Research Article

Comparison of the Umbilical Artery Doppler Indices in Predicting Adverse Fetal Outcome in Women with Preeclampsia

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ABSTRACT

Background: Umbilical artery Doppler (UAD) is a non-invasive method of antenatal fetal surveillance for detecting hemodynamic changes prior to the occurrence of adverse fetal outcome and thus useful for averting adverse fetal outcome in preeclampsia. This study aims to compare the umbilical artery Doppler PI, RI, S/D ratio in predicting adverse fetal outcome in women with preeclampsia.

Methods: This was a prospective observational study in which 170 consecutively consenting women with preeclampsia were recruited. An UAD was done using Voluson P8 ultrasound. The Pulsatility Index (PI), Resistance Index (RI), Systolic/Diastole (S/D) ratio, was measured. The participants were divided into two groups based on UAD indices findings. Both groups were followed up to determine their fetal outcome.

The data was analyzed using SPSS version 20.0 for windows (IBM SPSS Inc, Chicago, IL, USA). Categorical variables were analyzed using Chi-Square (x^2) test and Fisher's exact test. The sensitivity, specificity, PPV and NPV of UAD PI, RI S/D ratio were determined.

Results: This study found that UAD PI was most sensitive in predicting IUGR (75.4%) and Apgar score <7 (80.0%) in women with preeclampsia. The UAD S/D ratio (62.0%) was the most sensitive in predicting low birth weight. UAD PI and RI have similar sensitivity of 74.2% in predicting preterm delivery.

Conclusion: The UAD PI was the most reliable individual indices in predicting adverse fetal outcome and thus, recommends its use alone or in combination of with other indices in predicting adverse fetal outcome in preeclampsia.

Keywords: Comparison; Umbilical artery doppler indices; Fetal outcome

INTRODUCTION

Preeclampsia is a complicated hypertensive disease occurring after the twentieth week of pregnancy with elevated blood pressure ≥140/90mmHg and proteinuria in a woman who was previously normotensive and non-proteinuric [1]. This condition constitutes a major cause of maternal and perinatal morbidity and mortality especially in developing countries like Nigeria [1,2]. It complicates 2-10% of pregnancies and accounts for about 76,000 maternal deaths and 500,000 fetal deaths annually world-wide [2,3].

The pathogenesis of preeclampsia is mediated through vascular endothelial damage and vasospasm which have negative impact on fetal hemodynamics resulting in reduced organ perfusion leading to impaired perfusion of the placental resulting in fetoplacental insufficiency which leads to adverse fetal outcome [4,5].

Doppler Ultrasonography is a non-invasive method of fetal surveillance which allows for assessment of blood flow velocity waveform of maternal and fetal blood vessels [6,7]. These hemodynamic changes can easily be detected by umbilical artery

Doppler indices prior to the occurrence of adverse fetal outcome in high risk pregnancies like preeclampsia. Thus, serves as a useful antenatal fetal surveillance in preventing adverse fetal outcome [7,8].

From literature search comparing the various umbilical artery Doppler indices in predicting adverse fetal outcomes in preeclampsia, there is no consensus on which of the indices is better predictor of adverse fetal outcome [8-15]. Therefore, there is a need for more studies to compare and determine which of the umbilical artery indices is a better predictor of adverse fetal outcome in preeclamptic women. The purpose of this study is to compare the umbilical artery Doppler PI, RI, S/D ratio in predicting adverse fetal outcome in women with preeclampsia.

AIMS

To compare the umbilical artery Doppler PI, RI, S/D ratio in predicting adverse fetal outcome in women with preeclampsia.

OBJECTIVES

1. To compare the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of umbilical artery PI, RI, S/D ratio in predicting intrauterine growth restriction in women with preeclampsia.

2. To compare the sensitivity, specificity, PPV and NPV of umbilical artery PI, RI, S/D ratio in predicting low birth weight in women with preeclampsia.

3. To compare the sensitivity, specificity, PPV, and NPV of umbilical artery PI, RI, S/D ratio in predicting preterm delivery in women with preeclampsia.

4. To compare the sensitivity, specificity, PPV, and NPV of umbilical artery PI, RI, S/D ratio in predicting Apgar score <7.

MATERIALS AND METHODS

This was a prospective observational study conducted in the Department of Obstetrics and Gynecology at the Federal Medical Centre, Makurdi between January to August, 2018. Ethical clearance was obtained from the ethical committee of the Federal Medical Centre, Makurdi. One hundred and seventy consecutive consenting pregnant women with singleton fetus at a gestational age of ≥ 28 weeks diagnosed of preeclampsia were recruited to participate in the study. Part of the data used in this study was previously published in the original research article titled the role of umbilical doppler indices in predicting perinatal outcome in preeclampsia in International Journal of Research in Medical Sciences.

Inclusion criteria

All consenting pregnant women with singleton fetus at a gestational age of ≥ 28 weeks diagnosed of preeclampsia were recruited to participate in the study.

Exclusion criteria

All pregnant women with Preeclampsia <28 weeks, normal pregnancy, gestational hypertension without proteinuria, chronic hypertension, intrauterine fetal death, multiple gestation, having a fetus with congenital abnormality, history of antepartum hemorrhage, smoking, hepatic disease, renal disease, systemic lupus erythematosus (SLE), and patient who declined consent were excluded from the study.

Sample size determination

The formula that was used for sample size determination in this study is that by Kelsey [16] for independent cohort study.

The formula is given below;

$$n = (Z_{\alpha/2} + Z_\beta)^2 \, P(1-P) \, (r+1) / \, r \, (P_0 - P_1)^2$$

Where,

n = Minimum sample size.

$Z_{\alpha/2}$ = Standard normal deviate for a two tailed test based on alpha (α) level. α is the probability of type I error. With α= 0.05 at 95% confidence interval, the value of $Z_{\alpha/2}$ is 1.96.

Z_β = Standard normal deviate for one tailed test based on beta level (relates to the power). Beta (β) is the probability of type II error. With β= 0.20 at 80% power, the value of Z_β is 0.84.

P_0 = Proportion of exposed with disease, using the study in India by Lalthantluanga [17], 58% of the study population had abnormal S/D ratio (S/D ratio ≥ 3), therefore the value P_0 is 0.58.

P_1 = Proportion of unexposed with disease. From above study [17], 42% of the study population had normal S/D ratio (S/D ratio < 3), therefore value of P_1 is 0.42.

r = Ratio of unexposed to exposed in sample, which is usually 1.0 for equal samples.

$P = P_0 + rP_1/r+1 = 0.58 + 1(0.42)/1+1 = 0.5$

Therefore,

$n = (1.96 + 0.84)^2 0.5(1-0.5) \, (1+1)/1(0.58-0.42)^2$

= 153

Adding non-response rate of 10% with anticipated rate of 90%,

The minimum sample size to be selected for this study will be 153/0.9= 170.

Procedure for Doppler Ultrasound Scan/Study protocol

Doppler studies were done using Voluson P8 ultrasound with 3-5 MHz transabdominal probe developed and produced by GE health care LTD. With each patient in the supine position, umbilical artery was localized and sampled from a free-floating part of the cord. The waveforms obtained were optimized using the necessary knobs like wall filter, baseline and scale. The wave forms were recorded once there were equal wave of at least five consecutive pulsatile arterial wave form with all the crests at the same levels and also all the troughs at the same level. Umbilical artery Doppler were performed at least twice on each patient and the last Doppler before delivery was used for calculation of the indices. The umbilical artery Doppler Pulsatility IndexPI), Resistance Index (RI), Systolic/Diastole (S/D) ratio was measured automatically by the Ultrasound scan. However, these can be calculated from the formula below [10,18].

*   Systolic(S)/Diastolic (D) ratio=S/D

*   Resistance Index (RI) = S-D/S

*   Pulsatility Index (PI) = S-D/mean velocity

Where; S= Peak systolic velocity, D= End systolic velocity

The values of S/D ratio ≥3.0, PI > 0.85, and RI > 0.60 were considered as abnormal umbilical artery Doppler indices. These abnormal values were based on previously published research work [8,17,19,20].

The study participants were divided into two groups based on the second UAD indices findings (abnormal and normal). Those with normal umbilical artery Doppler indices were used as control. Both groups were followed up to determine fetal outcomes (adverse and normal). Those with abnormal umbilical artery Doppler indices were admitted and had other ultrasound findings determined including biophysical profile and treatment in preparation for delivery. Fetal outcomes determined include intrauterine growth restriction, low birth weight (birth weight <2.5kg), prematurity, five minutes Apgar score <7. Those fetuses with any of the above parameters were labeled as adverse outcome, while others were labeled as having normal outcome.

DATA COLLECTION

Data was collected prospectively using a Proforma designed for the purpose of this study to extract information from all consecutively consenting patients who fulfilled the inclusion criteria. This was done in the labor ward; antenatal ward and antenatal clinic after obtaining inform consent from the clients at admission or discharge. Additional information was obtained from the antenatal and labor ward records (Figure1).

The data was analyzed using statistical package for social sciences version 20.0 for windows (IBM SPSS Inc, Chicago, IL, USA). Quantitative variables were converted to categorical variables. Categorical variables were analyzed using Chi-Square (x^2) test and Fisher's exact test. The comparison of the umbilical artery Doppler indices (PI, RI & S/D ratio) in predicting adverse fetal outcome was made using specificity, sensitivity, positive predictive value (PPV) and negative predictive value (NPV).

RESULTS

Table 1 shows the socio-demographic characteristics of the study participants. Most of the study participants were within the age group of 26-30 years (41.2%) and few participants were within the age group of ≤ 20 years (6.5%) and ≥ 40 years (4.1%). About sixty three percent of participants were multigravida, 44.1% were multiparous and 85.9% were booked. One hundred and seven (62.9%) participants had severe preeclampsia. The commonest mode of delivery among the study participants was caesarean section (50.6%).

Table 2 shows the comparison of umbilical artery PI, RI, and S/D ratio as predictors of intrauterine growth restriction (IUGR) in women with preeclampsia. The umbilical artery PI was the most sensitive (75.4%) of the three indices in predicting IUGR, while the S/D ratio has the highest specificity (71.4%) and PPV (57.7%). The NPV of the RI was more (78.2%) compared to that of PI (77.5%) and S/D ratio (75.8%).

Table 3 shows the comparison of umbilical artery PI, RI and S/D ratio as predictors of low birth weight. The S/D ratio was more sensitive (62.0%) than RI (55.4%) and PI (52.5%) in predicting low birth weight, while the specificity of RI (74.4%) was the highest among the three indices. The umbilical artery PI and S/D ratio has the highest PPV (73.2%) and NPV (72.9%) respectively.

Table 4 shows the comparison of umbilical artery PI, RI and S/D ratio as predictors of preterm delivery. Both PI and RI have similar sensitivity of 74.2% in predicting preterm delivery. The S/D ratio has the highest specificity of 68.5% and PPV (52.1%). The NPV of RI (79.5%) was the highest among the indices.

Table 5 shows the comparison of umbilical artery PI, RI and S/D ratio as predictors of 5th Minute Agar score < 7 in women with preeclampsia. The umbilical PI (80%) was the most sensitive of the indices in predicting 5th minute Agar score <7, While the S/D ratio has the highest specificity (66.2%) and PPV (38.0%). The umbilical artery PI has the highest PPV of 88.7%.
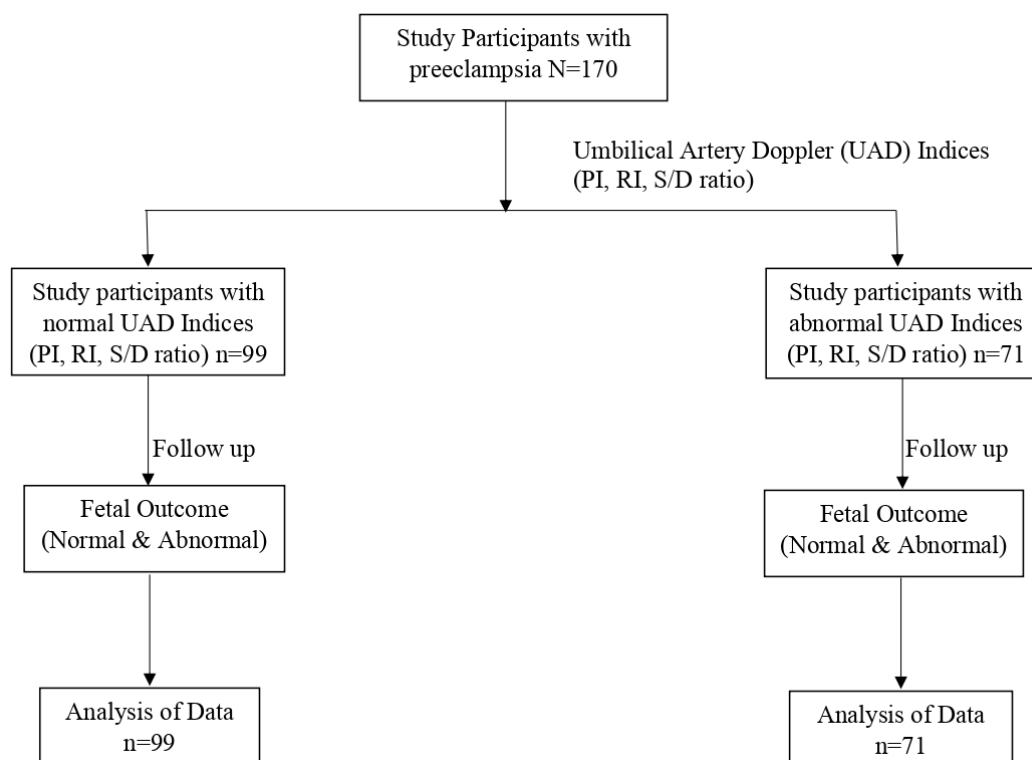

Figure 1. Study Flow Chart.

Table 1. Socio-demographic characteristics of study participants.

Characteristics	Number (Total=170)	Percentage
Age group (in years)		
≤ 20	11	6.5
21-25	17	10.0
26-30	70	41.2
31-35	46	27.1
36-40	19	11.2
≥41	7	4.1
Gravidity		
Primigravida	63	37.1
Multigravida	107	62.9
Parity		
Primipara	73	42.9
Multipara	75	44.1
Grand multipara	22	13.0
Booking status		
Booked	146	85.9
Unbooked	24	14.1
Severity of preeclampsia		
Mild	63	37.1
Severe	107	62.9
Mode of delivery		
Spontaneous vaginal delivery	33	19.4
Induction of Labor	51	30.0
Caesarean section	86	50.6

Table 2. Comparison of the umbilical artery PI, RI and S/D ratio as predictors of intrauterine growth restriction (IUGR) in women with preeclampsia.

Doppler Test	Sensitivity %	Specificity %	Positive Predictive Value %	Negative Predictive %
PI	75.4	52.4	49.5	77.5
RI	73.4	58.1	52.2	78.2
S/D Ratio	63.1	71.4	57.7	75.8

PI = Pulsatility index, RI = resistance index, S/D = systolic/diastolic

Table 3. Comparison of the diagnostic values of umbilical artery PI, RI and S/D ratio as predictors of low birth weight.

Doppler Test	Sensitivity %	Specificity %	Positive Predictive Value %	Negative Predictive %
PI	52.5	73.2	73.2	52.5
RI	55.4	74.4	71.8	58.6
S/D Ratio	62.0	72.7	62.0	72.9

PI = Pulsatility index, RI = resistance index, S/D = systolic/diastolic

Table 4. Comparison of umbilical artery PI, RI and S/D ratio as predictors of preterm delivery in women with preeclampsia.

Doppler Test	Sensitivity %	Specificity %	Positive Predictive Value %	Negative Predictive %
PI	74.2	50.7	46.5	77.5
RI	74.2	57.4	50.0	79.5
S/D Ratio	59.7	68.5	52.1	74.7

PI = Pulsatility index, RI = resistance index, S/D = systolic/diastolic

Table 5. Comparison of the diagnostic values of umbilical artery PI, RI and S/D ratio as predictors of 5th Minute Agar score < 7 in women with preeclampsia.

Doppler Test	Sensitivity %	Specificity %	Positive Predictive Value %	Negative Predictive %
PI	80.0	48.5	32.3	88.7
RI	72.5	51.5	31.5	85.9
S/D Ratio	67.5	66.2	38.0	86.9

PI = Pulsatility index, RI = resistance index, S/D = systolic/diastolic

DISCUSSION

This study demonstrated that UAD PI was most sensitive in predicting IUGR (75.4%) and Apgar score <7 (80.0%) in women with preeclampsia. The UAD S/D ratio (62.0%) was the most sensitive in predicting low birth weight. Both the umbilical artery PI and RI has similar sensitivity of 74.2% in predicting preterm delivery in preeclamptic women.

The UAD PI (75.4%) was more sensitive than UAD RI (73.4%) and S/D ratio (61.3%) in predicting IUGR in women with preeclampsia. This corroborates the findings by Singh et al who found that UAD PI (83.3%) was the most sensitive of the three indices in predicting fetus affected with IUGR due to preeclampsia [21]. This finding differs from that of Moawad et al and Syed et al who in their independent studies found that UAD RI (68.4%) and SD ratio (90.9%) respectively was the most sensitive indices in predicting IUGR [1, 12].This implies that the UAD PI, RI and S/D ratio are useful indices in predicting of IUGR in preeclampsia and their clinical significance could be more when combined together in predicting IUGR in women with preeclampsia.

Although this current research found UAD S/D ratio as the most sensitive (62.0%) in predicting low birth weight among the three indices, this finding does not agree with the study by Adedo et al who found UAD PI to be more sensitive than RI and S/D ratio respectively in predicting low birth weight [22].This variation may be due to differences in the study population because this index study uses only preeclamptic patients.

The UAD PI and RI (74.2%) were found to be more sensitive than the S/D ratio (59.7%) in predicting preterm delivery. This implies that UAD PI and RI have equal effectiveness in predicting preterm delivery in women with preeclampsia.

This study found UAD PI as the most sensitive indices in predicting 5th minutes Apgar score <7 in women with preeclampsia. This finding correlates with that of Moawad et al and Adedo et al who similarly found UAD PI more sensitive 59% and 100% respectively in predicting 5th minutes Apgar score<7 [1,22]. This infers that has the UAD PI has the best of the three indices in predicting 5th minutes Apgar score <7.

CONCLUSION

Although this current study has shown the varying predictive abilities of the UAD indices in prognosticating various adverse fetal outcomes in women with preeclampsia, however UAD PI was found to be more sensitive in predicting most of the adverse fetal outcomes when compared to UAD RI and S/D ratio. This finding is in support with other studies [9,21]. Therefore, this study shows that UAD PI is the most reliable individual indices in predicting adverse fetal outcome and thus, recommends its use alone or in combination of with the RI and S/D ratio in predicting adverse fetal outcome.

CONFLICT OF INTEREST

None to report

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