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Evaluation of Fetal Pulmonary Artery Acceleration / Ejection Time Ratio as an Independent Predictor of Fetal Lung Maturity

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Abstract: ***Objective: The purpose of the study is to measure the fetal main pulmonary artery acceleration/ejection time ratio in preterm pregnancies and its subsequent correlation with occurrence of respiratory distress syndrome in neonates. Materials and methods: 175 preterm consenting pregnant females were subjected to fetal main pulmonary artery (MPA) doppler velocimetry along with routine obstetric ultrasound. Post natal follow up of neonate was done to assess for respiratory distress syndrome (RDS). Results: In our study, 82 out of 175 eligible fetuses developed neonatal RDS. Statistically significant correlation was found between the mean Acceleration to Ejection time ratio (AT/ET) and development of RDS as the mean AT/ET was significantly lower in the RDS +ve group (mean 0.24) in comparison to the RDS -ve group (mean 0.34) (p <0.001). A cutoff value of 0.287 for AT/ET predicted the development of RDS with high sensitivity (95.7%) and specificity (96.3%). Conclusion: Fetal MPA AT/ET ratio can act as a potential independent predictor of fetal lung maturity and thus can be valuable for planning preterm deliveries and better post-natal care of the neonate.***

Keywords: Fetal main pulmonary artery, Doppler ultrasound, Acceleration to Ejection time ratio, Neonatal respiratory distress syndrome, fetal lung maturity

1. Introduction

Neonatal respiratory distress syndrome (RDS) continues to be a significant challenge faced in the field of neonatology. It is predominantly seen in preterm infants, whose underdeveloped lungs are unable to produce adequate levels of surfactant—a lipoprotein essential for reducing surface tension within the alveoli, enabling efficient gas exchange, and maintaining pulmonary stability. Despite remarkable advancements in neonatal care, RDS continues to contribute significantly to neonatal morbidity and mortality worldwide. Hence, prenatal evaluation of fetal lung maturity plays a crucial role in determining the optimal time to safely deliver a preterm fetus but is often a challenging ordeal for obstetricians and has been historically dependent on tests requiring invasive amniocentesis which has its own risks and complications. Thus the limitations of current diagnostic methods underscore the need for innovative approaches that are non-invasive, safe, cost-effective, accessible, and capable of providing reliable real-time assessments of fetal lung maturation.

The fetal pulmonary vasculature undergoes modifications as gestation increases. With progressive vascular smooth muscle maturation and increase in cumulative diameters of the proximal pulmonary arteries, there is a corresponding rise in pulmonary blood flow. “This phenomenon is attributed to a reduction in pulmonary arterial vascular resistance and an increase in the number of pulmonary arteries” (1)

Acceleration time (AT) is the interval from the onset of systolic flow to the peak systolic velocity (PSV) on a doppler waveform. Ejection time (ET) is the time interval from the onset of systolic flow to the end of forward flow in the pulmonary artery. AT/ET reflects the compliance and resistance of the fetal pulmonary vasculature.

Doppler ultrasound represents a simple, novel, inexpensive and non-invasive way to appreciate relative changes in acceleration time of the fetal pulmonary vasculature.

Aim: To evaluate fetal main pulmonary artery acceleration to ejection time ratio (AT/ET) as an independent predictor of fetal lung maturity

Objectives: To measure the fetal main pulmonary artery acceleration time, ejection time and their ratio (AT/ET) in preterm pregnancies and its subsequent correlation with occurrence of respiratory distress syndrome in neonates.

2. Materials and Methods

A hospital based prospective observational study was conducted in the Department of Radiodiagnosis, Jorhat Medical College & Hospital, Jorhat among 175 preterm consenting pregnant females aged between 18-40 years admitted for elective caesarean section, or attending the delivery unit either in labor or indicated for selective caesarean section for a period of 12 months (Nov 2023-Nov 2024).

Inclusion criteria:
- Age: 18-40 years
- Accurate gestational age: less than 37 weeks of gestation (calculated from the LMP if reliable or by first-trimester ultrasound through measurement of CRL)
- Singleton uncomplicated pregnancy
- Live intrauterine fetus
- Ultrasonography done within a period of 48 hours before delivery
- Newborns with complete clinical data

Exclusion Criteria:
- Gestational age more than or equal to 37 weeks 0 days
- Uncertain gestational age
- Multiple pregnancies
- Major congenital or structural anomaly identified after delivery / major fetal malformation diagnosed antenatally
- History of cardiac disease or any pregnancy related complications (hypertension, preeclampsia, diabetes mellitus), autoimmune diseases
- Macrosomia or IUGR
- Corticosteroid administration between ultrasound examination and delivery

Ethics approval was obtained from the committee of the Medical Ethics of the hospital. All patients provided their written informed consent in the study as per the regulations under PC-PNDT Act.

3. Study Procedure

Detailed patient particulars with patient history was taken which included obstetric history (gravida, parity, stillbirth, abortion, preterm birth, congenital malformations, macrosomic neonate and previous gestational diabetes), menstrual history, personal history and past history (history of diabetes or hypertension)

Using a Samsung RS80A Prestige ultrasound machine equipped with a 3.5 to 5 MHz convex multiband transducer, standard antepartum sonographic assessments were made including estimation of fetal biometric parameters, gestational age, AFI and estimated fetal weight.

Doppler measurements were obtained at a physiologic fetal heart rate of 120-160 beats/min. Examination of the fetal heart was done in a systematic manner (the four-chamber view, the outflow tracts and the three-vessel view).An axial section of the fetal thorax at the level of the 4-chamber cardiac view (4CH) was magnified until the thorax occupies about most of the screen, avoiding any obvious acoustic shadows from the fetal ribs or spine. Subsequently the three-vessel view(3VV) was obtained by slightly translating the transducer superiorly. Pulsed Doppler sample gate is kept in the middle of fetal MPA (between pulmonary valves and pulmonary artery bifurcation). After enhancing the image as much as possible, sample gate is set to 3 mm. Angle of insonation was kept between 15-30^0. Fetal MPA waveforms create a certain "spike and dome" pattern and small notch at the end of systole. (2) The image was frozen with at least five continuous stable Doppler waves. After the ideal fetal MPA waveform was collected, the following doppler velocity parameters for each case were measured by a manual trace three times with calculation of mean -
- Acceleration time (AT; time period from base to top of the PSV)
- Ejection time (ET; from the start to the end of the ventricular systole)
- Estimation of mean AT /mean ET ratio.

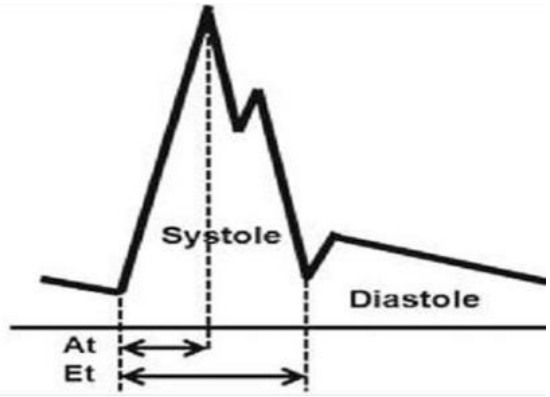


Figure 1: Acceleration time (At) & Ejection time (Et)

Upon delivery, the clinical outcome and data of all fetuses was abstracted from the medical records, including-gestational age at delivery, route of delivery, birth weight, fetal gender, APGAR scores, neonatal intensive care unit (NICU) admission, presence or absence of respiratory distress syndrome (RDS) with Downes Score. Postnatal development of RDS was diagnosed by neonatal paediatricians blinded to the fetal MPA doppler index. Neonates with respiratory distress due to causes other than RDS were excluded from the analysis.

Statistical Analysis- Data analysis using SPSS version 27.0. The following tests were used:
- Description of quantitative variables as mean, SD and range
- Independent samples T test for parametric quantitative data between the two groups
- The diagnostic accuracy of Doppler parameters was evaluated using the receiver operating characteristic (ROC) curve. Area under curve (AUC) value of ROC curve was used to determine prediction values of the doppler indices in diagnosis of RDS. The optimal cut off point with highest 'sensitivity' and 'specificity' for diagnosis of RDS was determined by using-

Youden's Index= Sensitivity + specificity – 1

All statistical comparisons were calculated with a significance level, where,
- $P \leq 0.05$ indicated significant
- $P < 0.001$ indicated highly significant difference
- $P > 0.05$ indicated nonsignificant difference.

4. Results & Observations

In the study, out of the 175 eligible pregnancies available for analysis, 82 (46.86 %) developed RDS.

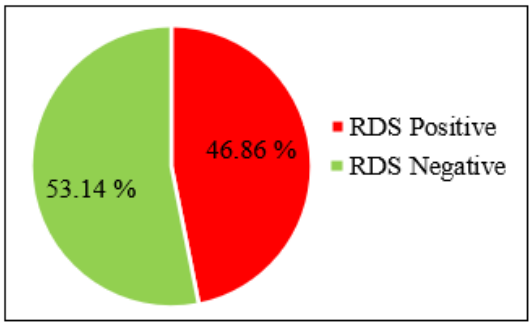


Figure 2: Pie Chart Showing the Distribution of RDS

Among the doppler parameters, statistically significant difference was found between the two groups with respect to the mean values of Acceleration time (AT), Ejection time (ET) and AT/ET Ratio. The mean Acceleration time (AT) and AT/ET Ratio values were significantly lower in RDS positive group while the mean Ejection time (ET) values were significantly higher in RDS positive group.

ROC curves were plotted for the variables showing statistically significant differences in the two groups in order to determine the variable with the highest Area Under Curve (AUC). Cutoff values with the best sensitivity and specificity were obtained from ROC curve coordinates and Youden's Index.

Table 1: Comparison of doppler indices in two groups

Sl No.	Variables (doppler indices)	Respiratory distress syndrome				Independent Samples t-Test	
		RDS positive		RDS negative			
		Mean	Std. Dev.	Mean	Std. Dev.	t value	p value
1	Acceleration time (AT) (ms)	67.837	13.26031	89.541	16.24435	9.602	<0.001
2	Ejection time (ET) (ms)	278.560	41.84925	262.641	42.20814	2.5	0.013
3	AT/ET Ratio	0.244	0.03381	0.344	0.05513	14.62	<0.001

The mean Acceleration time (AT) values were significantly lower in RDS positive group (67.837±13.260) compared to RDS negative group (89.541±16.244) with p value < 0.001.

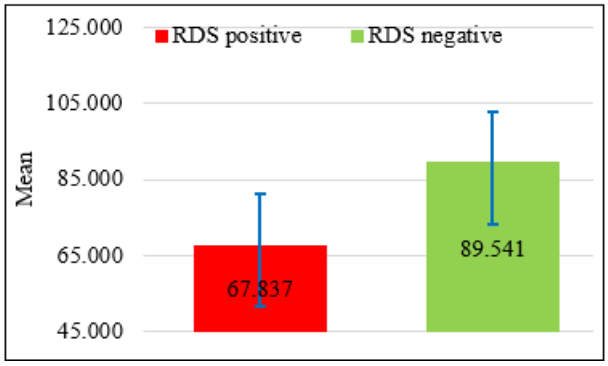


Figure 3: Acceleration Time

The mean Ejection time (ET) values were significantly higher in RDS positive group (278.56±41.849) compared to RDS negative group (262.64±42.208) with p value = 0.013.

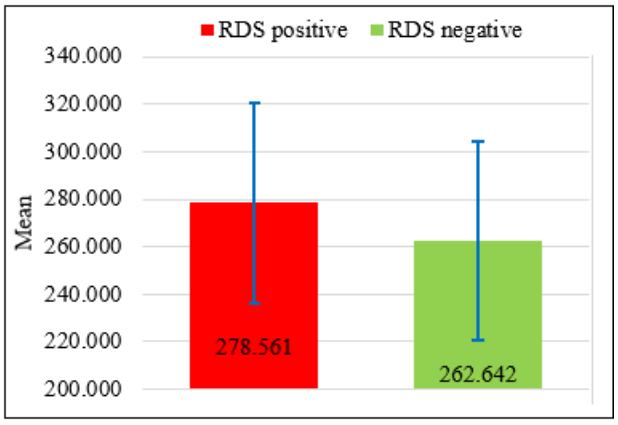


Figure 4: Ejection Time

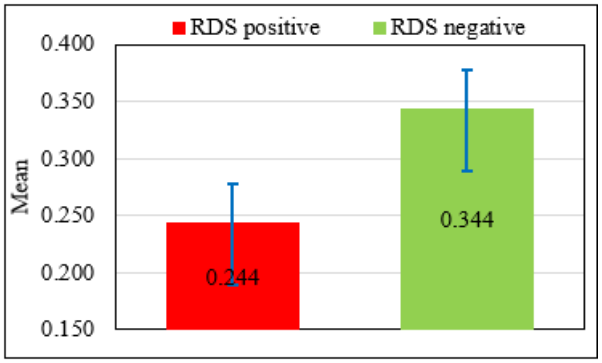


Figure 5: AT/ET Ratio

The mean AT/ET ratio values were significantly lower in RDS positive group (0.244±0.033) compared to RDS negative group (0.344±0.055) with p value < 0.001

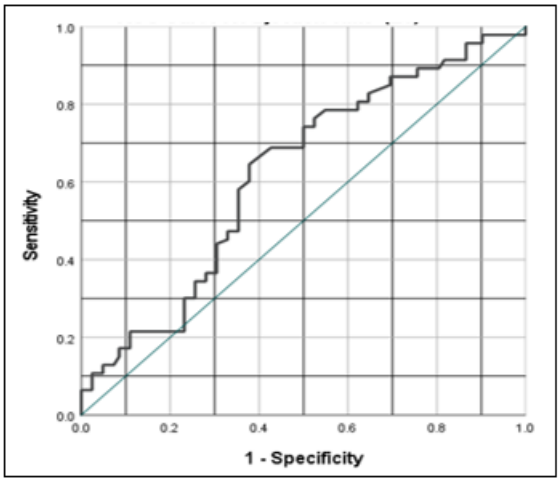


Figure 6: ROC Curve for Acceleration time (AT)

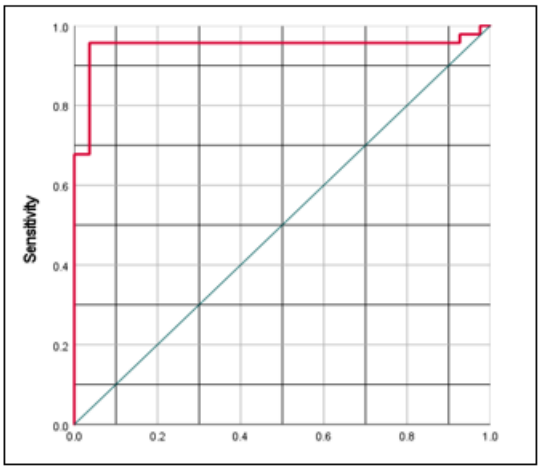


Figure 7: ROC curve for Ejection Time (ET)

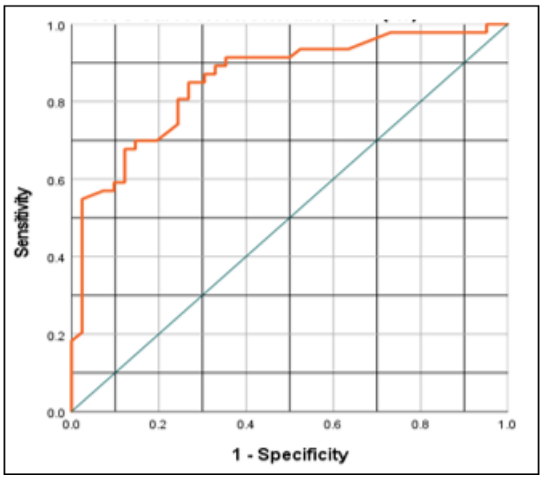


Figure 8: ROC Curve for AT/ET Ratio

Table 2: Cutoff values and diagnostic performance of MPA doppler indices

Test Result Variable(s)	AUC (ROC)	Std. Error	Asymptotic 95% Confidence Interval		p-value	Cut off	Sensitivity (%)	Specificity (%)	NPV (%)	PPV (%)
			Lower Bound	Upper Bound						
AT/ET RATIO	0.949	0.021	.908	.990	<0.001	0.287	95.7	96.3	95.8	96.21
AT (ms)	0.856	0.028	.800	.912	<0.001	74.5	84.9	73.2	73.64	84.61
ET (ms)	0.622	0.043	.538	.706	0.013	272.83	68.8	57.3	58.69	67.56

AT/ET ratio showed the highest Area Under Curve (AUC) value of 0.949 and showed the highest sensitivity, specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV) of 95.7%, 96.3%, 95.8% and 96.2% respectively for a cutoff value of 0.287 making it an excellent predictor of the test (Figure 8, Table 2).

5. Discussion

With increasing gestational age, there is simultaneous development of pulmonary vasculature with increase in number of pulmonary arteries and pulmonary vascular compliance and decrease in pulmonary arterial vascular resistance.[5],[6] With this rationale, the evaluation of fetal MPA AT/ET ratio in predicting the occurrence of neonatal RDS in preterm fetuses was examined in the study. The gestational age (less than 37 weeks) was appropriately chosen considering the fact that RDS is predominantly associated with fetal lung immaturity and preterm fetuses. Hence this serves as an optimal timeline for prediction of RDS for an obstetrician before considering to deliver a fetus in this particular gestational age range.

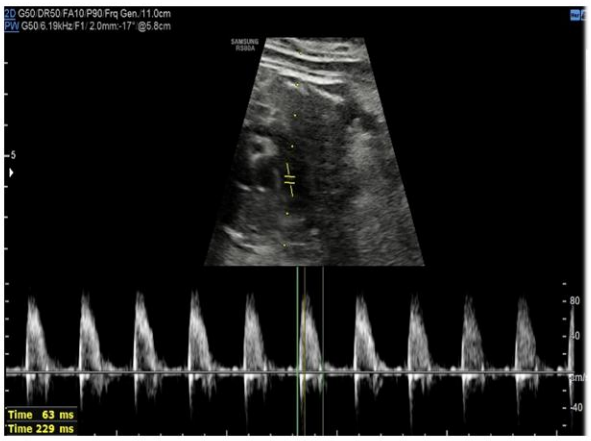
The study findings revealed that fetuses who developed RDS had considerably lower AT/ET, AT values compared to fetuses that did not develop RDS. This implies that foetuses with RDS have lower pulmonary blood flow and increased pulmonary vascular resistance as compared to healthy ones. Few prior research have found that 'MPA AT/ET' was lower in preterm foetuses with RDS, which is consistent with our findings. Infact the cut-off value of 0.287 for AT/ET ratio in our study demonstrated one of the highest overall sensitivity and specificities of 95.7% and 96.3%, respectively in comparison to few similar study designs in the past (Table 3).

Table 3: Comparisons with other studies

Study	Cut off value	Sensitivity	Specificity
Taha HMG et al., [3]	0.25	76.9%	100%
Keshuraj V et al., [4]	0.31	93%	96%
Hassan HGEMA et al., [5]	0.305	76%	84%
Schenone MH et al., [6]	0.314	73%	93%
Seth N et al., [7]	0.29	82%	82%
Khanipouyani F et al., [8]	0.305	76.9%	84.1%
Büke B et al.,[9]	0.327	77.1%	90.9%
Komal Yadav et al.,[10]	0.30	98.33%	86.67%
Present study	0.287	95.7%	96.3%

6. Cases

Case 1:

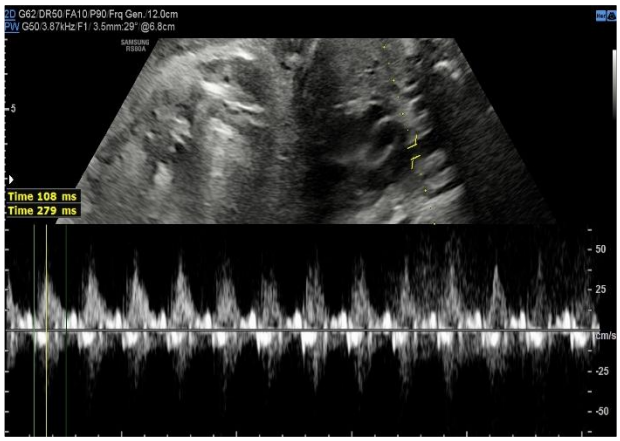


A late preterm fetus 35w+6d with the typical "spike and dome" pattern of fetal main pulmonary artery with a relatively low mean AT/ET ratio =0.26 with subsequent postnatal diagnosis of neonatal RDS.with a Downes score of 6

Case 2:

A early preterm fetus 30w+6d with the typical "spike and dome" pattern of fetal main pulmonary artery with a relatively low mean AT/ET ratio =0.21 with subsequent postnatal diagnosis of neonatal RDS.with a Downes score of 8.

Case 3:



A late preterm fetus 34w+5d with the typical "spike and dome" pattern of fetal main pulmonary artery with a relatively higher mean AT/ET ratio =0.38. Post natal 1 min APGAR score was 8 and 5min APGAR was 9 with no evidence of neonatal RDS.

Case 4:

A late preterm fetus 34w+5d with the typical "spike and dome" pattern of fetal main pulmonary artery with a relatively higher mean AT/ET ratio =0.34. Post natal 1 min APGAR score was 7 and 5min APGAR was 9 with no evidence of neonatal RDS.

7. Conclusion

- Mean fetal main pulmonary artery acceleration time and AT/ET ratio values are significantly lower in RDS positive group compared to RDS negative group
- Fetal MPA AT/ET ratio can independently predict neonatal RDS with high sensitivity, high specificity, high negative predictive value and high positive predictive value
- Predictive power of this doppler index in identifying neonates at risk of RDS may enable targeted interventions, such as antenatal corticosteroid administration to promote lung maturity, planning preterm deliveries or specialized postnatal care to mitigate complications.
- This research reinforces the value of integrating fetal pulmonary artery doppler study in preterm pregnancies to improve outcomes for vulnerable newborns.

8. Future Scope

- Factors such as sample size, variability in doppler measurements, and the influence of other maternal or fetal conditions warrant further investigation.
- Larger, multicenter studies are recommended to validate these findings and refine the predictive models.
- Further studies recommended for gestational age specific cutoffs.

References

[1] Chaoui R, Taddei F, Rizzo G, Bast C, Lenz F, Bollmann R. Doppler echocardiography of the main stems of the pulmonary arteries in the normal human fetus. Ultrasound Obstet Gynecol. 1998;11(3):173–9.
[2] Khalil, O., Abdel Ghany, H., Osman, N., & Abdelhamid, M. (2019). The role of different fetal pulmonary artery Doppler indices in the prediction of neonatal respiratory distress syndrome. Minia Journal of Medical Research, 30(2), 64-71. doi: 10.21608/mjmr.2022.221988
[3] Taha HMG, Al Ghorab NM, Al-Namory MM, Hussein NA. Role of fetal pulmonary artery doppler in prediction of neonatal respiratory distress in neonates of diabetic mothers. Int J Reprod Contracept Obstet Gynecol. 2022;11(12):3236 41. www.ijrcog.org
[4] Keshuraj V, Prakash A, Boruah DK, Ramanna HC, Sowmyashree AR, Mithun SK. Validity of foetal doppler indices in predicting postnatal respiratory distress syndrome: A prospective study. Egypt J Radiol Nucl Med. 2022;53:183.
[5] Hassan HGEMA, Nagi MAMA, Salama AMM, Dawoud MOAEA, Elgendy GG, Abdelrahman AS. Sonographic prediction of fetal main pulmonary artery (MPA) Doppler indices of lung maturity and neonatal respiratory distress syndrome (RDS) development. J Ultrasound. 2023;26(2):525-33. Doi: 10.1007/s40477 023-00780-w. Epub 2023 Apr 20.
[6] Schenone MH, Samson JE, Jenkins L, Suhag A, Mari G. Predicting fetal lung maturity using the fetal

pulmonary artery Doppler wave acceleration/ejection time ratio. Fetal Diagn Ther. 2014;36(3):208–14.

[7] Seth N, Verma S.Foetal Pulmonary Artery Derived Doppler Parameters for Foetal Lung Maturity Assessment: An Observational StudyJ Clin of Diagn Res.2024; 18(8):TC01-TC05Guan Y, Li S, Luo G, Wang C, Norwitz ER: The role of doppler waveforms in the fetal main pulmonary artery in the prediction of neonatal respiratory distress syndrome. Journal of Clinical Ultrasound Jcu》 2015, 43:375.

[8] Khanipouyani F, Abbasalizade F, Abbasalizade S, Fardiazar Z, Ghaffari S, Sarbakhshi P: PREDICTING FETAL LUNG MATURITY USING THE FETAL MAIN PULMONARY ARTERY DOP PLER INDICES. Acta Medica Mediterranea 2016, 32(Specia):921-926.

[9] Büke B, Destegül E, Akkaya H, Şimşek D, Kazandi M: Prediction of neonatal respiratory distress syndrome via pulmo nary artery Doppler examination. The Journal of Maternal-Fetal & Neonatal Medicine 2017:1-6.

[10] Yadav, Komal et al. “Role of Fetal Pulmonary Artery Doppler in predicting risk of neonatal respiratory distress syndrome.” International Journal of Medical Reviews and Case Reports (2022): n. pag.