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The Comparison of Left Ventricular Myocardial Performance Index (Tei index) in Term and Premature Neonatal Calves

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Abstract

The neonatal heart is different from the adult heart in regard to both biochemical and structural features. Echocardiographic studies in human neonatology show that the myocardial function of left ventricle (LV) of premature infants differs from term infants. No study involving myocardial performance index (MPI) in neonatal animals has been performed until now. The objective of the present study was to evaluate LV MPI in premature calves and compare it to healthy newborn term calves. Ten healthy term and 20 premature calves were used. Echocardiographic evaluations were performed at days 1, 2, and 3 after birth and isovolumic contraction time (IVCT), isovolumic relaxation time (IVRT), ejection time (ET), and MPI calculated with PW tissue Doppler imaging (PW-TDI). Results of the study showed that the IVRT of the LV of premature calves was shorter than seen in healthy term calves. The LVMPI of healthy term calves was also higher than in premature calves. In conclusion, MPI measurement is feasible in neonatal calves. Significant decrements in MPI and shorter IVRT of preterm calves could be the result of the non-closure of the ductus arteriosus (DA), and along with the decreased afterload. Echocardiography and Doppler imaging technique are useful tools for exploring and follow up the cardiovascular system in neonatal calves.

Anahtar Kelimeler: Doppler, echocardiography, myocardial performance index, premature

Sol Ventriküler Miyokardiyal Performans İndeksinin (Tei indeksi) Term ve Prematüre Yenidoğan Buzağılarda Karşılaştırılması

Öz

Yenidoğan kalbi, hem biyokimyasal hem de yapısal özellikler açısından yetişkin kalbinden farklıdır. İnsan neonatolojisindeki ekokardiyografik çalışmalar, prematüre bebeklerin sol ventrikülünün (LV) miyokardiyal fonksiyonunun zamanında doğan bebeklerden farklı olduğunu göstermektedir. Şimdiye kadar neonatal hayvanlarda miyokardiyal performans indeksini (MPI) içeren hiçbir çalışmaya rastlanılmamıştır. Bu çalışmanın amacı prematüre buzağılarda LV MPI'yi değerlendirmek ve sağlıklı yeni doğmuş buzağılarla karşılaştırmaktır. Gününde doğmuş 10 sağlıklı buzağı ve 20 prematüre buzağı çalışmaya dahil edildi. Ekokardiyografik değerlendirmeler doğumdan sonraki 1, 2 ve 3. günlerde yapıldı ve izovolümik kontraksiyon zamanı (IVCT), izovolümik relaksasyon süresi (IVRT), ejeksiyon zamanı (ET) ve MPI PW doku Doppler görüntüleme (PW-TDI) ile değerlendirildi. Çalışmanın sonuçları, prematüre buzağıların LV IVRT'sinin sağlıklı term buzağılara göre daha kısa olduğunu gösterdi. Sağlıklı gününde doğmuş buzağıların LVMPI değeri prematüre buzağılara göre daha yüksekti. Sonuç olarak, MPI ölçümü neonatal buzağılarda uygulanabilir bir yöntemdir. Prematüre buzağıların MPI'sindeki önemli düşüşler ve daha kısa IVRT, duktus arteriyozusun (DA) kapanmamasının ve azalmış afterload'un bir sonucu olarak ortaya çıkabilmektedir. Ekokardiyografi ve Doppler görüntüleme tekniği, neonatal buzağılarda kardiyovasküler sistemi incelemek ve izlemek için yararlı araçlar olduğu ortaya konulmuştur.

Key Words: Doppler, ekokardiyografi, miyokard performans indeksi, prematüre

INTRODUCTION

In human neonatology, varies in the systolic and diastolic function of the left ventricle (LV) and right ventricle (RV) mirrors the immaturity of the myocardium and fetal circulation in term and preterm neonates (1, 2). Tei et al firstly described that myocardial performance index (MPI) is as a simple, easy to estimate, and reproducible way to evaluation of myocardial function. It has been reported to be a better method compared to the fractional shortening, ejection fraction (EF), some Doppler-derived methods such as mitral inflow (3, 4). The MPI is easily applied using conventional pulse wave (PW) Doppler echocardiography and PW-tissue Doppler imaging (PW-TDI). Previous studies have reported that the MPI is independent of blood pressure (3, 5), heart rate (6), atrioventricular valve insufficiency (7), afterload (8) and preload (9). Echocardiographic studies have been

reported that MPI has a reverse association with EF (systolic index) and direct with IVRT (diastolic index) (10). Although there are some studies about MPI in human neonates (11-15), LV function in neonatal calves (16), and cardiac biomarkers in premature calves (17) no study to date has dealt with MPI in neonatal animals. So, the aim of the present study was to assess the LV MPI in term and premature neonatal calves by PW-TDI during the first three days of life.

MATERIAL AND METHOD

The study protocol was approved by the domestic animal care and use committee at Selcuk University (No. 2017/03).

Healthy Term Calves

Ten healthy Holstein calves were included in the study. Calves were considered to be healthy according to the clinical examination and laboratory analysis findings (18).

Premature Calves

Twenty premature calves admitted to the large animal hospital with gestation age between 230-260 days were included in the study. The criteria for prematurity were a short hair coat, low gestation weight, supple hooves, the incomplete eruption of incisors, and the absence of sucking reflex. The premature calves after admission had the standard support, oxygen therapy, and feeding protocol (19).

Echocardiography

The echocardiography was performed 1st, 2nd, and 3rd days after birth in left lateral recumbency, and apical four-chamber view was performed (16). The PW-TDI was performed by 2.0 to 4.0 MHz transducer (SIUI ultrasonography machine, Apogee 3500, China). Sample volumes were placed in the mitral annulus corresponding to the septum region to record prime velocity-time intervals: IVCT, IVRT and ET (Figure 1) (4). For calculation of MPI the following formula was used: MPI= (IVRT+IVCT)/ET (3). The TDI tracing was recorded over three cardiac cycle and the mean of measurements were calculated. Simultaneously the ECG records were performed by the same machine using base apex or lead II derivation.

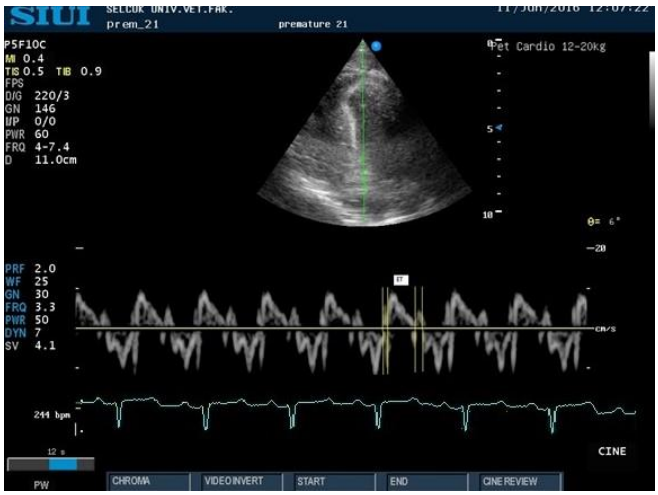

Figure 1. Recorded major velocity time intervals: isovolumic relaxation time (IVRT), isovolumic contraction time (IVCT), and ejection time (ET) in a premature calf by pulsed wave tissue Doppler imaging (PW-TDI)

Statistical Analysis

To evaluate the normal distribution of data the Kolmogorov-Smirnov test was used. All variables had normal distribution and presented as mean± standard deviation (SD). Independent samples t-test and ANOVA along post hoc Tukey tests were used for comparing the difference between groups. The significance was considered as P <0.05.

RESULTS

The gestational age of premature calves was between 230-260 days and they met the criteria for prematurity before inclusion. Premature calves had findings of the respiratory distress syndrome including tachypnea, and respiratory effort. Tachycardia, cyanotic mucosal membranes, hypothermia, weakness, and absence of suckling reflex were found in premature neonatal calves.

The PW-TDI findings represent that there was not significant difference in IVRT, IVCT, and ET from day one to day three in term and premature neonatal calves. The only significant difference was an increase in the MPI of term neonatal calves on the third day (Table 1). When comparing the PW-TDI findings of the term and premature calves at days 1, 2, and 3, the IVRT was clearly shorter in premature calves than term calves (Figure 2). The MPI was higher in term calves compared to the premature calves within 3 days life (Table 2) (Figure 3).

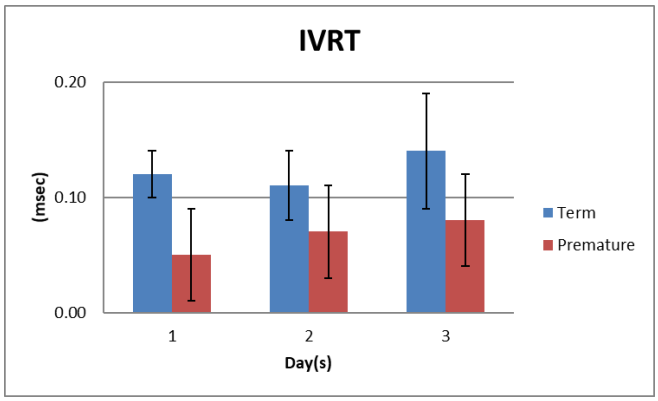

Figure 2. Mean values ±SD (standard deviation) of isovolumic relaxation time (IVRT) for left ventricles in term and premature calves

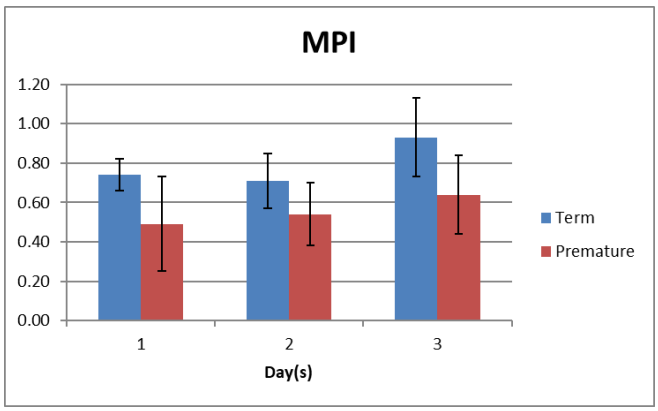

Figure 3. Mean values ±SD (standard deviation) of myocardial performance index (MPI) for left ventricles in term and premature calves

Table 1. Comparison of left ventricle IVRT, IVCT, ET and MPI of healthy term (n:10) and premature (n:20) calves from day 1 to day 3

Parameter	Healthy Term (day)			Premature (day)		
	1	2	3	1	2	3
IVRT (msec)	0.12±0,02	0.11±0.03	0.14±0.05	0.05±0.04	0.07±0.04	0.08±0.04
IVCT (msec)	0.03±0.01	0.03±0.005	0.04±0.007	0.04±0.01	0.04±0.01	0.04±0.01
ET (msec)	0.21±0.02	0.20±0.01	0.20±0.01	0.20±0.04	0.20±0.03	0.19±0.03
MPI	0.74±0.08b*	0.71±0.14	0.93±0.20	0.49±0.24	0.54±0.16	0.64±0.20

Table 2. Comparison of LV IVRT, IVCT, ET and MPI between healthy term (n: 10) and premature (n: 20) calves from day 1 to day 3

Parameter	Day 1		Day 2		Day 3	
	Term	Premature	Term	Premature	Term	Premature
IVRT (msec)	0.12±0,02	0.05±0.04**	0.11±0.03	0.07±0.04**	0.14±0.05	0.08±0.04*
IVCT (msec)	0.03±0.01	0.04±0.01	0.03±0.005	0.04±0.01	0.04±0.007	0.04±0.01
ET (msec)	0.21±0.02	0.20±0.04	0.20±0.01	0.20±0.03	0.20±0.01	0.19±0.03
MPI	0.74±0.08	0.49±0.24**	0.71±0.14	0.54±0.16*	0.93±0.20	0.64±0.20**

DISCUSSION AND CONCLUSION

In fetal life, because lungs are ineffective DA and foramen ovale have an important role in blood circulation. During delivery and activation of spontaneous breathing, DA closed and it results in the separation of systemic and pulmonary blood circulation (13). In calves for some hours after birth, blood flow pass from DA via aorta to the pulmonary artery and this amount is close to 3%-25% (20). Therefore, in the situation of DA or foramen ovale, the functions of RV or LV are usually measured as supra-normal (11). Studies in humans (21, 22) and animals (16) showed that prematurity can lead to cardiovascular dysfunction and particularly suppress the LV systolic and diastolic functions. In a study, Bokiniec et al (11) were estimated both LV MPI and RV MPI in term and preterm neonates and they showed a significant reduction in RV MPI and the low magnitude of postnatal LVMPI changes in term and preterm newborns infants. They suggested that varies between RV and LV MPI may reflect the hemodynamic changes of the transitional circulation and myocardial immaturity, respectively. In our study, the IVRT was shorter in the premature calves than the healthy term calves at days 1, 2, and 3 (Table 2) (Figure 2). On the other hand, the LVMPI was higher in the term calves than premature calves within 3 days of life (Table 2) (Figure 3). So, it is showed that premature calves had better LV systolic and diastolic functions than term calves. The differences in LV MPI can reflect the differences in myocardial maturity stage in term and premature neonatal calves. In the preterm neonates, because of prematurity of the myocardium, its more water content, and less contractile structure, the compliance of the myocardium and at the same time systolic capability are poorer than term neonates (11). The immature myocardium of the premature calves might be less sensitive to afterload due to extended closing time of DA. Our results are supported by the studies performed by Noori et al (23), Agha et al (14), and Elsheikh et al (15). All these studies showed that significant increments in LVMPI have been determined after closing patent ductus arteriosus. If we concern this to our study, significant decrements in MPI of preterm calves could be the result of not closing of DA, shorter IVRT, and decreased afterload.

In conclusion, MPI measurement is feasible in neonatal calves. Our results showed that significant decrements in MPI and shorter IVRT of preterm calves could be the result of the non-closure of the DA, and along with the decreased afterload. More studies are necessary for longer following the fetal myocardium and display the changes of LV systolic and diastolic functions of neonatal calves. Echocardiography and Doppler imaging technique are useful tools for exploring and following the cardiovascular system in neonatal calves.

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