant difference was observed for the mean velocity solely of the Em wave in the LV between days 1 and 28 of life. The mean velocity of myocardial motility in terms of Em, Am and Sm waves for all measurements was higher in the RV than in the LV ($p < 0.05$)

Time interval analysis

Analysis of the mean time interval values recorded in the RV and LV revealed an overall increasing trend for Am-IV, Am-Sm, Sm-Am on day 3 of life, followed by a decrease in these values on day 28 of life. A statistically significant difference was observed in the RV for Am-IV and Am-Sm (day 1–3), $p < 0.02$, IV-Am (day 1–28), $p < 0.005$ and Sm-Am (day 1–28), $p < 0.01$. A statistically significant difference was

Table 3. Tissue Doppler imaging derived time intervals

Time intervals [ms]	RV (1st day)	RV (3rd day)	RV (28th day)	P	LV (1st day)	LV (3rd day)	LV (28th day)	P
Am-IV	86.20 ± 16.4	97.70 ± 13	80.00 ± 14.2	Day 1–3: < 0.02 Day 1–28: NS	78.50 ± 22.4	82.10 ± 15.4	65.50 ± 14.2	Day 1–3: NS Day 1–28: < 0.05
Am-Sm	123.00 ± 16.8	134.40 ± 16.6	119.00 ± 18.3	Day 1–3: < 0.02 Day 1–28: NS	124.80 ± 26.4	128.60 ± 20.2	106.20 ± 17.3	Day 1–3: NS Day 1–28: NS
IV-Am	375.30 ± 27.4	387.30 ± 43.2	331.20 ± 36.6	Day 1–3: NS Day 1–28: < 0.005	372.50 ± 31.1	391.30 ± 53.1	353.80 ± 44.2	Day 1–3: NS Day 1–28: NS
Sm-Am	339.20 ± 29.6	349.60 ± 44.6	294.70 ± 38.5	Day 1–3: NS Day 1–28: < 0.01	324.20 ± 34.2	348.60 ± 55.1	314.20 ± 42.8	Day 1–3: NS Day 1–28: < 0.01
ICT	36.80 ± 9.6	36,70 ± 8.9	39.00 ± 11.3	Day 1–3: NS Day 1–28: NS	46.30 ± 15.2	44.90 ± 10.7	40.70 ± 9.3	Day 1–3: NS Day 1–28: < 0.01
IRT	53.20 ± 14.3	50.9 ± 13.4	48.80 ± 16.9	Day 1–3: NS Day 1–28: NS	55.60 ± 16.7	48.10 ± 16	42.50 ± 7.6	Day 1–3: NS Day 1–28: < 0.01

ICT— isovolumetric contraction time; IRT — isovolumetric relaxation time; rest abbreviations as in Figures 2 and 3

observed in the LV for Am-IV (day 1–28), $p < 0.05$ and Sm-Am (day 1–28), $p < 0.01$. Mean interval values for ICT and IRT remained constant for all measurements performed on the RV. However, both ICT and IRT intervals in the LV were statistically significantly different between days 1 and 28 ($p < 0.01$). A decrease in cardiac function, which was not statistically significant, was observed between the first and third days of life with a statistically significant increase between days 1 and 28 ($p < 0.02$). Similar relationships were observed for the average values of systolic pressure and diastolic pressure, as well as for mean pressure. E and A wave mitral and tricuspid valve velocities were also measured with conventional pulse Doppler and a statistically significant increase in these values was evident between days 1 and 28 of life.

DISCUSSION

Developments in neonatal medicine, and intensive neonatal therapy in particular, require increasingly a specific assessment of haemodynamics of the circulatory system and of the cardiac function. The need to distinguish between very dynamic physiological changes which occur in the circulatory system at birth, as opposed to any pathological changes, means that modern techniques to assess cardiac muscle must be applied.

In 1999 Harada et al. [6] were the first to publish a paper including an analysis of the motility of the myocardium in 30 foetuses based on TDI. TDI is an echocardiographic technique which utilises the phenomenon of the pulse Doppler together with that of colour coding to measure the velocity of the myocardium in motion. This is a non-invasive method for the direct assessment of the motility and function of the cardiac muscle which is currently in use for echocardiography of the foetus, child and adult [1, 2, 5, 7].

Sm wave velocity correlates with ejection fraction measurements in the LV [8]. A decrease in the Sm wave velocity occurs during hypoxia of the cardiac muscle both in adults and in neonates, and is associated with the pathological motility of the cardiac muscle. Wei et al. [9] observed a depression of the Sm wave in hypoxic neonates in the 24th hour of life. In our study, the mean value of the Sm systolic wave in healthy neonates both in the RV and LV increased in the first month of life, which is evidence of the increasing contractile power of the cardiac muscle, but it was significantly lower than in adults. In pulmonary hypertension, the Sm, Em and IV wave are all depressed [10]. The Sm wave velocity increases with the contractility of the cardiac muscle during infusion of dobutamine and in adults during physical exercise [11].

On standard echocardiography, the assessment of LV diastolic function is based upon the measurement of mitral valve flow and reflects the difference in the pressure gradient between the left atrium and LV. Left atrial pressure may be estimated by comparing the flow observed with TDI and the spectral flow through the mitral valve. Since the nature of the flow through the mitral valve is very dependent on preload, this method has its limitations. The assessment of diastolic function with TDI is less dependent on preload than with measurement of blood flow using standard Doppler ultrasound. The Em wave reflects the early diastolic phase, when the annulus of the valve migrates towards the base of the heart during the rapid early filling of the LV. Because of the difference in the cardiac fibre system, the measurement of the Em wave at the septum is characterised by somewhat lower velocities than those at the valve annulus. Em wave velocity is above 20 cm/s, and may be higher in children and young adults, but its value decreases with age.

It is known from some studies that the value of the Em wave velocity is more closely correlated with age than with cardiac function [11]. In our study on neonates, in the first day of life the mean value of the Em wave in the LV was 6.75 cm/s. In the study recently published by Negrine et al. [8], the Em wave velocity for the LV in 16 term neonates was lower than in our study, with a mean value of 5.3 cm/s. In adults, Em wave values below 8 cm/s indicate a disturbance of the contractile function of the LV [11].

These results prove that normal values for different ages are needed, and that norms for adults cannot be used for neonates. The value of the Em wave velocity is more closely correlated with age than with cardiac function [11]. In neonates, the heart rate decreases in the first days after birth. A decrease in the heart rate was observed with a mean value of 132/min on the first day of life to 121/min on the third day, followed by an increase to 146/min on the 28th day of life. In the paper by Nii et al. [5], the Am-IV interval was on average longer (98.3 ms) for foetuses at 35–42 weeks of gestation than for the neonates in our study on day 1 (86.20 ms), and this was comparable with the value obtained on the third day of life [5]. A decrease in the Am-IV interval was observed near the end of the neonatal period.

There are no reports on the measurement of conduction times in the neonate. The results presented here reflect the dynamics of the adaptive changes which occur in the circulation of the neonate immediately after birth and in the first month of life. They are expressed as changes in the contractile function of the ventricles by comparing the changes in velocity and AVCT. The results presented here are the sole preliminary reports concerning this matter published to date.

Limitations of the study

It must be stressed that the myocardial mass of the RV is greater in this period than that of the LV, and it is always easier to obtain a good TDI recording in the RV than in the LV, which may influence the results obtained.

The simultaneous interpretation of conduction interval times together with ECG recording is not possible in all neonates.

CONCLUSIONS

1. Cardiac Doppler tissue imaging is feasible in the neonate.
2. In neonates, the diastolic and systolic function recorded in the RV was better than that in the LV. This may reflect the ‘persistent’ foetal status of this ventricle in the first day of life.
3. The differences observed in conduction times also reflect the haemodynamic changes which occur in the circulatory system of the neonate in the first month of life.
4. Further investigation of a larger population of neonates throughout the whole neonatal period is indicated.

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Conflict of interest: *none declared*

References

1. Harada K, Orino T, Yasuoka K et al. Tissue Doppler imaging of left and right ventricles in normal children. J Exp Med, 2000; 191: 21–29.
2. Mori K, Nakagawa R, Nii M et al. Pulsed wave Doppler tissue echocardiography assessment of the long axis function of the right and left ventricles during the early neonatal period. Heart, 2004; 90: 175–180.
3. Ciccone MM, Scicchitano P, Zito A et al. Different functional cardiac characteristics observed in term/preterm neonates by echocardiography and tissue Doppler imaging. Early Hum Dev, 2011; 87: 555–558.
4. Ekici F, Atalay S, Ozcelik N et al. Myocardial tissue velocities in neonates. Echocardiography, 2007; 24: 61–67.
5. Nii M, Hamilton RM, Fenwick L et al. Assessment of fetal atrioventricular time intervals by tissue Doppler and pulse Doppler echocardiography: normal values and correlation with fetal echocardiography. Heart, 2006; 92: 1831–1837.
6. Harada K, Tsuda A, Orino T et al. Tissue Doppler imaging in the normal fetus. Int J Cardiol, 1999; 71: 227–234.
7. Ohte N, Narita H, Kimura G. Evaluation of cardiac function using tissue Doppler imaging. Med Rev, 2000; 73: 30–35.
8. Negrine RJS, Chikermane A, Wright JGC et al. Assessment of myocardial function in neonates using tissue Doppler imaging. Arch Dis Child Fetal Neonatal Ed, 2012; 97: F304–F306.
9. Wei Y, Xu T, Xu J et al. Left ventricular systolic function of newborn with asphyxia evaluated by tissue Doppler imaging. Pediatr Cardiol, 2009; 30: 741–746.
10. Patel N, Mills JF, Cheung MMH. Assessment of right ventricular function using tissue Doppler imaging in infants with pulmonary hypertension. Neonatology, 2009; 96: 193–199.
11. Ho CY, Solomon SD. A clinician’s guide to tissue Doppler imaging. Circulation, 2006; 113: e396–e398.

Ocena ruchu miokardium i czasów przewodzenia przedsionkowo-komorowego u noworodków donoszonych w opcji doplera tkankowego

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Streszczenie

Wstęp i cel: Przy użyciu echokardiograficznej metody doplera tkankowego oceniono zmiany ruchu miokardium dla lewej i prawej komory oraz czasy przewodzenia przedsionkowo-komorowego u noworodków donoszonych w pierwszym miesiącu życia.

Metody: Badania wykonano u 20 zdrowych noworodków urodzonych miedzy 37.–41. tygodniem ciąży. Pomiar prędkości miokardium wykonywano w projekcji koniuszkowej, w osi długiej serca, jako obraz 4 jam serca kodowany kolorowym doplerem tkankowym. Odczytywano zapis cyklu serca przedstawionego za pomocą trzech fal: fala skurczowa (Sm; kiedy płatki zastawki wędrują w kierunku koniuszka serca), fala wczesnej fazy rozkurczowej (Em; kiedy pierścień zastawki oddala się od koniuszka serca) oraz fala związana z fazą skurczu przedsionków (Am). Ponadto wykonano pomiary następujących czasów: czas Am-IV (od początku fali Am do początku fali IV); czas Am-Sm (od początku fali Am do początku fali Sm); czas IV-Am (od początku fali IV do początku kolejnej fali Am); czas Sm-Am (od początku fali Sm do początku następnej fali Am). Zmierzono też czas skurczu izowolumetrycznego (IVCT) i czas rozkurczu izowolumetrycznego (IVRT). Wszystkie pomiary wykonano u każdego noworodka 3-krotnie: 1. pomiar — bezpośrednio po urodzeniu w 1. dobie życia, 2. pomiar — w 3. dobie życia oraz 3. pomiar — na koniec okresu noworodkowego w 28. dobie życia.

Wyniki: We wszystkich pomiarach wartości średniej prędkości ruchu miokardium w zakresie fal Em, Am i Sm były wyższe dla komory prawej niż dla komory lewej. Zmianę istotną statystycznie odnotowano dla komory prawej w zakresie czasów: Am-IV i Am-Sm (między dobą 1. a 3.), $p < 0,02$; IV-Am (miedzy dobą 1. a 28.), $p < 0,005$; Sm-Am (miedzy dobą 1. a 28.), $p < 0,01$. Dla komory lewej zmianę istotną statycznie wykazano w zakresie czasów: Am-IV (między dobą 1. a 28.), $p < 0,05$ oraz Sm-Am (między dobą 1. a 28.) $p < 0,01$. Średnie wartości IVCT i IVRT pozostawały stałe we wszystkich pomiarach dla komory prawej. Natomiast dla komory lewej zarówno w zakresie IVCT i IVRT wykazano różnicę istotną statycznie między 1. i 28. dobą życia ($p < 0,01$).

Wnioski: Zaobserwowane różnice w średnich wartościach prędkości miokardium i w średnich wartościach czasów przewodzenia odzwierciedlają zmiany w hemodynamice układu sercowo-naczyniowego charakterystyczne dla okresu noworodkowego.

Słowa kluczowe: dopler tkankowy, noworodek, miokardium

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