

Evaluation of the Role of Uterine Artery Color Doppler Ultrasound in the Assessment of Low-Risk Pregnancies and in Predicting their Outcome

Bushra Jarallah

Department of Medicine, College of Medicine, University of Garmain, Iraq

Article Info.

Keywords:

low-risk pregnancy,
Color Doppler ultrasound,
Uterine artery,
Fetal Outcome

Received: 08.31.2025
Accepted: 11.28.2025
Published online: 04.10.2026
Published: 04.10.2026

Abstract

Introduction: The majority of babies have acceptable growth in the uterus. However, occasionally, fetal growth is influenced by factors other than maternal factors. Doppler ultrasound has been used to study the fetoplacental (umbilical) circulation since 1977 and used to study the uteroplacental (uterine) circulation and fetal circulation since 1980s. In this study, we aim to determine the predictive value of early color Doppler ultrasound for outcomes in low-risk pregnancies.

Material and methods: This prospective cohort study included 176 nonselected low-risk pregnancies in the late second trimester who underwent uterine artery (UA) color Doppler ultrasound. Different ultrasound equipment's was used, with a frequency of 5 MHz. The UA resistance index was used and compared with normal standards. Complicated pregnancies were excluded.

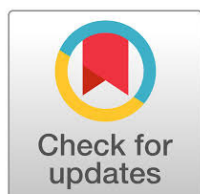
Results: Of the 176 healthy pregnant cases studied, 47 (26.7%) had abnormal Resistance Index (RI) of the UA and were followed until the end of the pregnancy. The rate of intervention was high in this study group, as shown by the increased caesarean section rate of 114 (64.6%) compared to the vaginal deliveries of 59 (33.7%). The baby's condition was normal in 169 (96%) after 2 years of follow-up, compared with only 7 (4%) who were unwell.

Conclusion: The data suggest that Doppler evaluation in early low-risk pregnancies has a significant association with the detection of early-onset pre-eclampsia and intrauterine growth restriction. Thus, assessing low-risk pregnancies with early Doppler assessment may improve perinatal outcomes. The study supports the use of UA Doppler at least one time in low-risk pregnancies to discover and treat the cases of sudden and unknown causes of fetal growth restriction and loss.

1. Introduction

Most pregnancies, labor, and deliveries are components of a normal biological process that result in safe and healthy outcomes for mothers and babies. Any abnormalities in this biological process can result in substantial morbidity and/or mortality for both the mother and the baby [1]. One of the primary objectives of routine antenatal assessment is to evaluate for potential risks to pregnancy outcomes [2]. Many of the causes that can result in compromise to the babies and/or the mothers are usually identifiable causes; however, there is still a rate of unexplained fetal losses in

otherwise healthy pregnancies [3]. Most of these losses are attributed to unexplained intrauterine growth restriction (IUGR) [3]. It is important to note that there is a difference between small for gestational age (SGA) and IUGR, and the inability to differentiate between these two conditions could result in misdiagnosis of IUGR, which may lead to stillbirths [4]. IUGR has been associated with multiple perinatal complications, including interventricular hemorrhage, necrotizing enterocolitis, bronchopulmonary dysplasia, hypothermia, pulmonary hemorrhage, and hypoglycemia [3]. Thus, early assessment, treatment, and appropriate delivery scheduling may contribute to a



*Corresponding author: Bushra Jarallah: bushra.jaralla@garmian.edu.krd

How to cite this article: Jarallah B. Evaluation of the Role of Uterine Artery Color Doppler Ultrasound in the Assessment of Low-Risk Pregnancies and in Predicting their Outcome. Baghdad Journal of Biochemistry and Applied Biological Sciences, 2026, Vol. 7, No. 2, 149–154. <https://doi.org/10.47419/bjbabs.v7i2.456>

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less consequential delivery, thereby leading to healthier outcomes for the baby and the mother [1]. Multiple methods have been used to assess fetal outcomes in high-risk pregnancies, including non-stress tests, daily fetal movements, and biophysical profile [5].

Doppler ultrasound Assessment has been associated with a reduced rate of mortality and obstetric interventions. Uterine artery (UA) Doppler ultrasound can be used to predict potential complications, including recurrent pregnancy loss, pre-eclampsia, fetal growth restriction, stillbirth, and spontaneous preterm birth [6].

UA Doppler recordings are based on the penetration of the spiral arteries in the first half of pregnancy [7] and maternal supply of the uteroplacental unit [8].

The role of UA ultrasound in predicting these outcomes may be explained by its association with placenta-tion in the development of these diseases [3]. In this study, we aim to assess the role of routine antenatal UA Doppler ultrasound in low-risk pregnancies.

2. Material and Methods

This is a prospective cohort study conducted in Kalar city, the Kurdistan region of Iraq, over a period of about 1 year, from January 2021 to the end of 2022. Kalar city is located about 205 km to the north of Baghdad and 160 km to the south of Sulaymaniyah.

Kalar Maternity Hospital is a specialist obstetrics and gynecology hospital located in the territory of the federal Kurdistan region of Iraq, where the population is a mix of Kurds, Arabs, and other minorities, including the Turkmans. The hospital had an annual delivery of 5000–6000 deliveries between these nationalities (mostly Kurdish) between normal and surgical deliveries. Low-risk pregnancies with access to US (ultrasound) assessment were included. 176 patients underwent color Doppler ultrasound of the UA and followed up till the end of pregnancy and for 2 years after delivery. The assessments were carried out by the same set of radiologists using the same ultrasonographic machine to reduce interoperator variability. The data were logged into a Microsoft Excel sheet, and the SPSS 20 version of the software was utilized to interpret the data.

Ethical approval from College of Medicine, University of Garmian, Kalar, Kurdistan, Iraq was obtained (approval number: 495,29\7\2024).

Of 176 pregnant women beyond 24 weeks of gestation, 1 was 18 weeks (Doppler requested by the patient). Detailed histories were taken from the patients. Gestational age was determined by biparietal diameter (BPD), femur length (FL), and abdominal circumference (AC). Placental location and condition were also determined. Fetal weight and amniotic fluid index were calculated; complicated pregnancies like hypertensive, diabetics, thyroid disease, and other medical problems were excluded. The flow patterns of the uterine arteries were assessed, and the resistive index (RI) assessed and correlated with fetal outcome.

3. Statistical Analysis

Statistical analyses were performed using SPSS Statistical Package for Social Sciences (version 20.0 for windows, SPSS, Chicago, IL, USA). Qualitative data are represented as number and percentage. The chi-square test was used to test the relationship between the studied groups. P value of < 0.5 was considered significant.

4. Results

Of the 176 cases with low-risk pregnancies, ultrasonography and Doppler studies were done. They underwent Doppler ultrasonography after 24 weeks of gestation (except one case sent at 18 weeks of gestation according to her request). A detailed history was taken from all the participants. Gestational age was determined using BPD, head circumference (HC), AC, and femoral length (FL). Placental grading and position were assessed and noted. Estimated fetal weight and the amniotic fluid index were calculated. A Doppler study was conducted, and the findings of Doppler indices, such as pulsatility index (PI) and RI, in the UA of low-risk pregnancies were documented and compared with standards. There was a correlation with fetal outcomes. The data for demographic variable included in the study were summarized in Table 1, which includes (age, nationality, gravida, mode of pregnancy, mode of delivery, previous CS, and coagulation studies).

Table (1): Demographic variables of the included subjects.

		Count	%
Age in Years	<20	20	11.5
	20-25	44	25.3
	20-25	45	25.9
	31-35	32	18.4
	36-40	21	12.1
	>40	12	6.9
Nationality	Kurd	73	41.5
	Arab	101	57.4
	Turkmen	2	1.1
Gravida	Primigravida	46	26.1
	Multigravida	130	73.9
Mode of Pregnancy	Physiological	173	99.4
	Induced	1	0.6
Mode of Delivery	Vaginal	59	33.7
	CS	113	64.6
	Loss of Follow up	3	1.7
Previous CS	0	106	60.9
	1	34	19.5
	2	25	14.4
	3	7	4.0
	4	2	1.1

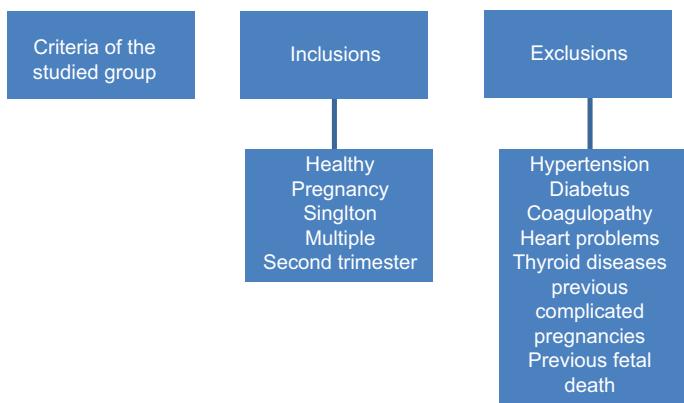


Figure (1): The inclusion and exclusion criteria of the studied group.

Table (2): As shown, the majority of pregnancies were singleton and mature, with normal fetal weight and overall, well fetal conditions. Maternal outcomes have also been reported along with a history of previous abortions, and for the neonatal condition, the APGAR scoring was normal in the majority of the neonate and the admission to the NICU was also low.

		Count	%
Single/multiple	Singleton	170	97.7
	Twin	4	2.3
Maturity	Normal	168	95.5
	Abnormal	8	4.5
Fetal weight	2.1-3 kg	18	10.2
	3.1-4 kg	154	87.5
	F loss	4	2.3
Fetal condition	APGAR>7	169	96.0
	APGAR<7	7	4.0
Admission to NICU	Yes	6	2.3
	No	170	97.7
PPH	Yes	2	1.1
	No	172	98.9
Previous abortion	0	132	75.9
	1	35	20.1
	2	7	4.0

*NICU: neonatal intensive care unite; APGAR score: Activity Pulse Grimace Appearance Respiration of the neonate; PPH: postpartum hemorrhage.

In the studied group, fetal maturation was normal in 168 cases (95.5%) and abnormal in 8 (4.5%) of cases, as shown in Table 2.

Out of the 176 patients ,129 (73.3%) had a normal flow rate of the UA, and 47(26.7%) had abnormal flow of the UA, as shown in Table 3.

There was a significant relation between UA ultrasound with UA affection (P = 0.05) Chi-square test, as seen in Table 4.

There was no significant relationship between UA ultrasound and maternal demographic characteristics

Table (3): Rate of abnormal US findings of uterine arteries with specification of which branch has been affected mostly.

Variables		No	%
UA US	Normal	129	73.3
	Abnormal	47	26.7
Rt Lt UA	Normal	129	73.3
	Rt	11	6.2
	Lt	7	4
	Both	29	16.5

Table (4): Ratios of the extent of uterine artery US abnormality have been reported, and the association has been assessed using the Chi-Square test.

Variables		UA US		P Value
		Normal No.	Abnormal No.	
Rt Lt UA	Normal	129	0	0.005
	Rt	0	11	
	Lt	0	7	
	Both	0	29	

(P value 0.05), except for coagulation (P value 0.05). This is mostly due to the higher number of (not done) in the normal group, as seen in Table 5. Coagulation studies were done for 21 patients, in which it was normal in 10(%) and abnormal in 11(%) patients, as shown in Table 5.

170 patients (97.7%) had singleton pregnancies, and 4 patients (2.3%) had twin pregnancies, as shown in Table 2. Regarding the fetal weight, 154 patients (87.5%) had birth weight of 3.1-4.0 kg, 18 (10.2) had birthweight of 2.1-3 kg, 4 (2.3%) patients not known as shown in Table2. 2 (1.1%) patients of the studied group, their delivery had been complicated by postpartum hemorrhage as shown in Table 2. Of the studied group, 35 (20.1%) patients had one previous miscarriage, 7 (4.0%) had previous 2 miscarriages, and 132(75.9%) had none as shown in Table 2. Follow-up of these babies was done by monitoring their APGAR scores, which were normal in most cases. At 2-year follow-up, the baby's condition was well in 169 (96.0) patients and unwell in 7 (4.0) babies, as shown in Table 2. There was no significant relation (P value 0.05), Chi square test.

5. Discussion

The resistance index (RI), the PI, the systolic/diastolic (S/D) ratio, and the presence of an early diastolic notch are common indicators for evaluating UA blood flow [6]. The UA speed is at its maximum when the heart initially ejects blood from the left ventricle, during systole [9]. This artery supplies blood and nutrients to the mother's womb [10]. This artery becomes vein-like vessel during pregnancy. Blood flow in arteries differs from that in veins. In our study, we examined the Doppler velocities in uterine arteries in low-risk pregnancies. A low-risk pregnancy

Table (5): Relation between UA ultrasound with maternal demographic characteristics and coagulation studies. (Notice that we have the same figures in table 1; here, we correlate these figures with UA doppler result). As we see, there is a significant relation between age and abnormal UA doppler (increased between 26 and 30, more abnormal doppler in Arabic patients than in Kurdish patients, more abnormal doppler in multiparous patients, and more abnormal doppler seen in physiological pregnancies than in induced pregnancies).

		UA US				P Value
		Normal		Abnormal		
		Count	%	Count	%	
Age in Years	<20	16	12.6	4	8.5	0.937
	20-25	33	26	11	23.4	
	26-30	33	26	12	25.5	
	31-35	24	18.1	9	19.1	
	36-40	14	16	7	14.9	
	>40	8	6.3	4	8.5	
Nationality	Kurd	54	41.9	19	40.4	0.062
	Arab	75	58.1	26	55.3	
	Turkmen	0	0.0	2	4.3	
Gravida	Primigravida	38	29.5	8	17	0.121
	Multigravida	91	70.5	39	83	
Mode of Pregnancy	Physiological	128	99.2	45	100	0.999
	Induced	1	0.8	0	0	
Mode of Delivery	Vaginal	446	35.9	13	27.7	0.199
	CS	81	63.3	32	68.1	
	Loss of Follow Up	1	0.8	2	4.3	
Previous CS	0	82	63.6	24	53.3	0.750
	1	24	18.6	10	22.2	
	2	17	13.2	8	17.8	
	3	5	3.9	2	4.4	
	4	1	0.8	1	2.2	

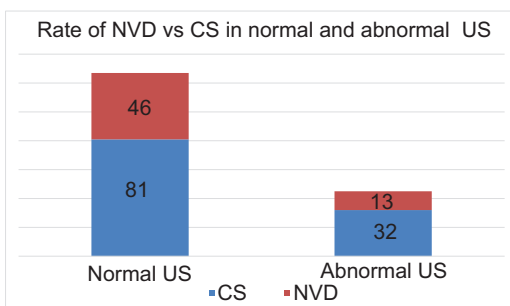


Figure (2): The mode of the deliveries in the studied group in both normal and abnormal Doppler.

is defined as a pregnant woman attending non-specialist antenatal care outpatient clinics and being classified as “low risk” at the time of inclusion according to local clinical guidelines, based on obstetric and clinical assessment [11].

The predictive value of Doppler studies in low-risk pregnancies was assessed, and its role in detecting high-risk pregnancies was established. This may be due to the possibility of detecting significant vascular abnormalities during pregnancies through the assessment of uterine

arteries. Uterine placental vascular impedance declines gradually during angiogenesis and stabilizes after 24th gestational week [6].

In our study, we evaluated the RI of UA. As the study was on nonselected low-risk pregnancies, the RI, PI, and S/D (Systolic/Diastolic) ratio decreased with gestational age, as reported by Snehil Dixit et al. [12]. Of the 176 patients, 129 (73.3%) had normal UA flow, and 47 (26.7%) had abnormal UA flow, in which the RI of the UA was studied (ranging from 0.60 to 0.85). Of the 47 cases, 11 cases (6.2%) had abnormal right uterine RI.

7 (4.0%) had an abnormal left UA index, and 29 (16.5%) had abnormal indices on both sides, as shown in Table 3. The percentages of normal and abnormal UA ultrasound are also shown. There was no significant relationship between UA ultrasound and fetal demographic characteristics ($P > 0.05$), as shown in Table 6, and this is also reported by Snehil et al. (2023). There was no significant association between UA ultrasound and maternal demographic characteristics ($P > 0.05$), as shown in Table 5.

Normal impedance to flow in the uterine arteries is associated with a low risk of complications related to placental insufficiency [13]. However, in patients with

Table (6): The relationship between UA ultrasound with fetal demographic characteristics.

		UA US				P value
		Normal		Abnormal		
		Count	%	Count	%	
Single/Multiple	Singleton	126	97.7	44	97.8	0.999
	Twin	3	2.3	1	2.2	
Maturity	Normal	124	96.1	44	93.6	0.444
	Abnormal	5	3.9	3	6.4	
Neonatal weight	2.1–3 kg	16	12.4	2	4.3	0.177
	3.1–4 kg	111	86.0	43	91.5	
	F loss	2	1.6	2	4.3	
Neonatal condition	Well	126	97.7	43	91.5	0.083
	Unwell	3	2.3	4	8.5	

increased impedance to blood flow, it is recommended to perform fetal well-being scans to monitor the baby's growth [13]. In a study conducted by Kirkinen et al. (1987), it was found that Doppler investigations had advanced significantly and were now recognized as a crucial tool for predicting heart failure in hypoxic fetuses. The pulsed Doppler method was used to record blood flow velocity waveforms from fetal intracranial arteries in 84 high-risk pregnancies and 83 low-risk pregnancies. Typically, there was a decremental pattern of waveform RI as the pregnancy progressed, with forward flow continuing in the arteries. A low RI had 57% sensitivity and 94% specificity for predicting small-for-dates infants and subsequent cardiococographic abnormality [14].

As a rule, some caution should be taken with the routine use of Doppler in pregnancy, due to the concerns related to heating/thermal effects from the high intensities of Doppler waves [15]. No evidence is available to assess the effect on long-term outcomes, such as neurodevelopment and maternal outcomes, particularly maternal satisfaction [1].

The rate of intervention was high, as seen in Table 1: 113 (64.4%) were delivered by caesarean section, compared to 59 (33.7%) delivered vaginally. This was similar to Kale et al. 2023 [5]. In Table 6, we see that there was no significant relationship between UA ultrasound and fetal demographic characteristics ($P = 0.05$), which is consistent with the study by Amin et al. [16].

The age distribution for our studied group was between less than 20 and more than 40 years age, with a maximum age of between 21 and 25 years old, and the least was more than 40 years old in both groups, as seen in Table 2, which also shows fetal conditions, number of postpartum hemorrhage, and number of miscarriages. In a study by Kale et al. (2023), the age ranged from 21 to 25, with a mean of 26.73, which is similar to ours [5]. In our study, we followed up these babies for up to 2 years post-delivery. 126 (97.7) were well, 3 (2.3) were unwell, and we lost contact with the rest, as shown in Table 6. A randomized prospective controlled trial assessed the long-term effects of ultrasonographic assessment on childhood outcomes up to 8 years of age. The data showed that

multiple prenatal ultrasonographic examinations from the 18th week of gestation were correlated with effects on fetal growth but were followed in childhood by growth and developmental outcomes similar to those in children who had received a single prenatal scan [17].

The study shows the role of this noninvasive nonexpensive promising tool. It shows the need to do at least one time Doppler study in pregnancy in the second trimester, which is consistent with the findings of Dominik et al who investigated the role of UA Doppler examination in normal singleton pregnancies from 2008 to 2017 [18], and a study done by Dall and Asta et al. [19] and a study done by Valerie et al. [20]. However, Alfirevic et al. [1]’s work did not provide evidence that would support the routine use of umbilical and UA Doppler in low-risk populations [3].

6. Conclusion

The study shows the promising value of uterine artery US Doppler ultrasound in detecting early causes of abnormal fetal perfusion and growth. It shows that sufficient uterine perfusion is crucial for a successful pregnancy. It is found that although these patients had no risk factor, but a proportion of them had abnormal Doppler waveforms, and this may explain a lot of cases of unexplained fetal death that occur without any risk factor. So, our study shows the promising role of Doppler ultrasound during pregnancy, a noninvasive, inexpensive test that can be performed at the bedside and has been approved as safe, to detect these patients and follow them properly, leading to a decrease in the rates of unexplained fetal losses. It is important to remember the role of this test: it is a screening test. There is a need to follow these babies to determine the effects of Doppler ultrasound on long-term development.

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