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Prenatal Prediction of Fetal Lung Maturity Using 3D Lung Volume, Lung-to-Liver Intensity Ratio Tissue Histogram and Pulmonary Artery Doppler Indices

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ABSTRACT

Background: Fetal lung maturity assessment is regarded as the most critical factor for identifying the optimal delivery time. A noninvasive sonographic technique is necessary to evaluate fetal lung development, as amniocentesis is an invasive method that result in real hazard to pregnancy.

Aim of the study: This study aimed to predict maturity of fetal lung utilizing 3D lung volume ultrasound, lung to liver intensity ratio, and pulmonary artery Doppler indices measurement.

Patients and Methods: Three-dimensional [3D] ultrasound [3DUS] has been performed to determine the fetal lung volume [FLV] then fetal lung-to-liver intensity ratio [FLLIR] [tissue histogram] and the main pulmonary artery doppler parameters [MPA]; acceleration time-to-ejection timer ratio [At/Et], pulsatility index [PI] and resistive index [RI] have been performed to two hundred pregnant females from thirty-two to forty weeks age at pregnancy during one week from delivery.

Results: Of 200 fetuses investigated, 113 cases [56.5%] have been investigated with respiratory distress syndrome. The MPA RI and PI were significantly greater in fetuses investigated with respiratory distress syndrome comparing with those with no [2.6± 0.3 and 0.9±0.05 vs. 1.9±0.3 and 0.8±0.2, p-value less than 0.001, less than 0.001 respectively]. MPA At/Et was significantly lesser for fetuses with RDS than fetuses without RDS [0.2±0.1 vs. 0.3±0.1 respectively, p-value less than 0.001]. FLLIR was significantly lesser in RDS positive group comparing with RDS negative group [0.9±0.2 versus 1.3±0.3 respectively, p-value less than 0.001] and FLV was significantly smaller in fetuses with respiratory distress syndrome comparing with those with no [31.5±2.5 vs. 38.1±2.8; p-value less than 0.001].

Conclusion: The utilization of main pulmonary artery Doppler indices, together with mean fetal lung volume and FLLIR for assessing fetal lung is a quick noninvasive accurate technique for estimate of neonatal FLM and respiratory distress syndrome.

Keywords: Fetal; Lung Volume; Lung Maturity; Histogram; Doppler.

INTRODUCTION

Neonatal respiratory distress syndrome [RDS] continues to be an important reason of mortality & morbidity in newborn infants, mostly because their lungs are not fully developed. It primarily affects newborns who are born prematurely, and it correlated reversely with age of pregnancy at birth [1].

The decision to delay or remain delivery based frequently on the capability to accurately estimate the maturation of the fetal lung [2].

An avoidable rise in neonatal morbidity & admissions to the neonatal intensive care unit [NICU] is associated with elective delivery before 39 weeks, resulting in increased costs [3].

Neonatal intensive care units' success rates & resources are critical to the survival of neonates [4].

Maturity of lung was frequently evaluated by age of pregnancy & the alternative was amniocentesis that is expensive, invasive, & may only be carried out by trained personnel. Additionally, it can result in complications. Ultrasound is the most cost-effective, non-invasive, common, and simple instrument for routine obstetric scanning [5].

The aim of the work was to predict maturity of fetal lung utilizing 3D lung volume ultrasound, lung to liver intensity ratio, and pulmonary artery Doppler indices measurement.

PATIENTS AND METHODS

This research is observational cross-sectional research that has been performed at obstetrics & gynecology department Menoufia University hospital following it has been accepted by the hospital study ethics committee under code number [4/2022OBSG35]. Informed written consent to participate in the study was provided by all participating patients. Participants: 200 females between the ages of eighteen & forty-one & the gestational age of thirty-two to thirty-nine weeks, who were admitted for elective caesarean or attendance the delivery unit in active labor.

Inclusion criteria were 1] Gestational age [GA] from thirty-two to thirty-nine weeks gestational age, 2] Females with a singleton uncomplicated pregnancy, and 3] Fetuses that are delivered within 1 week of the US scan

Exclusion criteria were 1] Women who have any gestation-correlated conditions such as: Autoimmune illness, diabetes mellitus, preeclampsia, or hypertension.2] Fetal condition included congenital anomalies, intrauterine growth restriction, macrosomia & twin pregnancies, and 3] GA forty weeks or more.

Ultrasound technique: Within 1 week of delivery, obstetric ultrasonography was conducted utilizing a Voluoson s6 after a complete history and consent were obtained.

First 2D ultrasound was conducted to determine the amniotic fluid index, fetal biometry & placental site. The primary pulmonary artery doppler parameters [RI, At/Et ratio & PI] were measured utilizing pulsed wave Doppler & color Doppler. The grey scale-histogram was utilized to calculate the fetal lung to liver intensity ratio. Then, the Virtual Organ Computer-Aided Analysis [VOCAL] feature was utilized to measure the FLV utilizing three-dimensional [3D US] ultrasound.

The FLV: The VOCAL feature of the 3D US was utilized to determine the FLV. The transverse view of the 4-chamber view of the fetal heart has been recorded in a three-dimensional volume. The VOCAL has been subsequently utilized to find a sequence of six sections of every lung, each of which was rotated by thirty degrees from the previous section, from the apex to the base, around a fixed axis. The three-dimensional volume measurement was obtained by automatically drawing the contour of each lung in the six dimensions.

The border of every plane was manually encircled following the automatic calculation. The software has the capability to automatically reconstruct the three-dimensional image and supply the volume measurement. The volumes of left & right lungs have been determined, respectively, & the mean lung volume have been determined [sum of the left and right lung volumes/2].

FLLIR: The grey scale histogram function was utilized to detect the FLLIR. This function described the number of pixels in each intensity level & illustrates the distribution of pixels in the image. The liver & lung sample boxes were positioned equal size & at the same depth, preventing the structures of large blood vessel. A histogram of the sampling area is created by the software automatically. The FLLIR has been determined by recording the average gray values of the fetal liver lung. Pulmonary artery Doppler parameters: Respiratory movements have been measured using Doppler technology at a normal fetal heart rate of 120-160 beats per minute, & in the absence of the fetal or maternal body. The examiner conducted a thorough examination of the fetal heart, which included assessing the outflow tracts, the 4-chamber view & the 3-vessel view.

A transverse section of the fetal chest has been performed to visualize the pulmonary artery at the level of the 4-chamber view of the heart. The pulmonary artery has been followed till the bifurcation of the right & left branches was observed. The acceleration time-to-ejection timer ratio, pulsatility index and resistive index were manually traced after the optimal fetal main pulmonary artery waveform was obtained. To calculate the At/Et ratio, divide the period interval from the beginning of ventricular systole to the peak [" known as acceleration time"] by the period between the beginning and ending of right ventricular systole ["known as ejection time"].

Follow-up after delivery & analysis of respiratory distress syndrome: gestational age, route of delivery, Apgar score [at one & five minutes] & neonatal birth weight [NBW] were documented during the delivery process. Radiological evaluation of neonatal lung ± clinical signs of respiratory distress [tachypnea, retraction, grunting, or cyanosis] were used to diagnose respiratory distress syndrome.

Statistical analysis:

The data have been tabulated, collected, coded, & imported into the statistical software for social science [SPSS v 19]. Absolute frequencies [number] and relative frequencies [percentage] have been utilized to described categorical qualitative variables, while continuous quantitative variables, include age, were defined as the mean ± SD. The validity of the screening tests [TVS and MRI] has been assessed as regarded predictive value negative, predictive value positive, specificity, sensitivity & accuracy. Predictive value is negative when True Negative is divided by [True Negative + False Negative]. Predictive value is positive when True Positive is divided by [True Positive + False positive]. Sensitivity = True Positive / [True Positive + False Negative]. Specificity is calculated as True Negative / [True Negative + False positive]. ACCURACY = True Positive + False positive + False Negative + True Negative /grand total.

RESULTS

A total of two hundred fetuses have been studied, of these 113 [56.5%] have been analyzed with RDS. & 87 cases [43.5 %] were diagnosed without. The age of participants ranges from eighteen to forty years, with gestational age range from 31.28 to 39 weeks. Sixty [thirty percent] had premature rupture of membrane [PROM], 24[12%] cases were admitted with preterm labor pain, 68[34%] cases had antepartum hemorrhage due to placenta Previa, others 48 [24%] cases admitted to emergency room in labor. One hundred & forty-nine cases [74.5%] had caesarian section, 31 [15.5%] had normal vaginal delivery, 113[56.5%] newborns admitted to Neonatal Intensive care unit admission **[Table 1]**.

APGAR score [at five minutes] in non- respiratory distress syndrome. [mean 9.1± 0.5], in respiratory distress syndrome. [mean equal 6.7±0.8]. Fetuses that developed respiratory distress syndrome had a significantly lesser neonatal birth weight, lesser Apgar scores, lesser gestational age at delivery, & have been admitted to NICU. Statistical insignificance has been observed according to mode of delivery or female & male sex. The main pulmonary artery doppler parameters such as resistive index & pulsatility index were significantly greater in fetuses analyzed with respiratory distress syndrome comparing with those without [2.6± 0.3 & 0.9± 0.05 vs. 1.9 ± 0.3 & 0.8 ± 0.2; p-value less than 0.001 respectively] **[Table 2]**.

The main pulmonary artery doppler parameter is acceleration time-to-ejection timer ratio was significantly lesser in fetuses with respiratory distress syndrome [0.2 ±0.1 vs 0.3 ± 0.1; p-value less than 0.001]. Furthermore, fetal lung-to-liver intensity ratio was significantly lesser within the same group [0.9± 0.2 vs 1.3± 0.3; p-value less 0.001. The mean fetal lung volume was significantly smaller in fetuses with respiratory distress syndrome vs. those without [31.5 ± 2.5 vs 38.1 ±2.8 cm3; p-value less than 0.001] **[Tables 2, 3, 4].**

The optimum cutoff for the main pulmonary artery pulsatility index was 2.195cm/s & resistive index was 0.855cm/s. Neonates with a main pulmonary artery pulsatility index less than 2.195 cm/s, & or resistive index less than 2.195 cm/s were significantly low likely to have respiratory distress syndrome [area under curve = 0.946; p-value less than 0.018, with diagnostic accuracy of 94.6% for main pulmonary artery pulsatility index & area under curve = 0.876; p-value less than 0.001, with a diagnostic accuracy of 87.6% for main pulmonary artery resistive index] **[Table 5, figures 1 & 2]**.

The cut off for main pulmonary artery acceleration time-to-ejection timer ratio was 0.298. Newborns with a main pulmonary artery acceleration time-to-ejection timer ratio higher 0.298 were significantly low likely to have respiratory distress syndrome [area under curve = 0.909; p-value less than 0.001 with a diagnostic accuracy of 90.9%] **[Table 5, figure, 3]**.

While the cutoff for mean fetal lung volume was 34.94 cm3. Such that neonates with fetal lung volume greater than 34.94 cm3 were significantly low likely to have respiratory distress syndrome [area under curve = 0.981; p-value less than 0.001, with a diagnostic accuracy of 98.1% **[Table 5, figure 5]**.

Predictive values have been assessed for the combination of these parameters. Combining the Doppler parameters [main pulmonary artery acceleration time-to-ejection timer ratio, resistive index, & pulsatility index] demonstrated greater sensitivity, therefore greater negative predictive value [99.1 & 98.4% respectively] **[Table 6]**.

Addition of fetal lung-to-liver intensity ratio to the combined doppler parameters, demonstrated minimal decrease of specificity & positive predictive value [70.1 & 81.2%] versus [72.4% & 82.4%], while further adding of the mean fetal lung volume demonstrated greater decrease of the specificity & PPV to [66.7% & 79.6% respectively], with highly statistical significance less than 0.001 **[Table 6]**.

Table [1]: Descriptive statistics of the participants [Number= 200]

Variables		Values
Age [years]	**Mean±SD**	28.8±4.9
	Min.-Max.	19-40
Gestational age [weeks]	**Mean±SD**	35.1±2.1
	Min.-Max.	31.28-39.0
Parity [n, %]	Nullipara Primipara Multipara	14[7.0%] 50 [25.0%] 136 [68.0%]
Time of delivery [n.%]	Early pre-term Late pre-term Term	88 [44.0%] 64 [32.0%] 48[24.0%]
Fetal outcome	RD grade 1 RD grade 2 RD grade 3 RD grade 4 No RD	11 [5.5%] 26 [13.0%] 49 [24.5%] 27 [13.5%] 87 [43.5%]
NICU admission	Yes No	113 [56.5%] 87 [43.5%]

SD: standard deviation, Range: minimum- maximum, RD: respiratory distress, NICU: neonatal ICU

Table [2]: Relation among fetal respiratory distress and pulmonary artery Doppler

	Fetuses with RD **[n=113]**	**Fetuses without** RD **[n=87]**	test	**P-value**
	Mean ± SD Range	Mean ± SD Range		
Pulmonary Acceleration time [ms]	57.8 ±21.6 22-165	78.6 ±24.9 23-147	6.58	**<0.001***
Pulmonary Ejection time [ms]	238.5 ±56.6 122-382	232.2 ±56.7 129-382	0.77	0.440
Acceleration on Ejection time [At/ Et ratio]	0.2 ±0.1 0.1-0.7	0.3 ±0.1 0.1-0.5	9.91	**<0.001***
Indices				
Peak systolic velocity [PSV] [cm]	52.4±14.8 29.4-100.5	57.8±19.2 20.2-106.1	2.25	**0.026***
PI	2.6±0.3 0.9-3.0	1.9±0.3 0.8-2.8	15.45	**<0.001***
RI	0.9±0.05 0.7-1.1	0.8±0.2 0.5-2.1	9.15	**<0.001***
HR [bpm]	146.6±27.0 24-182	140.9±21.6 36-179	1.61	0.109

Table [3]: Relation between fetal respiratory distress and tissue histogram

	Fetuses with RD[n=113]	**Fetuses without RD [n=87]**	**test [U]**	**P-value**
	Mean ± SD Range	Mean ± SD Range		
lung histogram	83.9 ±30.7 23.0-190.0	102.3 ±28.3 42.0-155.0	4.31	**<0.001***
Liver histogram	95.8 ±34.3 34.0-213.0	79.6 ±27.1 19.0-126.0	3.11	**0.002***
FLLIR [fetal lung to liver intensity ratio]	0.9 ±0.2 0.3-2.4	1.3 ±0.3 0.99-3.0	T 10.92	**<0.001***

Table [4]: Relation between fetal respiratory distress and 3D lung volume [mean fetal lung volume]

	Fetuses with respiratory distress [n=113]	Fetuses without respiratory distress [n=87]	Student t test [t]	P-value
	Mean ± SD Range	Mean ± SD Range		
3D lung volume mean FLV	31.5±2.5 24-36	38.1±2.8 32-43	17.51	**<0.001 [HS]**

Table [5]: ROC curve for different lung parameters in prediction of fetal respiratory distress

	Cut-off point	AUC	Accuracy	Sig.	Sensitivity	Specificity	95% CI
PI	≥ 2.195	0.946	94.6 %	0.018	87.6%	93.1 %	0.91-0.98
RI	≥ 0.855	0.876	87.6%	<0.001	87.6%	89.7%	0.82-0.94
At/ Et ratio	≤ 0.298	0.909	90.9%	<0.001	97.3%	86.2%	0.86-0.96
FLLIR	≤ 1.053	0.960	96.0%	<0.001	90.3%	96.6%	0.93-0.99
3D lung volume [mean FLV]	≤ 34.94	0.981	98.1%	<0.001	97.3%	95.4%	0.96-0.99

AUC: area under curve, CI: confidence interval [lower-upper]

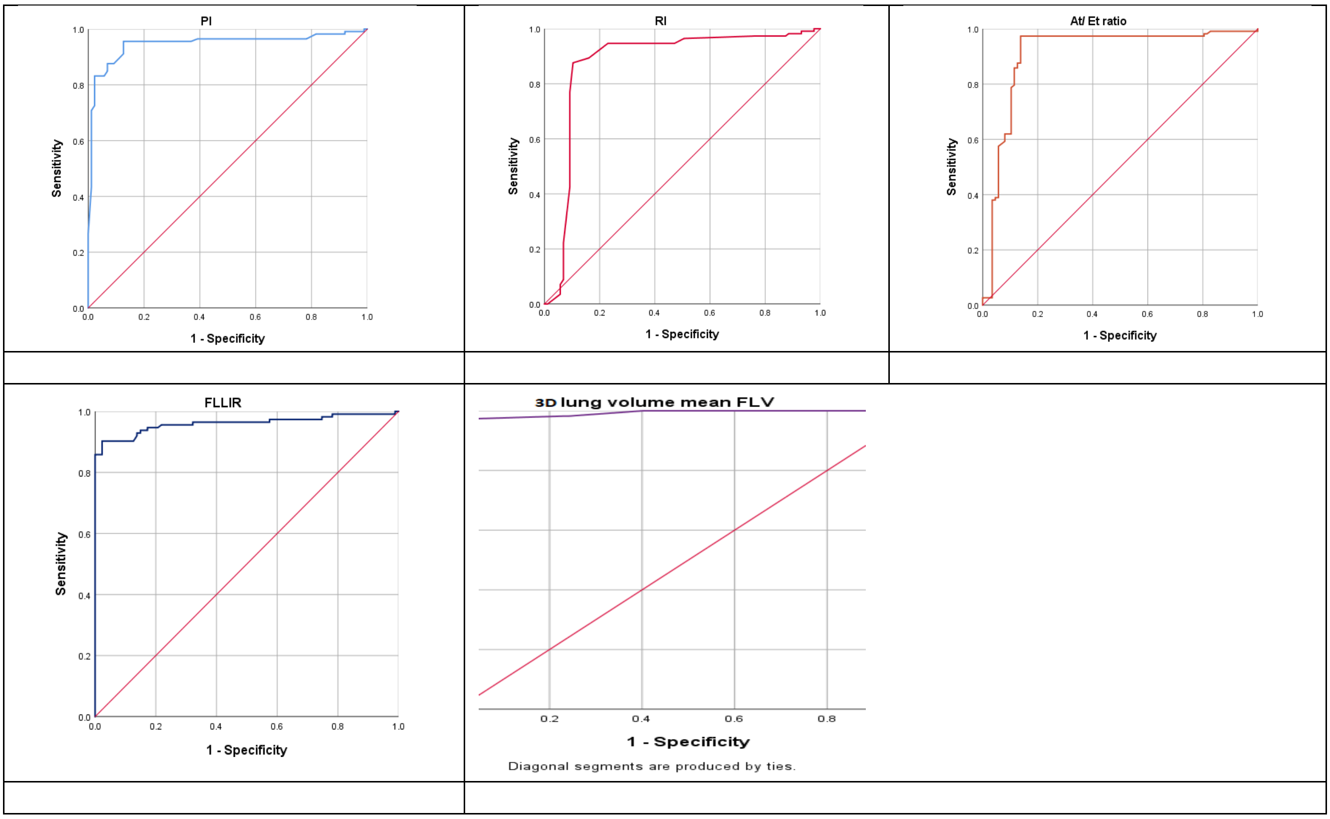

Table [6]: Accuracy of different parameters combinations in diagnosis of fetal RD

	Lung parameter	Accuracy	Sensitivity	Specificity	PPV	NPV
Doppler	PI ≥ 2.195 RI ≥ 0.855 At/Et≤ 0.298	87.5%	99.1%	72.4%	82.4%	98.4%
Doppler plus FLLIR	FLLIR ≤ 1.053	86.5	99.1	70.1	81.2	98.4
Doppler, FLLIR plus mean FLV	Mean FLV ≤ 34.94	85.5	100	66.7	79.6	100

χ^2: Chi-square test, HS: highly significant, PPV: positive predictive value, NPV: negative predictive value

DISCUSSION

This research is observational cross-sectional research which examine the validity and reliability of FLV evaluated by virtual organ computer-aided analysis, MPA blood flow parameters [RI, PI, A/ET, PSV] and FLLIR as noninvasive parameters that might be utilized to expect the improvement of neonatal respiratory distress syndrome in preterm and term pregnancies. The current research included 200 pregnant women with gestational age between 32 and 39 weeks. Improvement of respiratory distress has been observed to be fewest when fetuses have been delivered following thirty-nine weeks of pregnancy, so they were not included in this research. Out of the 200 born neonates, 113 [56.5%] admitted to NICU with respiratory distress syndrome, and 87 [43.5%] born without RDS.

Measurement of main pulmonary artery Doppler indices in the form of At/Et, pulsatility index and resistive index ratio was done. The outcomes of the present research demonstrated a highly significant variance between fetuses with RDS and those without RDS regarding At/Et [acceleration on ejection ratio] [p-value less than 0.001] with a Mean± SD [0.2±0.1] for fetuses with respiratory distress syndrome & a Mean ± SD [0.3±0.1] for fetuses without respiratory distress syndrome. Receiver-operating characteristic [ROC] curve for prediction of respiratory distress syndrome using At/Et ratio had an excellent predictive value [Receiver-operating characteristic = 0.909, p-value less than 0.001]. A cut off criterion for prediction of fetal RDS was ≥ 0.298 with a sensitivity of 97.3% and specificity of 86.2%.

Our outcomes associated well with the research performed by **Keshuraj *et al.*** [6]**.** The neonatal RDs has been analyzed in forty-seven fetuses' out of 342 fetuses involved in the research. Fetuses analyzed with RDs had statistically lesser At/Et ratio than those analyzed without RDs with a cut off value 0.2865 for GA between [34 0/7 and 36 6/7] weeks of gestation [sensitivity 89.45%, specificity 94.79 %, AUC 0.883] and a cutoff value of 0.3155 for GA between [37 0/7 & 38 6/7] weeks of gestation, [sensitivity 93.22%, specificity 96.78%, AUC 0.926] showing a significant correlation with GA.

All these outcomes positively correlate with **Khalifa *et al.*** [7] done after examination and final analysis for 143 fetuses, 38 were diagnosed with respiratory distress syndrome. MPA At /Et was significantly lesser [0.24±0.04] in fetuses with RD than those without RD [0.35±0.04]. With a cutoff value for prediction of lung maturity 0.3 with [sensitivity 89.5%, specificity 96.2 %, PPV 89.5%, NPV 96.2%].

The current research demonstrated that fetuses with RDs had a greater pulsatility index and resistive index values when compared with those without respiratory distress syndrome [2.6± 0.3 and 0.9±0.05 vs., 1.9±0.3 & 0.8±0.2, p-value less than 0.001, less than 0.001 respectively. Receiver-operating characteristic curve for prediction of RDS utilizing PI and resistive index demonstrated a cut off point for PI ≥2.195 [AUC 0.946, sensitivity 87.6 % & specificity of 93.1%] and for RI ≥0.855 [AUC 0.876, sensitivity 87.6 % and specificity 89.7%] for fetuses with respiratory distress syndrome. All this results come in agree with **Khalifa *et al.*** [7] which demonstrated powerful association among MPA PI & RI with the improvement of the RD giving cutoff value equal 2.33 for MPA PI [100.0% specificity, 79.0% sensitivity, 94.4% diagnostic accuracy, 100.0 % PPV, & 92.9 NPV], & cutoff value equal 0.89 for MPA RI [89.5% specificity, 84.2% sensitivity, 94 NPV, 88.1% diagnostic accuracy, & 74.4 % PPV].this research revealed that the MPAPI & resistive index were significantly greater in fetuses analyzed with respiratory distress syndrome comparing with those without [2.51±0.33 & 0.90±0.03 cm/s vs.1.96± 0.20 & 0.84 ± 0.01 cm/s, p-value less than 0.001& less than 0.001 respectively].

Keshuraj *et al.* [6] revealed that fetuses with RDS had statistically greater PI & RI values, in GA [34 0/7 -36 6/7] MPA PI [2.67±0.14265for fetuses with respiratory distress syndrome Versus 2.32± 0.16640for fetuses without], the RI value for the same GA was [0.92 ±0.16839for fetuses with respiratory distress syndrome versus 0.83 ± 0.08695for those without]

In GA [37 0/7 - 38 6/7] MPA PI [2.55 ± 0.10468 for fetuses with respiratory distress syndrome Versus 2.02 ± 0.19822for fetuses without], the RI value for the same GA was [0.81 ± 0.02630 for fetuses with respiratory distress syndrome versus 0.75 ± 0.07112 for those without] indicated that fetuses that developed respiratory distress syndrome had pressure and pulmonary vascular resistance that was greater and lesser pulmonary blood flow comparing with those without respiratory distress syndrome.

Our research does not agree with **Hawas *et al.*** [8] research which carried out on 200 pregnant women with GA between 36 -40 weeks, 47 diagnosed with RD & found that PARI was not a significant predictor for neonatal RD with [p –value 0.842]. Witha Mean of [0.82 ±0.07 for fetuses with respiratory distress syndrome versus 0.83 ±0.05 for fetuses without respiratory distress syndrome].

Also, our research did not correlate well with **Khalil *et al.*** [9] carried on 40 eligible fetuses,9 [22%] developed respiratory distress syndrome, this result found that MPA pulsatility index & resistive index with statistically insignificant variance among fetuses with RD & fetuses without respiratory distress syndrome [2.24±0.56 & 0.77±0.13 vs. 2.43±0.48 & 0.82±0.11- p-value = 0.317 & p-value 0.247] for both pulsatility index & resistive index respectively. the same research found a significant association among acceleration time-to-ejection timer ratio & the improvement of respiratory distress syndrome as acceleration time-to-ejection timer ratio was significantly lesser in RD positive group [mean 0.27] comparing to the respiratory distress syndrome negative group [mean 0.34], [p-value0.001] with a cut off value of 0.3 for At/Et predicted the improvement of respiratory distress syndrome [specificity 83.87% and sensitivity

77.78%] and this outcome regarding this parameter agree with our research outcome.

Guan *et al.* [10] demonstrated that fetuses that go on to improve respiratory distress syndrome have greater pressure & pulmonary vascular resistance, and lesser pulmonary blood flow compared to those that do not. The AT, acceleration time-to-ejection timer ratio [but not pulsatility index or resistive index] were significantly lesser in the respiratory distress syndrome group than in the non- respiratory distress syndrome group.

MPA indices measured at our research [PI, RI, & At/Et ratio] are a promising noninvasive tool which help in predicting respiratory distress fetuses with elevate specificity & sensitivity, in comparison with other invasive predictors for fetal lung maturity depending on amniocentesis

Schenone *et al.* [11] have found that main pulmonary artery acceleration time-to-ejection timer ratio & the TDxFLM-II were positively associated, meaning that an elevated acceleration time-to-ejection timer ratio is correlated with FLM & a less risk of developing respiratory distress syndrome, that support our results.

In contrast, **Azpurua *et al***. [12] have found that acceleration time-to-ejection timer ratio was inversely correlated with L/S ratio obtained by amniocentesis. Nevertheless, their sample size was small [Twentynine fetuses] & with only one infant analyzed with respiratory distress syndrome.

Another noninvasive tool which can predict fetal lung maturity is fetal lung volume measured by VOCAL. **Araujo *et al.*** [13] comparing lung volume measurements by two-dimensional ultrasonography utilizing a special formula, Virtual Organ Computer-Aided Analysis, & MRI for twelve cases who had been pregnant for nineteen to thirty-four weeks & were carrying fetuses with urinary tract anomalies. The investigators discovered a powerful association among the 3 procedures. However, The VOCAL method provides the benefits of simultaneous organ display in three orthogonal planes & the ability to modify the outline following calculation of volume.

The results of the present research demonstrated that there is a statistically significant variance among infants born with RDS & without respiratory distress syndrome regarding mean Fetal lung volume calculated by VOCAL in RDS & non-RDS group [31.5±2.5cm vs 38.1±2.8 cm] respectively & Receiver-operating characteristic curve for prediction of RDS utilizing fetal lung volume had also an excellent predictive value [area under curve = 0.981, p-value less than 0.001]. A cutoff criterion of estimated fetal lung for prediction of RDS is ≤ 34.94 cm3 with [sensitivity of 89.5% & specificity of 95.4%].

Our research associate well with **Khalifa *et al.*** [7] research which observed a powerful association among the mean fetal lung volume & the FLM analyzed by neonatal result, with a cutoff value of 35.75 cm3 giving 76.2% specificity, 92.1% sensitivity, 96.4 NPV, 58.3% PPV, & 80.4% diagnostic accuracy.

Laban *et al.* [14] research found that; comparing with newborns with RDS, healthy neonates had significantly greater fetal lung volumes [p-value less than 0.001], with a mean fetal lung volume ≥32.0 cm3 as a cutoff value demonstrating [95.7% specificity, 81.8% sensitivity, 75.0% PPV, 93.8% diagnostic accuracy, 97.1% NPV]. The variance in their cutoff value can be contributed to the variance of the gestational age range of the research group [thirty-seven to forty] weeks.

The last predictor of fetal lung maturity included in our research is fetal lung to liver intensity ratio which has been determined with the gray scale histogram function & compared the tissue echogenicity of both lung & liver, **Serizawa and Maeda** [15] examined the ultrasonic gray level histogram width [GLHW] as a noninvasive technique to expect FLM.

In our research FLLIR revealed a highly significant variance among fetuses with RDS and fetuses without respiratory distress syndrome [0.9±0.2 -1.3±0.3, p value <0.001] respectively, with a cut off value ≤1.053 for calculation of fetal respiratory distress syndrome [AUC 0.960, Accuracy 96.0%, sensitivity 90.3%, specificity 96.6%]. This came in agree with **Khalifa *et al.*** [7] which observed a powerful association among the FLM & FLLIR, with a cut off value of 1.1, demonstrating [96.8% PPV, 92.9% NPV, 93.7% diagnostic accuracy79.0% sensitivity, & 99% specificity.

Our result also matched with the cutoff value performed by **Wang *et al.*** [16]**,** that also discovered a powerful association among L/S ratio & the FLLIR as an indicator for FLM with [61.75% specificity, 83.56% PPV, 80.5% sensitivity, 56.78% NPV]. We discovered that combining the mean fetal lung volume with the main pulmonary artery Doppler & FLLIR, decreased the PPV & specificity.

In contrast, the research performed by **Laban *et al.***[14] demonstrated elevated specificity, this is because their research population gestational age was thirty-seven to forty weeks, while in our research the range was thirty-two to thirty-nine weeks gestational age, thus there was a wide range of normal mean fetal lung volume parameters, the specificity & positive predictive value of lung volumes are reduced as a result of a certain overlap in the distribution of values between fetuses with normally developing lungs. Nevertheless, the presence of an adequate amount of surfactant is necessary for normal lung function, that cannot be associated with normal lung volumes. So, combining the mean fetal lung volume to the other measurements rather than utilizing this measure alone is suggested as it develops the negative predictive value & the sensitivity.

Khalifa *et al.* [7] found the same result of decreasing both specificity & PPV when combining Mean fetal lung volume, MPA Doppler & FLLIR with 100% sensitivity & 100% NPV, mostly due to wide range of normal fetal lung volume parameter in the GA [32 to 40 weeks] involved in this research.

The strength of this research is that it involved variant parameters of lung, that all were variable & reliable. Furthermore, the research done on wide variety of GA [32 to 40] weeks making the outcomes more applicable in clinical practice.

A limitation of our research is that it did not involve patients that were at more risk for preterm labor, included patients of placental insufficiency, multiple pregnancy and medical conditions e.g. [preeclampsia, chronic hypertension, gestational & pregestational diabetes & autoimmune illness]. Similarly, future research on a larger sample size required to confirm our outcomes.

Conclusion: the utilization of main pulmonary artery doppler indices, together with fetal lung-to-liver intensity ratio & mean fetal lung volume for fetal lung evaluation is a rapid noninvasive accurate technique for prediction of FLM & neonatal respiratory distress syndrome, it can be done after routine obstetric fetal scan & before delivery to avoid or anticipate the need for NICU admission due to respiratory distress syndrome in case of elective or emergency birth respectively.

REFERENCES

1. 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]:525-533. doi: 10.1007/s40477-023-00780-w.

2. Ghorayeb SR, Bracero LA, Blitz MJ, Rahman Z, Lesser ML. Quantitative Ultrasound Texture Analysis for Differentiating Preterm From Term Fetal Lungs. J Ultrasound Med. 2017 Jul;36[7]:1437-1443. doi: 10.7863/ultra.16.06069.

3. Bates E, Rouse DJ, Mann ML, Chapman V, Carlo WA, Tita ATN. Neonatal outcomes after demonstrated fetal lung maturity before 39 weeks of gestation. Obstet Gynecol. 2010 Dec;116 [6]:1288-1295. doi: 10.1097/AOG.0b013e3181fb7ece.

4. Gong A, Johnson YR, Livingston J, Matula K, Duncan AF. Newborn intensive care survivors: a review and a plan for collaboration in Texas. Matern Health Neonatol Perinatol. 2015 Oct 19; 1:24. doi: 10.1186/s40748-015-0025-2.

5. Ahmed B, Konje JC. Fetal lung maturity assessment: A historic perspective and Non - invasive assessment using an automatic quantitative ultrasound analysis [a potentially useful clinical tool]. Eur J Obstet Gynecol Reprod Biol. 2021 Mar; 258:343-347. doi: 10.1016/j.ejogrb. 2021.01.025.

6. Keshuraj V, Prakash A, Boruah DK, Ramanna HC, Sowmyashree AR, Mithun SK. Validity of fetal Doppler indices in predicting postnatal respiratory distress syndrome: a prospective study. Egyptian Journal of Radiology and Nuclear Medicine. 2022;53[1]:183. doi: 10.1186/ s43055-022-00865-2.

7. Khalifa YEA, Aboulghar MM, Hamed ST, Tomerak RH, Asfour AM, Kamal EF. Prenatal prediction of respiratory distress syndrome by multimodality approach using 3D lung ultrasound, lung-to-liver intensity ratio tissue histogram and pulmonary artery Doppler assessment of fetal lung maturity. Br J Radiol. 2021 Dec;94 [1128]:20210577. doi: 10.1259/bjr.20210577.

8. Hawas MR, Nammory MME, Dorf AAE, Zeid EHA. Fetal lung volume and pulmonary artery resistance index for prediction of neonatal respiratory distress syndrome. Int J Reprod Contracept Obstet Gynecol 2023; 12:322-8. doi: 10.18203/2320-1770.ijrcog20230116

9. Khalil OA, Abdel Ghany HS, Osman NM, Abdelhamid MK. The role of different fetal pulmonary artery Doppler indices in the prediction of neonatal respiratory distress syndrome. Minia J Med Res. 2019;30 [2]:64-71.

10. Guan Y, Li S, Luo G, Wang C, Norwitz ER, Fu Q, et al. The role of doppler waveforms in the fetal main pulmonary artery in the prediction of neonatal respiratory distress syndrome. J Clin Ultrasound. 2015;43 [6]:375-83. doi: 10.1002/jcu.22219.

11. 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. doi: 10.1159/000358299.

12. Azpurua H, Norwitz ER, Campbell KH, Funai EF, Pettker CM, Kleine M, et al. Acceleration/ejection time ratio in the fetal pulmonary artery predicts fetal lung maturity. Am J Obstet Gynecol. 2010 Jul;203[1]: 40.e1-8. doi: 10.1016/j.ajog.2010.01.075.

13. Araujo Júnior E, De Oliveira PS, Nardozza LM, Simioni C, Rolo LC, et al. Fetal lung volume in fetuses with urinary tract malformations: comparison by 2D-, 3D-sonography and magnetic resonance imaging. J Matern Fetal Neonatal Med. 2010 Jan;23[1]:60-8. doi: 10.3109/ 14767050903121415.

14. Laban M, Mansour GM, Elsafty MSE, Hassanin AS, EzzElarab SS. Prediction of neonatal respiratory distress syndrome in term pregnancies by assessment of fetal lung volume and pulmonary artery resistance index. Int J Gynaecol Obstet 2015; 128: 246–50. doi: 10.1016/j.ijgo. 2014.09.018

15. Serizawa M, Maeda K. Noninvasive fetal lung maturity prediction based on ultrasonic gray level histogram width. Ultrasound Med Biol 2010; 36: 1998–2003. doi: 10.1016/j.ultrasmedbio.2010.08.011

16. Wang S-S, Tian X-Y, Yan H-W, Yuan T, Zheng X-Y, Han Z. Prenatal assessment of pulmonary maturity on 3-D ultrasound. J Obstet Gynaecol Res 2016; 42: 1086–93. doi: 10.1111/jog.13006

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