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Original Article

Evaluation of the umbilical artery using Doppler Ultrasound in pregnant women with preeclampsia

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ABSTRACT

Pre-eclampsia (PE) is considered one of the major causes of maternal death in pregnant women in both developed and developing countries. To identify umbilical artery doppler indices and their prognostic capabilities in pre-eclamptic mothers using doppler Ultrasound (U\S).A prospective study containing 79 high-risk pregnant women in a governmental hospital in Jazan, Saudi Arabia. Blood pressure and doppler U\S parameters from the umbilical arteries of the mothers and the fetus were measured for them using a general electric (GE) U\S machine with a 3.5 MHz curvilinear transducer. Study sample demographic variables included (maternal age, fetal weight, and amount of amniotic fluid), also doppler U\S indices (Resistivity Index (RI), Pulsatility Index (RI), and the systolic-diastolic ratio (S/D) were recorded. In the current study it was revealed that (67.1%) of them had a normal pregnancy, while (32.9%) were had preeclampsia, the mean value for the PI equal to 0.98 and 1.30 also for the S/D ratio the mean values are equal to 2.37 and 3.5 for normal and preeclampsia respectively. According to this study's findings, the value of doppler US to exclude preeclampsia is high. doppler velocimetry investigations of the umbilical artery can provide obstetricians with information about fetal welfare, allowing them to enhance fetal outcomes. Umbilical artery PI is the best predictor of PE. Implications for practice: The study will be shared with the obstetricians to improve their skills on the feasibility of using doppler parameters to predict bad pregnancy outcomes.

Keywords: Preeclampsia, Ultrasound, Doppler indices, Resistivity index, Pulsatility index

Introduction

Preeclampsia is one of the great obstetrical syndromes in which multiple and sometimes overlapping pathologic processes activate a common pathway consisting of endothelial cell activation [1]. Preeclampsia considers the main cause of fetal prematurity, and intrauterine growth retardation (IUGR) [2]. Pre-eclampsia is a life-threatening disease of pregnancy unique to humans and a leading cause of maternal and neonatal morbidity and mortality [3]. Important contributors to maternal and neonatal morbidity and mortality include pre-eclampsia and IUGR. High-resistance spiral arteries that are present during normal pregnancies are converted to low-impedance uteroplacental circulation by trophoblastic invasion. In preeclampsia and IUGR, this uteroplacental circulation is still not complete [4]. Additionally, decreased uteroplacental circulation and the subsequent intrauterine growth restriction are linked to hypertensive diseases of pregnancy [5]. Doppler U\S of hemodynamic vessels and structures including umbilical vessels can provide significant information to evaluate the fetal-related abnormality [6]. Studies have revealed that the blood flow

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parameters of the middle cerebral artery (MCA) and the umbilical artery (UA) of fetuses with fetal distress are significantly different from those of normal fetuses, and their changes well reflect the partial pressure of oxygen in the placenta and cerebral blood circulation [7].

To minimize serious complications screening of preeclampsia allows antenatal surveillance and optimal scheduling of fetal birth, which led to the notion of using uterine and umbilical artery doppler assessment as a screening tool for predicting pre-eclampsia [8]. The global incidence of PE ranges from 3% to 8%, with PE accounting for approximately 12.5% of maternal deaths each year [9, 10]. The pathophysiological underpinning for the development of preeclampsia is thought to be aberrant placental vasculature, which could be reflected in abnormal uterine doppler velocimetry [11].

The umbilical artery has also been mentioned in several publications as an important pertinent vessel in the assessment of PE [12]. The most often altered doppler parameters in either their solo or combined form for each artery, however, are not fully documented.

U\S studies for the doppler indices including Pulsatility and Resistance Indices, in addition to the ratio of peak systolic and diastolic blood flow velocity (PI, RI, and S/D respectively) of the uterine artery frequently used for evaluation and detection of preeclampsia [13], because it represents the maternal vascular condition . Studies of an umbilical and cerebral artery by doppler indices have been introduced by some authors to evaluate the fetus's condition and to detect preeclampsia [14-16].

Materials and Methods

A prospective study was conducted on 79 pregnant women selected through consecutive sampling techniques from medical records of women who successfully underwent Obstetrics and doppler U\S imaging for the umbilical artery to identify the normal and abnormal fetal and maternal conditions at a governmental hospital in Jazan City. This study was approved by the Ethics Committee of both the Department of Diagnostic Radiography Technology, and the governmental hospital at Jazan with Ref number DRT\MBN (12\2022), and study data was taken from the medical records of the selected sample.

Doppler U\S was carried out using a transabdominal approach U\S examination was performed using a GENERAL ELECTRIC LOGIQ P5 U\S machine with a curved array 3.5–5.0 MHz transabdominal transducer. All of the scans were performed by a sonographer with more than 10 years of expertise in prenatal sonography and produced a longitudinal image of the umbilical artery, which was subsequently stored in the U\S machine. Doppler U\S of the umbilical arteries was performed at 32–34 weeks of gestation, considering normal fetal and maternal heart conditions five to six spectral continuous and identical waves were considered for umbilical doppler examination. The insonation angle was always kept at 15 degrees. The information extracted from the fetal U\S included gestational age, fetal weight, Resistance index, Pulsatility index, S/D ratio, and placental positions). RI and PI values above the 95th percentile standardized for the gestational age (GA) are considered abnormal for the umbilical arteries. The doppler value is measured and compared to the data obtained from the International Perinatal doppler Society. The pregnancy outcome is carefully noted including any complications of delivery preeclampsia, expected date of delivery, GA, fetal weight, and umbilical cord conditions. Only pregnant women with a singleton were included in the study, and we excluded pregnant women with multiple pregnancies and fetuses with known deformities . The data were analyzed using the IBM SPSS (Statistical Package for the Social Sciences) statistics for Windows, version 25.0 using the independent sample t-test to identify the relation between the doppler indices and maternal parameters for normal and preeclampsia, and the difference was statistically significant at ($p < 0.05$).

Results and Discussion

The summary statistics that best discriminate parameters between the different ROIs using the data revealed that (67.1%) were normal pregnancies and (32.9%) were preeclampsia cases; The mean age of the study participants was 32.9±6.5 years, at 32 - 38weeks gestation with a singleton pregnancy and most of them were nulliparous women. The mean value for the RI is equal to 0.58 and 0.87, and PI is equal to 0.98 and 1.30 also for the S/D ratio the mean values are equal to 2.37 and 3.5 for normal and preeclampsia respectively, as shown in **Figures 1 and 2** and **Tables 1 and 2**.

Abnormal PI and RI were statistically associated with low fetal weight ($p < 0.06$, < 0.08 respectively), as shown in **Table 3**. The **Table 4** shows that there is a statistically significant relationship at a significant level ‹between the placenta status and the pulsatility index (p value 0.024) , while there is no relationship ‹between the placenta status and the resistance index and between the placenta status and the percentage of S/D.

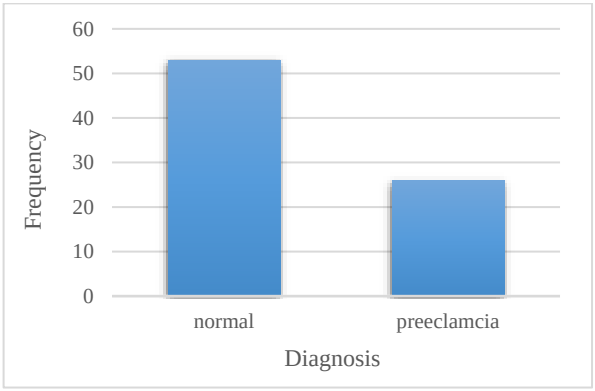

Figure 1. Frequency distribution of the diagnosis

Table 1. Showed patient-related variables of the samples

Variables	History	No	Mean	Std. D
Age	Normal	53	32.6	5.65
	Preeclampsia	26	33.7	8.128

Fetal Weight	Normal	53	2537.9	823.3
	Preeclampsia	26	2195.9	760.9
Gestational Age	Normal	53	34.04	3.5
	Preeclampsia	26	33.35	3.7

Table 2. The independent sample t-test showed the relation of ultrasound indices with the patient's condition at p<0.05, and a confidence level of 95%.

Variables	History	No	Mean	Std. D	Sig. (2-tailed)
Amniotic fluid index	Normal	53	8.55	4.025	0.36
	Preeclampsia	26	9.49	4.707	
Resistance index	Normal	53	0.58	0.065	0.000
	Preeclampsia	26	0.87	0.075	
Pulsatility Index	Normal	53	0.98	0.528	0.006
	Preeclampsia	26	1.30	0.344	
S/D ratio	Normal	53	2.37	0.292	0.000
	Preeclampsia	26	3.50	0.921	

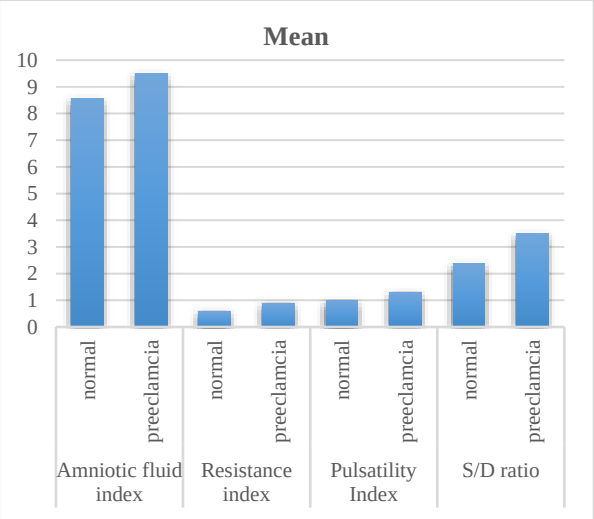

Figure 2. Difference of mean values of Doppler U\S indices for normal and preeclampsia women.

Table 3. Association between the Fetal weight and Doppler Ultrasound.

Correlations between RI, PI, and Fetal weight		
Doppler U\S	**Pearson Correlation**	**Sig. (2-tailed)**
Resistance index	-.207-	0.06
Pulsatility index	.087	0.08
S/D ratio	-.049-	0.04

*There is a significant correlation between the variables at the 0.01 level (2-tailed).

Table 4. Association between the Placenta position and Doppler Ultrasound (n=79).

Doppler Ultrasound	Correlations between RI, PI, and placenta position								
	previa	fundal	posterior	fundal anterior	fundal posterior	high posterior	anterior	high anterior	P- value
	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	
Resistance index	.50	.73	.63	.64	.73	.77	.50	.71	0.445
Pulsatility index	.70	1.09	.73	.98	1.17	1.10	.80	41.45	**0.024**
S/D ratio	2.20	2.74	1.90	2.72	2.85	3.16	2.60	2.93	0.131

* There is a significant correlation between the placenta status and the pulse index, was p < 0.05

To identify umbilical artery doppler indices and their prognostic capabilities in pre-eclamptic mothers using doppler U\S, the mean age of the study sample was 32.9±6.5 years. Among the 79 pregnant women collected in April-Oct 2022, there were 53 normal pregnancies (67.1%) and 26 pre-eclampsia (32.9%) pregnancies, as in **Figure 1**. Preeclampsia is accounted to have a frequency of 5%-10% among permanent ladies [16]. This result indicates a higher epidemiological distribution of preeclampsia than reported in the literature [1]. On other hand in the United States, the Centers for Disease Control and Prevention (CDC) reported that hypertensive disorders of pregnancy, including preeclampsia, affected 14.6% of pregnancies during 2017–2019 [17].

The mean gestation age of the patients was 33.7± 3.5 weeks at the time of diagnosis for both normal and abnormal patients. Filho *et al*. [18] stated that there is no linear correlation between gestational age. For instance, a study by Sibai *et al*. (2021) observed that preeclampsia typically presents between 20-37 weeks, with severe cases often identified around 32-34 weeks. Similarly, a study conducted in Ethiopia reported a mean gestational age of 34.5±3.2 weeks for preeclamptic patients, slightly later than findings in the current study A Chinese cohort study by Zhang *et al*. (2022) identified preeclampsia at an average of 33 weeks, consistent with findings in the present study, suggesting similarities in healthcare protocols and diagnostic criteria [19].

Significant independent sample t-test at p-value <0.05, a confidence interval of 95% was intended to investigate the difference between the normal and preeclampsia patient for patient-related valuables and doppler U\S as well. Age, fetal weight, and gestational age showed a strong, insignificant correlation with the diagnosis. The maternal age showed no significant difference with patient history compared with advanced maternal age has been identified as an independent risk factor for adverse outcomes in first-time mothers with preeclampsia [20]; Advanced maternal age has been identified as a significant risk factor for preeclampsia. A study published in *BMJ Open Diabetes Research & Care* found that women aged 35 years and older had a 1.74 times higher risk of developing preeclampsia compared to younger women [21] where the fetal weight is noted to be higher in the normal women at 2537.9gm, in contrast to 2195.9gm in the preeclampsia patient, and the same result was noted for the gestational age as well, as in **Table 1**. Preeclampsia is often associated with fetal growth restriction. Research in *JAMA Network Open* reported that infants born to mothers with

preeclampsia had lower birth weights compared to those born to normotensive mothers [22-24].

A significant correlation was found between the patient's diagnosis or is still with U\S in indices at, 0.000, 0.006, and 0.000 for resistance index, Pulsatility index, and S/D ratio respectively. Study variables were classified into normal and preeclampsia to test the significant difference between them, RI; the normal value should be less than 0.7 where the higher than this is considered preeclampsia. The mean value for the RI is 0.58 and 0.87 for normal and preeclampsia. For PI the mean result for normal patients was 0.98 and preeclampsia =1.30 also for the S/D ratio the mean values were equal to 2.37 and 3.5 respectively, as in **Tables 2 and 3**. Acharya *et al*. identify the normal value for umbilical doppler indices by 10.5%, 6.8 %, and 13.0 as coefficients of variation for RI, and PI S/D ratio respectively [16]. Other studies reported that; these parameters were higher at the fetal end compared to the placental end of the cord [25].

Normally the placental position does not affect the vascular indices in some literature [26, 27], but we note that the largest value was the fundal anterior position, while the lowest value was the position of the Previa, as in **Table 4**. Additionally, a 2024 study found that lateral placental location is associated with adverse pregnancy outcomes due to preeclampsia, though this association is not yet conclusively proven [28]. who reported that; after normalization for the angle of insonation, the PSV was higher and the end-diastolic velocity was lower at the fetal than at the placental end of the cord.

Different results on the doppler parameter that best predicts PE among high-risk patients have been published by earlier researchers; these include Uterine Artery Pulsatility Index (PI): A PI greater than 1.45 in the second trimester has been identified as a critical indicator in predicting PE in low-risk pregnant women [29], combining fetal and uterine doppler indices, may contribute to predicting adverse perinatal outcomes and early-onset PE [29]. The presence of bilateral notches during 14-20 weeks and a Notch Depth Index (NDI) greater than 0.14 within 14-20 and 20-28 weeks indicate preeclampsia susceptibility in low-risk pregnancies [30], and early diastolic notch in the second trimester on one side [19]. The diastolic notch is only present in roughly 25% of instances during the second trimester, according to Nagar *et al*. (2015), who also pointed out that it is not frequently observed [31].

Conclusion

According to the findings of this study, the value of doppler US to exclude preeclampsia is high, indicating that the umbilical doppler US provides a clear indication for evaluation and diagnostic value for preeclampsia. doppler velocimetry investigations of the umbilical artery can provide obstetricians with critical information about fetal welfare, allowing them to enhance fetal outcomes. These findings will be shared with obstetricians to improve their expertise in predicting unfavorable pregnancy outcomes using doppler measurements.

Limitations of the study

The study was limited in that it did not consider other prenatal factors such as uterine artery. Furthermore, the sample size employed may be insufficient for generalization to the entire population.

Recommendation

We recommend conducting a multicenter study in the southern part of Saudi Arabia, thereby commencing timely management to minimize or reduce adverse pregnancy outcomes to the bare minimum.

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Ethics statement: Confidential consent and authorship requirements have been met in this study.

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