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# Role of umbilical artery and fetal middle cerebral artery doppler study in prediction of pregnancy outcome in high-risk pregnancies

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ORIGINAL ARTICLE

# Role of umbilical artery and fetal middle cerebral artery doppler study in prediction of pregnancy outcome in high-risk pregnancies

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Abstract

*Background:* ***Doppler ultrasonography has shown to be a valuable technique for evaluating the blood flow in the foetus and placenta, as well as predicting adverse results throughout pregnancy.***

*Aim and objectives:* ***To investigate the sensitivity and specificity of umbilical artery middle cerebral artery Doppler pulsatility index resistive index as diagnostic value for antepartum assessment of fetal well-being prediction of adverse outcome in high-risk pregnancy.***

*Patients and methods:* ***This was Prospective observational research performed on 100 pregnant women collected from the obstetric outpatient clinic at Mansoura General Hospital (MGH), especially in radiology department, obstetric department and outpatient clinic and NICU (neonatal intensive care unit). Patients were separated into two groups.***

*Results:* ***A highly statistically significant (p-value < 0.001) reduced 5 min APGAR, birth weight and in-cases group compared with the control group. A highly statistically significant (p-value < 0.001) raised the percentage of NICU and CS delivery in the cases group compared with the control group. However, there was no statistically significant variance (p-value > 0.05) among the examined groups (cases and control) regarding the percentage of neonatal death.***

*Conclusion:* ***There is an essential relationship between Doppler abnormalities and adverse neonatal results, suggesting that assessing these vessels (Umbilical artery and middle cerebral artery) is essential to determine delivery timing. This indicates that multi-vessel Doppler ultrasonography is reliable for categorising IUGR foetuses with placental vascular insufficiency into different risk groups.***

*Keywords:* Umbilical Artery; High-Risk Pregnancies; Doppler Ultrasound

## 1. Introduction

Doppler US has shown to be a valuable technique for evaluating the blood flow in the fetus and placenta, as well as predicting adverse pregnancy results.[1]

Doppler imaging of the umbilical artery has been utilised to monitor growth-restricted fetuses during high-risk pregnancies; Doppler knowledge has a good effect on decreasing hospital admission days in hospitals for mothers and fetuses in patients of suspected intrauterine growth restriction(IUGR) and ultrasound examination used in the first and second trimester of pregnancies to assess fetal growth disorders and detect fetal malformation, Approximately 4-10% of pregnant women have preeclampsia, a condition that leads to maternal morbidity & preterm iatrogenic births, as well as intrauterine development restriction .[2]

Doppler US is employed as a component of the clinical procedure for monitoring pregnancies that are at high risk. It provides explicit data on the circulation between the foetus and the placenta, & detects any issues with the placental blood flow. Doppler US offers the benefit of being a rapid and consistent procedure that may be conducted regularly.[3,4]

The purpose of this research was to investigate the sensitivity and specificity of the umbilical and middle cerebral artery Doppler pulsatility index and resistive index as diagnostic values for antepartum assessment of fetal well-being and prediction of adverse outcomes in high-risk pregnancy.

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## 2. Patients and methods

This Prospective observational research was performed on 100 pregnant females collected from the obstetric outpatient clinic at Mansoura General Hospital (MGH), especially in the radiology department, obstetric department, outpatient clinic, and NICU (neonatal intensive care unit). Cases were separated into two groups: 1st group involved 50 pregnant females in high-risk "Study group", and 2nd group involved 50 pregnant females with uncomplicated pregnancies "Control group".

Inclusion criteria: Singleton pregnant woman, Gestational age at 28 weeks till 34 weeks, For 1st group "Study group": Diagnosed cases of high-risk pregnancies (DM, hypertensive pregnant women, PET (Preeclampsia toxaemia), heart diseases pregnant women, Intrauterine growth restriction (IUGR), Eachadults pregnant women have pregnancy-induced hypertension; Gestational hypertension: BP reading of 140/90 mmHg or above for the 1st time during pregnancy after 20 weeks of gestation. It is characterised by the absence of proteinuria and the recovery of BP to normal within 12 weeks following childbirth. Preeclampsia and gestational diabetes mellitus are conditions that can coexist with gestational hypertension.

Exclusion criteria: Fetal congenital anomalies and Woman has a history of renal disease, liver disease, and blood disorders.

Ethical consideration

The study was approved by the ethical committee of the Department of Diagnostic Radiology, Faculty of Medicine, Al-Azhar University. All recruited women had informed written consent.

Methods

All cases were subjected to the following:

History taking: Individual history, Historical obstetrics, Gravidity, parity, previous delivery method, pregnancy-induced hypertension, current pregnancy weight gain, the first day of the last menstrual period, and regularity of menstruation are all factors to consider. Previous history, An Analysis: General assessment: Vital signs and examination of the local area: "Fundamental level and abdominal grips".

Umbilical artery (UA) Doppler method:

A transducer is positioned on the mother's belly to acquire waveforms from the umbilical artery and vein. A pulsed wave Doppler system incorporates an ultrasonic scan and colour-flow mapping. The blood flow through the umbilical vein increases during foetal inspiration and reduces during expiration. Avoid doing umbilical artery Doppler investigations when the foetus is engaged in breathing activities.5

Middle cerebral artery (MCA) Doppler method

An image of the foetal brain is captured from a side view at the point when the width of the brain is measured, and a technique called colour flow imaging is employed to examine the middle cerebral artery. A pulsed Doppler sample gate is positioned to acquire flow velocity waveforms. Ensuring a low insonation angle and exerting minimum pressure on the maternal abdomen is essential for obtaining precise outcomes.

## 3. Results

Table 1 reveals no statistically significant variance (p-value = 0.185) among examined groups (cases & control) concerning age

*Table 1. comparison among studied groups concerning age.*

| | | CASES (N = 50) | CONTROL (N = 50) | STAT. TEST | P-VALUE |
|---|---|---|---|---|---|
| AGE (YEARS) | Median | 27.5 | 26 | MW = | 0.185 |
| | IQR | 24 - 29 | 22 - 29 | 1058 | NS |

MW: Mann Whitney U test. NS: p-value > 0.05 is considered non-significant.

Table 2 Statistically significant (p-value = 0.004) increased AC in cases group, highly statistically significant (p-value < 0.001) decreased gestational age at delivery in cases group when contrasted with control group, but there was no statistically significant variance (p-value > 0.05) among examined groups (cases & control) concerning FL, BPD & gestational age.

*Table 2. comparison among examined groups concerning fetal measures.*

| | | CASES (N = 50) | CONTROL (N = 50) | MW | P-VALUE |
|---|---|---|---|---|---|
| FL (MM) | Median | 55 | 56 | 995.5 | 0.077 |
| | IQR | 52 – 57 | 54 – 58 | | NS |
| BPD (MM) | Median | 75 | 76 | 1059.5 | 0.181 |
| | IQR | 74 – 77 | 75 – 77 | | NS |
| AC (MM) | Median | 276 | 275 | 841 | 0.004 S |
| | IQR | 275 – 278 | 274 – 276 | | |
| GESTATIONAL AGE (WEEKS) | Median | 31 | 31 | 1240 | 0.944 |
| | IQR | 29 – 33 | 29 – 33 | | NS |
| G. AGE AT DELIVERY (WEEKS) | Median | 35 | 39 | 147 | < 0.001 |
| | IQR | 34 - 36 | 38 – 39 | | HS |

S: p-value < 0.05 is considered non-significant. T: independent sample T test. HS: p-value < 0.001 is considered highly significant. X2: Chi-square test

Table 3 reveals highly statistically significant (p-value below 0.001) decreased 5 min APGAR, birth weight and in cases group when compared with control group. highly statistically significant (p-value below 0.001) raised percentage of NICU and of CS delivery in cases group when contrasted with control group, but no statistically significant variance (p-value above 0.05) among examined groups (cases and control) concerning percentage of neonatal death.

*Table 3. comparison among examined groups concerning neonatal data.*

| | | CASES (N = 50) | | CONTROL (N = 50) | | STAT TEST | P-VALUE |
|---|---|---|---|---|---|---|---|
| APGAR (5 MIN) | Median | 6 | | 8.5 | | MW = 108 | < 0.001 HS |
| | IQR | 5 – 7 | | 7 – 9 | | | |
| BIRTH WEIGHT (GRAM) | Median | 2100 | | 3100 | | MW = 353 | < 0.001 HS |
| | IQR | 1887 - 2800 | | 2900 - 3300 | | | |
| NICU | No | 20 | 40% | 49 | 98% | $X^2$ = 39.3 | < 0.001 HS |
| | Yes | 30 | 60% | 1 | 2% | | |
| NEONATAL DEATH | No | 47 | 94% | 50 | 100% | $X^2$ = 3.09 | 0.079 NS |
| | Yes | 3 | 6% | 0 | 0% | | |
| MODE OF DELIVERY | NVD | 5 | 10% | 40 | 80% | $X^2$ = 49.5 | < 0.001 HS |
| | CS | 45 | 90% | 10 | 20% | | |

Table 4 reveals highly statistically significant (p-value below 0.001) increased SBP & DBP in cases group when compared with control group

*Table 4. comparison among examined groups concerning blood pressure.*

| | | CASES (N = 50) | CONTROL (N = 50) | STAT TEST | P-VALUE |
|---|---|---|---|---|---|
| SBP (MMHG) | Median | 150 | 100 | MW = 303.5 | < 0.001 HS |
| | IQR | 117 – 150 | 90 – 110 | | |
| DBP (MMHG) | Median | 100 | 70 | MW = 345.5 | < 0.001 HS |
| | IQR | 80 - 110 | 70 - 80 | | |

Table 5 reveals highly statistically significant (p-value below 0.001) increased umbilical artery RI and Statistically significant (p-value equals 0.001) increased umbilical artery PI in cases group when compared with control group

*Table 5. comparison among examined groups concerning umbilical artery RI & PI.*

| UMBILICAL ARTERY | | CASES (N = 50) | CONTROL (N = 50) | MW | P-VALUE |
|---|---|---|---|---|---|
| RI | Median | 0.77 | 0.66 | 162.5 | < 0.001 HS |
| | IQR | 0.76 – 0.82 | 0.64 – 0.7 | | |
| PI | Median | 1.4 | 1.2 | 784 | 0.001 S |
| | IQR | 1.2-1.7 | 0.97 – 1.4 | | |

Table 6 reveals Statistically significant (p-value equals 0.011) decreased umbilical artery RI and highly statistically significant (p-value below 0.001) reduced umbilical artery PI in cases group when compared with control group

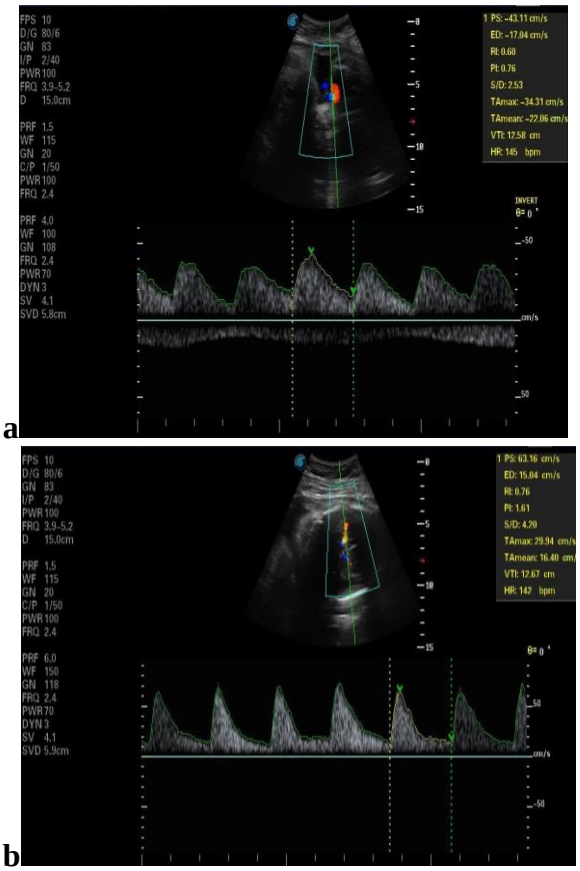
*Table 6. comparison among examined groups concerning MCA RI & PI.*

| MCA ARTERY | | CASES (N = 50) | CONTROL (N = 50) | MW | P-VALUE |
|---|---|---|---|---|---|
| RI | Median | 0.8 | 0.83 | 953.5 | 0.011 S |
| | IQR | 0.77– 0.86 | 0.78 – 0.9 | | |
| PI | Median | 1.2 | 2 | 0.0 | < 0.001 HS |
| | IQR | 1 – 1.3 | 1.9 – 2.1 | | |

CASE PRESENTATION

Case one:

Clinical history: An 18 years old female, not diabetic, not hypertensive, gestational age 33 weeks at examination. Clinical data: Systolic blood pressure 90 mmHg, diastolic blood pressure 70 mmHg, normal vaginal delivery, Birth weight at delivery 2500 gm, APGAR score 7, no need NICU, no neonatal death. Doppler examination: Umbilical artery RI 0.52, PI 0.79 and middle cerebral artery RI 0.83 PI 1.99



a



b

Figure 1. Shows case 1

## 4. Discussion

Doppler ultrasonography is commonly used to assess the arterial system, including the umbilical and middle cerebral arteries, in foetuses with intrauterine growth restriction. The Doppler velocimetry results for these arteries can be either normal or abnormal. The aberrant umbilical artery velocimetry indicated an elevated resistance to blood flow in the placenta. In this scenario, a growth limitation is caused by the placenta's insufficient function. Additionally, there may be alterations in the foetal cerebral Doppler waves, indicating an augmented blood supply to the brain, known as the "brain-sparing effect" [6,7]

The main results of our study were as follows:

In our study, the two groups were nearly matched regarding demographic data, with no statistically significant variance (p-value equals 0.185) among examined groups (cases and control) concerning age. median age in the cases group was 27.5 years with an IQR of 24 – 29 years, whereas median age in the control group

was 26 years with an IQR of 22 – 29 years

This study shows statistically significant (p-value equals 0.004) raised AC in the cases group (median = 276, IQR = 275 – 278 mm) when compared to AC of the control group (median = 275, IQR = 274 – 276 mm. Highly statistically significant (p-value below 0.001) reduced gestational age at delivery in the cases group (median = 35, IQR = 34 – 36 weeks) when compared with the control group (median = 39, IQR = 38 – 39 weeks. No statistically significant variance (p-value above 0.05) among examined groups (cases & control) concerning FL, BPD, or gestational age.

This was in agreement with Nguyen et al., who found that Fetal growth limitation was observed during the whole duration of pregnancy, starting early on and continuing until delivery. However, the specific time of development halting differed depending on the measure being considered. For HC, BPD, and AC, growth restriction began by 20 weeks of gestation. In contrast, FL showed growth restriction starting after 30 weeks of gestation. US measurement below the 10th percentile was linked to a two to four times increase in the chance of SGA at delivery compared to foetuses above the 50th percentile. The highest odds ratios were observed for AC. The mean foetal growth parameter of SGA infants was notably lower, starting from 14 weeks. [8]

Hiersch and Melamed found that it is crucial to consider the possibility of even a tiny overestimation or underestimation of foetal size during the initial ultrasound examination. This is because such errors can significantly impact the expected growth trajectory of the foetus, potentially leading to either over-diagnosis or under-diagnosis of FGR. There may be an overestimation or underestimation of the size of the foetus during the conditioning examination. This can happen due to errors in foetal biometry, measurement technique changes, and significant measurement variations between observers. Recent studies have shown that this variation can be as high as five percent for HC, nine percent for AC, and eleven percent for FL. [9]

This study reveals Highly statistically significant (p-value below 0.001) reduced 5 min APGAR in the cases group (median = 6, IQR = 5 – 7) when compared to 5 min APGAR of the control group (median = 8.5, IQR = 7 – 9). Highly statistically significant (p-value below 0.001) decreased birth weight in the cases group (median = 2100, IQR = 1887 – 2800 grams) when compared with the control group (median = 3100, IQR = 2900 – 3300 grams). Highly statistically significant (p-value below 0.001) raised percentage of NICU in the cases group (30 cases, 60%) when compared with the control group (1 case, 2%). Highly statistically significant (p-value below 0.001) raised percentage of CS delivery in the cases group (45 cases, 49%) when compared with the control group (10 cases, 20%). There was no statistically significant variance (p-value above 0.05) among examined groups (cases and control) concerning the percentage of neonatal death.

These findings align with Li et al.'s research, which demonstrated the predictive significance of the APGAR score for infant survival throughout neonatal and post-neonatal periods. The result of the interest was infant mortality within one year of birth. The Cox proportional hazards model was employed to calculate the risk ratio of newborn death based on various APGAR scores. For infants having a meagre APGAR score of 1-3 at 5 minutes after birth, the rates of death during the neonatal and post-neonatal periods were consistently high until reaching full term at more than 37 weeks. Conversely, in cases when the APGAR score is high (>7) at birth, the rates of neonatal and post-neonatal death drop gradually as the gestational age increases. They asserted that the APGAR score system is valuable for predicting bad outcomes in both term and preterm newborns immediately after birth and in the postnatal period.[10]

Harper et al. found that determining the gestational age of intended delivery in pregnancies affected by chronic hypertension can help reduce the risk of perinatal mortality and severe adverse outcomes. The study revealed that the mean systolic and diastolic blood pressure throughout the periods of 28-32 weeks and 32-36 weeks were notably elevated in the group that underwent scheduled delivery at 36 weeks. However, it is essential to note that both averages remained below the 140/90 mm Hg threshold. Of the women who had scheduled delivery at 36 weeks, 10.0% experienced the key neonatal composite result. Within the intended delivery cohort, there were two unfavourable neonatal composite outcomes, which included one newborn fatality resulting from cardiorespiratory failure and one child requiring mechanical ventilation for seven days. Within the expectant management cohort, there were a total of 17 neonatal composite outcomes, comprising 4 cases of stillbirth, six instances of infants being placed on a ventilator, and 1 case of an infant necessitating continuous positive airway pressure. The minimal duration of ventilator usage was one day.[11]

In contrast, the study conducted by Ehrenstein held a different viewpoint, stating that the APGAR score was not originally designed to predict outcomes beyond the immediate period after birth. However, due to the correlation between low scores and prenatal and postnatal difficulties,

several studies have investigated the connection between the APGAR score value, the duration of low scores (<7), and the subsequent occurrence of death or neurological disability.[12]

In our study, highly statistically significant (p-value below 0.001) raised SBP in the cases group (median = 150, IQR = 117 – 150 mmHg) when compared with the control group (median = 100, IQR = 90 – 110 mmHg). Highly statistically significant (p-value below 0.001) rose DBP in the cases group (median = 100, IQR = 80 – 110 mmHg) when compared with the control group (median = 70, IQR = 70 – 80 mmHg).

Harper et al. found that determining the gestational age for planned delivery in pregnancies affected by chronic hypertension can reduce the risk of perinatal mortality and severe adverse outcomes. The study revealed that the mean systolic and diastolic blood pressure throughout the periods of 28-32 weeks and 32-36 weeks were notably elevated in the group that underwent scheduled delivery at 36 weeks. However, it is essential to note that both averages remained below the threshold of 140/90 mm Hg.[11]

In our study, Highly statistically significant (p-value below 0.001) raised umbilical artery (UA) RI in the cases group (median = 0.77, IQR = 0.76 – 0.82) when contrasted with the control group (median = 0.66, IQR = 0.64 – 0.7). Statistically significant (p-value equals 0.001) decreased UA PI in the cases group (median = 1.2, IQR = 0.97 – 1.4) when contrasted with the control group (median = 1.4, IQR = 1.2 – 1.7),

this study Statistically significant (p-value = 0.011) increased middle cerebral artery (MCA) RI in cases group (median = 0.83, IQR = 0.78 – 0.9) when compared with control group (median = 0.8, IQR = 0.77 – 0.86). Highly statistically significant (p-value below 0.001) reduced middle cerebral artery (MCA) PI in the cases group (median = 1.2, IQR = 1 – 1.3) when compared with the control group (median = 2, IQR = 1.9 – 2.1).

### *4. Conclusion*

Doppler anomalies in the umbilical and middle cerebral arteries are strongly associated with adverse results in newborns. Therefore, it is crucial to analyse these arteries to establish the optimal timing for delivery. This indicates that multi-vessel Doppler ultrasonography is reliable for categorising IUGR foetuses with placental vascular insufficiency into different risk groups.

## Disclosure

The authors have no financial interest to declare in relation to the content of this article.

## Authorship

All authors have a substantial contribution to the article

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## Conflicts of interest

There are no conflicts of interest.

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