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Prediction of neonatal respiratory distress by evaluating the colour doppler of the foetal pulmonary artery

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Abstract
Background: Colour doppler of foetal pulmonary artery is non-invasive tool in predicting neonatal respiratory distress.
Materials and Methods: This was a hospital based observational study conducted among 110 pregnant women who presented for institutional delivery in Department of Obstetrics & Gynaecology, Department of Radiodiagnosis & Department of Paediatrics Mahatma Gandhi Medical College & Research Institute, Pondicherry, India, over a period of two years from January 2021 to June 2022 after obtaining clearance from Institutional Ethics Committee & written informed consent from study participants.
Results: In this observational study difference in proportion of foetal MPA Pulsatility index (PI), Resistive Index (RI), acceleration time/ejection time ratio (AT/ET), neonate oxygen support >24 hours, & APGAR score < 7 between neonate respiratory distress was statistically significant. Difference in proportion of PI between NRD is statistically significant with a p value < 0. 001. Difference in proportion of RI between NRD is statistically significant with a p value < 0. 001. Difference in proportion of AT/ET between neonatal RD is statistically significant with a p value < 0.001. AT/ET ratio had a sensitivity of 95.31 %, specificity of 93.48 %, PPV of 95.31 % & NPV of 93.48 % in predicting NRD. Difference in proportion of neonates requiring oxygen support >24 hours between NRD is statistically significant with p value < 0.001.
Conclusion: Difference in proportion of neonatal pulmonary artery AT/ET between neonatal RD is statistically significant with a p value < 0.001. AT/ET ratio had a sensitivity of 95.31 %, specificity of 93.48 %, PPV of 95.31 %, & NPV of 93.48 % in predicting RD in neonates.

Keywords: Colour doppler, foetal main pulmonary artery, acceleration time/ejection time (AT/ET), Pulsatility index (PI), Resistive index (RI) & Neonatal Respiratory Distress (NRD)

Introduction
Respiratory distress (RD) is a frequent & morbid condition of neonate which develops due to deficiency of surfactant in lung alveoli. Ineffective gaseous exchange results from this, which in turn impairs respiratory function [1]. RD is reported in roughly 50 % of new-born before 30 weeks of gestation across world [2]. Neonatal respiratory distress incidence of 15 – 30 % in new- born at 32-36 weeks [3]. 200,000 infants affected with NRD each year in India [4]. RD continues to have a 40-60 % new-born mortality rate. Neonatal death & morbidity are largely attributed to RD [5].
Lecithin/Sphingomyelin ratio & Colour Doppler of neonatal pulmonary artery acceleration time/ejection time (AT/ET) ratio are two techniques used for determination of neonatal respiratory distress [8]. Neonatal pulmonary artery AT/ET ratio can be used to predict occurrence of neonate respiratory distress (NRD) [9, 10]. Colour Doppler evaluation of main pulmonary artery is useful in predicting neonatal respiratory distress has no risks involved in amniocentesis.

Material and Methods
This was a hospital based observational study conducted among 110 pregnant women who presented for institutional delivery in Obstetrics ward, Department of Paediatrics & Department of Radio diagnosis, Mahatma Gandhi Medical College & Research Institute,

Pondicherry, India, over a period of two years from January 2021 to June 2022 after obtaining clearance from Institutional Ethics Committee & written informed consent from study participants.

Inclusion criteria

Pregnant women with gestational age 34 to 38 completed weeks are admitted for safe confinement & expected to deliver within one week were included in study.

Exclusion criteria

1. Foetal chromosomal abnormality
2. Multiple pregnancies.

Before enrolling subject for study, a written consent was taken.

Statistical Methods

PI pulmonary artery, RI pulmonary artery, AT/ET ratio of pulmonary artery, neonate requiring oxygen support more than 24 hours, APGAR (appearance, pulse, grimace, activity, respiration) score < 7 were considered as primary outcome variables & respiratory distress was considered as primary explanatory variable.

Descriptive analysis was carried out by mean & standard deviation for quantitative variables, frequency & proportion for categorical variables.

Categorical outcomes were compared between study groups using Chi square test.

Sensitivity & specificity of screening test along with their 95 % CI were presented. Reliability of screening test was assessed by kappa statistic along with its 95 % CI & p value. P value < 0.05 was considered statistically significant.

Data analysis is done by co Guide statistics software, Version 1.0

1. BDSS Corp. Released 2020. Co Guide statistics software, Version 1.0, India: BDSS corp.

Results

45 (40.91 %) participants were < 2.25 & remaining 65 (59.09 %) participants were > 2.25 Pulsatility index of pulmonary artery. 45 (40.91 %) participants were < 0.9 & remaining 65 (59.09 %) participants were > 0.9 Resistive index of pulmonary artery as shown in Table 1.

Table 1: Descriptive analysis of pulsatility & resistive index of pulmonary artery in study population (N = 110)

Pulsatility index of pulmonary artery	Frequency	Percentage
< 2.25	45	40.91 %
> 2.25	65	59.09 %
Descriptive Analysis of Pulsatility Index of Pulmonary Artery in Study Population (N = 110)		
Resistive index of pulmonary artery	**Frequency**	**Percentage**
< 0.9	45	40.91 %
> 0.9	65	59.09 %
Descriptive Analysis of Resistive index of Pulmonary Artery in Study Population (N = 110)		

Table 2: Descriptive Analysis of AT/ET Ratio of pulmonary artery & neonate requiring oxygen support more than 24 hours in the study population (N = 110)

AT/ET Ratio of Pulmonary Artery	Frequency	Percentage
<0.305	64	58.18 %
>0.305	46	41.82 %
Descriptive Analysis of AT/ET Ratio of Pulmonary Artery in Study Population (N = 110)		
Neonate Requiring Oxygen Support More Than 24 Hours	**Frequency**	**Percentage**
Yes	65	59.09 %
No	45	40.91 %
Descriptive Analysis of Neonate Requiring Oxygen Support More Than 24 Hours in the Study Population (N = 110)		

46 (41.82 %) participants were < 0.305 & remaining 64 (58.18 %) participants were > 0.305 AT/ET ratio of pulmonary artery. 65 (59.09 %) participants required neonate oxygen support > 24 hours as shown in Table 2.

Table 3: Descriptive Analysis of Neonate Respiratory &Predictive Validity of AT/ET in Predicting Respiratory Distress (N = 131)

Neonate Respiratory Distress		Frequency	Percentage
Yes		64	58.18 %
No		46	41.82 %
Descriptive Analysis of Neonate Respiratory Distress in the Study Population (N = 110)			
Parameter	**Value**	**95 % CI**	
		Lower	**Upper**
Sensitivity	95.31 %	86.91 %	99.02 %
Specificity	93.48 %	82.10 %	98.63 %
False positive rate	6.52 %	1.37 %	17.90 %
False negative rate	4.69 %	0.98 %	13.09 %
Positive predictive value	95.31 %	86.91 %	99.02 %
Negative predictive value	93.48 %	82.10 %	98.63 %
Diagnostic accuracy	94.55 %	88.51 %	97.97 %
Predictive Validity of AT/ET in Predicting Respiratory Distress (N = 131)			

Table 4: Comparison of PI, RI & AT/ET ratio with Respiratory Distress in Study Population (N = 110)

Pulsatility Index	Neonate Respiratory Distress		Chi Square Value	P Value
	Yes	No		
< 2.25 (N = 45)	2 (4.44 %)	43 (95.56 %)	90.38	< 0.001
> 2.25 (N = 65)	62 (95.38 %)	3 (4.62 %)		
Comparison of PI (Pulsatility Index) with Respiratory Distress in Study Population (N = 110)				
Resistive index	Neonate Respiratory Distress		Chi Square Value	P Value
	Yes	No		
< 0.9 (N = 45)	2 (4.44 %)	43 (95.56 %)	90.38	<0.001
> 0.9 (N = 65)	62 (95.38 %)	3 (4.62 %)		
Comparison of RI (Resistive index) with Respiratory Distress in Study Population (N = 110)				
AT/ET ratio	Neonate Respiratory Distress		Chi Square Value	P Value
	Yes	No		
< 0.305 (N = 64)	61 (95.31 %)	3 (4.69 %)	86.72	< 0.001
> 0.305 (N = 46)	3 (6.52 %)	43 (93.48 %)		
Comparison of Acceleration Time/ Ejection Time (AT/ET) with Respiratory Distress in Study Population (N = 110)				

AT/ET ratio had sensitivity of 95.31 % (95 % CI 86.91 % to 99.02 %) in predicting respiratory distress. Specificity was 93.48 % (95 % CI 82.10 % to 98.63 %), false positive rate was 6.52 % (95 % CI 1.37 % to 17.9 %), false negative rate was 4.69 % (95 % CI 0.98 % to 13.09 %), positive predictive value (PPV)was 95.31 % (95 % CI 86.91 % to 99.02 %), negative predictive value (NPV) was 93.48 % (95 % CI 82.1 % to 98.63 %), & total diagnostic accuracy was 94.55 % (95 % CI 88.51 % to 97.97 %) as shown in Table 3. Foetuses with MPA PI < 2.25, 2 (4.44 %) developed no respiratory distress & foetuses with MPA PI > 2.25, majority of 62 (95.38 %) developed respiratory distress. Difference in proportion of PI between neonate respiratory distress was statistically significant (P value < 0.001). Foetuses with MPA RI < 0.9, 2 (4.44 %) developed no NRD & foetuses with RI > 0.9, majority of 62 (95.38 %) developed NRD. Difference in proportion of RI between neonate respiratory distress was statistically significant (P value < 0.001). Foetuses with MPA AT/ET ratio< 0.305, 61 (95.31 %) developed respiratory distress & foetuses with AT/ET ratio > 0.305, 3 (6.52 %) has no respiratory distress. Difference in proportion of AT/ET ratio between NRD was statistically significant (P value < 0.001) as shown in Table 4.

Representative Cases

Case 1

Pulmonary artery Doppler waveform of 30 yr old female with gestational age of 36W with amniotic fluid adequate

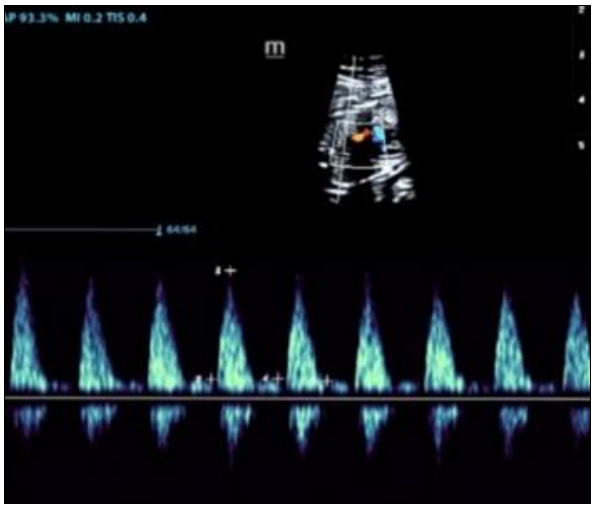

Fig 1: (AT/ET ratio-0.297)

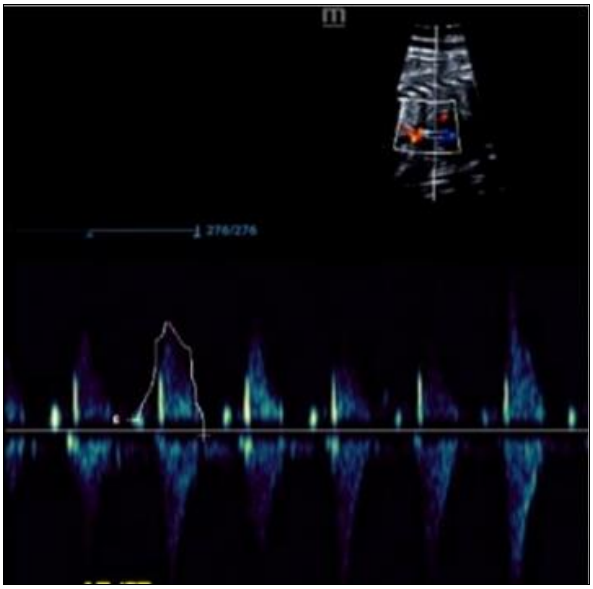

Fig 2: (PI-2.19 & RI-0.98)

Follow up – baby delivered through caesarean section with RD.

Case 2

Pulmonary artery Doppler waveform of 28 yr old female with gestational age of 36W with amniotic fluid adequate

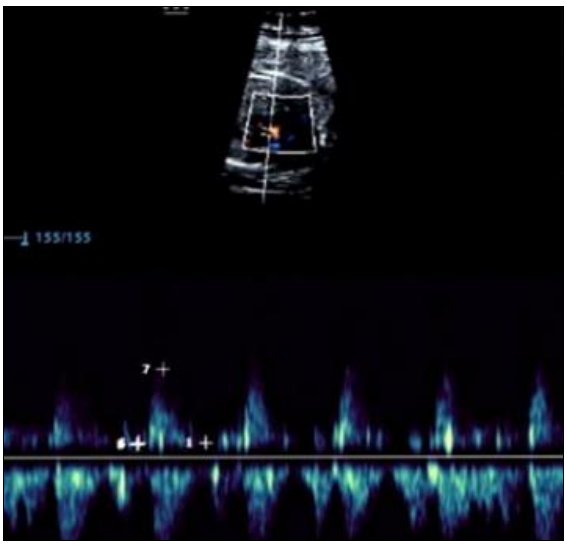

Fig 3: (AT/ET ratio-0.208)

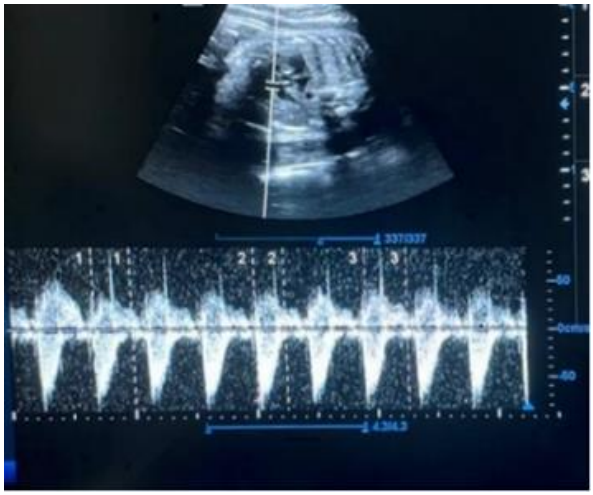

Fig 4: (PI-2.16 & RI-0.97)

Follow up – baby delivered through caesarean section with RD.

Case 3

Pulmonary artery Doppler waveform of 27 yr old female with gestational age of 38W with amniotic fluid adequate

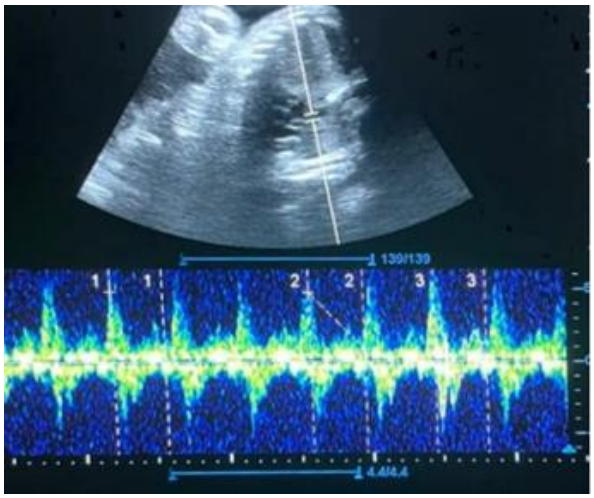

Fig 5: (AT/ET ratio-0.257)

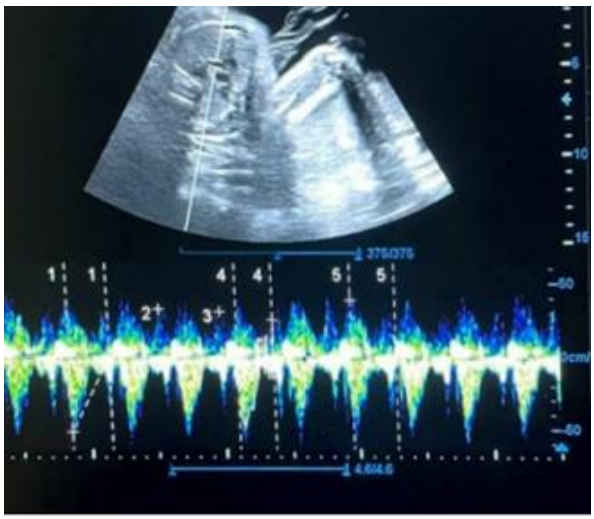

Fig 6: (PI-2.5 & RI-1.5)

Follow up – baby delivered through caesarean section with RD.

Discussion

Pulmonary artery PI & RI were significantly higher in RD positive neonates compared to RD negative neonates (2.27 ± 0.23& 0.8 ± 0.11 versus 2.18 ± 0.23 & 0.76 ± 0.09); P: 0.003 & 0.002, respectively in Moety *et al.*'s study who have also chosen GA 34 to 38 weeks [10].

Yadav *et al.* observed that a cut-off value of 0.30 for AT/ET ratio in foetal main pulmonary artery in late pre-terms (delivered between 34 & 36+6 weeks) was statistically significant in predicting development of respiratory distress. Predictive capability of pulmonary artery AT/ET ratio was also appreciated by recent works of Büke *et al.* on 105 women. Cut-off value of 0.327 provided optimal sensitivity of 77.1 %, a sensitivity of 90.9 %, a NPV of 95.4 % & PPV of 52.7 % [7].

Our results correlated with that of Alsheikh *et al.*, Keshuraj *et al.*, Moety *et al.* & Yadav *et al.* Khalil *et al.* & Büke *et al.* while found AT/ET is negatively correlated with development of RD, did not find any significant difference in PI & RI among neonates with & without RD. A foetus with an AT/ET <0.305 should be delivered in a well-equipped hospital with respiratory support facilities because it is at risk of developing neonatal RD.

Conclusion

Study found that all parameters, pulmonary artery RI, PI, & AT/ET ratio showed good performance as predictors of RD development in neonates.

It is recommended that a foetus with AT/ET <0.305 be delivered in a well-equipped hospital with respiratory support facilities, as it is at risk of developing neonatal RD.

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