ORIGINAL ARTICLE

Assessment of the Fetal Diastolic Component of the Cardiac Cycle with Spectral Doppler E/A Ratio Through the Atrioventricular Valves in Normal Fetuses and Intrauterine Growth-restricted Fetuses

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ABSTRACT

Background: The fetal heart's structural evaluation is well established. Functional evaluation using pulsed-wave Doppler is another option. E/A ratios describe the relationship between the maximal velocities of the E and A ventricular filling waveforms. E/A ratios in normal fetuses are usually <1 but show a constant increment during gestation, which is primarily related to the increment of the E wave. E/A ratios are lower in intrauterine growth restriction (IUGR) fetuses than in normally grown fetuses at the same gestational age. In normal fetuses, the right ventricle contributes the majority of the combined cardiac output (55–60%). In IUGR fetuses, this preponderance switches to the left ventricle to improve blood supply to the fetal body and brain. Systolic and diastolic heart functions are also measured by the myocardial performance index (MPI). IUGR can affect the fetal and newborn health in the long run. IUGR can be associated with various fetal and maternal conditions; hence, it is necessary to establish an early diagnosis and a therapeutic strategy. It is necessary to determine whether obstetric intervention via preterm delivery is recommended to improve these patients' perinatal outcomes. Our study's objective was to determine the distribution of these Doppler values with neonatal outcome in both normal and IUGR fetuses. We did this by measuring the fetal diastolic component of the cardiac cycle using spectral Doppler through the atrioventricular valves. **Methods:** We did a cross-sectional study of 217 patients out of 3200 screened patients at routine antenatal visits from January 2020 to October 2021 in SKNMC and GH, Pune. **Observation:** In our study of 217 patients, we observed that all 100% IUGR cases showed an abnormal E/A ratio which was decreased as compared to normal fetuses in the same gestational age. **Conclusion:** We conclude that E/A ratio with Doppler echocardiography can help evaluate fetal cardiac status and identify IUGR fetuses with cardiac problems. Early intervention for IUGR fetuses with cardiac compromise can improve outcomes and reduce risks.

Keywords: Intrauterine growth restriction, E/A ratio, fetal diastolic component, atrioventricular valves

INTRODUCTION

Stillbirth is the death of a baby before or during delivery. Stillbirth is a devastating event that affects about 2.6 million pregnancies worldwide every year. India is having a maximum number of stillbirths in the world.[1-3]

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It can have various causes, such as placental problems, infections, and chromosomal abnormalities. Fetal growth restriction, also known as intrauterine growth restriction (IUGR), is a condition in which the fetus fails to achieve its genetic growth potential due to various causes, such as placental insufficiency, maternal disease, or fetal infection. The prevalence of IUGR in India is reported to be around 8–10% among the pregnant women. IUGR is associated

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with an increased risk of adverse perinatal outcomes, such as stillbirth, neonatal morbidity and mortality, and long-term neurological and metabolic sequelae.[4,5] Therefore, early detection and appropriate management of IUGR fetuses are essential for optimizing fetal and neonatal wellbeing.

Doppler ultrasound is one method for assessing fetal growth and wellbeing because it can measure blood flow velocity and resistance in various fetal and maternal vessels. Doppler ultrasound can provide information on fetal cardiac function, placental perfusion, and fetal oxygenation.[6] The E/A ratio is one of the most commonly used Doppler parameters for evaluating fetal cardiac function. The E/A ratio is the ratio of the peak velocities of the ventricle's early (E) and late (A) diastolic filling waves as measured by atrioventricular (AV) valve pulsed Doppler. The E/A ratio reflects the ventricular myocardium's compliance and relaxation, as well as the preload and afterload conditions. The E/A ratio increases with gestation in normal fetuses as ventricular compliance improves and atrial contraction becomes less important. The E/A ratio is often altered in IUGR fetuses, indicating impaired diastolic function and/or hemodynamic adaptation to chronic hypoxia.[3,5] Other factors, such as fetal heart rate, cardiac rhythm, and fetal movements, can also influence the E/A ratio. As a result, the E/A ratio should be interpreted in conjunction with other Doppler parameters that are more comprehensive indicators of fetal cardiac function, such as combined cardiac output, individual ventricular ejection forces, and the Tei index (MPI).[3,5]

The purpose of this paper is to assess the fetal diastolic component of the cardiac cycle with spectral Doppler E/A ratio through the AV valves in normal fetuses and intrauterine growth-restricted fetuses, as well as to discuss its clinical implications and limitations.

METHODS

From January 2020 to October 2021, a cross-sectional study was conducted in the Foetal Medicine Department, SKNMC, Pune. During this time, 3200 women were screened at standard antenatal visits, and 217 of them were chosen.

Inclusion Criteria

1. Pregnant women more than or equal to 25 weeks of gestation
2. Women who are willing to perform the Doppler study (written informed consent taken).

Exclusion Criteria

1. Pregnant women who are <25 weeks of gestation
2. Multifetal pregnancies
3. Any congenital heart disease diagnosed antenatally in the present pregnancy.

During this appointment, the mother's characteristics and medical history were noted, and the trans-abdominal ultrasound measurements of the fetus' biparietal diameter, head circumference, abdominal circumference, and femur length were used to estimate its size. Menstrual history or measurements of the fetal crown-rump length at 11–13 weeks 6 days gestation or the fetal head circumference at 19–24 weeks were used to determine gestational age.[4]

Doppler examinations were carried out by a single fetal medicine specialist utilizing a Seimens Acuson ×300 ultrasound equipment, 5-MHz sector transducers, and high-pass filters at 50–100 Hz with spatial peak temporal average intensities below 50 mW/cm^2. Every photograph has been downloaded and saved to IMPACS.

For the evaluation of fetal cardiac function, a wide variety of US techniques have been used, including the basic image (2D image), M-mode, all Doppler modes, including directional color, power, spectral conventional, and tissue Doppler, as well as more recently, tomographic US imaging and spatiotemporal image correlation. Each of these has advantages and restrictions of its own. Spectral Doppler is used to examine the fetal diastolic portion of the heart cycle through the AV valves. In a typical fetus, a biphasic waveform is typically visible at the Doppler sampling gate, which is situated directly beneath the AV valves. The first part is referred to as the E (early or passive) wave and is connected to the ventricle-applied negative pressure and the process of myocardial relaxation. The A (atrial, active, or late) wave, which is the second component, is a representation of the atrial contraction during ventricular filling. The ratio is calculated by dividing the E and A waveform peak velocities.[4]

RESULTS

The purpose of this study was the assessment of the fetal diastolic component of the cardiac cycle with spectral Doppler E/A ratio through the AV valves in normal fetuses and intrauterine growth-restricted fetuses. The results of the patients studied were tabulated using Microsoft Excel. The observations of these 217 patients were compiled and analyzed.

In our study, a total of 217 patients from 3200 screened patients were included. Out of these, we found that 187 were normal fetuses and 30 were IUGR fetuses. Among these 189 had term delivery and 28 had preterm delivery with 25 having NICU stay.

In <28 weeks, all 6 fetuses showed normal E/A ratio in the range of 0.60–0.66 and followed by full-term normal delivery.

In 28–32 weeks, out of 91 fetuses [Chart 1] 87 were in normal condition with E/A ratio in the range 0.72–0.78. In 4 IUGR cases, E/A ratio was decreased as compared to normal fetuses in the range of 0.57–0.63. Among IUGR fetuses E/A ratio was abnormal in 100% of cases in which 4 patients showed preterm delivery and 1 had NICU stay.

In 32–37 weeks, out of 82 fetuses [Chart 2] 67 were in normal condition with E/A ratio in range 0.73–0.83. In 15 IUGR cases, E/A ratio was decreased as compared to normal fetuses in the range of 0.55–0.69. Among IUGR fetuses, E/A ratio was abnormal in 100% of cases in which 14 patients showed preterm delivery and 12 had NICU stay.

In >37 weeks, out of 38 fetuses [Chart 3] 27 were in normal condition with E/A ratio in range 0.85–0.93. In 11 IUGR cases, E/A ratio was decreased as compared to normal fetuses in range of 0.59–0.77. Among IUGR fetuses, E/A ratio was abnormal in 100% of cases in which 8 patients showed preterm delivery and 9 had NICU stay.

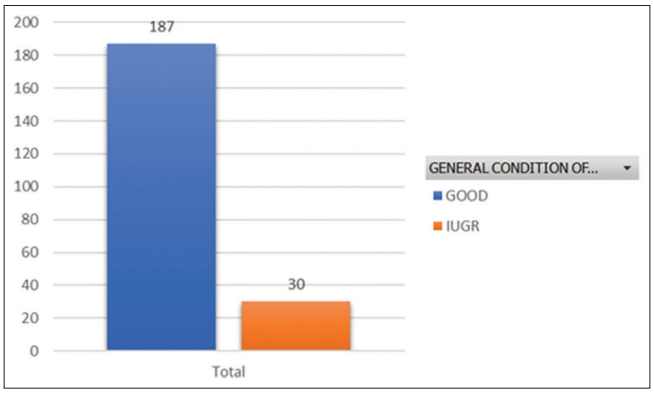

Chart 1: General condition of fetus

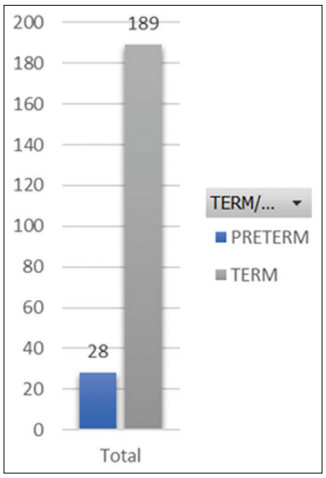

Chart 2: Delivery

DISCUSSION

IUGR can have long-term consequences for the fetal and neonatal health, such as neurodevelopmental impairment, metabolic syndrome, and cardiovascular disease. Due to the potential conflict between the risk of intrauterine permanency and the issue of prematurity, IUGR can be linked to a variety of fetal and maternal problems, necessitating the development of an early diagnosis and treatment plan. To improve the perinatal outcomes of these individuals, it is crucial to decide whether obstetric intervention through a preterm delivery is advised. Ultrasound and Doppler velocimetry is the main imaging modality to screen and diagnose IUGR by measuring fetal biometry, estimating fetal weight, assessing amniotic fluid volume, fetal hemodynamic and placental resistance and helping identify fetuses at risk of adverse outcomes of these patients. It has been observed that performing MPI requires specialized units, higher-end machines, and trained persons. India is having a maximum number of stillbirths in the world.[3] Hence, there is an urgent need to find out which fetuses are at risk for hypoxia and intrauterine death. This study will guide Indian clinicians in limited resource settings regarding the timing of intervention at term so as to have good perinatal outcome.

The evaluation of fetal cardiac function is crucial in the assessment of fetal well-being and the detection of IUGR. The diastolic component of the fetal cardiac cycle, which includes the filling of the ventricles, is particularly important for the proper functioning of the fetal heart and can provide information about the fetal circulation and oxygen supply. Spectral Doppler and the E/A ratio through the AV valves have been widely used in the assessment of fetal cardiac function and have been shown to provide valuable information about fetal cardiac performance. The purpose of this study is to assess the diastolic component of the fetal cardiac cycle using

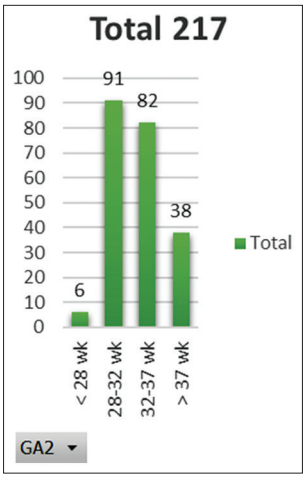

Chart 3: Weeks of pregnancy

spectral Doppler and the E/A ratio through the AV valves in both IUGR fetuses and normal fetuses, with the aim of providing a new diagnostic tool for the detection of IUGR in utero.

The assessment of the fetal cardiac cycle through spectral Doppler E/A ratio is an important tool in evaluating fetal cardiac function and can help diagnose IUGR [Figure 1]. The E/A ratio is the relationship between the early diastolic flow (E) and the late atrial contraction flow (A) across the AV valves [Figure 2]. A normal E/A ratio indicates an efficient left ventricular filling, while an abnormal ratio can be a sign of impaired cardiac function.

The E/A ratio is influenced by several factors, such as gestational age, preload, afterload, and myocardial compliance. In normal fetuses, the E/A ratio increases with advancing gestation [Figure 3], as the E wave becomes more dominant due to the increased compliance of the ventricular myocardium and the decreased importance of atrial contraction. Both E and A waves rise during pregnancy, though the E wave is more pronounced because of greater ventricular compliance and myocardial relaxation.[7,8] In contrast to the A wave, which only varies from 30 cm/s to 45–50 cm/s throughout the same period, the E wave's peak velocity is roughly 16 cm/s at 16 weeks of gestation and rises to 45–50 cm/s at term. Throughout gestation, both AV valves' E/A ratios gradually rise as a result of this steady increase in E wave velocity.[9-11] While the atrial contraction continues to contribute during the diastolic part of the cardiac cycle after birth, the E wave is still higher than the A wave.[12,13]

In IUGR fetuses, the E/A ratio is lower than in normal fetuses of the same gestational age, indicating impaired diastolic function. This may be due to the chronic hypoxia and acidosis that affect the myocardial relaxation and contractility in IUGR fetuses. The E/A ratio may also be affected by the hemodynamic changes that occur in IUGR fetuses, such as the redistribution of blood flow to the brain and the heart, the increased afterload, and the decreased preload. Reduced E/A ratios show that atrial contraction, rather than relaxation-induced negative pressure, is what drives ventricular filling. Chronic hypoxia and cardiac overload, the two main factors affecting the ratios, may have an impact on the relaxation process and thus lower the E/A ratios. When there is IUGR, the fetus has altered ventricular function and decreased cardiac output, which might lower the E/A ratio. This reduction in the E/A ratio is a result of the limited growth and reduced cardiac reserve in IUGR fetuses, which can result in decreased cardiac performance and decreased left ventricular filling. The E/A ratio can be used as a marker of cardiac dysfunction and fetal compromise in IUGR fetuses, as it has been shown to correlate with adverse perinatal outcomes, such as neonatal acidosis, low Apgar

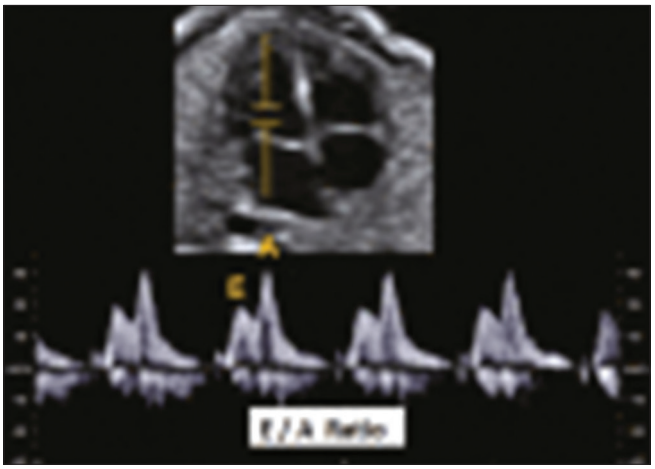

Figure 1: Spectral Doppler imaging showing the E and A waves through the fetal heart mitral valve

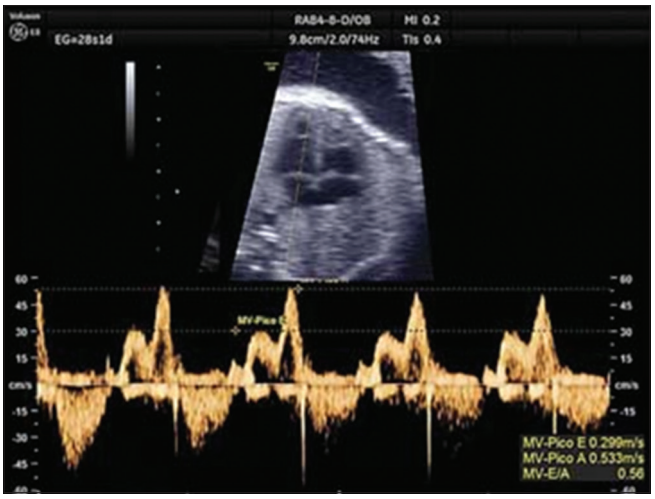

Figure 2: Fetal E/A ratio

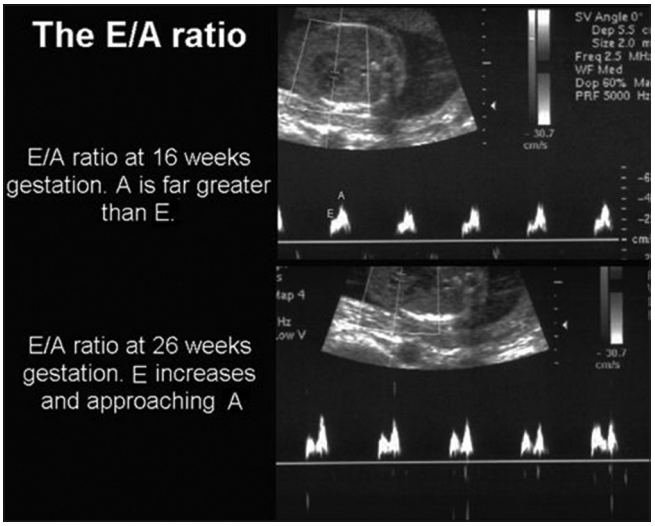

Figure 3: E = First peak and represents passive ventricular filling in early diastole. A = Second peak and represents atrial contraction in late diastole

scores, and perinatal mortality. However, the E/A ratio has some limitations, such as the variability of measurements, the dependence on fetal heart rate and rhythm, and the lack of normative values for different gestational ages and fetal conditions. Therefore, the E/A ratio should be interpreted in conjunction with other parameters of fetal cardiac function, such as the MPI, the cardiac output, and ventricular ejection forces.

Increased isovolumetric relaxation time, which indicates inadequate myocardial relaxation, predicts diastolic functional impairment with IUGR, as was previously reported.[1,2,14] The E/A ratio, which measures the ratio between a passive diastolic ventricular filling and extra active filling during atrial contraction (E- and A-wave on Doppler signal), can also be used to measure diastolic function. In growth-restricted fetuses, neonates, and newborns, different E/A ratio outcomes have been observed. A decreased E/A ratio in some investigations[14,15] when compared to AGA controls points to increased ventricular wall stiffness and delayed relaxation. Others, however, have discovered comparable[16,17] or elevated[1,2] ratios. A decreased E/A ratio is followed by "pseudo-normalization" and a rise in the ratio in adults with progressive diastolic dysfunction.[18] Thus, disparate results can represent various levels of diastolic dysfunction.

It is important to note that while the E/A ratio is a useful tool in evaluating fetal cardiac function, it is just one aspect of the evaluation. Other factors such as fetal biometry, blood flow, and contractility should also be considered in the overall assessment of fetal cardiac function.

CONCLUSION

These findings suggest that Doppler echocardiography can be a valuable tool to evaluate the fetal cardiac status and to identify the fetuses at risk of adverse outcomes. The spectral Doppler E/A ratio through the AV valves is a useful parameter for assessing fetal cardiac diastolic function, and it is significantly reduced in IUGR fetuses compared to normal fetuses. The E/A ratio through the AV valves is also correlated with other parameters of fetal cardiac function.

The early detection and management of IUGR fetuses with cardiac compromise can improve the perinatal and neonatal outcomes, and reduce the long-term morbidity and mortality associated with this condition.

It has been discovered that performing MPI necessitates the use of specialized units, high-end machines, and trained personnel. It is critical to identify which fetuses are at risk of hypoxia and intrauterine death. This study will advise Indian clinicians in low-resource settings regarding the timing of intervention at term to achieve a positive perinatal outcome.

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