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Original Research Article

Comparison of Doppler studies in normal pregnancy and high risk pregnancy and their perinatal outcome

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ABSTRACT

Background: Doppler ultrasound is one of the most valuable techniques available for assessing fetal well-being, especially in high risk pregnancies. It helps to evaluate fetal circulation by measuring blood flow in key vessels. These waveforms are generated based on ultrasound frequency shifts from blood movement and are influenced by factors such as fetal cardiac contraction, blood viscosity, vessel elasticity and vascular resistance.
Methods: This is a prospective study.100 pregnant women including normal and high risk pregnancy are selected and they undergo Doppler ultrasonography to assess the umbilical artery, middle cerebral artery, and uterine artery flow parameters. The following indices will be measured: pulsatility index (PI); resistance index (RI) and systolic/diastolic (S/D) ratio. Perinatal outcomes will be recorded and analysed.
Results: The PI, RI, and S/D values normal with normal pregnancy group whereas in the high risk group, these values are variable in the uterine and umbilical arteries. In high risk pregnant women shows higher umbilical artery PI and lower middle cerebral artery PI compared to normal pregnant women. Neonatal intensive care unit (NICU) admissions in normal pregnancy and high risk pregnancy (5% versus 35%; $p<0.01$), low APGAR scores in normal pregnancy 3% and high risk pregnancy 25% ($p<0.01$) and respiratory distress syndrome in normal pregnancy 3% and high risk pregnancy 25% ($p<0.01$).
Conclusions: Evaluating doppler waveforms across different maternal and fetal conditions, we can predict early complications of pregnancy like preeclampsia, IUGR in high risk pregnancy and its management. Abnormal doppler results need frequent antenatal checkups and follow up with doppler waveforms to guiding clinical decision making.

Keywords: Normal pregnancy, High risk pregnancy, Abnormal doppler studies

INTRODUCTION

Doppler is a non-invasive technique to study uteroplacental fetal blood flow and it is safe and reproducible and allows for quick detection of abnormalities. Doppler ultrasound is one of the most valuable techniques available for assessing fetal well-being, especially in high risk pregnancies. The first study utilizing Doppler ultrasound to assess umbilical artery waveforms was published in 1977. It helps to evaluate fetal circulation by measuring blood flow in key vessels, including the umbilical artery, middle cerebral artery and ductus venous.[1]

In fetal Doppler, the uterine artery assesses maternal–placental circulation; normally it shows low resistance with no early diastolic notch after 24 weeks, while persistent notching or high pulsatility index (PI) suggests defective trophoblastic invasion and risk of preeclampsia/IUGR.[2]

The umbilical artery reflects placental resistance; normally diastolic flow increases with gestation, whereas raised

PI/resistance index (RI), absent end-diastolic flow (AEDF), or reversed end-diastolic flow (REDF) indicate worsening placental insufficiency and fetal hypoxia.[3]

The middle cerebral artery evaluates fetal adaptation; normally it has high resistance, but in hypoxia there is vasodilation with reduced PI/RI ("brain-sparing"), while increased peak systolic velocity (PSV>1.5 MoM) signals fetal anemia.[4] The cerebroplacental ratio (MCA PI / UA PI) <1 is a strong marker of adverse outcome.

The ductus venosus (DV) Doppler assesses fetal cardiac function and central venous pressure by measuring blood flow from the umbilical vein to the inferior vena cava/right atrium. Normally, it shows a triphasic forward flow with a tall systolic (S) wave, early diastolic (D) wave, and a smaller but still forward atrial contraction (a) wave.[5] Abnormal findings—such as absent or reversed a-wave or increased PI for veins—indicate elevated central venous pressure and myocardial dysfunction, seen in severe hypoxia, acidosis, hydrops, or chromosomal anomalies. It helps in monitoring severe IUGR (where changes appear late and signal imminent fetal deterioration).[6]

These waveforms are generated based on ultrasound frequency shifts from blood movement and are influenced by factors such as fetal cardiac contraction, blood viscosity, vessel elasticity and vascular resistance. Fetal hypoxia can be assessed by abnormal wave patterns obtained from the vessel.

This study was conducted to enable the accurate assessment of fetal wellbeing in high risk pregnancies, with the aim of improving perinatal outcomes.

Objective

The objective of the study was to compare Doppler indices, including the umbilical artery, middle cerebral artery, uterine artery between normal and high risk pregnant women and their perinatal outcome.

METHODS

Source of data

Pregnant women attending the Department of Obstetrics and Gynaecology, Navodaya Medical College Hospital and Research Centre, Raichur, Karnataka during the study period.

Study design

It was a prospective study.

Study period

The duration of the study was for 1 year (May 2024 to April 2025).

Sample size

100 samples were a part of the study (group A-50 normal pregnancy and group B-50 high risk pregnancy).

Inclusion criteria

Singleton pregnancies at 28–40 weeks of gestation, normal pregnancies with no maternal or fetal complications, and high-risk pregnancies (e.g., preeclampsia, fetal growth restriction, gestational diabetes, oligohydraminos) were included in the study.

Exclusion criteria

Patients with multiple pregnancies, polyhydraminos, antepartum haemorrhage, major congenital fetal anomalies, and patients with known vascular disorders affecting Doppler indices were excluded.

Procedure

Participants will undergo Doppler ultrasonography to assess the umbilical artery, middle cerebral artery, and uterine artery flow parameters. The following indices will be measured: PI, RI, and systolic/diastolic ratio (S/D ratio).

$$Pulsatility\ index\ (PI) = Systole - diastole/mean\ velocity$$

$$Resistance\ index\ (RI) = Systole - diastole/systole$$

Perinatal outcomes, including birth weight, APGAR scores, NICU admissions, and neonatal morbidity, will be recorded and analyzed.

Statistical analysis

The statistical package for the social sciences (SPSS) version 27 was employed to perform these analyses. in descriptive statistics frequencies and percentages were employed. Inferential statistics' Chi square test for independence and binary logistic regression were used to determine the extent of associations. $p \leq 0.05$ was the cutoff point for statistical significance. The significant variables from the bivariate analysis were brought into binary logistic regression for further analysis. The qualitative data was subjected to thematic analysis.

RESULTS

In the present study, n=100 patients in group A (50 normal pregnant women) and group B (50 high risk pregnant women) attending the antenatal clinic and labor ward are chosen. Patients underwent doppler study and PI, RI and S/D ratio of key vessels are noted. They were followed up till delivery and perinatal outcome was recorded. Results thus obtained were analysed and expressed in tables.

The most frequent age group in group A is 21-24 years and in group B it is 30-34 years (Table 1).

Table 1: Age wise distribution of patients.

Age (years)	Group A (n=50) (%)	Group B (n=50) (%)
<20	6 (12)	4 (8)
21-24	20 (40)	8 (16)
25-29	15 (30)	12 (24)
30-34	7 (14)	21 (42)
35 and above	2 (4)	5 (10)

40% of each group are primigravida and 60% are multigravida (Table 2).

Table 2: Gravida of patients.

Gravida	Group A (n=50) (%)	Group B (n=50) (%)
Primigravida	22 (44)	20 (40)
Multigravida	28 (56)	30 (60)

In group B, 30% are hypertensive, 40% has oligohydramnios and 24% has fetal growth restriction (Table 3).

Group B pregnancies consistently demonstrated significantly higher umbilical artery PI ($p<0.001$ across all gestational ages) compared group A. Similarly, Middle cerebral artery PI was significantly lower in group B ($p<0.001$ across all gestational ages) (Table 4).

Table 3: Risk factors in group B.

Variable	Group B (mean±SD or %)
BMI (kg/m²)	27.1±3.1
Hypertension	15 (30)
Oligohydraminos	20 (40)
Fetal growth restriction	12 (24)

Umbilical artery doppler indices (PI, RI, S/D ratio) are significantly increased ($p<0.001$) in group B. Middle cerebral artery doppler indices are significantly lower PI and RI in group B ($p<0.001$) (Table 5).

NICU admission was seven times higher in group B (35% versus 5%, $p<0.001$). Respiratory distress syndrome (RDS) was observed in 25% of group B neonates compared to only 3% in group A ($p<0.001$). Neonatal jaundice was also more common in group B ($p<0.003$) (Table 6).

Normal Doppler waveforms were associated with a low rate of neonatal complications (NICU admission 5%, low APGAR 3%). However, increased umbilical artery PI and reduced MCA PI significantly correlated with worse outcomes, including higher NICU admissions and low APGAR scores.

The most concerning group was those with absent/reversed end-diastolic flow (EDF), where 50% of newborns required NICU admission, and 10% experienced stillbirths ($p<0.001$) (Table 7).

Table 4: Comparison of Doppler indices at different gestational ages.

Gestational age (weeks)	Umbilical artery PI (group A)	Umbilical artery PI (group B)	P value	Middle cerebral artery PI (group A)	Middle cerebral artery PI (group B)	P value
28-30	1.05±0.2	1.40±0.3	0.002	1.40±0.3	1.10±0.2	<0.001
31-33	1.00±0.2	1.35±0.3	<0.001	1.35±0.3	1.00±0.2	
34-36	0.98±0.2	1.30±0.3	<0.001	1.30±0.3	0.95±0.2	
37-40	0.95±0.2	1.25±0.3	<0.001	1.28±0.3	0.90±0.2	

Table 5: Comparison of Doppler indices.

Parameters	Group A (mean±SD)	Group B (mean±SD)	P value
Umbilical artery PI	0.96±0.2	1.35±0.3	<0.001
Umbilical artery RI	0.58±0.1	0.75±0.2	
Umbilical artery S/D ratio	3.2±0.5	4.5±0.8	
Middle cerebral artery PI	1.34±0.3	0.9±0.3	
Middle cerebral artery RI	0.67±0.1	0.55±0.2	
Middle cerebral artery S/D ratio	4.1±0.7	3.2±0.6	
Uterine artery PI	1.0±0.2	1.4±0.3	
Uterine artery RI	0.5±0.1	0.65±0.2	
Uterine artery S/D ratio	2.8±0.5	3.5±0.7	

Table 6: Perinatal outcomes.

Outcome	Group A (mean±SD or %)	Group B (mean±SD or %)	P value
Birth weight (kg)	2 (3)	7 (14)	<0.001
Low APGAR score at 5 min	1 (2)	5 (10)	<0.001
NICU admission (%)	3 (5)	17 (35)	<0.001
Stillbirths (%)	0	3 (5)	-
Respiratory distress	2 (3)	12 (25)	<0.001
Neonatal jaundice	5 (10)	15 (30)	<0.003

Table 7: Perinatal outcomes comparison.

Doppler abnormality	NICU admission (%)	Low APGAR score (%)	Stillbirth (%)	P value
Normal Doppler findings	3 (5)	2 (3)	0	-
Increased umbilical artery PI	15 (30)	12 (25)	3 (5)	<0.001
Reduced MCA PI (brain sparing)	17 (35)	15 (30)	4 (7)	<0.001
Absent/reversed EDF	25 (50)	23 (45)	5 (10)	<0.001

DISCUSSION

In the present study, the most frequent age group in group A is 21-24 years and in group B it is 30-34 years. In the present study, 40% of each group are primigravida and 60% are multigravida. In a study by Dixit et al, 60% of each group are primigravida.[7]

In present study, umbilical artery Doppler indices (PI, RI, S/D ratio) were significantly higher in group B ($p<0.001$), suggesting increased placental resistance and impaired fetal circulation. These findings are consistent with studies by Alfirevic et al, which demonstrated that abnormal umbilical artery Doppler waveforms are associated with fetal growth restriction and perinatal morbidity.[8]

In a study by Trudinger et al reported that elevated uterine artery resistance is strongly linked to preeclampsia and placental insufficiency, aligning with the increased uterine artery PI and RI observed in group B in this present study.[9]

In present study, middle cerebral artery (MCA) Doppler indices were significantly lower in group B ($p<0.001$), indicating a fetal adaptive response to chronic hypoxia, known as the brain-sparing effect. In a study by Baschat et al suggests that a lower MCA PI correlates with an increased risk of adverse perinatal outcomes, including neonatal distress and neurodevelopmental impairment.[10]

Analysis of perinatal outcomes revealed that high umbilical artery PI (>1.2) and low MCA PI (<1.0) were significantly associated with increased NICU admissions, low APGAR scores, and higher rates of perinatal distress ($p<0.001$). In a study Lees et al, emphasized the importance of Doppler monitoring in timing deliveries to optimize neonatal outcomes, which supports the clinical relevance of the findings in present study.[11]

In present study, uterine artery PI >1.3 was strongly correlated with preeclampsia, fetal growth restriction, and increased stillbirth rates. These findings are in agreement with the GRIT study, which highlighted that Doppler abnormalities in high-risk pregnancies warrant close surveillance and possible early delivery to prevent fetal compromise.[12]

Limitations

The relatively small sample size and single-center design limit the external validity of this study. Additionally, the absence of long-term neonatal follow-up restricts the ability to assess outcomes beyond the immediate perinatal period. Doppler assessments were not fully standardized in terms of timing and frequency, and inter-observer variability was not evaluated, which may affect the consistency of measurements. Furthermore, potential confounding factors such as maternal comorbidities, nutritional status, and medication use were not controlled for. These limitations should be considered when interpreting the results and applying them to broader clinical practice.

CONCLUSION

Doppler velocimetry not only serves as a non-invasive and reliable tool for monitoring maternal and fetal well-being but also helps clinicians in making evidence-based decisions regarding the timing of delivery, thereby improving perinatal outcomes and reducing maternal as well as neonatal morbidity and mortality. By systematically evaluating Doppler waveforms across different maternal and fetal vessels, early complications such as pre-eclampsia, IUGR, and placental insufficiency can be predicted with greater accuracy, especially in high-risk pregnancies. Abnormal Doppler results warrant closer antenatal surveillance, frequent follow-up with repeat Doppler assessments, and timely interventions to minimize the risk of fetal hypoxia, acidosis, or stillbirth. In cases where preterm delivery is anticipated, corticosteroid administration is essential to accelerate fetal lung maturity

and reduce the incidence of neonatal respiratory distress syndrome.

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