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Dr. Kundeti Rakesh Yadav
PGJR3, Radiodiagnosis Mahatma Gandhi Medical College & Research Institute, Sri Balaji Vidyapeeth University, Puducherry, Puducherry Union Territory, India

Dr. Lokesh Kumar T
Associate Professor, Radiodiagnosis Mahatma Gandhi Medical College & Research Institute, Sri Balaji Vidyapeeth University, Puducherry, Puducherry Union Territory, India

Dr. Col. Sudhir Sachar
Professor & Hod, Radiodiagnosis Mahatma Gandhi Medical College & Research Institute, Sri Balaji Vidyapeeth University, Puducherry, Puducherry Union Territory, India

Dr. Karthikeyan K
Professor, Pediatrics, Radiodiagnosis Mahatma Gandhi Medical College & Research Institute, Sri Balaji Vidyapeeth University, Puducherry, Puducherry Union Territory, India

Dr. Rupal Samal
Professor, Obstetrics &Gynecology, Radiodiagnosis Mahatma Gandhi Medical College & Research Institute, Sri Balaji Vidyapeeth University, Puducherry, Puducherry Union Territory, India

Corresponding Author:
Dr. Kundeti Rakesh Yadav
PGJR3, Radiodiagnosis Mahatma Gandhi Medical College & Research Institute, Sri Balaji Vidyapeeth University, Puducherry, Puducherry Union Territory, India

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

Dr. Kundeti Rakesh Yadav, Dr. Lokesh Kumar T, Dr. Col. Sudhir Sachar, Dr. Karthikeyan K and Dr. Rupal Samal

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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

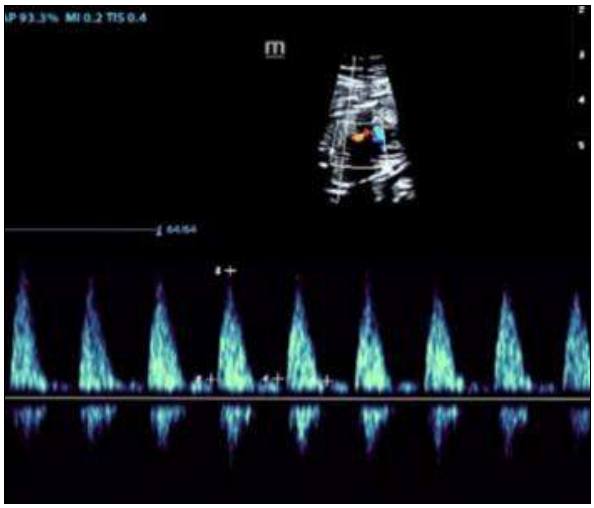

Fig 1: (AT/ET ratio-0.297)

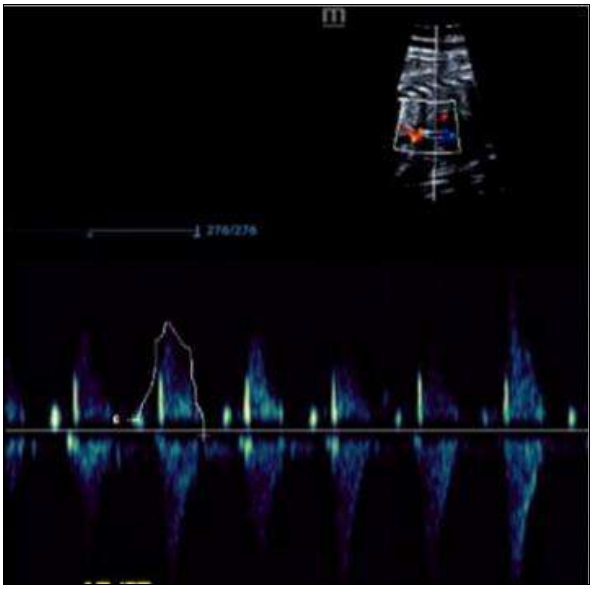

Fig 2: (PI-2.19 & RI-0.98)

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

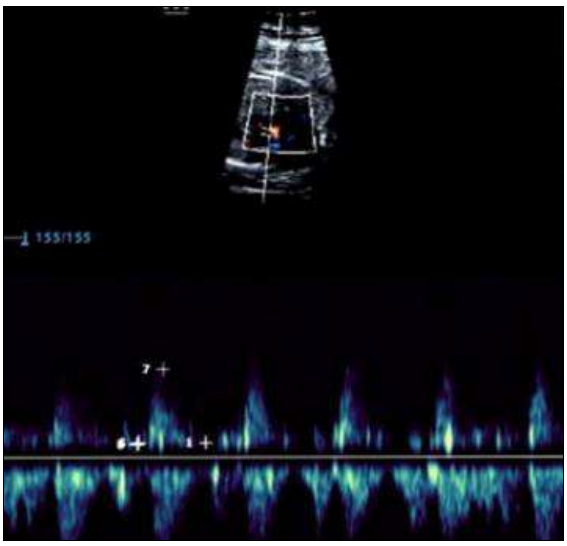

Fig 3: (AT/ET ratio-0.208)

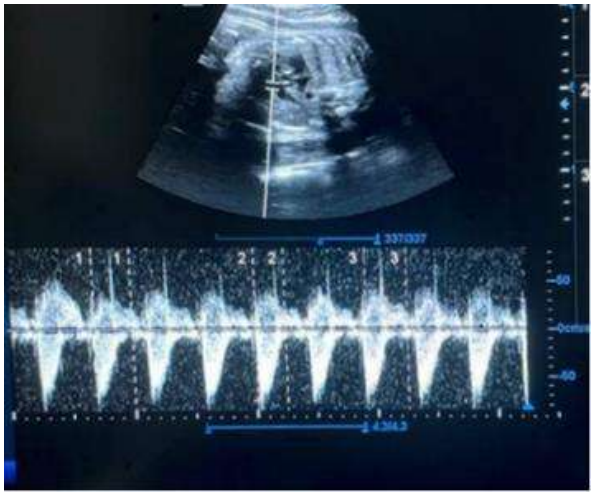

Fig 4: (PI-2.16 & RI-0.97)

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

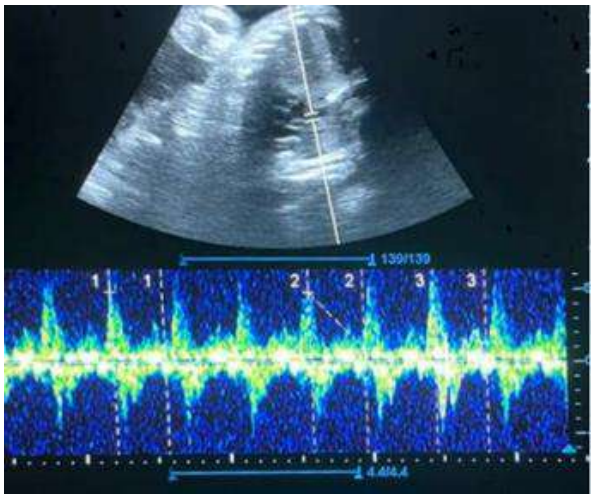

Fig 5: (AT/ET ratio-0.257)

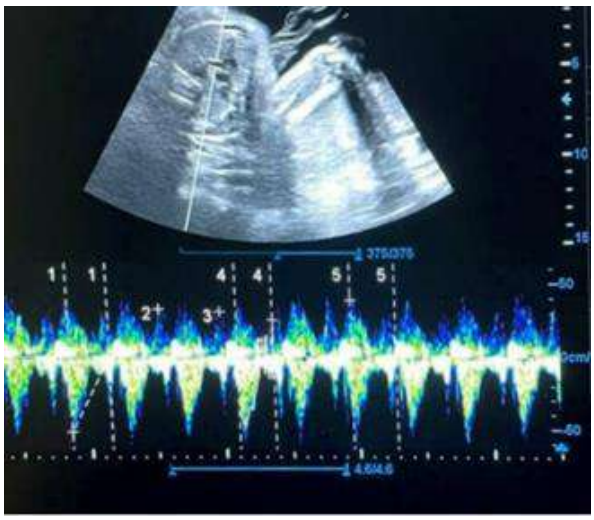

Fig 6: (PI-2.5 & RI-1.5)

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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