Myocardial performance index (Tei index) in term and preterm neonates during the neonatal period

Renata Bokiniec¹, Paweł Własienko², Maria K. Borszewska-Kornacka¹, Dariusz Madajczak¹, Joanna Szymkiewicz-Dangel¹

¹Neonatal and Intensive Care Department, Medical University of Warsaw, Warsaw, Poland
²Perinatal Cardiology Unit, Medical University of Warsaw, Warsaw, Poland

Abstract

Background: The myocardial performance index (MPI) is a noninvasive method to measure global systolic and diastolic myocardial function. 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.

Aim: To assess MPI (or Tei indices) of both ventricles in term and preterm newborns, and to observe MPI trends throughout the neonatal period.

Methods: Heart ultrasound imaging was performed on the first day of life (DOL), after patent ductus arteriosus (PDA) closure, and on the 28th DOL, in 29 term and 29 preterm newborns. RVMPI and LVMPI were measured within the preterm group at 40 weeks of post-conception age (PCA).

Results: A statistically significant reduction in RVMPI was observed in both term and preterm newborns. In term newborns, the RVMPI value on the first DOL was 0.42 ± 0.14, dropping to 0.29 ± 0.09 after PDA closure, and finally reaching 0.22 ± 0.09 on the 28th DOL. The respective RVMPI values for the preterm newborns were 0.44 ± 0.15, 0.30 ± 0.12, and 0.21 ± 0.08. Little variability in the mean values of LVMPI was observed in both groups throughout the neonatal period. The LVMPI for term neonates in successive measurements was 0.37 ± 0.10, 0.39 ± 0.07, and 0.37 ± 0.11, respectively, and for the preterm neonates it was 0.37 ± 0.10, 0.35 ± 0.09, and 0.36 ± 0.10, respectively. The MPI values from preterm newborns taken at 40 weeks PCA (RVMPI = 0.28 ± 0.09; LVMPI = 0.37 ± 0.05) were comparable to those measured in term newborns after PDA closure.

Conclusions: Observed postnatal changes in RVMPI correspond to changes in ventricular function, reflecting the haemodynamic changes of the transitional circulation. The relatively small postnatal changes in LVMPI in term and preterm newborns may reflect an immature myocardium. The RVMPI and LVMPI values at 40 weeks PCA in preterm newborns correlate best with MPI values in term newborns just after PDA closure.

Key words: myocardial performance index, neonates, Doppler

INTRODUCTION

In both term and preterm neonates, changes in the systolic and diastolic function of the left ventricle (LV) and right ventricle (RV) reflect the degree of neonatal myocardial immaturity, the co-existence of foetal circulation, and the presence of concurrent diseases. For example, impairment of myocardial systolic and diastolic function accompanies intrauterine and secondary infections, and affects preterm neonates with bronchopulmonary dysplasia (BPD), hypoxia, and intrauterine growth retardation [1–5]. Conventional methods of evaluation...
of myocardial function have limitations in adults, which be-
come even more problematic in the immature myocardium of
the preterm neonate. Firstly, there is a limitation in the eval-
uation of the haemodynamics of the circulatory system if the
assessment of the cardiac output of the right ventricle (RVCO)
is performed in the presence of an open patent foramen ovale,
and, similarly, if the left ventricle (LVCO) is measured when
there is leakage through the ductus arteriosus (DA). The RVCO
solely reflects the pulmonary flow when the foramen ovale is
closed, and the LVCO reflects the systemic flow only with a
closed DA. Secondly, evaluation of the fractional shortening
(FS) and the ejection fraction (EF) in M-mode echocardiogra-
phy (ECHO) also has its limitations. M-mode recording
solely reflects movement of the anterior and posterior walls
of the LV. Furthermore, weak movement of the anterior wall
of the LV can be observed during systole, as opposed to the
posterior and lateral walls in the preterm neonate. Therefore,
LV function is often underestimated using these conventional
methods, which are largely dependent on the myocardial
gеомetry, cardiac function, preload, and afterload. For these
reasons, non-invasive, bedside methods are being developed
and applied more frequently in both neonatal and adult medi-
cine for the early evaluation of global systolic and diastolic
myocardial function.

The myocardial performance index (MPI), introduced
during the mid-nineties by Tei et al. [6], is a non-invasive way
to measure global systolic and diastolic myocardial function.
The MPI, also known as the Tei index, was introduced for the
assessment of myocardial function in adults with dilated
cardiomyopathy [6]. Initially, Tei et al. [6] used two meas-
urements for the calculation of the index: (a) isovolumetric
time, measured from the end of the A wave to the initiation
of the E wave, and (b) ejection time (ET), measured as the
outflow from the LV or RV [6]. The formula (a–b)/b defines
the Tei index [6]. The MPI value is inversely proportional
to myocardial function; an increase in MPI points towards
a deterioration in global myocardial function. The methodol-
gy for the measurement of MPI has been developed over
time by researchers studying various foetal pathologies. For
example, Friedman et al. [7] proposed that LVMI should
be calculated from a single recording of the Doppler wave,
representing both the outflow and inflow to the LV. This would
allow simultaneous calculation of the isovolumetric contrac-
tion time (ICT) and the isovolumetric relaxation time (IRT)
[7]. To improve accuracy of the MPI measurement, Raboison
et al. [8], and later Hernandez-Andrade et al. [9], developed
the MPI modification (Mod-MPI), in which the opening and
closing movements of the aortic valve (AV) and mitral valve
(MV), or clicks, were used as the reference points for the
measurement of ICT and IRT. The record of the Doppler wave
is obtained by placing a Doppler gate on the medial wall of
the ascending aorta, and from this projection it is possible
to record the movement of both the AV and MV. Harada et
al. [10] proposed another method for the evaluation of MPI
in the foetus and neonate, in which myocardial movement
in tissue Doppler was recorded. The aim of the study is to
assess MPI (or Tei indices) of both ventricles in term and
preterm newborns, and to observe MPI trends throughout
the neonatal period.

METHODS
The study involved term (n = 29) and preterm (n = 29) new-
borns. The 29 healthy, term infants were born at 37–41 weeks
of gestation with a mean gestational age of 39 weeks. This
group (18 boys and 11 girls) had a mean birth weight of 3443 g
(min 2700 g, max 4200 g). Twenty-nine preterm neonates
(15 boys and 14 girls) were selected with a mean gestational
age of 26 ± 2 weeks and mean birth weight of 916 ± 310.5 g.
In this group of preterm neonates, seven had mild BDP on
the 28th day of life (BPD28DOL), and three had severe BPD
in the 36th week post-conception age (BPD36PCA). Thus,
only 19 newborns were included in the group of preterm
neonates born without BPD for statistical comparison with
the term neonates.

Neonates were included in the study if they had normal
cardiac morphology and if the mother had a normal perinatal
history. Selected clinical parameters of all neonates are pre-
sented in Table 1. Prior parental consent was obtained for all
neonates involved in the study. The study was approved by
the Ethical Committee of the Medical University of Warsaw.

Imaging was obtained using the Philips HD 11XE Ul-
trasound with a 12-MHz sector probe. The ICT, IRT, and ET
were measured, and the MPI calculated using the formula
(ICT + IRT)/ET, and easily calculated as (a–b)/b as per the
Hernandez-Andrade et al. modification [8, 9]. We used the
Doppler ECHO (clicks) of the opening and closing of the AV
and MV as reference points to estimate the timing of the eje-
cnt period (Fig. 1) [8, 9]. During the ultrasound examination,
it was possible to obtain a continuous record of electrocar-
diogram (EKG). In order to reduce examination times, the
MPIs for the RV and LV were calculated using Cardiac Arena
cardiology software.

The tricuspid inflow waves were recorded from the api-
cal four-chamber view with the pulsed-wave Doppler sample
volume positioned at the tips of the tricuspid leaflets in diasto-
le (Fig. 2). Right ventricular ET was measured separately from
the parasternal short-axis scan plane with a pulse-wave Doppler
signal placed at the pulmonary valve annulus in the RV outflow
tract (Fig. 3). The ECG was recorded continuously during the
examination. The calculation of the Tei index (RVTei) was
considered meaningful for the RV if the difference in heart
rate for the inflow and outflow path was 5 bpm or more.

A gated pulsed Doppler sample volume was placed in
the LV outflow tract in the apical five-chamber view (Fig. 2).
For the Tei index (LVTei), the Doppler sample volume was
placed below the MV towards the ventricular septum with the
pulsed Doppler trace including the E/A waveform (positive) and the aortic (negative) blood flow waveforms.

The ICT, IRT, and ET were measured in term neonates three times. The first measurement was after birth within the first DOL, the second measurement was within the third DOL prior to discharge home (after patent ductus arteriosus [PDA] closure), and the third measurement was at the end of the neonatal period within the 28th DOL. Four children failed to attend for examination on the 28th DOL.

In the preterm neonates, four measurements of the ICT, IRT, and ET were recorded. The first measurement was taken as soon as possible after birth, the second after PDA closure, the third on the 28th DOL, and the final measurement in the 40th week post-conception. The latter serves to compare the MPI values between preterm and term neonates.

### Statistical analysis

Statistical tests were used to analyse the significance of any observed differences. For analysis of continuous variables, two types of Wilcoxon tests were used. For independent samples, the changes in variables during the neonatal period were analysed using the Wilcoxon signed-rank tests. Chi-square or Fisher’s exact tests (depending on the number of cases) were used for analysis of the relationship between quantitative variables. A p value < 0.05 was taken as statistically significant.

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**Table 1. Clinical characteristics of infants enrolled in the study**

<table>
<thead>
<tr>
<th></th>
<th>Term (n = 29)</th>
<th>Preterm (n = 29)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gestational age [weeks]</td>
<td>39 (min 37; max 41)</td>
<td>26 (min 24; max 32)</td>
</tr>
<tr>
<td>Male</td>
<td>18</td>
<td>15</td>
</tr>
<tr>
<td>Female</td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td>Birth weight [g]</td>
<td>3443 (min 2700; max 4200)</td>
<td>916 (min 468; max 1920)</td>
</tr>
<tr>
<td>Caesarean delivery</td>
<td>11 (38%)</td>
<td>18 (62%)</td>
</tr>
<tr>
<td>One-minute Apgar score</td>
<td>Median 10 (min 5; max 10)</td>
<td>Median 5 (min 1; max 10)</td>
</tr>
<tr>
<td>Five-minute Apgar score</td>
<td>Median 10 (min 7; max 10)</td>
<td>Median 7 (min 2; max 10)</td>
</tr>
<tr>
<td>PDA surgical ligation</td>
<td>No</td>
<td>5 (17.2%)</td>
</tr>
<tr>
<td>PDA pharmacological ligation</td>
<td>No</td>
<td>8 (27.5%)</td>
</tr>
<tr>
<td>BPD (28th day of life)</td>
<td>No</td>
<td>7 (24.1%)</td>
</tr>
<tr>
<td>BPD (36th PCA)</td>
<td>No</td>
<td>3 (10.3%)</td>
</tr>
</tbody>
</table>

BDP — bronchopulmonary dysplasia; PCA — post-conception age; PDA — patent ductus arteriosus
Tei index (MPI) in term and preterm neonates during the neonatal period

In term neonates on the first DOL, the value of the MPI for the LV was 0.37 ± 0.10. A follow-up measurement performed after closure of the PDA revealed that the LVMPI had risen only slightly to 0.39 ± 0.07, but this increase was not statistically significant, with a p value of 0.549. On the 28th DOL, at the end of the neonatal period, the mean value of the LVMPI remained unchanged (0.37 ± 0.11, p = 0.524) compared to the measurement performed on the first DOL and after PDA closure. In the first DOL, the RVMPI was 0.42 ± 0.14, which was higher than that for the LV. After closure of the PDA, there was a dramatic decrease in RVMPI to 0.29 ± 0.09 (p < 0.05), and on the 28th DOL the mean value of the RVMPI had fallen further to 0.22 ± 0.09 (p < 0.05) (Table 2, Fig. 4).

In preterm neonates the MPI was higher for the RV (0.44 ± 0.15) than for the LV (0.37 ± 0.10) on the first DOL (Tables 2, 3). The MPI for the LV remained unchanged after PDA closure (0.35 ± 0.09, p = 0.4392), but there was a statistically significant decrease in the index for the RV (from 0.44 ± 0.15 to 0.30 ± 0.12, p = 0.0002). In the preterm neonates on the 28th DOL, the mean LVMPI value remained relatively stable at 0.36 ± 0.10. For the RV, however, it decreased even further to 0.21 ± 0.08 (p < 0.05) (Fig. 4).

Term neonates with measurements made during the first DOL were also compared to a group of preterm neonates in week 40 PCA (Table 3). No statistically significant differences were observed in the term neonates LVMPI (0.37 ± 0.10) compared to the preterm neonates (0.37 ± 0.05, p = 0.6740). In contrast to the LV measurements, a statistically significant difference was observed for the RVMPI (term RVMPI = 0.42 ± 0.14; preterm RVMPI = 0.28 ± 0.09; p = 0.0305).

When comparing the RVMPI in term neonates after PDA closure (0.29 ± 0.09) with the preterm group at 40 weeks PCA (0.28 ± 0.08), no difference was observed (p = 0.9964) (Table 3). A decrease in the heart rate was observed between the first measurement and those made at the end of the first week of life.

Some of the preterm newborns were born with mild (BPD28DOL) or severe (BPD36PCA) BPD. The mean RVMPI values in the first DOL were comparable to those in preterm newborns not suffering from BPD (0.44 ± 0.15), in both the mild (0.48 ± 0.16) and severe (0.47 ± 0.23) BPD groups. On the 28th DOL, the RVMPI was markedly higher in the BPD36PCA group (0.31 ± 0.10) than in the BPD28DOL (0.22 ± 0.06) and healthy groups (Fig. 4). Due to the small sample size of the BPD group, statistical analysis was not conducted.

**DISCUSSION**

This study analysed the changes in MPI for the RV and LV for term and preterm neonates throughout the neonatal period up until the 28th DOL. The differences in MPI, which can act as a proxy of global myocardial function, reflect the differences in myocardial maturity in both study groups. In preterm

Table 2. Comparison of RVMPI and LVMPI in term and preterm neonates during the neonatal period

<table>
<thead>
<tr>
<th>Time point</th>
<th>1st DOL</th>
<th>After closure PDA</th>
<th>P</th>
<th>28th DOL</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Term neonates</td>
<td>RVMPI 0.42 ± 0.14</td>
<td>0.29 ± 0.09</td>
<td>&lt; 0.05</td>
<td>0.22 ± 0.09</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td></td>
<td>LVMPI 0.37 ± 0.10</td>
<td>0.39 ± 0.07</td>
<td>NS</td>
<td>0.37 ± 0.11</td>
<td>NS</td>
</tr>
<tr>
<td>Preterm neonates</td>
<td>RVMPI 0.44 ± 0.15</td>
<td>0.30 ± 0.12</td>
<td>0.0002</td>
<td>0.21 ± 0.08</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td></td>
<td>LVMPI 0.37 ± 0.10</td>
<td>0.35 ± 0.09</td>
<td>NS</td>
<td>0.36 ± 0.10</td>
<td>NS</td>
</tr>
</tbody>
</table>

Data shown as mean ± standard deviation. DOL — day of life; LVMPI — left ventricular myocardial performance index; RVMPI — right ventricular myocardial performance index; PDA — patent ductus arteriosus
neonates, the myocardium has more water and less contractile mass, leading to diminished compliance and force generated per sarcomere compared to term neonates. Furthermore, the immature myocardium is more sensitive to increases in afterload immediately following PDA ligation, due to an increase in systemic vascular resistance [11].

These differences may contribute to the MPI discrepancies between both groups to a greater extent than the haemodynamic changes of the transitional circulation observed immediately after birth. The haemodynamic changes due to the presence of a PDA can influence myocardial function to a greater extent than the differing MPI values of the ventricles observed in neonates of differing maturity. For example, in cases of postnatal significant PDA left-to-right shunting, the systemic pressure is already high, causing increased flow through the pulmonary circulation. Increment of blood flow into the left atrium leads to its enlargement, with subsequent LV expansion.

In our study, the highest RVMPI values in both term and preterm neonates were obtained on the first DOL. This was followed by large reductions in the mean value of the RVMPI after PDA closure, and a further significant decline by the 28th DOL. In preterm neonates the RVMPI was raised once more in week 40 PCA.

Our results are similar to those of other researchers only in part, most likely due to the different DOL on which the measurements were recorded. For example, Malakan-Rad and Montazmanesh [12] analysed the MPI index for the RV in 51 term neonates at up to 72 h of life and obtained an value of 0.23 ± 0.14. In our study, such low values were only obtained towards the end of the neonatal period after PDA closure. On the third DOL the RVMPI was 0.28 ± 0.8, while on the first DOL the values were much higher (0.42 ± 0.14). One can suspect that the measurements performed by Malakan-Rad and Montazmanesh [12] were taken closer to the third DOL, rather than the first.
Elevated pressure within the pulmonary circulation (high afterload) observed in newborns, particularly in the first three DOL, reflects the so-called transitional circulation. This elevated pressure adequately explains the high RV MPI values during the early period of life. Throughout the gestational period, the development of the RV and LV in human foetuses is similar. Although the stroke volume is higher in the RV compared to the LV, which is reflected in the higher mean RV MPI values observed in human foetuses (0.35 ± 0.07) [13].

Even though MPI declines in both ventricles with increasing gestational age (Tsutsumi et al. [13]), immediately after birth the RV MPI will peak, and then this is followed by a fall in MPI during the subsequent hours and days of life. The most striking changes occur in the first two DOLs, as shown by Murase et al. [14] in very low birth weight neonates. The authors demonstrated a significant drop in RV MPI between the 12th and 24th hours of life (from 0.42 ± 0.33 to 0.30 ± 0.16), and a further drop to 0.24 ± 0.14 by the 36th hour. Respective values observed for LV MPI were 0.45 ± 0.21, 0.38 ± 0.15, and 0.32 ± 0.15. This work is in partial accordance with our own results. While we observed RV MPIs averaging 0.44 ± 0.15 in the first DOL in preterm neonates, the mean LV MPI was 0.37 ± 0.10 on the first DOL and only declined slightly in subsequent days (although this was not statistically significant). We did not observe an increase in LV MPI immediately after birth in preterm neonates.

The differences observed in our study compared to Murase et al. [14] could be explained by our choice of measurement times. As opposed to Murase et al. [14], we only assessed the MPI once in the first DOL, and secondly we chose PDA closure as our second measurement time, which can vary in preterm neonates weighing under 1000 g. In term neonates, we did not observe a statistically significant increase in LV MPI after PDA closure (only a slight increase from 0.37 ± 0.10 to 0.39 ± 0.07). These values remained reasonably constant in subsequent days. The available literature suggests the increase in LV MPI in the early neonatal period is caused predominantly by changes in diastolic LV function due to an increase in the IRT [6, 14, 15].

Among our 29 preterm neonates, only four required operative PDA closure, eight were treated medically with ibuprofen, and the remaining 17 underwent spontaneous PDA closure. Noori et al. [11] previously assessed the LV MPI after PDA ligation in 23 preterm neonates and observed a significant increase in LV MPI 2 h after the procedure. If we compare this to our study, it can be inferred that spontaneous or pharmacological DA closure does not dramatically influence the changes in LV MPI.

A few studies support the notion that increased pressure in the pulmonary circulation, including neonates with pulmonary hypertension of any cause, results in an elevated RV MPI [5, 16, 17]. However, literature regarding pulmonary hypertension in neonates suffering from BPD is still scarce. Czernik et al. [2] compared the RV MPI value in preterm neonates without BPD to those who developed BPD by 36 weeks PCA. In neonates who had developed BPD at 36 weeks PCA the authors did not observe a decrease in RV MPI on the 7th, 14th, and 28th DOLs compared to the second DOL. The RV MPI on the second DOL was equal in both groups and averaged 0.39 (min 0.33, max 0.55). These values are lower compared to those obtained in our study (RV MPI = 0.47 ± 0.23). Nevertheless, we confirmed the results obtained by Czernik et al. [2] after PDA closure (RV MPI = 0.32 ± 0.08 on the 7th DOL), and those obtained on the 28th DOL (RV MPI = 0.31 ± 0.10). Similarly to Czernik et al. [2], we observed increased RV MPI (0.31 ± 0.1) values on the 28th DOL in BPD sufferers diagnosed at 36 weeks PCA, compared to the mild BPD (0.22 ± 0.06) and healthy term neonates (0.23 ± 0.1). Such elevated RV MPI values in children with severe BPD reflect a persistently elevated pressure in the pulmonary circulation, resulting from a lower number of blood vessels surrounding the pulmonary alveoli, hypertrophy of the vessel media, muscularisation of small peripheral vessels, and inappropriate vasoreactivity [2]. Although the authors are aware of the limitations of the study, the aim was to present the dynamics of the changes in the mean values of LV MPI and RV MPI in different groups of neonates depending on their maturity. In clinical practice, knowledge of MPI trends in the neonatal period may provide a basis for comparison of mean values for LV MPI and RV MPI in other important pathologies of the neonatal period such as in the case of the challenges concerning echocardiographic diagnosis of BPD hypertension. In view of the increasing use of the Tei index in the youngest group of patients, and following the inclusion of a larger group of subjects, it seems appropriate to establish a net of centiles for this index, both at the start and at the conclusion of the neonatal period for term neonates and for preterm neonates in relation to gestational age.

Limitations of the study
A limitation of the study was the small sample sizes of both study groups (term, n = 29, preterm, n = 29).

CONCLUSIONS
Myocardial performance index measurement is feasible in neonates. Postnatal changes in RV MPI in both term and preterm newborns reflect both systolic and diastolic RV function well, which is influenced by the haemodynamic changes of the transitional circulation. The low magnitude of postnatal LV MPI changes in term and preterm newborns may reflect myocardial immaturity. Both PDA closure and co-existent BPD may affect MPI values in neonates. Comparing systolic and diastolic myocardial function between term and preterm newborns is not straightforward. RV MPI and LV MPI measured at 40 weeks PCA in preterm newborns correlate best with MPI values in term neonates after PDA closure. Further studies with...
larger numbers of neonates throughout the whole neonatal period are indicated.

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**Conflict of interest:** none declared

**References**


Wskaźnik sprawności mięśnia sercowego (wskaźnik Tei) w okresie noworodkowym u dzieci urodzonych o czasie i u wcześniaków

Renata Bokiniec¹, Paweł Własienko², Maria Katarzyna Borszewska-Kornacka¹, Dariusz Madajczak¹, Joanna Szymkiewicz-Dangel¹

1Klinika Neonatologii i Intensywnej Terapii Noworodka, Warszawski Uniwersytet Medyczny, Warszawa
2Poradnia Perinatologii i Kardiologii Perinatalnej, II Katedra i Klinika Położnictwa i Ginekologii, Warszawski Uniwersytet Medyczny, Warszawa

Streszczenie

Wstęp: Wskaźnik sprawności tkankowej (MPI, wskaźnik Tei) to nieinwazyjna metoda służąca do oceny globalnej, zarówno skurczowej, jak i rozkurczowej funkcji miokardium. U noworodków donoszonych oraz u wcześniaków zmiany funkcji skurczowej i rozkurczowej komory lewej (LV) i prawej (RV) odzwierciedlają stopień niedojrzałości noworodkowego miokardium oraz współistnienie krążenia płodowego.

Cel: Celem pracy była ocena MPI dla komory prawej (RVMPI) i lewej (LVMPI) u noworodków donoszonych i wcześniaków w okresie noworodkowym.

Metody: W grupie 29 noworodków donoszonych i 29 wcześniaków wykonano badania echokardiograficzne w pierwszej dobie życia, po zamknięciu przewodu tętniczego oraz w 28. dobie życia. Dodatkowo w grupie wcześniaków wykonano pomiar RVMPI i LVMPI w 40. tygodniu życia postkoncepcyjnego.

Wyniki: W obydwu grupach noworodków zaobserwowano istotne statystycznie obniżenie wartości RVMPI. U noworodków donoszonych w pierwszej dobie życia wartość RVMPI obniżyła się z 0,42 ± 0,14 do 0,29 ± 0,09 po zamknięciu przewodu tętniczego, a w 28. dobie życia do 0,22 ± 0,09. Odpowiednio dla noworodków przedwcześnie urodzonych wartości RVMPI wynosiły: 0,44 ± 0,15; 0,30 ± 0,12 i 0,21 ± 0,08. W obydwu grupach zaobserwowano małą zmienność wartości LVMP. U noworodków donoszonych wartości LVMP wynosiły odpowiednio: 0,37 ± 0,10; 0,39 ± 0,07; 0,37 ± 0,11, a w przypadku wcześniaków: 0,37 ± 0,10; 0,35 ± 0,09 i 0,36 ± 0,10. Wartości MPI uzyskane u wcześniaków w 40. tygodniu życia postkoncepcyjnego dla RVMPI wynosiły 0,28 ± 0,09, a dla LVMP — 0,37 ± 0,05 i były porównywalne z wartościami MPI uzyskanymi u noworodków donoszonych po zamknięciu przewodu tętniczego.

Wnioski: Istotne obniżenie wartości RVMPI odzwierciedla zmiany hemodynamiczne zachodzące w układzie sercowo-naczyniowym noworodka („krążenie przejściowe”) po urodzeniu. Stosunkowo małe zmiany w zakresie wartości LVMP mogą świadczyć o niedojrzałości noworodkowego miokardium. Wartości RVMPI i LVMP uzyskane u noworodków przedwcześnie urodzonych w 40. tygodniu życia postkoncepcyjnego najlepiej korelują z wartościami MPI noworodków donoszonych uzyskanymi po zamknięciu przewodu tętniczego.

Słowa kluczowe: wskaźnik sprawności mięśnia sercowego, noworodki, badanie doplerowskie

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