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Assessment of the Cardiac Functions in Term Neonates by Tissue Doppler Imaging

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ABSTRACT

Background: To establish physiological values of systolic and diastolic indexes in healthy term newborns by tissue Doppler imaging (TDI)

Objective: To measure the ventricular and septal myocardial velocities using tissue Doppler imaging in the first 72 h of life in neonates.

Material and Methods: Left and right ventricular peak systolic (Sm), early diastolic (Em) and late diastolic (Am) myocardial velocities were measured at three different sites (Left ventricle, Inter ventricular septum and Right ventricle) using tissue Doppler imaging along with standard echocardiography. TEI index was also calculated.

Results: Forty normal term neonates were recruited. The mean velocity of the myocardial motility (Em, Am and Sm waves) obtained from the septum were significantly lower than those from the RV or LV, and the RV had significantly greater velocities than the LV and Septal during systole and late diastole (p<0.05).

Conclusion: TDI is a non-invasive, feasible and an effective method for the evaluation of the cardiac function and myocardial velocities through the cardiac cycle in the neonate.

Key words: Tissue doppler imaging, Inter ventricular septum, Right ventricle, Cardiac cycle, Neonate

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INTRODUCTION

Tissue Doppler imaging (TDI) is an important part of the assessment of myocardial systolic and diastolic function in cardiology [1]. In contrast to the pulse Doppler method, this allows for the assessment of the motility of the cardiac muscle. The method is based upon the measurement of the signal obtained from the myocardial wall which is characterized 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. However, the study of TDI values according to the age has been insufficient in neonatal and infantile age groups. Previous authors [2,3] reported that there were no significant correlations between age and TDI values. In contrast, other authors [4-6] found positive correlations between age and my-ocardial velocities. Also, there are a limited number studies about cardiac growth and TDI values. The myocardial impairment of systolic and diastolic function accompanies intrauterine and secondary infections, and affects preterm neonates with bronchopulmonary dysplasia (BPD), hypoxia, and intrauterine growth retardation. However, there is scanty literature regarding echocardiographic evaluation of left ventricular diastolic functions in healthy neonates. The measurement of both systolic and diastolic components can be made simultaneously with Myocardial performance index (MPI) or Tei index which is used for the evaluation of the ventricular functions [7,8]. No reference values were available for neonatal cardiac function in our geographical area, thus we decided to perform a study with an aim was to determine the cardiac function of term babies by TDI.

MATERIAL AND METHODS

This study was carried out in the Neonatology Unit, Department of Pediatric, AVBRH hospital, Sawangi (Meghe), Wardha. It was a hospital based cross-sectional study conducted from Jan 2017 to June 2017. The examination was performed on 40 healthy, term infants born at 37–42 weeks of gestation. Patients who had congenital heart disease, dysmorphic findings, poor general status, asphyxia, prematurity, severe respiratory distress, a history of traumatic delivery and findings of intrauterine infection were excluded from the study. Neonates of diabetic mothers were also excluded as such infants are known to have left ventricular dysfunction. Parental consent was obtained for all neonates involved in the study, prior to examination. The study protocol was approved by the ethical institutional committee. Data including prenatal history, mode of delivery (normal vaginal vs. cesarean section), gestational age, postnatal age (as hours), sex, weight and vitals were recorded. The preterm neonates were excluded. By using Phillip echocardiography machine, two-dimensional (2D), M-mode, Doppler and Tissue Doppler Imaging was per-formed.

Echocardiographic examination

The measurements of M-mode parasternal short-axis were conducted at end-diastole for inter-ventricular septal thickness, LV posterior wall thickness and left ventricular diameter in diastole and systole. Aorta and left atrial dimensions were recorded in left parasternal long axis view. The fractional shortening and ejection fraction was estimated using M-mode and Simpson in the parasternal long- and short-axis views as well as in the apical four-chamber view. To record mitral flow velocities with the pulsed Doppler method, sample volume was placed at the level of tip of both leaflets during diastole. Early (E) and late diastolic velocities (A) were recorded and E/A ratio was calculated. All data were obtained according to the recommendations of the American Society of Echocardiography.

Myocardial velocity measurement was performed in parasternal long-axis and apical four-chamber views with colour flow coded tissue Doppler by placing a sample volume at three different site i) Below the lateral mitral annulus (Left Ventricle) ii) Intraventricular Septum and iii) Below the lateral tricuspid annulus (Right Ventricle). Peak systolic myocardial velocities (Sm), peak early diastolic myocardial velocity (Em) and peak late diastolic myocardial velocity (Am) were recorded with TDI in all subjects. Their Isovolemic contraction (IVCT), isovolemic relaxa-tion time (IVRT) and ejection time (ET) were analysed at each site. The Tei index was calculated by using the formula (IVCT + IVRT / ET) [9,10].

Table 1: Standard Echocardiography parameters in study cases.

Echocardiography Parameter	Study Cases (Means ± SD)
M-Mode	
LA	9.62 ± 2.14
LVIVSd	4.05 ± 0.46
LVIDd	13.5 ± 1.75
LVPWd	4.27 ± 0.71
Shortening Fraction	33.24 ± 4.71
2-Dimension	
Ejection Fraction	68.28 ± 8.71
Doppler	
Mitral E (cm/s)	46.21 ± 8.05
Mitral A (cm/s)	54.61 ± 8.22
Mitral E/A	0.86 ± 0.18

Table 2: TDI derived parameters in study cases.

TDI Parameter	Study Cases (Means ± SD)
TDI Below Lateral Mitral Annulus (LV)	
LV Em(cm/s)	4.45 ± 1.61
LV Am(cm/s)	5.62 ± 1.97
LV Sm(cm/s)	4.72 ± 1.58
LV Em/ Am	0.87 ± 0.41
LV Tei Index	35.20 ± 8.72
TDI Interventricular Septum	
Septal Em(cm/s)	3.32 ± 0.80
Septal Am(cm/s)	4.65 ± 0.80
Septal Sm(cm/s)	3.67 ± 0.79
Septal Em/ Am	0.73 ± 0.25
Septal Tei Index	32.25 ± 7.84
TDI Below Lateral Tricuspid Annulus (RV)	
RV Em(cm/s)	8.27 ± 1.20
RV Am(cm/s)	11.2 ± 1.60
RV Sm(cm/s)	8.12 ± 1.12
RV Em/ Am	0.74 ± 0.17
RV Tei Index	41.65 ± 8.66

Statistical analysis

Statistical analysis was performed by STATA software. Continuous variables are presented as means ± SDs, and categorical variables are given as frequencies with percentages. To compare continuous variables the student's t-test was applied. All p values < 0.05 was considered statistically significant.

RESULTS

The examination was performed on 40 healthy, term infants born at 37–41 weeks of gestation. The neonates included 22 male and 18 female. The mean birth weight was 2.67 ± 0.80 kg. The mothers of the neonates had undergone normal vaginal delivery (n = 24) or caesarean sections (n = 16). Mean age of the neonates were 2.50 ± 2.50 days. Mean heart rate was 124.67 ± 1.24/min. Table 1 shows the Standard Echocardiography parameters in study cases. Table 2 shows the TDI parameters in study cases. The mean velocity of the myocardial motility (Em, Am and Sm waves) obtained from the septum were significantly lower than those from the RV or LV. Whereas the RV had significantly greater velocities of the myocardial motility than the LV and Septal during systole and late diastole ($p<0.05$).

DISCUSSION

TDI is an echocardiographic technique which utilizes the phenomenon of the pulse Doppler together with that of colour coding to measure the velocity of the myocardium in motion. It is less dependent on loading conditions, and it has been applied more frequently for cardiac evaluation in foetus also. 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 [11,12]. TDI is an accurate echocardiographic method to provide quantitative information about myocardial wall velocities and their directions. In systole, important prognosticators of TDI include peak systolic velocity in ejection period measured at mitral annu-lus (Sa) or at myocardial segments (Sm). In diastole, potentially important prognosticators include peak myocardial early diastolic velocity measured at the mitral annulus (Ea) or myocardial segments (Em).

Sm wave velocity correlates with ejection fraction measurements in the LV [13]. A decrease in the Sm wave velocity occurs during hypoxia of the cardiac muscle in neonates, and is associated with the pathological motility of the cardiac muscle. Wei, et al. [14] re-ported that a depression of the Sm wave in hypoxic neonates. In our study, the mean value of the Sm systolic wave in healthy neonates were lower in the LV and septal as compared to RV. The Sm wave velocity increases with the contractility of the cardiac muscle during infusion of dobu-tamine and depressed in pulmonary hypertension [15,16]. The study done by Nagueh, et al. [17] found a significant decrease in the left ventricular E’, A’ and S’ velocities in patients with hypertrophic cardiomyopathy. Notomi, et al. [18] assessed LV performance in healthy controls found that the LV performance increased significantly with age. The growth of myocardium and increase in blood pressure related to age may lead to greater myocardial velocities during systole in order to maintain adequate cardiac output.

Mitral inflow velocity is known to be a useful indicator for evaluating diastolic function. 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 characterized by somewhat lower velocities than those at the valve annulus. As Em represents myocardial tension in early diastole, the Em velocity is related with relaxation of the myocardium. It is considered to be a variable which indicates ventricular relaxation independent of volume load and Em value of <8 cm/s has been reported to indicate relaxation dysfunction [19,20]. In our study, the mean value of the Em velocity in healthy neonates was higher in RV (8.27 ± 1.20 cm/s) as compared to LV (4.45 ± 1.61 cm/s). In the study published by Negrine, et al. [13], the Em wave velocity for the LV (5.3 cm/s) in 16 term neonates was higher than our study. In adults, Em wave values below 8 cm/s indicate a disturbance of the contractile function of the LV [16]. 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 [16]. Mori, et al. [11] found the mean Em values <8 cm/s which was obtained from the left ventricle, right ventricle and septum of healthy newborns. On Tissue Doppler Imaging, early findings of diastolic dysfunction is significant reduction in Em, increase in Am velocities and reversal of the Em/ Am ratio (<1).

Nevertheless, in healthy children, there are just a limited number of studies about usefulness of tissue Doppler index as cardiac function evaluation indicators. There are several reasons why the adult tissue Doppler findings cannot be inferred to children. Physiologically, infants and children have much smaller velocities than adults, and as the velocities increase with child growth, there is an inexplicably larger increase of longitudinal systolic velocities than radial velocities. Hiarada, et al. [4] suggested that there was positive correlation between age and E/A ratio. Eidem, et al. [6] found positive correlation between E/A ratio and age, and negative correlation between E/Em ratio and cardiac growth (i.e., age, LVED d), and they observed LVEDd had been showed the most significant correlations with TDI parameters. The echocardiographic measurement of the left ventricular dimensions, ejection fraction and fractional shortening were similar to observations of previous workers [11] was found. 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. Previous workers have also observed that E-wave velocity is higher than A-wave velocity in Doppler evaluation of mitral flow [11-13].

The Tei index or MPI is a noninvasive method which shows systolic and diastolic functions of the left and right ventricle. The Tei index may be more accurate in pediatric patients because it is less altered by heart rate variability [10-14]. In neonates, changes in the systolic and diastolic function of the ventricle reflect the degree of neonatal myocardial immaturity and the co-existence of foetal circulation. The Tei index is not a gold standard method for the diagnostic approach to various heart diseases. However, it appears to be reliable for the evaluation of the severity of myocardial dysfunction in an appreciable number of diseases and can help determine which patients need early intervention. Rad, et al. [21] demonstrated that the normal range of RV MPI in neonates was 0.23 ± 0.14. Eidem, et al. [22] reported that no statistically different from the group of normal children in whom the LV MPI was 0.35 ± 0.03 and the RV MPI was 0.32 ± 0.03. In our study, the mean value of the Tei index in healthy neonates was higher in RV (41.65 ± 8.66) as compared to LV (35.20 ± 8.72) and septal (32.25 ± 7.84). Postnatal changes in RVMPI in both term newborns reflect both systolic and diastolic RV function well, which is influenced by the haemodynamic changes of the transitional circulation. Whereas the low magnitude of postnatal LVMPI changes in term newborns may reflect myocardial immaturity. A limitation of the study was the small sample sizes of the study population.

CONCLUSION

TDI is a non-invasive, feasible and an effective method for the evaluation of the cardiac function and myocardial velocities through the cardiac cycle in the neonate. Right ventricle shows impaired relaxation pattern during first 72 hours.

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