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Predicting Neonatal Complications in Preeclampsia Pregnant Women by Evaluating the Value of Uterine Artery Doppler Ultrasound Indices

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ABSTRACT

Background & Objective: Preeclampsia is related to numerous maternal and fetal complications, like intrauterine increase restriction, preterm delivery, and a raised danger of baby death. In order to determine the predictive amount of uterine artery Doppler sonography indices for neonatal complications in pregnant patients with preeclampsia, the present study was conducted.

Materials & Methods: In 2020, in Alwiyah Hospital for Obstetrics and Gynecology, Al-Jadiriah Private Hospital, Al-Karama Teaching Hospital, and Yarmouk Teaching Hospital in Baghdad, 87 pregnant women with preeclampsia and 160 healthy pregnant women participated in the present prospective study. The Doppler signal of the uterine arteries was evaluated during a supine abdominal Doppler ultrasound examination between 26 and 36 weeks of pregnancy. The survey form was updated with information about the birth of the children following the termination of the pregnancy. The data were evaluated using SPSS software (version 19) and independent t, Mann-Whitney, and chi-square tests.

Results: The mean uterine artery pulsatility index of mothers with preeclampsia had the greatest sensitivity, specificity, and positive predictive amount of predicting a baby's low birth weight at 54.8%, 87.3%, and 91.6%, respectively. In addition, the sensitivity, specificity, and positive predictive amount of the mean uterine artery resistance index for predicting a baby's low birth weight were 65.2%, 96.4%, and 95.4%, respectively.

Conclusion: Although uterine artery indices in Doppler ultrasound do not have a high sensitivity for predicting neonatal complications, abnormal indices can predict low birth weight with high confidence.

Keywords: Preeclampsia, Doppler sonography, Uterine artery, Complications

Introduction

Preeclampsia is the main regular pregnancy-related medical complication and, along with bleeding and infection, one of the three leading reasons of maternal death **(1)**. The World Health Organization has identified this complication as a global problem for women's health. Preeclampsia is the most common type of blood pressure disorder, which is urinary protein excretion of 300 mg in day, in the urine, or stable presence of protein at the rate of 30 mg/dL in random **(2, 3)**. Approximately 3% of pregnant women experience this multisystem disorder. Preeclampsia is a leading cause of death worldwide, accounting for approximately 10 to 15 percent of maternal deaths **(4)**.

The incidence of preeclampsia is affected by numerous factors, including race, ethnicity, obesity, diabetes, age over 31 years, null parity, and social and economic factors **(5)**. The complex interaction of placental, maternal, and pregnancy-related vascular factors and immunological adaptations causes preeclampsia **(6)**. These interactions primarily involve the cardiovascular and inflammatory systems, which disrupt maternal endothelial function and cause organ

hurt from vascular disorders (7). Therefore, preeclampsia is an incoherent syndrome that maybe doesn't always follow the similar pathophysiological pathways but instead results from the interaction of a complex set of factors that result in the occurrence of different forms of the disease during pregnancy (8).

Some studies distinguish placental and maternal preeclampsia as two separate diseases. Early-onset preeclampsia before the 34th week of pregnancy and late-onset preeclampsia after the 34th week characterize maternal preeclampsia (9). Early-onset preeclampsia is characterized by the absence of trophoblast invasion and the inability to replace normal spiral arteries. Arteries result in placental ischemia and oxidative stress factor production (10). In contrast, late-onset preeclampsia is primarily caused by maternal factors, which increases the mother's vascular sensitivity to the natural inflammation of a stage of pregnancy or atherosclerosis in the initially normally growing placenta (11). However, preeclampsia most likely results from the interaction of the factors mentioned above.

Several biochemical tests for predicting preeclampsia have been reported and evaluated up to this point (12). Numerous studies have been conducted to identify screening tests (13, 14). Early screening for preeclampsia aims to identify high-risk pregnancies and implement preventative treatment protocols. Unfortunately, there is no simple test currently available, and preeclampsia can only be detected through repeated visits during pregnancy and repeated analysis of measured blood pressure and urine (15). This method detects preeclampsia late, is costly, and lacks sensitivity and specificity. However, scientists are searching for methods to identify mothers at risk for preeclampsia (16). Since preeclampsia is associated with abnormal growth and function of the placenta, efforts are focused on identifying placental biomarkers associated with pathophysiological changes due to defective trophoblastic invasion in early pregnancy to evaluate risk factors (17).

Doppler ultrasound, as a non-invasive method, is a suitable test for predicting the extent of uterine vascular involvement, despite the lack of a fully validated method for identifying the extent of vasospasm and vascular involvement (18). Preeclampsia can be effectively diagnosed in high-risk individuals if a Doppler abnormality is detected between weeks 11 and 14 (19). A unilateral or bilateral cut in the diastolic wave or a high resistance index (RI), or a high pulsatility index (PI) are examples of abnormal Doppler ultrasound findings (20). There is currently no definitive and effective treatment for preeclampsia; therefore, its prevention is crucial. Calcium, vitamin E, and aspirin are also recommended to prevent preeclampsia. Aspirin in low doses is a medication that prevents or moderate's preeclampsia (21).

Due to the high prevalence of preeclampsia among pregnant women and the numerous risks and types of neonatal complications, it is necessary to conduct research in this area. Preventive measures can also improve the prenatal prognosis in the event of timely diagnosis of fetal and neonatal complications, which is of particular importance. The current study aimed to determine the uterine artery Doppler ultrasound indices for neonatal complications in preeclamptic pregnant women. Most studies have been conducted on intrauterine growth disorder (IUGR). In contrast, the current study focuses on complications, such as the need for hospitalization in the neonatal intensive care unit (NICU), prematurity, and infant death.

Methods

The current prospective study was conducted in 2020 on pregnant women referred to Alwiyah Hospital for Obstetrics and Gynecology, Al-Jadiriah Private Hospital, Al-Karama Teaching Hospital, and Yarmouk Teaching Hospital in Baghdad, Iraq. The statistical population comprised 376 pregnant women, from which 247 were randomly selected to participate in the study. Eighty-seven pregnant women with preeclampsia and 160 healthy pregnant women were placed in two experimental and control groups, respectively. Inclusion criteria included all pregnant women interested in participating in the research, carrying a singleton, and gestational age between 26 and 36 weeks. Exclusion criteria included women with psychological abnormalities, underlying diseases such as diabetes, hypertension, ischemic heart disease, kidney disease, and autoimmune diseases, and faulty completion of the checklist. A checklist designed for this purpose was used to record mothers' information. In order to comply with ethical considerations, the participants were informed of the research's objectives and methodology before the study began. Participants were also assured that their identity and information would remain confidential and that they could leave the study at any time if they desired.

A Doppler abdominal ultrasound was performed between 26 and 36 weeks of pregnancy. Supine ultrasound examinations were performed on all subjects by a single radiologist. All subjects had bilateral uterine artery velocity measurements performed. Ultrasound of the abdomen revealed the uterine arteries in an oblique plan of the pelvis, where the right and left uterine arteries cross the external iliac vessels. Then, the Doppler signal was obtained from the uterine arteries, and qualitative and quantitative indicators were evaluated whenever the three fundamental waves were similar.

The variables under investigation are the mother's age, the gestational age at the time of ultrasound, and the fetal biometrics. In addition, the pre-designed checklist included the mean pulsatility index (PI), mean resistance index (RI), and the mean ratio of systolic to diastolic velocity (S/D) of bilateral uterine arteries. The criterion for determining the normality of

the indices was their placement between the 5th and 95th percentiles of the reference charts **(22)**.

After delivery, the case of the mother and infant was evaluated, and the outcomes, including birth weight, gestational age at birth, the need for hospitalization in the NICU, and infant mortality, were recorded on the pertinent checklist. Indicators of descriptive statistics (such as frequency and mean ± standard deviation) were used to describe the data in the form of tables. The SPSS statistical software version 19 and the independent t, Mann-Whitney, and chi-square tests were used to analyze the data. It was determined to be significant if the *P*-value was lower than 0.05.

Results

This section indicates the demographic variables and Doppler ultrasonography indices presented in Table 1.

The mean age of women who participated in the study was 29.67±5.13, the mean duration of pregnancy was 32.51±3.79 weeks, and the mean birth weight was 2766.14±547 grams. Table 1 shows no statistically significant difference between the two groups on the demographic variables of age and pregnancy week ($P>0.05$). While there is a statistically significant difference between the birth weight values of babies in the two groups ($P<0.001$), so that the weight of babies in the experimental group is significantly lower than the control group. The mean indices of the right and left uterine arteries in healthy and preeclamptic mothers indicate that the experimental group has consistently greater PI and RI values than the control group. The two groups differ significantly in PI, RI, and S/D indices ($P<0.001$).

Table 1. Comparison of two groups' mean demographic variables and uterine artery indices

Variable		Mean ± SD*		P-value
		Experimental group	Control group	
Demographic	Age (year)	31.17±5.26	28.73±4.84	0.21
	Pregnancy week	33.18±3.64	32.27±3.54	0.38
	Baby's birth weight (gr)	1893.58±671	3071.27±382	<0.001
Sonography	PI	1.28±0.57	0.91±0.42	<0.001
	RI	0.64±0.23	0.49±0.16	<0.001
	S/D	3.07±1.42	2.14±0.73	<0.001

***SD= Standard deviation**

Table 2 displays the mean indices of the uterine artery in pregnant women with preeclampsia based on pregnancy results. Table 2 presents the uterine artery for four significant neonatal complications, including the baby's birth weight, NICU admission, premature baby, and baby death. There is a statistically significant difference between the presence and absence of four neonatal complications in examining each uterine artery ($P<0.05$), except for the complication of premature baby in the PI ($P>0.05$).

Table 2. Comparison of two groups' mean demographic variables and uterine artery indices

Neonatal complications		PI		RI		S/D	
		Mean±SD*	P-value	Mean±SD*	P-value	Mean±SD*	P-value
Low birth weight	Yes	1.27±0.48	<0.001	0.71±0.16	<0.001	3.64±1.26	0.008
	No	0.79±0.31		0.53±0.11		1.92±0.73	
NICU admission	Yes	1.36±0.58	0.024	0.72±0.26	0.016	4.15±2.81	0.006
	No	1.04±0.42		0.61±0.17		2.67±1.13	
Premature baby	Yes	1.34±0.48	0.134	0.63±0.12	0.003	4.06±1.34	0.017
	No	0.98±0.32		0.51±0.07		2.33±0.84	
Baby death	Yes	1.56±0.76	0.019	0.73±0.18	0.037	4.83±2.91	0.023
	No	1.21±0.54		0.66±0.14		3.16±1.86	

***SD= Standard deviation**

Table 3 shows the sensitivity, specificity, and positive predictive value of uterine artery indices for predicting neonatal complications in preeclamptic mothers. It is worth noting that the uterine artery's mean RI had a high specificity in predicting all adverse pregnancy outcomes.

Table 3. Sensitivity, specificity and positive predictive value of uterine artery indices

Index	Neonatal complications	Sensitivity	Specificity	Positive predictive value
PI	Low birth weight	54.8%	87.3%	91.6%
	NICU admission	45.6%	66.4%	61.7%
	Premature baby	38.2%	72.6%	70.3%
	Baby death	41.8%	59.4%	34.1%
RI	Low birth weight	65.2%	96.4%	95.4%
	NICU admission	13.7%	93.8%	63.2%
	Premature baby	11.9	91.6	61.4
	Baby death	0	89.7	0

Discussion

The current study aimed to examine the effect of uterine artery Doppler ultrasound values on predicting neonatal complications in preeclamptic pregnant women. Preeclampsia causes numerous perinatal complications, including low birth weight, NICU hospitalization, prematurity, and intrauterine death. Preeclampsia can reduce neonatal complications and mortality if identified and treated promptly. Doppler ultrasound at the end of the 2nd trimester can predict a damaging pregnancy result in a population with preeclampsia. In the current study, the RI in patients with preeclampsia was higher than in healthy women, which is consistent with the findings of the vast majority of studies in this field **(23, 24)**.

In patients with chronic hypertension, uterine artery Doppler velocimetry and determination of RI at 26-32 weeks of gestation have aided in diagnosing intrauterine growth retardation and pregnancy complications **(25, 26)**. Additionally, the abnormal resistance index of uterine vessels is related to a higher incidence of intrauterine growth disorder, meaning that an increase in the RI index reduces intrauterine growth. In the present study, patients with abnormal RI and PI were likelier to have low birth weight and premature birth. Additionally, infants born to mothers with abnormal uterine artery indicators required NICU hospitalization more frequently. Doppler velocimetry of uterine vessels appears to detect high-risk pregnancies and neonatal complications. Much research has focused on the incidence of intrauterine growth disorder (IUGR). However, the present study investigated several complications, including low birth weight, prematurity, NICU hospitalization, and infant mortality.

According to some studies, the PI index of the uterine artery is more significant for predicting preeclampsia and fetal complications **(27)**. In the present study, the mean uterine artery PI index had the greatest sensitivity, specificity, and positive predictive value for predicting low birth weight in mothers with preeclampsia. In addition, the mean index of uterine artery RI demonstrated the greatest of mentioned factors for predicting low birth weight. The mean uterine artery RI index demonstrated high specificity in predicting all adverse pregnancy outcomes.

Doppler ultrasound has become an exquisite tool for studying uterine blood flow, and by measuring uterine artery flow resistance, the progression of trophoblastic swelling can be monitored. Between 6 and 24 weeks of a normal pregnancy, vascular resistance to blood flow decreases gradually and remains constant. Therefore, persistent resistance to maternal uterine blood flow identifies the abnormal growth of placental vessels associated with preeclampsia. Abnormal waves in the uterine artery can accurately predict preeclampsia.

According to several studies, the prevalence of preeclampsia is higher at both ends of the reproductive age spectrum **(28, 29)**. Taking advantage of abnormal vascular adaptations in pregnancy, such as unfavorable adaptive changes of the uterine artery via Doppler ultrasound, may also enhance the predictive power of preeclampsia. The optimal strategy to increase the predictive power of preeclampsia is to combine all three categories. Therefore, it is suggested that longitudinal and prospective studies be conducted with the objectives mentioned above.

Although uterine artery indices in Doppler ultrasound do not have a high sensitivity for predicting neonatal complications, the mean index of resistance and the mean index of pulsatility of the uterine artery, have a great value for predicting low birth weight, according to the findings of the current study. If the indicators in a pregnant woman with preeclampsia are abnormal, it is possible to predict with high confidence

that the baby will have a low birth weight. 10% of live births are associated with low birth weight. If low birth weight is predicted, improved care interventions can improve infant health and reduce infant mortality.

Researchers have found that, for infants with low birth weight, delivery in a hospital with a well-equipped NICU significantly reduces the mortality risk compared to delivery in a hospital without a NICU or with a poor NICU **(30, 31)**. Several studies have demonstrated that performing Doppler ultrasound in different trimesters of pregnancy, particularly between 14 and 11 weeks, can predict neonatal complications more accurately **(32)**. In the current study, only one ultrasound was performed between 26 and 36 weeks of pregnancy. Some studies have also demonstrated that adding placental indices to uterine artery Doppler ultrasound may increase its diagnostic value **(33-35)**.

Limitations of this Study

The most significant limitation of the current research is that it was conducted on patients of the Baghdad hospitals. Consequently, it is recommended to investigate regions with distinct races and climates. In addition, due to a lack of access to patients and limited financial resources, it was not possible to perform Doppler ultrasounds during different trimesters of pregnancy. It is suggested that pregnant patients be evaluated at different stages of pregnancy in order to conduct future research.

Conclusion

Although uterine artery indices in Doppler ultrasound do not have a high sensitivity for predicting neonatal complications, they can predict low birth weight with high confidence if abnormal. Examining uterine artery Doppler indices in the 3rd trimester of pregnancy has a significant diagnostic value in forecasting damaging pregnancy results. It should be investigated routinely in high-risk pregnancies.

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Conflict of Interest

The authors of the article have no conflict of interest.

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