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Original Article

Umbilical Artery Systolic/Diastolic Ratio and Amniotic Fluid Index in Prediction of Fetal Outcome in Term Pregnancies

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Abstract

Background: Amniotic fluid index (AFI) and umbilical artery (UA) Doppler velocimetry both form an essential part of the antenatal surveillance in the assessment of fetal well-being. The aim of this work was to assess sensitivity, specificity, positive predictive values (PPV) and negative predictive values (NPV) of UA systolic/diastolic (S/D) ratio and AFI in prediction of fetal outcomes in term pregnancies.

Methods: This prospective observational cohort study was carried out on 113 female patients aged from 18 to 40 years old, with term pregnancy (37w6d -40w) and singleton pregnancy. All patients were subjected to UA S/D ratio and AFI measurement.

Results: APGAR score was significantly higher at 10 min than at 1 min and 5 min (P <0.001). S/D ratio and AFI can't significantly predict appearance, pulse, grimace, activity, and respiration (APGAR) score at 10 min and respiratory distress syndrome (RDS) grade 1 respectively (P= 0.374, 0.497, 0.062, <0.001) at cut-off <3,>8,<3,<8 with 100%, 56.67%, 57.14%, 85.71% sensitivity, 9.43%,45.28%, 49.06%, 56.60% specificity, 55.6%, 54%, 6.9%, 11.5% PPV and 100%, 48%,94.5% and 98.4% NPV. Systolic\diastolic ratio and AFI can significantly predict meconium- stained aspiration respectively (P = 0.001, 0.050) at cut-off <3, <8 with 75.00%, 75.00% sensitivity, 72.48%, 55.96% specificity, 5.9% PPV and 98.7% and 98.4% NPV.

Conclusions: AFI and umbilical artery S/D ratio can significantly predict APGAR score at 5 minutes. AFI can predict meconium-stained aspiration and RDS grade 1.

Keywords: Umbilical Artery, Systolic/Diastolic Ratio, Amniotic Fluid Index, APGAR Score

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Introduction:

Antepartum fetal surveillance is the cornerstone of management in pregnancy. [1] It is done primarily to reduce the incidence of adverse fetal outcomes. It minimizes morbidity by optimizing the timing of delivery. Fetus at risk of chronic hypoxia is identified and unnecessary interventions are avoided. However, fetal surveillance acts as a diagnostic modality to detect the influence of maternal, placental, and fetal factors on the fetus. The timely detection of morbid changes in the fetal status followed by adequate interventions to avoid death or disability is one of the most important objectives of prenatal care. [2]

Tests now commonly done for antepartum fetal surveillance are nonstress test (NST), amniotic fluid index (AFI), biophysical profile, Doppler study of umbilical artery (UA), and middle cerebral artery (MCA) [3, 4] .However, AFI and UA Doppler velocimetry both form an essential part of the antenatal surveillance in the assessment of fetal well-being. UA Doppler is a powerful tool that allows the obstetrician to follow a sequence of fetal hemodynamic events that happen in response to placental insufficiency [5] .However, several studies have reported higher sensitivities and specificities for UA Doppler ratio for prediction of fetal prognosis [3, 4] . Amniotic fluid is the product of complex and dynamic fetal and placental physiological processes. Disruption of the fine balance may result in overproduction or underproduction of fluid. Liquor adequacy often reflects the fetal status. Oligohydramnios is associated with increased perinatal loss. Furthermore, other studies indicate that UA velocimetry is a predictor of adverse outcomes in pregnancies complicated by oligohydramnios. [6, 7] Thus, arterial Doppler velocimetry measurement may be useful in predicting adverse pregnancy outcomes adjunct to other antenatal surveillance tests, especially the AFI. Therefore, the present study will be done to evaluate the comparative assessment of UA ratio and AFI in predicting adverse perinatal outcomes.

The aim of this work was to assess sensitivity, specificity, positive and negative predictive values of UA systolic/diastolic (S/D) ratio and AFI in prediction of fetal outcomes in term pregnancies.

Patients and Methods:

This prospective observational cohort study was carried out on 113 female patients aged from 18 to 40 years old, with term pregnancy (37w6d -40w) and singleton pregnancy. The study was done from July 2023 and July 2024 after approval from the Ethical Committee Sohag University Hospitals, Sohag, Egypt (approval code: Soh-Med-24-03-09MS). An informed written consent was obtained from the patients.

The exclusion criteria were patients with preeclampsia, intrauterine growth restriction (IUGR), diabetes mellitus and congenital anomalies of fetus.

All patients were subjected to complete history taking, clinical examination, laboratory investigations [complete blood count (CBC), random blood sugar (RBS), liver function tests: alanine transaminase (ALT), aspartate aminotransferase (AST), renal function test: creatine, blood urea nitrogen (BUN) and urine analysis] and radiological investigations [color Doppler and ultrasound (US)].

All women were subjected to color Doppler (UA S/D ratio) and AFI measurement. On ultrasound examination (GE logic P7, United States), fetal and placental positions were recorded. Four quadrant assessments of amniotic fluid were made. The deepest pocket in each quadrant was measured by callipers contained within the ultrasound unit and was recorded. The sum of these measurements yielded AFI.

A low-frequency Doppler probe was used for color Doppler imaging to assess the UA. The probe was placed on the maternal abdomen, ideally in the midline or slightly off-center, depending on the position of the fetus. The gait or angle of insonation was set to <30 grades to ensure accurate flow measurements.

The Doppler angle was kept as close to zero grades as possible to minimize error in the measurement. The uterus was divided into four quadrants using the transducer in longitudinal view. The transducer was adjusted, with the uterus split into upper-right, upper-left, lower-right, and lower-left sections.

In each quadrant, the deepest pocket of amniotic fluid (without any fetal parts or umbilical cord) was measured using callipers provided within the ultrasound system. The pocket should measure at

least 1 cm in depth to be considered viable for measurement.

The measurements from all four quadrants were summed up to obtain the AFI. A normal AFI typically ranges between 5 cm and 25 cm. An AFI below 5 cm suggests oligohydramnios (low amniotic fluid), while an AFI above 25 cm suggests polyhydramnios (excessive amniotic fluid).

Umbilical arterial S/D ratio is a parameter used in obstetric imaging as part of (UA Doppler assessment. It is the ratio between the systolic velocity and the diastolic velocity. This is measured using the following Doppler equations: RI: Peak systolic velocity – diastolic velocity/peak systolic velocity. S/D Ratio : peak systolic velocity/diastolic velocity. [8]

All patients also subjected to mode of delivery, fetal weight of fetus admitted to NICU, meconium aspiration, respiratory distress syndrome (RDS) or normal and Apgar score of fetuses.

Sample Size Calculation:

Using p Epi-Info program version 3, the sample size was calculated by considering sensitivity (Sn) – 66.6% for appearance, pulse, grimace, activity, and respiration (APGAR) score for AFI criteria as per the reference article [1], precision [D] – 10%, power – 80%, confidence interval – 95%, and nonresponse rate – 10% by using the formula N = Z2 × Sn (1–Sn)/D2 . The final calculated sample size was 113. 113 or more measurements \ surveys are needed to have a confidence level of 80.

Statistical analysis

Statistical analysis was done by SPSS v26 (IBM Inc., Chicago, IL, USA). Quantitative variables were presented as mean and standard deviation (SD) and compared between the two groups utilizing unpaired Student's t-test. Qualitative variables were presented as frequency and percentage (%) and analyzed using the Chi-square or Fisher's exact test when appropriate. A two-tailed P value < 0.05 was considered statistically significant.

Results:

Demographic data, S/D ratio, RI, PI, AFI, placental position and mode of delivery were enumerated in **Table 1.**

Table 1: Demographic data, S/D ratio, RI, PI, AFI, placental position and mode of delivery of the studied patients

		N=113
Age (years) **<20 year** **20-24 year** **25-29 years** **30-34 years** **35-40 year**		28.2±5.38 6(5.31%) 26(23.01%) 38(33.63%) 27(23.89%) 16(14.16%)
Gestational age (weeks)		38.3±0.87
Parity	**Primipara**	20(17.7%)
	Multipara	93(82.3%)
Abortion	**One time**	31(27.43%)
	Two times	7(6.19%)
	Three times	5(4.42%)
	Four times	2(1.77%)
Abortion	**1st trimester**	30(66.67%)
	2nd trimester	15(33.33%)
Gravida status	**Primigravida**	16(14.16%)
	Multigravida	97(85.84%)
S/D ratio		2.5±0.47
S/D ratio <3		80(70.8%)
S/D ratio >3		33(29.2%)
RI		0.6±0.08
PI		0.9±0.36
AFI (cm)	**AFI <8 (cm)**	51(45.13%)
	AFI >8 (cm)	62(54.87%)
Placental position	**Fundal**	36(31.86%)
	Anterior	16(14.16%)
	Posterior	7(6.19%)
	Fundo anterior	22(19.47%)
	Fundo posterior	30(26.55%)
	Previa centralis	2(1.77%)
Mode of delivery	**VD**	48(42.48%)
	Elective CS	40(35.4%)
	Emergency CS	25(22.12%)

Data are presented as mean ± SD or frequency (%). RI: resistive index, PI: pulsatilty index, AFI: amniotic fluid index, VD: vaginal delivery, CS: cesarean section, S/D: systolic/diastolic.

APGAR score was significantly higher at 10 min than at 1 min and 5 min (P <0.001). **Table 2**

Table 2: APGAR score of the studied patients

	At 1 min	At 5 min	At 10 min	P
APGAR score	4(3 – 6)	6(6 – 8)	9(8 – 10)	**<0.001***

Data is presented as median (IQR). * Significant P value <0.05. APGAR: appearance, pulse, grimace, activity and respiration.

Fetal weight with a mean of 3073.1±303.76. Admission to NICU was present in 1 (0.88%) patient. 12 neonates were not attenuated to NICU but received nasal oxygen for 2h at department. Meconium stained was present in 4 (3.54%) patients. RDS grade 1 was present in 7 (6.19%) patients. **Table 3**

Table 3: Neonatal outcomes of the studied patients

		N=113
Fetal weight (g)		3073.1±303.76
Admission to NICU	**Yes**	1(0.88%)
	No	112(99.12%)
Meconium stained	**Yes**	4(3.54%)
	No	109(96.46%)
RDS grade 1	**Yes**	7(6.19%)
	No	106(93.81%)

Data are presented as mean ± SD or frequency (%). NICU: neonatal intensive care unit, RDS: respiratory distress syndrome.

There was no significant difference between placental position and fetal outcomes. **Table 4**

Table 4: Relation between placental position and fetal outcomes of studied groups

	Fundal (n=36)	Fundo anterior (n=22)	Fundo posterior (n=30)	Posterior (n=7)	Anterior (n=16)	Previa centralis (n=2)	P
Fetal weight	3106.9±305.7	2988.6±323.22	3085.2±306.84	3257.1±269.92	3006.3±279.21	3100±141.42	0.356
Admission to NICU	1(2.78%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0.826
Meconium stained	0(0.0%)	1(4.55%)	2(6.67%)	0(0.0%)	1(6.25%)	0(0.0%)	0.404
Respiratory distress grade 1	2(5.56%)	3(13.64%)	2(6.67%)	0(0.0%)	0(0.0%)	0(0.0%)	0.580

Data are presented as mean ± SD or frequency (%). NICU: neonatal intensive care unit.

S/D ratio and AFI can't significantly predict APGAR score at 10 min and RDS grade 1 respectively (P= 0.374, 0.497, 0.062, <0.001 AUC = 0.549 ,0.537, 0.553 and 0.799) at cut-off <3, >8, <3, <8 with 100%, 56.67%,57.14%, 85.71% sensitivity,9.43%,45.28%, 49.06%, 56.60% specificity, 55.6%, 54%, 6.9%, 11.5% PPV and 100%, 48%,94.5% and 98.4% NPV. Systolic\diastolic ratio and AFI can significantly predict meconium-stained aspiration respectively (P = 0.001, 0.050 and AUC = 0.729 and 0.659) at cut-off <3, <8with 75.00%, 75.00% sensitivity, 72.48%, 55.96% specificity, 5.9% PPV and 98.7% and 98.4% NPV. **Figure 1**

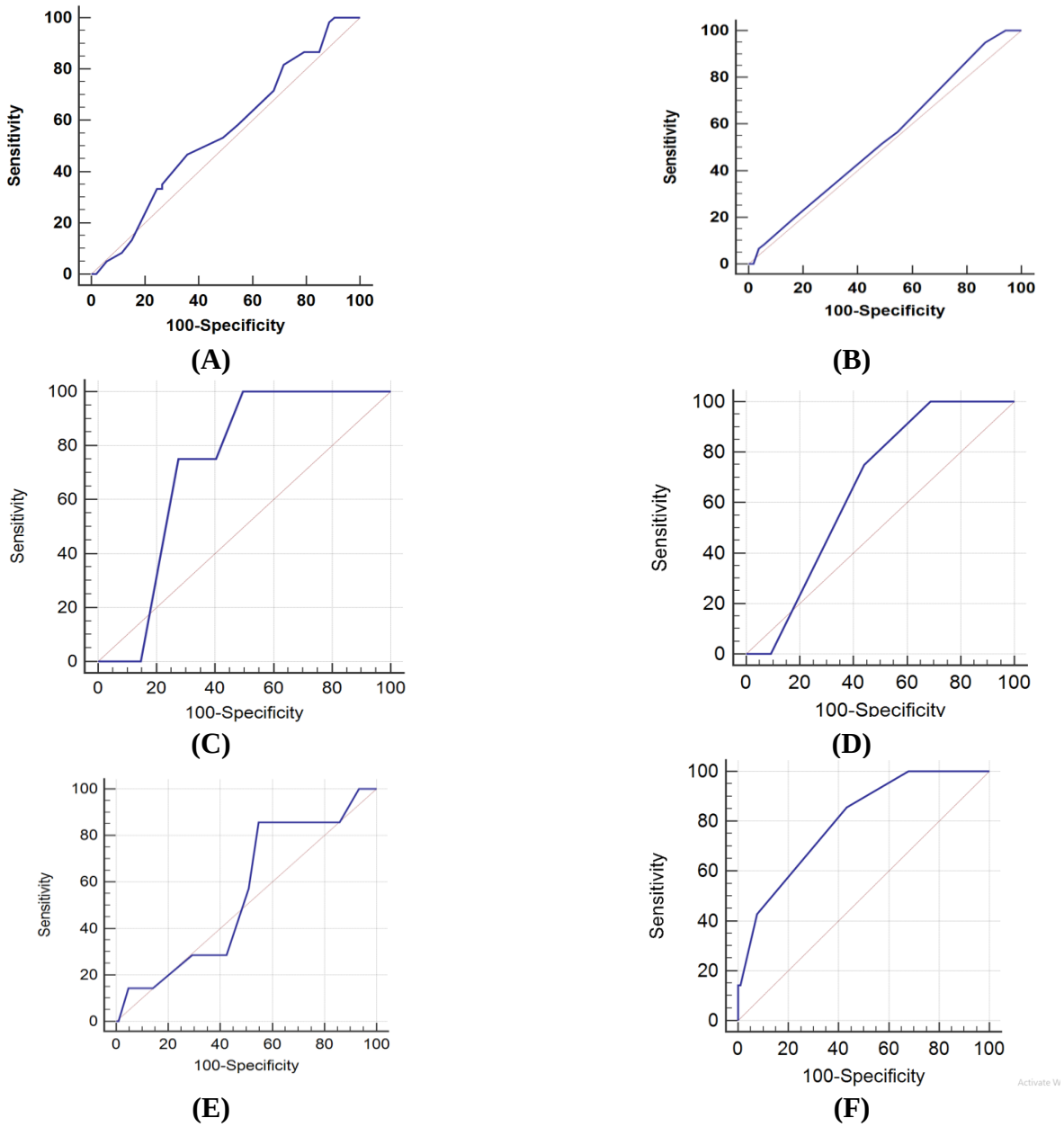

Figure 1: ROC curve of (A) systolic\diastolic ratio, (B) amniotic fluid index in prediction of APGAR score at 10 min, (C) systolic/diastolic ratio, (D) amniotic fluid index in prediction of meconium stained, (E) systolic/diastolic ratio and (F) amniotic fluid index in prediction of respiratory distress syndrome grade1

Apgar score at 10 min was significantly lower in S/D ratio<3 than S/D ratio>3 (P<0.001). Admission to NICU, meconium stained and RDS grade 1 were insignificantly different between both groups. Apgar score at 10 min, admission to NICU, meconium stained and RDS grade 1 were insignificantly different between both groups. **Table 5**

Table 5: Relation between S/D ratio, AFI and neonatal outcomes of the studied groups

	S/D ratio<3 (n=80)	**S/D ratio>3 (n=33)**	**P**
Apgar score at 10 min	8.55±1.08	9.42±1.23	**<0.001***
Admission to NICU	1(1.25%)	0(0.0%)	0.830
Meconium stained	4(5.0%)	0(0.0%)	0.830
RDS grade 1	5(6.25%)	0(0.0%)	0.830
	AFI <8 (n=51)	**AFI >8 (n=62)**	
Apgar score at 10 min	8.61±1.06	8.97±1.27	0.109
Admission to NICU	1(1.96%)	0(0.0%)	0.830
Meconium stained	3(5.88%)	0(0.0%)	0.830
RDS grade 1	6(11.76%)	0(0.0%)	0.830

Data are presented as mean ± SD or frequency (%). * Significant P value<0.05. NICU: neonatal intensive care unit, S/D: systolic/diastolic, AFI: amniotic fluid index, RDS: respiratory distress syndrome.

Discussion

Antepartum fetal surveillance is the cornerstone of management which has been revolutionized using Ultrasound. [9]

In our study, placental position was fundal in 31.86% patients, anterior in 14.16% patients, posterior in 6.19% patients, fundo anterior in 19.47% patients, fundo posterior in 26.55% patients and previa centralis in 1.77% patients. Mode of delivery was vaginal delivery in 42.48% patients, elective CS caesarean section in 35.4% patients and emergency CS in 22.12% patients. 50 patients had previous two CS or more and 15 patients had abnormal presentation and fetal distress. Supporting our results, Sharma et al. [10] showed that the mode of delivery was vaginal delivery in 36% women, caesarean section in 47% women and emergency caesarean section in 17% women. Also, Amani et al. [11] found that 46 (30.67%) women had normal vaginal delivery in the cases group was, 91 (60.67%) women underwent caesarean section and 13(8.66%) of them had instrumental vaginal delivery and in the control group was 100 (66.67%) women had normal vaginal delivery, 46 (30.67%) women underwent caesarean section and 4 (2.66%) women had instrumental vaginal delivery.

In the current study, systolic\diastolic ratio with a mean of 2.5 ± 0.47. Systolic\diastolic ratio <3 was present in 70.8% patients and systolic\diastolic ratio >3 was present in 33 (29.2%) patients. Resistive index ranged from 0.21 to 0.77 with a mean value (± SD) of 0. 6 (±0.08). Pulsatilty index with a mean of 0.9 ±0.36. The AFI ra with a mean of 9.5± 2.41. AFI <8 was present 45.13% patients and AFI >8 was present in 54.87% patients. Supporting our result, Sharma et al. [10] showed that the mean AFI was 9.39 ± 2.55. Adekanmi et al. [12] illustrated that, mean S/D in non-adverse maternal outcome was 1.86 ±0.33 and in had adverse maternal outcome was 2.36 ±1.02. RI in non-adverse maternal outcome was 0.48 ±0.15 and in had adverse maternal outcome was 0.53 ±0.16 and PI in non-adverse maternal outcome was 0.72 ±0.21 and in had adverse maternal outcome was 1.08 (±0.54).

In our study, the APGAR score was significantly higher at 10 min than (at 1 min and 5 min). The median (IQR) of APGAR score at 1min was 4(3-6) and at 5 min was 6(6-8). Newborns undergo rapid physiological changes as they transition from intrauterine to extrauterine life. This process involves significant cardiovascular and respiratory adaptations. As time progresses, these adaptations become more established, potentially leading to improved APGAR scores. [13] Nevertheless, Amani et al. [11] found that APGAR score at 5 min <7 in case group was 37 (24.67%) babies and APGAR score ≥7 was in 113 (75.33%) babies while in control group 8 (5.33%) babies were with APGAR score <7 and 142 (94.67%) babies were with APGAR score≥7. Abdelrazik Abdelfattah et al. [14] showed that APGAR score at 5 min was normal (≥7) in (82%) and low (<7) in (18%).

In the present study, fetal weight with a mean value of 3073.1 ±303.76. Admission to NICU was present in 0.88% woman. 12 children didn't attend NICU but received nasal oxygen for 2h at department. Meconium stained was present in 3.54% women. RDS grade 1 was present in 6.19% women. Supporting our result, Jabeen et al. [15] carried out a cross-sectional descriptive study on 64 women. They found that the mean fetal weight was 2450, within a range of 1055 to 3686 ± 758. However, Abd Rabou et al. [16] reported that fetal weight with a mean value was 4070.98 ± 388.03.

Regarding the association between placental position and fetal weight, fetal weight in fundal position ranged from 2100 to 3900g with a mean of 3106.9 ± 305.7, fetal weight in fundo anterior position with a mean of 2988.6± 323.22, fetal weight in fundo posterior position with a mean of 3085.2 ± 306.84, fetal weight in posterior position with a mean value of 3257.1 ± 269.92 , fetal weight in anterior position with a mean of 3006.3± 279.21 and fetal weight in previa centralis position with a mean of 3100 ± 141.42.

Regarding the association between placental position and admission to NICU,1 (2.78%) child was in fundal placental position admitted to NICU. Regarding the association between placental position and meconium stained, 1 (4.55%) child was in fundoanterior placental position, 2 (6.67%) children were in fundo posterior position, and 1 (4.55%) child was in anterior placental position stained with meconium. Regarding the association between placental

position and respiratory distress grade 1, 2 (5.56%) children were in fundal placental position, 3 (13.64%) children were in fundo anterior placental position, and 2 (6.67%) children were in fundo posterior placental position had respiratory distress grade 1. There was no significant difference between placental position and fetal outcomes.

In our study, the AFI and systolic\diastolic ratio can't significantly predict APGAR score at 10 min respectively at cut-off >9, ≤2.2 with 51.67%, 53.33% sensitivity, 50.94%, 50.94% specificity, 54.4%,55.2% PPV and 48.2%, 49.1% NPV. The S/D ratio increases when there is increased resistance in the placental circulation, which may indicate placental insufficiency. This came in the line with Sharma et al. [10] showed that AFI can't significantly predict APGAR score at 5 min with 50% sensitivity, 79.66% specificity, 29.41% PPV and 90.38% NPV and showed that showed that S/D ratio can significantly predict APGAR score at 5 min with 60% sensitivity, 91.52% specificity,54.54% PPV, and 93.10% NPV . However, Goyal et al. [1] showed that AFI and S/D can predict APGAR score at 5 min respectively with 66.6%, 72.2% sensitivity, 74.3%,83.3% specificity, 50.0%, 68.4% PPV , 85.3% and 85.7% NPV.

In the present study, AFI can significantly predict meconium stained and RDS grade 1 respectively at cut-off <8, <8 with 75.00%, 85.71% sensitivity, 55.96%, 56.60% specificity, 5.9%, 11.5%PPV and 98.4%, 98.4% NPV. In agreement with our results, Sharma et al. [10] showed that AFI can significantly predict meconium stained with 53.84% sensitivity, 79.66% specificity, 36.84% PPV, and 88.67% NPV and showed that AFI can't significantly predict RDS grade with 43.75% sensitivity, 79.66% specificity, 36.84%% PPV, and 83.92% NPV.. Moreover, Goyal et al. [1] showed that AFI can predict meconium stained and RDS respectively with 57.1%, 50.0% sensitivity, 75.8%,69.4% specificity, 60.0% , 45.0% PPV, 73.5% and 73.5% NPV.

In the present study, S/D ratio can significantly predict meconium-stained aspiration at cut-off <3 with 75.00% sensitivity, 72.48% specificity, 9.1% PPV and 98.7% NPV. In the same line, Sharma et al. [10] showed that showed that S/D ratio can significantly predict meconium-stained with 61.53% sensitivity, 91.52% specificity, 61.53% PPV, and 91.52% NPV. Also, Goyal et al. [1] showed that S/D ratio can predict meconium-stained with 66.7% sensitivity, 80.6% specificity, 63.1% PPV, and 82.9% NPV.

In our study, S/D ratio can't significantly predict RDS grade 1 at cut-off <3 with 57.14% sensitivity, 49.06% specificity, 6.9% PPV and 94.5% NPV. However, Sharma et al. [10] showed that S/D ratio can significantly predict RDS grade with 62.5% sensitivity, 91.52% specificity, 66.66% PPV, and 90% NPV. Also, Goyal et al. [1] showed that S/D ratio can predict RDS grade with 61.1% sensitivity, 77.9% specificity, 57.9% PPV, and 80% NPV.

In the current study, Apgar score at 10 min was significantly lower in systolic\diastolic ratio<3 than systolic\diastolic ratio>3. Admission to Nicu, meconium stained and RDS grade 1 were insignificantly different between both groups. If the Apgar score is higher at 5 minutes for babies with a S/D ratio less than 3, it suggests that these babies have better cardiovascular health and are better able to adapt to the outside world. This may be because their blood vessels are not under as much stress, which allows for better blood flow to vital organs, including the lungs, heart, and brain. This improved circulation can lead to better respiratory effort, heart rate, and colour, all of which contribute to a higher Apgar score .Ghosh et al. [17] found that doppler examinations of the uterine and/or the umbilical arteries seem to be comparable as predictors of outcome in pregnancies complicated by fetal growth restriction (FGR).

Limitations of the study included that the sample size was relatively small. The study was in a single center. Comparison of AFI with the single deepest pocket for perinatal outcome was not done. Severity of oligohydramnios was also not categorized further in relation to the fetal outcome. High number of C.S in the current study may affect the study outcomes.

Conclusions:

AFI and S/D ratio can significantly predict APGAR score at 5 min. AFI can predict meconium-stained aspiration and RDS grade 1.

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Conflict of Interest: Nil

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