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ROLE OF FETAL MAIN PULMONARY ARTERY DOPPLER IN PREDICTING NEONATAL RESPIRATORY DISTRESS SYNDROME

Radio-Diagnosis

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ABSTRACT

Background: Neonatal respiratory distress syndrome (RDS) is a major cause of neonatal morbidity and mortality, particularly in preterm infants. Accurate antenatal prediction of fetal lung maturity is important for early intervention and optimal neonatal management. Doppler evaluation of the fetal main pulmonary artery (MPA) has emerged as a promising non-invasive method for predicting neonatal RDS.**Aim:** To evaluate the role of fetal MPA Doppler parameters in predicting neonatal respiratory distress syndrome.**Materials and Methods:** A prospective analytical study was conducted in 100 third-trimester pregnant women at JJM Medical College and associated hospitals, Davangere, from March 2024 to September 2025. Doppler evaluation of the fetal MPA was performed using a Voluson E6/GE P10 ultrasound machine. Parameters recorded included acceleration time (AT), ejection time (ET), and AT/ET ratio. Neonates were followed for the development of RDS within 48 hours after delivery. Statistical analysis was performed using SPSS version 20.0.**Results:** Among 100 neonates, 47 developed RDS. Mean AT was significantly lower in the RDS group (61.38 ± 16.25 ms) compared to the non-RDS group (89.43 ± 12.81 ms) ($p < 0.001$). Mean ET was significantly higher in RDS cases (285.47 ± 37.11 ms) than non-RDS cases (258.04 ± 37.18 ms) ($p = 0.0004$). The AT/ET ratio was markedly reduced in neonates with RDS (0.215 ± 0.047 vs 0.351 ± 0.058; $p < 0.001$). ROC analysis showed excellent diagnostic accuracy of the AT/ET ratio with an AUC of 0.958, sensitivity of 86.8%, and specificity of 91.5% at a cut-off value of approximately 0.29.**Conclusion:** Fetal MPA Doppler, especially the AT/ET ratio, is a reliable and non-invasive predictor of neonatal respiratory distress syndrome and may aid in antenatal risk stratification and perinatal management.

KEYWORDS

Respiratory Distress Syndrome; Main Pulmonary Artery Doppler; At/et Ratio; Fetal Lung Maturity; Neonatal Outcomes

INTRODUCTION

Neonatal respiratory distress syndrome (RDS) remains one of the leading causes of neonatal morbidity and mortality worldwide, particularly among preterm and late-preterm infants. It primarily results from surfactant deficiency and structural immaturity of the lungs, leading to alveolar collapse, reduced lung compliance, and impaired gas exchange. Clinically, RDS presents with tachypnea, nasal flaring, expiratory grunting, chest retractions, and cyanosis within the first few hours after birth. Despite significant advances in neonatal intensive care, surfactant therapy, and ventilatory support, RDS continues to contribute substantially to neonatal intensive care unit (NICU) admissions and healthcare burden, especially in developing countries.[1,3]

Accurate antenatal prediction of fetal lung maturity is essential for optimizing perinatal management and improving neonatal outcomes. Early identification of fetuses at risk allows timely administration of antenatal corticosteroids, which accelerate fetal lung maturation and reduce the incidence and severity of neonatal RDS, intraventricular hemorrhage, and neonatal mortality. [4] In addition, appropriate timing and mode of delivery and delivery at tertiary care centers with adequate neonatal support can be planned effectively. Therefore, reliable assessment of fetal lung maturity before delivery is of major clinical importance. [4,5]

Traditionally, fetal lung maturity has been evaluated using invasive biochemical analysis of amniotic fluid, including lecithin–sphingomyelin (L/S) ratio, phosphatidylglycerol estimation, and lamellar body count. Although these tests are considered reliable, they require amniocentesis, which is invasive, costly, and associated with potential complications such as infection, preterm labor, placental injury, and fetal loss. [5, 6] Furthermore, these methods are not feasible for routine clinical use in many resource-limited settings. Consequently, there has been increasing interest in non-invasive imaging techniques for assessing fetal lung maturity and predicting neonatal respiratory outcomes. [6]

Doppler ultrasonography has emerged as a valuable non-invasive modality for evaluating fetal circulation and hemodynamics. The fetal main pulmonary artery (MPA) plays a crucial role in pulmonary circulation, and its Doppler waveform reflects pulmonary vascular resistance and compliance. In the fetus, pulmonary vascular resistance is relatively high because the lungs are fluid-filled and non-functioning, resulting in characteristic Doppler flow patterns. As gestation advances and fetal lung maturation occurs, pulmonary vascular resistance decreases, producing measurable changes in pulmonary artery Doppler parameters. [7,8]

The important Doppler indices derived from the MPA waveform include acceleration time (AT), ejection time (ET), pulsatility index (PI), resistance index (RI), and the acceleration time to ejection time ratio (AT/ET ratio). Among these, the AT/ET ratio has emerged as one of the most reliable and reproducible indicators of fetal pulmonary vascular resistance and fetal lung maturity. A reduced AT/ET ratio reflects increased pulmonary vascular resistance and has been associated with a higher risk of neonatal respiratory distress syndrome. [8,10]

Several international studies have demonstrated the utility of fetal MPA Doppler in predicting neonatal RDS; however, data from the Indian population remain limited. Regional variations in maternal and fetal characteristics necessitate further validation of these Doppler parameters in local populations. Therefore, the present study was undertaken to evaluate the role of fetal main pulmonary artery Doppler parameters in predicting neonatal respiratory distress syndrome in third-trimester pregnancies.

Objectives

1. To determine the role of fetal main pulmonary artery Doppler in predicting neonatal respiratory distress syndrome in third-trimester pregnancies.
2. To correlate MPA Doppler parameters with gestational age and postnatal outcomes.
3. To evaluate the association between MPA Doppler findings and prenatal parameters in predicting neonatal RDS.

Materials and Methods

This prospective analytical study was conducted in the Department of Radiodiagnosis, JJM Medical College and associated hospitals, Davangere, after institutional ethical committee approval. The study period extended from March 2024 to September 2025.

A total of 100 pregnant women in the third trimester (28–40 weeks gestation) were included after obtaining informed consent.

Inclusion Criteria
- Singleton pregnancies
- Gestational age between 28 and 40 weeks
- Maternal age between 19 and 45 years
- Fetuses delivered within 48 hours of Doppler examination

Exclusion Criteria
- History of antenatal corticosteroid administration
- Multiple pregnancies
- Major fetal structural or chromosomal anomalies
- Small or large for gestational age fetuses
- Patients unwilling to participate

Imaging Technique
Ultrasonography and Doppler evaluation were performed using a Voluson E6/GE P10 ultrasound system with a 1–6 MHz curvilinear transducer.

The fetal main pulmonary artery was visualized in the short-axis view of the fetal heart. Doppler sampling was performed in the mid-segment of the MPA using a sample gate of 3 mm with an insonation angle less than 20°.

The following Doppler parameters were recorded:
- Acceleration Time (AT)
- Ejection Time (ET)
- AT/ET Ratio
- Pulsatility Index (PI)
- Resistance Index (RI)

Outcome Assessment
Neonates were followed for 24–48 hours after birth for the development of respiratory distress syndrome based on clinical findings and chest radiographic features.

Statistical Analysis
Statistical analysis was performed using IBM SPSS Statistics version 20.0. Continuous variables were expressed as mean ± standard deviation. Statistical significance was considered at $p < 0.05$.

REPRESENTING CASES
CASE:1
A 28-year-old gravida 2 para 1 woman in the third trimester presented for routine antenatal scan.

Underwent evaluation of fetal main pulmonary artery Doppler to assess the risk of neonatal respiratory distress syndrome.

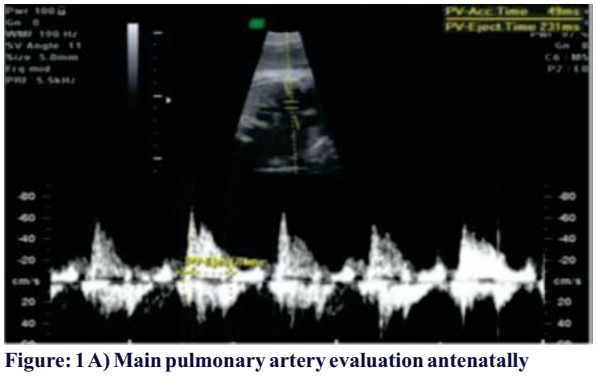

Figure: 1 A) Main pulmonary artery evaluation antenatally

The Doppler evaluation of the fetal main pulmonary artery demonstrated reduced acceleration time with increased ejection time resulted in a low AT/ET ratio of 0.21, indicating elevated pulmonary vascular resistance. This reflects fetal lung immaturity and a high risk of neonatal respiratory distress syndrome.

CASE: 2
A 28-year-old pregnant woman in the third trimester presented with leak PV and routine antenatal evaluation is done and assessment of fetal lung maturity using main pulmonary artery Doppler.

The Doppler evaluation of the fetal main pulmonary artery demonstrated reduced acceleration time with increased ejection time resulted in a low AT/ET ratio of 0.18, indicating elevated pulmonary vascular resistance. This reflects fetal lung immaturity and a very high risk of neonatal respiratory distress syndrome. Mild oligohydramnios is noted.

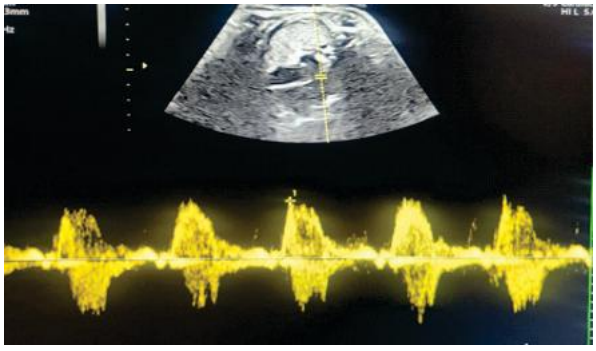

Figure 2: Main pulmonary artery evaluation antenatally

Observations and Results
A total of 100 antenatal cases in the third trimester were included in the present study to evaluate the role of fetal main pulmonary artery (MPA) Doppler parameters in predicting neonatal respiratory distress syndrome (RDS). All patients underwent detailed ultrasonography and fetal MPA Doppler assessment, and the neonates were followed for respiratory outcomes after delivery.

Among the 100 neonates studied, 47 neonates developed respiratory distress syndrome, while 53 neonates did not develop RDS. Thus, the incidence of neonatal RDS in the present study population was 47% (Table 1).

Table 1: Distribution of Respiratory Distress Syndrome

Parameter	RDS (Mean ± SD)	No RDS (Mean ± SD)	p-value
AT (ms)	61.38 ± 16.25	89.43 ± 12.81	<0.001
ET (ms)	285.47 ± 37.11	258.04 ± 37.18	0.0004
AT/ET ratio	0.215 ± 0.047	0.351 ± 0.058	<0.001

The fetal main pulmonary artery Doppler parameters showed significant differences between the RDS and non-RDS groups. The mean acceleration time (AT) was significantly lower in fetuses who subsequently developed neonatal RDS compared to those without RDS. The mean AT in the RDS group was 61.38 ± 16.25 ms, whereas it was 89.43 ± 12.81 ms in the non-RDS group, and this difference was statistically highly significant ($p < 0.001$).

In contrast, the mean ejection time (ET) was significantly higher in neonates who developed RDS. The mean ET in the RDS group was 285.47 ± 37.11 ms compared to 258.04 ± 37.18 ms in the non-RDS group ($p = 0.0004$).

The acceleration time to ejection time ratio (AT/ET ratio), which reflects fetal pulmonary vascular resistance and lung maturity, was markedly reduced in neonates with RDS. The mean AT/ET ratio in the RDS group was 0.215 ± 0.047 compared to 0.351 ± 0.058 in the non-RDS group. This difference was statistically highly significant ($p < 0.001$) (Table 2).

Table 2: Comparison of MPA Doppler Parameters

Outcome	Number	Percentage
RDS	47	47%
No RDS	53	53%
Total	100	100%

Other Doppler indices, including pulsatility index (PI) and resistance index (RI), did not demonstrate statistically significant differences between the two groups ($p > 0.05$). Similarly, no significant correlation was observed between Doppler parameters and gestational age, amniotic fluid index, or estimated fetal weight.

Receiver operating characteristic (ROC) curve analysis was performed to evaluate the diagnostic performance of the AT/ET ratio in predicting neonatal respiratory distress syndrome. The AT/ET ratio demonstrated excellent diagnostic accuracy with an area under the curve (AUC) of 0.958. The optimal cut-off value was approximately 0.29, which yielded a sensitivity of 86.8% and specificity of 91.5% for predicting neonatal RDS (Table 3).

The maternal demographic characteristics and routine antenatal

parameters including maternal age, gestational age, amniotic fluid index (AFI), estimated fetal weight, placental grade, fetal echogenicity, mode of delivery, and neonatal sex did not show statistically significant association with the occurrence of neonatal RDS ($p > 0.05$). However, birth weight demonstrated a statistically significant association with neonatal respiratory distress syndrome ($p = 0.033$), indicating increased occurrence of RDS among neonates with lower birth weight.

Table 3: Diagnostic Performance of AT/ET Ratio

Parameter	Value
AUC	0.958
Sensitivity	86.8%
Specificity	91.5%
Cut-off value	~0.29

Correlation analysis revealed a moderate positive correlation between acceleration time and ejection time ($r = 0.400$, $p = 0.001$). Overall, the findings of the present study indicate that fetal main pulmonary artery Doppler assessment, particularly the AT/ET ratio, is a highly useful non-invasive predictor of neonatal respiratory distress syndrome.

DISCUSSION

The present study evaluated the role of fetal main pulmonary artery (MPA) Doppler parameters in predicting neonatal respiratory distress syndrome (RDS) in third-trimester pregnancies. Among the studied Doppler indices, the acceleration time/ejection time (AT/ET) ratio demonstrated the strongest association with neonatal respiratory outcomes. Neonates who developed RDS showed significantly lower acceleration time and AT/ET ratio, while ejection time was significantly prolonged compared to neonates without RDS. The AT/ET ratio showed excellent diagnostic performance with an area under the ROC curve of 0.958, sensitivity of 86.8%, and specificity of 91.5% at a cut-off value of approximately 0.29. These findings suggest that increased fetal pulmonary vascular resistance, reflected by a reduced AT/ET ratio, is strongly associated with delayed fetal lung maturation and subsequent neonatal respiratory morbidity.

The findings of the present study are comparable with previous studies evaluating fetal pulmonary artery Doppler in the prediction of neonatal RDS. Azpurua et al. first demonstrated that the fetal pulmonary artery AT/ET ratio could predict fetal lung maturity, with lower ratios significantly associated with neonatal respiratory morbidity.[8] Similarly, Kim et al. reported that fetuses who developed RDS had significantly lower pulmonary artery acceleration times and AT/ET ratios compared to healthy neonates.[9] Moety et al. also found that fetal pulmonary artery Doppler indices showed high sensitivity and specificity for predicting neonatal RDS and suggested that these measurements may serve as a reliable non-invasive alternative to invasive biochemical tests for fetal lung maturity.[10] Acharya et al. described the physiological basis of these Doppler changes, explaining that pulmonary vascular resistance decreases progressively with advancing gestation and lung maturation, leading to characteristic changes in pulmonary artery flow velocity waveforms.[7] The present study supports these observations and further validates the utility of fetal MPA Doppler assessment in the Indian population, where limited regional data are available.

The present study had certain limitations. First, the sample size was relatively small and the study was conducted at a single tertiary care center, which may limit the generalizability of the findings to larger populations. Second, Doppler measurements are operator dependent and may be affected by fetal position, breathing movements, and insonation angle. To minimize these biases, all examinations were performed using a standardized Doppler protocol with an insonation angle less than 20° and optimization of Doppler settings. In addition, pregnancies with major fetal anomalies, abnormal fetal growth, multiple gestations, and prior antenatal steroid administration were excluded to reduce confounding factors affecting fetal lung maturity. Future multicentric studies with larger sample sizes, serial Doppler evaluations, and inclusion of additional pulmonary vascular indices may help establish standardized reference ranges and improve diagnostic accuracy.

In conclusion, fetal main pulmonary artery Doppler assessment, particularly the AT/ET ratio, is a reliable and non-invasive predictor of neonatal respiratory distress syndrome. A significantly reduced AT/ET ratio was associated with increased risk of neonatal RDS and demonstrated excellent diagnostic performance in the present study. Routine incorporation of fetal MPA Doppler into third-trimester antenatal ultrasonography may assist in identifying fetuses at risk for respiratory morbidity, thereby facilitating timely antenatal corticosteroid administration, optimized delivery planning, and improved neonatal management.

CONCLUSION

Fetal main pulmonary artery Doppler evaluation is a useful non-invasive method for predicting neonatal respiratory distress syndrome. Among the Doppler indices, the AT/ET ratio demonstrated the highest diagnostic accuracy. Routine incorporation of fetal MPA Doppler in third-trimester ultrasonography may help identify fetuses at risk for neonatal RDS and facilitate improved antenatal and neonatal management.

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