



EXAMINING THE CORRELATION BETWEEN CEREBROPLACENTAL RATIO (CPR) AND NEONATAL OUTCOMES IN CASES OF INTRAUTERINE GROWTH RESTRICTION (IUGR): A PROSPECTIVE STUDY

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ABSTRACT

Intrauterine growth restriction (IUGR) poses significant challenges in obstetric practice due to its association with adverse perinatal outcomes [1-4]. Doppler velocimetry, particularly assessing Umbilical Artery (UA) flow, aids in predicting these outcomes [1,5]. However, accurate diagnosis and optimal timing of delivery remain clinical dilemmas [6]. Recent attention has turned to the cerebroplacental ratio (CPR), derived from doppler indices, as a potential predictor of fetal well-being [11-13]. This study assessed the utility of CPR and its correlation with perinatal outcomes in IUGR. Methods: This study included 200 antenatal patients diagnosed with fetus with intrauterine growth restriction registered in OPD in a tertiary care hospital during a year. Ultrasonographic examination was done using 3.5Mhz convex assay and linear assay by "Toshiba SSA-660A XARIO USG" USG machine. The sensitivity, specificity, Positive Predictive Value (PPV) and Negative Predictive Value (NPV) of all dopplers were determined using statistical methods. Result: Most of the participants were primigravida 127 (63.50%). Most 153 (76.5%) were terminated by Caesarean section. Total 98 (49%) cases had abnormal Medial Cerebral Arterial Pulsatility Index (MCA-PI); 129 (64.5%) abnormal UA-PI. An abnormal CPR (< 1) was found in 112 (56%) cases. Out of 98 cases with abnormal MCA PI value 48 cases had fetal distress, 86 cases had APGAR score less than 7 at 5 minutes interval, 94 cases were admitted in NICU. Conclusion: The CPR demonstrated superior predictive value compared to individual Doppler indices (MCA PI and UA PI) in identifying adverse perinatal outcomes in cases of IUGR. This suggests that CPR could serve as a valuable tool for risk stratification and management decisions in pregnancies complicated by IUGR.

KEYWORDS

Intrauterine Growth Restriction (IUGR), cerebroplacental ratio (CPR), Middle Cerebral Artery (MCA), Umbilical artery (UA)

INTRODUCTION

Intrauterine growth restriction (IUGR) is associated with adverse perinatal outcomes.[1] Intrauterine growth restriction (IUGR) is defined as sonographic estimated foetal weight <10th percentile e for gestational age. Intrauterine growth retardation due to fetoplacental vascular insufficiency is very common in developing countries like India.[2]

Two-thirds of the pregnancies complicated by stillbirth demonstrate growth restriction. It is important to identify fetus at risk of growth restriction to reduce the risk of stillbirth.[3] IUGR is associated with an increased risk of short and long term morbidity and mortality, as well as impaired neurological and cognitive development. Suspected IUGR is defined in the antenatal period by sonographic estimation of fetal anthropometric measures using a wide range of seldom validated definitions and cut-off values.[4] Various methods exist for diagnosing and monitoring fetal wellbeing used in intra-uterine growth restricted foetus. Out of them Doppler velocimetry has been proven to possess the most predictive capacity in diagnosis and management of IUGR.[5] Current challenges in the clinical management of IUGR include accurate diagnosis of the truly growth-restricted fetus, selection of appropriate fetal surveillance, and optimizing the timing of delivery. Despite the potential for a complicated course, antenatal detection of IUGR and its antepartum surveillance can improve outcomes. Colour Doppler ultrasonography provides a very powerful tool in monitoring the complex vasculature of the uterus, placenta and fetus during implantation and pregnancy. Knowledge of Doppler flow velocimetry assist in perinatal diagnosis and management of complicated pregnancies. An assessment of fetal, maternal-placental and placental circulations is immensely necessary to assess the outcome and explore the prognosis of IUGR foetuses.

Commonly used Doppler assessment in obstetrics encompasses that of the Umbilical Artery (UA), Middle Cerebral Artery (MCA), Uterine Artery and Ductus Venosus (DV). The UA Doppler is most commonly used for the monitoring and timing of delivery of the fetus compromised by growth restriction.[7] UA velocimetry correlates with hemodynamic changes in the fetoplacental circulation.

In IUGR, umbilical blood flow is significantly reduced, mainly due to changes in the placental vascular resistance.[8] Fetal Umbilical Arterial Absent End-Diastolic Velocity (AEDV) with intrauterine

growth restriction is associated with high perinatal morbidity and mortality.[9] In a healthy fetus, MCA-PI falls with advancing gestational age and this decrease probably reflects a decreasing vascular resistance with increasing gestational age.[10] Doppler ultrasound studies of the human fetal circulation have shown that in fetuses with IUGR there is a significant reduction of MCA-PI when compared with those in normal fetuses. For many years clinical research has been concerned with doppler sonography as a noninvasive tool for intrauterine fetal status assessment. A new focus is now placed on the measurement of cerebroplacental index (CPR) as a predictor of fetal outcome.

The cerebroplacental ratio is the ratio of the two doppler sonographic parameters, the PI of the MCA and PI of the UA. Furthermore, it shows even discrete changes in the perfusion of only one of the two vessels as an index of two different vessels. According to the PROTO study, pathological CPR has been defined as 1.0): (1) lower gestational age at birth, (2) lower mean birth weight, (3) lower birth weight centile, (4) birth weight less than the 10th centile, (5) higher rate of caesarean delivery for fetal distress in labour, (6) higher rate of Apgar scores less than 7 at 5 minutes, (7) an increased rate of neonatal acidosis, (8) an 8 increased rate of newborn intensive care unit admissions, (9) higher rate of adverse neonatal outcome and (10) a greater incidence of perinatal death.[12,13,14] In study reported by Ebrashy et al, they found that CPR identified more fetuses with adverse outcome than did the biophysical profile.[14] The CPR may be useful as part of a risk stratification tool for prediction of low birth weight and adverse intrapartum and neonatal outcomes in IUGR foetuses.[15] The purpose of this study is to evaluate the usefulness of CPR and determine correlation between cerebroplacental ratio and perinatal outcome in IUGR.

MATERIAL AND METHODS

It was an observational prospective study conducted in the Department of Obstetrics and Gynaecology at tertiary care hospital. The purpose of the study was to evaluate the usefulness of CPR and determine its correlation with perinatal outcome in IUGR. For that the antenatal patients registered on OPD basis and diagnosed as having fetus with intrauterine growth restriction during October 2019 to December 2021 were selected as study population. The non-probability consecutive sampling technique was used to achieve the required sample size of 200 for the study. Of all the antenatal patients, those with singleton

pregnancy between 28 to 42 weeks of gestation with IUGR (estimated fetal weight below the 10th percentile as per gestational age) and willing to give consent were included for the study.

The selected 200 antenatal patients with singleton pregnancy between 28 to 42 weeks of gestation with IUGR were examined with ultrasound on regular and need basis. Ultrasonographic examination was done using 3.5Mhz convex assay and linear assay by "Toshiba SSA-660A XARIO-USG" USG machine. The ultrasonography was performed by Senior Medical Officer of the Radiology department and in a single machine to avoid errors. It was done with participant in supine position. Blood flow indices namely PI was studied in the UA and fetal MCA by Doppler ultrasonography. CPR of the PI of the fetal MCA and mid-cord of UA was calculated. A suitable amniotic fluid pocket was chosen with loops of umbilical cord floating in it in order to examine the UA. The UA Doppler was sampled from the free loop of umbilical cord midway between placental and abdominal wall insertion. The measurements were taken when a clear waveform was acquired in the absence of fetal breathing or body movement. The PI was obtained for UA. The MCA was examined in an axial view of fetal head at the level of cerebral peduncles; the colour doppler was used to visualize the circle of Willis. The Doppler samples were collected within 1 cm of the origin of MCA which is easily identified as a major branch running anterolateral from the circle of Willis towards the lateral edge of orbit. The PI of MCA were obtained, and the values noted down.

The measurements were performed weekly in cases with abnormal Doppler values or at the time of the next growth scan. The last measurement before delivery was used for analysis. The UA PI ratios were considered abnormal if the value was above the 95th percentile for the gestational age. The MCA PI was considered abnormal if the value was below the 5th percentile for the gestational age, according to reference values of D Gramellini et al. [16]. Of the various Doppler indices, PI has the smallest measurement error and narrow reference limits. The CPR is usually constant during the last 10 weeks of gestation. It is possible to use a single cut-off value after 38th week because CPR doesn't vary significantly between 38th and 40th weeks as reported by Wladimiroff et al. [17] who observed significant differences in CPR only between weeks 26 to 38.

CPR was considered as normal for the ratio above 1. An abnormal CPR was defined as a CPR of less than 1. Doppler results were analysed for prediction of perinatal outcomes. The studied parameters and perinatal outcome variables included: -

- 1) Maternal age at delivery (years)
- 2) Gestational age at Delivery (weeks)
- 3) Fetal Birth weight (kilograms)
- 4) Delivery mode (spontaneous vaginal / cesarean section)
- 5) Caesarean delivery for non-reassuring fetal status / fetal distress
- 6) 5-minute Apgar scores less than 7.0
- 7) NICU admissions
- 8) Umbilical cord pH less than 7
- 9) Respiratory distress syndrome
- 10) Perinatal mortality

Pregnancy was considered to have adverse outcome when any of the following complications were present,

- 1) Caesarean delivery for non-reassuring fetal status / fetal distress
- 2) 5-minute Apgar scores less than 7.0
- 3) NICU admissions
- 4) Umbilical cord pH less than 7
- 5) Respiratory distress syndrome
- 6) Perinatal mortality

Pregnancy outcome was considered to be uneventful or favorable when the above complications were absent.

STATISTICAL METHODS:

The diagnostic statistics were used to find the diagnostic value of UA PI, MCA PI and CPR in relation to perinatal outcome. The sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were determined for all Doppler measurements using the following formulae

A = True Positive B = False Positive
C = False Negative D = True Negative

$$\text{SENSITIVITY} = \frac{A}{A + C} \times 100 \quad \text{SPECIFICITY} = \frac{D}{B + D} \times 100$$

$$\text{NPV} = \frac{D}{C + D} \times 100 \quad \text{PPV} = \frac{A}{A + B} \times 100$$

Diagnostic statistic

Test	Criteria		
	Adverse	Uneventful	Total
+	A (TP)	B (FP)	A + B
-	C (FN)	D (TN)	C + D
Total	A + C	B + D	N

All the recorded observations were compared statistically and the results were analyzed and concluded. All the statistical analysis were carried out by SPSS (Statistical Package for Social Sciences) version 16. Microsoft word and Excel have been used to generate graphs tables etc. Chi-square test for goodness of fit was used wherever applicable. P value < 0.05 was considered significant.

RESULTS

This prospective analytical study comprised a total of 200 antenatal patients between 28 to 42 weeks of gestation registered on OPD basis in our hospital and diagnosed as having fetus with intrauterine growth restriction. All the cases were regularly followed up as per need basis and following observations were made.

In the current study the greatest number of mothers were found in 21-25 years of age group i.e. 88 (44%) followed by ≤ 20 years age group i.e. 66 (33%) respectively. Mean age of mothers was found to be 25.68 ± 0.68 years. The most of the mothers were primigravida and most of them were in range of 38 - 42 weeks of gestation; while majority of them were terminated by Lower Segment Caesarean section (LSCS). Table 1 shows the demographic and clinical characteristics of study participants.

Out of 200 total 153 (76.5%) were terminated by LSCS. The most common indication for LSCS was found to be Fetal Distress 61 (39.9%) followed by Severe Oligohydramnios 25 (16.3%), Previous LSCS 22 (14.4%), Meconium Stained Liquor 17 (11.1%), Preeclampsia or imminent eclampsia or eclampsia 15 (9.8%), failure of Induction 8 (5.2%), Non-Progress of Labour 4 (2.6%) and Breech 1 (0.7%).

In the current study post-delivery 143 (71.5%) neonates had APGAR Score < 7 at 5 minutes and 151 (75.5%) neonates were admitted in NICU, 51 (25.50%) neonates had umbilical cord pH < 7, 36 (18%) neonates developed respiratory distress syndrome. Out of 200 total 35 (17.5%) cases were of perinatal mortality including 4 (11.4%) Intrauterine Death and 31 (88.6%) neonatal deaths.

Table 1: Demographic and Clinical Characteristics of Studied Patients

Sr No	Category	N	(%)
A	Age in years		
1	≤ 20	66	33%
2	21-25	88	44%
3	26-30	39	19.5%
4	31-36	7	3.5%
	Total	200	100%
B	Parity		
1	Primigravida	127	63.5%
2	Multigravida	73	36.5%
	Total	200	100%
C	Gestational Age (weeks)		
1	28 - 32	5	2.5%
2	33 - 37	63	31.5%
3	38 - 42	132	66%
	Total	200	100%
D	Delivery Mode		

1	Normal Vaginal Delivery	47	23.5%
2	Lower Segment Caesarean Section	153	76.5%
	Total	200	100%

Note: Percentages and frequencies are calculated row-wise.

Middle Cerebral Arterial Pulsatility Index (MCA PI)

In this study MCA PI was considered abnormal if the value was below the 5th percentile for the gestational age. Out of 200 IUGR cases studied, 98 (49%) cases were found to have abnormal MCA PI values whereas 102 (51%) cases had normal MCA PI Values. Out of the 98 cases with abnormal MCA PI values, 48 underwent Lower Segment Caesarean Section (LSCS) due to fetal distress, compared to 13 cases out of the 102 with normal MCA PI values. Total 86 cases with abnormal MCA PI values had APGAR scores less than 7 at 5 minutes, compared to 57 cases with normal MCA PI values. Total 94 cases with abnormal MCA PI values required NICU admission, while 57 cases with normal MCA PI values were admitted to the NICU. Thirty-one cases with abnormal MCA PI values had umbilical cord pH levels below 7, compared to 20 cases with normal MCA PI values. Twenty-seven cases with abnormal MCA PI values developed respiratory distress syndrome, whereas 9 cases with normal MCA PI values had the same condition. Among the cases studied, 29 with abnormal MCA PI values experienced perinatal mortality, whereas 6 cases with normal MCA PI values had perinatal mortality. (Table 2).

Umbilical Artery PI (UA PI)

In this study UA PI values were considered abnormal / elevated if the value was above the 95th percentile for the gestational age. Out of 200 IUGR cases studied 129 (64.5%) cases had abnormal UA PI values and 71 (35.5 %) cases had normal UA PI Values. Total 61 cases were terminated by Lower Segment Caesarean Section (LSCS) due to fetal distress. Of these, 40 cases had elevated UA PI, while 21 cases had normal UA PI. Total 100 cases had APGAR scores less than 7 at 5 minutes; among them, 107 had elevated UA PI, while 44 had normal UA PI. Total 107 cases required admission to the Neonatal Intensive Care Unit (NICU). Of these, 39 had elevated UA PI, while 12 had normal UA PI. Thirty-nine cases had Umbilical Cord pH less than 7, and 28 cases developed respiratory distress syndrome. Among them, 27 and 8 cases respectively had elevated UA PI, while 12 and 8 cases respectively had normal UA PI. In total, 35 cases experienced perinatal mortality. Among them, 27 cases had elevated UA PI, while 8 cases had normal UA PI. (Table 3).

Cerebroplacental Ratio (CPR)

In the current study the CPR ratio above 1 was considered as normal and abnormal for less than 1. The CPR values were abnormal (< 1) in 112 (56%) cases in comparison to > 1 in 88 (44%) cases. Among 200 cases of Intrauterine Growth Restriction (IUGR), 44 cases with abnormal CPR and 17 cases with normal CPR values underwent LSCS due to fetal distress. Total 108 cases with abnormal CPR and 43 cases with normal CPR values had APGAR scores less than 7 at 5 minutes. Forty-three cases with abnormal CPR values, while 43 cases with normal CPR values were admitted to the NICU. In total, 35 cases experienced perinatal mortality. Among them, 34 cases had abnormal CPR values, while 1 case had normal CPR values. (Table 4).

The sensitivity, specificity, PPV & NPV of observed CPR values in relation to perinatal outcomes were calculated using SPSS software. (Table 2,3,4).

DISCUSSION

1. Age Distribution of Studied Cases

Most number of mothers were found in 21 - 25 years of age group i.e. 88 (44.00%) followed by ≤ 20 years age group i.e. 66 (33.00%) respectively. Mean age of mothers was found to be 25.68 ± 06.8 years. It was found to be 26.60 ± 06.83 by Odibo AO et al [1] whereas Sharma DD et al [85] reported 19-26 years age of the participants with mean maternal age of 23 years, El-Kady MA et al [86] reported mean age of 28.2 ± 2.8 years.

2. Parity of Patients

Present study found that most mothers studied were primigravida i.e. 127 (63.5%) in contrast to 73 number of multigravida mothers. Study conducted by Sharma DD et al [85] found most cases in primigravida i.e. 36/60 (60%) in comparison to multigravida i.e. 24/60 (40%). Similarly study done by El-Kady MA et al [86] found IUGR cases were most common in primigravida i.e. 21 (70%).

3. Gestational Age Distribution

In present study when cases were distributed according to gestational age in weeks then most numbered were found in range of 38 - 42 weeks of gestation i.e. 132 (66%) followed by 33 - 37 weeks i.e. 63 (31.5%). 5 cases were in the 28 to 32 weeks gestational age group. Mean gestational age at delivery $\pm$ SD in weeks were 37.67 ± 1.61 . Odibo AO et al [1] in their study found mean gestational age at delivery $\pm$ SD in weeks as 35.60 ± 3.60 . El-Kady MA et al [86] found mean gestational age at delivery $\pm$ SD in weeks in IUGR cases as 35.7 ± 01.50 . S Gupta et al [10] in their study correlating MCA Doppler with adverse perinatal outcomes in IUGR reported mean gestational age at delivery being 36 weeks.

5. Delivery Mode Distribution

The present study found that most cases were delivered by caesarean section i.e. 153 (76.5%) in comparison to 47 cases delivered spontaneously vaginally (23.5%). In comparison to present study, study conducted by Sharma DD et al [85] found cases delivered vaginally were 23 (38%) in comparison to LSCS i.e. 37 (61%).

Study conducted by Malik R et al [2] to evaluate role of color Doppler indices in diagnosis of IUGR in high risk pregnancy found most of the cases delivered by vaginal route (63%) in comparison to (37%) of cases delivered by LSCS.

6. Indication for Caesarean Section

In our study most common indication for Caesarean section was Fetal Distress i.e. 61 out of 153 (39.87%) followed by Severe Oligohydramnios (16.34%). Odibo AO et al [1] found 17 % of cases terminated by caesarean delivery for non-reassuring fetal heart status. Study conducted by Malik R et al [2] found the fetal distress as the most common indication of LSCS.

In comparison to present study, study conducted by Sharma DD et al [85] found majority of the patients (61%) had to undergo caesarean section, most common indication being foetal distress or meconium-stained liquor (32%) and severe pre-eclampsia with severe oligohydramnios (32%).

7. Perinatal Findings and Outcome

Our study reported a fetal distress rate of 61 (30.5%), contrasting with Odibo et al.'s study at (17%) and Bano et al.'s study at (20%) [1,8]. However, Sharma et al. observed a substantially higher rate of (63.3%) [85]. Similarly, the incidence of low APGAR scores (< 7) at 5 minutes varied notably among studies. Our study recorded a rate of 143 (71.5%), significantly higher than Gupta et al.'s finding of (12.22%) but lower than El-Kady et al.'s observation of (85%) [10,86]. While our study reported a NICU admission rate of 151 (75.5%), El-Kady et al. observed a higher rate at (62.5%), and Sharma et al. reported (53.3%) [10,85,86]. Umbilical cord pH below 7, an indicator of fetal acidosis, displayed variability across studies. Our study found a rate of 51 (25.5%), whereas Odibo et al. reported a lower incidence at (6%) [1]. In the current study 36 neonates (18%) developed respiratory distress syndrome which was close to Odibo AO et al [1] (16%). In our study 4 cases had Intrauterine Death and 31 cases were neonatal deaths amounting to total of 35 (17.5%) cases under perinatal mortality.

8. Middle Cerebral Arterial Pulsatility Index (MCA PI)

On our study 98 (49%) cases were found to have abnormal MCA PI values whereas 102 (51%) cases had normal MCA PI Values. Which could not be compared with the present literature.

9. Umbilical Artery PI (UA PI)

The present study found 129 (64.5%) cases had abnormal UA PI values and 71 (35.5 %) cases had normal UA PI Values. Bano S et al [8] also found umbilical artery pulsatility index were normal in 66% cases and abnormal in (24%) cases which was contrast to present study.

10. Cerebroplacental Ratio (CPR)

In our study the CPR values were abnormal (< 1) in 112 (56%) cases in comparison to > 1 in 88 (44%) cases. These findings were not found in the available literatures.

11. Observed perinatal outcome in relation to MCA-PI, UA-PI & CPR Values.

Our study recorded APGAR scores less than 7 at 5 minutes in 143 (71.5%), which was higher than Yoon et al (57%) [20]. Whereas NICU admissions in our study were less 36 (75.5%) compared to Yoon

et al. (93%) [20]. In terms of perinatal mortality, our study observed 35 (17.5%) cases which was lower than Yoon et al. (35%) [20].

12. Observed perinatal outcome in relation to cerebroplacental ratio.

Regarding APGAR scores less than 7 at 5 minutes, our study reported a rate of 100 (69.9%), while Gramellini et al. and Deshmukh et al. reported higher rates of (88.8%) and (86.7%) respectively.[16,21] Our study observed a higher NICU admission rate of 108 (71.52%, whereas Gramellini et al. reported a lower rate of (16%) and Deshmukh et al. reported a rate of (10.8%). [16,21]

In terms of the proportion of cases undergoing Lower Segment Caesarean Section (LSCS) due to fetal distress, our study reported a rate of 112 (72.1%), which is comparable to the rates reported by Gramellini et al. (77%) and Deshmukh et al. (70%).[16,21]Overall, the comparison of CPR values and associated fetal outcomes across these studies highlights the importance of CPR assessment in predicting adverse perinatal outcomes and guiding clinical management strategies in cases of intrauterine growth restriction. Further research is warranted to validate these findings across diverse populations and clinical settings.

Similarly, Bano et al[8] found that of the 90 pregnancies in the study, 24 showed abnormal UAPI. Among these, 21 (87.5%) were SGA and 19 (79.2%) had adverse perinatal outcome. Four of the 90pregnancies showed abnormal MCA PI and all four (100%) fetuses were SGA and all (100%) hadadverse perinatal outcome. Perinatal death was noted in one pregnancy, which showed a normal MCAPI but an abnormal UA PI and C/U ratio. Twenty of the 90 pregnancies showed an abnormal C/U ratio(<1.08). The sensitivity and negative predictive values (NPVs) were higher for the C/U ratio and UA PI,whereas significantly lower for MCA PI. The specificity and positive predictive value (PPV) of the C/Uratio and MCA PI were equal to each other but higher than that ofUAPI.

CONCLUSIONS

In conclusion, our study investigated the correlation between cerebroplacental ratio (CPR) and neonatal outcomes in cases of intrauterine growth restriction (IUGR). We observed that a significant proportion of the studied population exhibited abnormal CPR values, indicating potential fetal compromise. Maternal age distribution revealed a relatively young study population, with a majority being primigravida mothers. Hypertensive disorders of pregnancy were identified as the most common maternal risk factor associated with IUGR.

Notably, the mean gestational age at delivery was consistent with typical term pregnancies, but a high proportion of deliveries occurred via cesarean section, primarily due to fetal distress. Most neonates exhibited APGAR scores below 7 at 5 minutes, necessitating NICU admission for a considerable portion of the cohort. Additionally, a notable percentage of neonates developed respiratory distress syndrome, underscoring the perinatal challenges associated with IUGR.

Analysis of Doppler indices revealed a higher prevalence of abnormal CPR values compared to other Doppler parameters. Importantly, CPR demonstrated superior predictive value for adverse perinatal outcomes compared to other Doppler indices when assessed alone.

Overall, our findings emphasize the clinical significance of CPR assessment in predicting adverse neonatal outcomes in cases of IUGR. Incorporating CPR evaluation into routine antenatal care protocols may enhance risk stratification and facilitate timely intervention strategies to improve perinatal outcomes in high-risk pregnancies.

Table 2: MCA PI correlation with perinatal outcome

Sr No	Foetal Outcome	Abnormal PI	Normal PI	P- Value	Sensitivity	Specificity	Positive Predictive Value (%)	Negative Predictive Value (%)
1	Birth weight <10th percentile	98	102	<0.05	-	-	-	-

2	LSCS for foetal distress	48	13	<0.05	78.69 %	64.02 %	48.97%	87.25%
3	APGAR < 7(5min)	86	57	<0.05	60.13 %	78.94 %	87.75%	44.11%
4	NICU admission	94	57	<0.05	62.25 %	91.83 %	95.91%	44.11%
5	Umbilical cord pH <7	31	20	NS	44.96 %	39.21 %	68.36%	19.60%
6	Respiratory distress syndrome	27	9	<0.05	75.00 %	58.23 %	27.55%	91.66%
7	Perinatal mortality	29	6	<0.05	92.00 %	76.80 %	70.40%	94.11%

Note: Percentages and frequencies are calculated row-wise.

Table 3: Umbilical PI correlation with perinatal outcome

Sr No	Foetal Outcome	Elevated PI	Normal PI	P- Value	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)
1	Birth weight <10th percentile	129	71	< 0.05	-	-	-	-
2	LSCS for fetal distress	40	21	NS	65.57 %	35.97%	31.01%	70.42%
3	APGAR < 7 (5min)	100	43	< 0.05	69.93 %	49.12%	77.51%	39.43%
4	NICU admission	107	44	< 0.05	70.86 %	55.10%	82.94%	38.02%
5	Umbilical cord pH < 7	39	12	< 0.05	76.47 %	39.59%	30.23%	83.09%
6	Respiratory distress syndrome	28	8	NS	77.77 %	38.41%	21.70%	88.73%
7	Perinatal mortality	27	8	NS	77.14 %	38.18%	20.93%	88.73%

Note: Percentages and frequencies are calculated row-wise.

Table 4: CPR correlation with perinatal outcome

Sr No	Foetal Outcome	CPR < 1	CPR > 1	P- Value	Sensitivity	Specificity	Positive Predictive Value (%)	Negative Predictive Value (%)
1	Birth weight <10th percentile	112	88	< 0.05	-	-	-	-
2	LSCS for fetal distress	44	17	< 0.05	48.96 %	29.12%	62.99%	44.36%
3	APGAR < 7 (5min)	100	43	< 0.05	94.34 %	59.75%	73.35%	86.44%
4	NICU admission	108	43	< 0.05	92.99 %	55.30%	70.94%	82.74%
5	Umbilical cord pH < 7	43	8	< 0.05	84.31 %	53.69%	38.39%	90.90%

6	Respiratory distress syndrome	32	4	< 0.05	88.88 %	51.21%	28.57%	95.45%
7	Perinatal mortality	34	1	< 0.05	97.14 %	49.71%	27.86%	98.86%

Note: Percentages and frequencies are calculated row-wise.

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