

Predictive Value of Color Doppler Ultrasound of Spiral Artery Blood Flow in Mid First Trimester (4-8weeks) In Cases of Threatened Abortion

Mofeed F. Mohammed, Refaey A. Marey, Ahmed S. A. F. AlNagar *

Department of Obstetrics and Gynecology, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt

Abstract

Background: Medical professionals refer to vaginal bleeding that occurs during the first twenty weeks of pregnancy—when the fetus is clinically expected to be alive—as a threatened miscarriage. You might or might not feel pain in your abdomen when this bleeding occurs. Nearly half of pregnant women who experience threats of abortion end up losing their babies, and around one-fifth of all pregnant women have indications of such threats in the first trimester.

Aim and objectives: During the fourth to eighth week of a pregnancy, when the risk of abortion is at its highest, the spiral artery flow should be monitored and compared to that of healthy pregnancies.

Subjects and methods: In this case-control study, 100 pregnant women who were admitted between 2022 and 2024 to the obstetrics and gynecology department of Al-Hussien University Hospital at Al-Azhar University in Cairo, Egypt, participated..

Results: A crucial finding was the significant difference in abortion rates between groups, with 26% in the threatened abortion group compared to 8% in the control group($p=0.031$). The Doppler ultrasound findings revealed significantly higher impedance indices in the threatened abortion group. The mean S/D ratio was notably elevated in the threatened abortion group(2.32 ± 0.28) compared to controls(1.95 ± 0.24 , $p<0.001$).

Conclusion: Circular artery anomaly Pregnancies with a risk of miscarriage are more likely to end in abortion if certain Doppler indices are elevated, such as the S/D ratio, resistance index (RI), and pulsatility index (PI). The predictive accuracy of these Doppler parameters, particularly the RI with its high sensitivity and specificity, suggests they may serve as valuable early indicators of miscarriage risk.

Keywords: Color Doppler Ultrasound; Spiral Artery; Blood Flow; Threatened Abortion

1. Introduction

Women with a living embryo who have been threatened with abortion nevertheless face a 15% higher risk of miscarrying than the general population.¹

Predicting the outcome of a pregnancy in the first trimester would be a huge clinical boon for this population because spontaneous miscarriage is so common among them.²

However, spectral analysis and high-frequency transvaginal color Doppler ultrasonography have made this evaluation possible during early pregnancy. Abnormalities in the uteroplacental circulation have been linked to a number of pregnancy complications, including hypertension, intrauterine growth restriction (IUGR), fetal distress, and early pregnancy failure.³

A major factor in both early and late pregnancy issues is impaired vascular remodeling at the maternal-fetal interface, which has led to research into the possible application of trans-vaginal Doppler sonography, which can assess the circulation pattern in even the most terminal branches of the uteroplacental circulation, to predict early and late pregnancy difficulties caused by aberrant placentation.⁴

These days, everyone agrees that irregularities in the early stages of trophoblast invasion and the spiral arteries' consistently elevated resistance cause the majority of pregnancy problems.⁵

The researchers set out to compare and contrast the spiral artery flow in normal pregnancies with those in which the mother is in danger of having an abortion from the fourth to eighth week of the pregnancy.

Accepted 15 June 2025.
Available online 31 July 2025

* Corresponding author at: Obstetrics and Gynecology, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt.
E-mail address: ahmedsorouralnagar@gmail.com (A. S. A. F. AlNagar).

<https://doi.org/10.21608/aimj.2025.446642>

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2. Patients and methods

The participants in this case-control study were 100 pregnant women who were hospitalized between 2022 and 2024 to the obstetrics and gynecology department at Al-Hussien University Hospital, Al-Azhar University in Cairo, Egypt.

An ethical review board from Cairo University's Faculty of Medicine in Egypt gave its stamp of approval to the research. Every single patient gave their signed, informed consent.

Inclusion criteria:

A woman who tests positive for pregnancy in her urine and is under the age of 35 is considered to be in her mid-first trimester if she is experiencing vaginal bleeding or spotting (with or without abdominal pain) and has no other unusual medical history. Women who have only one gestational sac seen on transvaginal or abdominal ultrasonography in real-time will not be included. Determine the gestational age (GA) by adding up the number of days or weeks of menstruation. Pregnant women who were healthy and did not want to end their pregnancies made up the control group.

Exclusion criteria:

Individuals with a history of menstrual irregularities within the past six months, or those who are unsure of when they last had their period, may benefit from this service. Patients who have experienced an ectopic pregnancy are not eligible; those with a history of molar pregnancy or two or more consecutive miscarriages are also not eligible. Patients who have uterine abnormalities, such as fibroids or malformations, or who have a clinically visible lesion in the vagina or cervical region that may be causing the vaginal bleeding. Patients who cannot be accurately assessed using the spiral artery test, and/or those whose examinations could not be finished in 10 minutes.

Patients were categorized into two groups:

Half of the pregnant women in Group I presented with symptoms that could indicate a miscarriage, such as heavy or irregular periods of bleeding or spotting, along with or without stomach pain. Half of the pregnant women in Group II displayed no such symptoms and served as a control group.

Methodology:

Following the following procedures: participant counseling, study explanation, and written consent, all participants were asked to provide a detailed medical history, including their age, GA, parity, number of abortions, years since last pregnancy, the condition of their gestational sac, pelvic pain, fetal heart rate at inclusion, and results of a general and abdominal clinical examination, as well as ultrasound investigations.

Ultrasound/Doppler evaluation:

Because hypertensive disorders during

pregnancy are uncommon, we limited our inclusion criteria to women who were at high risk of complications during their pregnancy, such as first-time mothers or those who had a history of such complications, and who came to our obstetric department for an ultrasound evaluation prior to week 11 of their pregnancies. Furthermore, they had to be carrying a singleton pregnancy, have a known last menstrual period, and have an ultrasound that confirmed GA.

The Siemens Acuson X300 ultrasound equipment (Siemens Ultrasound, Munich, Germany) was used for all sonographic procedures. It was equipped with a real-time 6.0 MHz endovaginal probe. It was requested that the women empty their bladders before the inspection.

The patient was placed in a supine posture, and all measures were taken in a silent room. On three separate occasions, when uterine contractions were not present, measurements were taken: once between weeks 11 and 13, once between weeks 14 and 17, and once between weeks 18 and 24 of gestation. The procedure for each measurement was standard: following the foetal anatomy survey, the amount of amniotic fluid and predicted foetal biometry were recorded.

Triplex mode examination, which combines a grayscale image with color Doppler and a flow spectrum on the spectral wave, was used to analyze uterine spiral arteries. Utilizing power Doppler imaging, the coronary arteries just below the chorion frondosum were evaluated. To get the flow velocity waveforms, we activated the pulsed-wave Doppler function and placed the Doppler gate over the colored areas.

In order to detect the slowest blood flow, the wall filters were adjusted to a minimal level. To ensure that no sonographically detectable pathological lesions, such as infarction or calcification, were insonated, waveforms were collected from a minimum of two locations beneath the placenta's core region, at least three centimeters from the placental margin. Our decision to conduct all measurements within the core region of the placenta is based on the fact that there are notable differences in impedance indices acquired from this region compared to the periphery region.

Two measurements were taken of each artery, with the probe being repositioned after the first measurement. Online storage and analysis of flow velocity waveforms was done. By reviewing the medical records and conducting written follow-up, we were able to determine the pregnancy's trajectory and destination.

The location of the spiral artery right under the placenta and its distinctive waveform pattern allowed it to be distinguished from the radial and basal arteries. Due to the difficulty in determining the flow direction, the Doppler gate was adjusted to

the size of the vessel (typically 2 mm) once clear color flow imaging was achieved. The angle between the Doppler beam and the vessel was left unchanged.

A 2 mm width was selected for the pulsed Doppler sample volume. The mechanical index (MI) is 0.82, and the thermal index for sort tissue (TIS) is 7, with the high-pass filter set at 50 Hz (Figure 1).

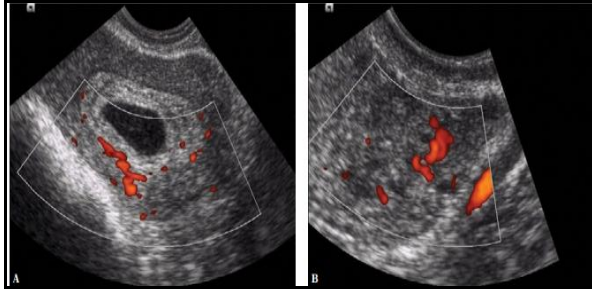


Figure 1. The spiral arteries are shown in the following power Doppler images: (A) a case of a potentially dangerous abortion at 5 weeks; (B) a normal case at 4 weeks and 5 days.

The machine's software program automatically determined the systolic/diastolic (S/D) ratio, resistance (RI), and pulsatility indices (PI). We took two successive waveforms of flow velocity readings from the spiral arteries and averaged them. To ensure consistency and eliminate bias, the same investigator conducted all sonographic procedures, (Figures 2&3).

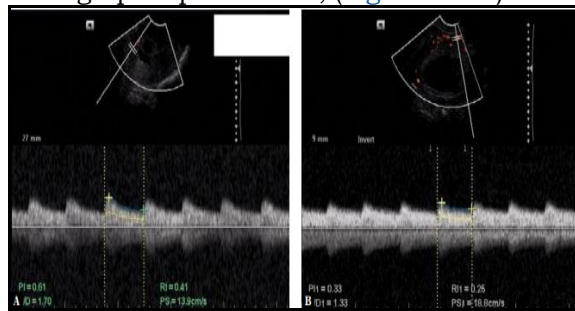


Figure 2. (A) a case of threatening abortion at 5 weeks and 2 days; (B) a normal case at 6 weeks; and (C) a Power Doppler waveform displaying the flow pattern of the spiral arteries.



Figure 3. A transvaginal sonography (TVS) imaging of a patient experiencing lower abdominal pain and vaginal bleeding at 5-week and 2-day intervals.

We documented all prenatal problems, delivery methods, neonate sex, birth weight, and postnatal issues.

Statistical analysis:

For this investigation, we consulted SPSS v26, developed by IBM Inc. of Chicago, Illinois, USA. To compare the two groups, we used quantitative data (means and standard deviations) and an unpaired Student's t-test. Qualitative variables were evaluated using Fisher's exact test or Chi-square test when appropriate. The variables were presented as frequencies and percentages. A result was considered statistically significant if the two-tailed P value was less than 0.05.

The ROC (Receiver Operating Characteristic) evaluation: Each test's overall diagnostic performance was evaluated using the ROC curve analysis. A perfect test is one that goes all the way from the bottom left to the top left and then all the way to the top right. Area under the curve (AUC) is used to evaluate a test's overall performance; an AUC greater than 50% is deemed acceptable, and an AUC near 100% is deemed ideal.

3. Results

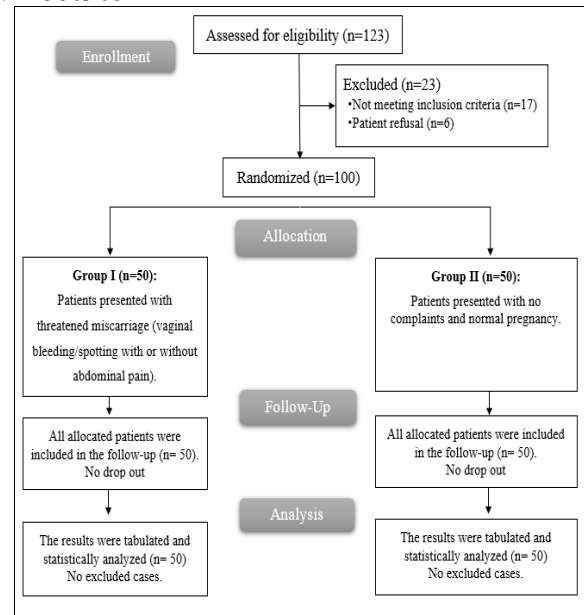


Figure 4. CONSORT flowchart showing the participants' progress at each trial stage.

Table 1. The demographic information of the groups under study.

		GROUP-I (N=50)	GROUP-II (N=50)	P-VALUE
AGE (YEARS)	Mean±SD	27.6±2.88	28.4±4.07	0.259
	Range	23-32	21-34	
WEIGHT (KG)	Mean±SD	79.3±5.38	81.6±6.93	0.067
	Range	71-90	69-93	
HEIGHT (CM)	Mean±SD	168.68±6.46	170.16±5.02	0.204
	Range	159-179	161-178	
BMI (KG/M ²)	Mean±SD	27.97±2.58	28.27±3.12	0.594
	Range	22.2-34	22-34.2	
GESTATIONAL AGE (WEEKS)	Mean±SD	5.92±1.5	6.2±1.48	0.350
	Range	4-8	4-8	

BMI: Body mass index.

There were negligible differences in age, height,

weight, body mass index (BMI), and GA between the two groups, (table 1).

Table 2. Abortion of the populations under study.

		GROUP-I (N=50)	GROUP-II (N=50)	P-VALUE
ABORTION	Yes	13(26%)	4(8%)	0.031*
	No	37(74%)	46(92%)	

Group I experienced substantially more abortions than Group II (P-value = 0.031), (table 2).

Table 3. Spiral arterioles doppler ultrasound findings of the studied groups.

		GROUP-I (N=50)	GROUP-II (N=50)	P-VALUE
S/D RATIO	Mean±SD	2.32±0.28	1.95±0.24	<0.001*
	Range	1.87-2.83	1.49-2.62	
RI	Mean±SD	0.45±0.08	0.26±0.08	<0.001*
	Range	0.32-0.64	0.14-0.49	
PI	Mean±SD	0.96±0.06	0.55±0.23	<0.001*
	Range	0.84-1.08	0.29-0.97	

S/D: Systolic to diastolic ratio, RI: Resistance index, PI: Pulsatility index.

S/D ratio, RI and PI were significantly higher in group-I than group-II (P-value<0.001), (table 3).

Table 4. Role of S/D ratio in prediction of abortion.

CUT-OFF	SENSITIVITY	SPECIFICITY	PPV	NPV	AUC	P-VALUE
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PPV: positive predictive value, NPV: negative predictive value, AUC: area under the curve.

S/D ratio can significantly predict abortion (P-value<0.001 and AUC=0.799) at cut-off >2.13 with 70.59% sensitivity, 66.27 specificity, 30% PPV and 91.7% NPV, (table 4; figure 4).

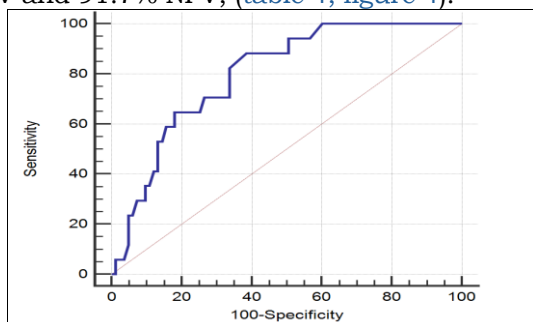


Figure 5. ROC curve of S/D ratio in prediction of abortion.

Table 5. Role of RI in prediction of abortion.

CUT-OFF	SENSITIVITY	SPECIFICITY	PPV	NPV	AUC	P-VALUE
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PPV: positive predictive value, NPV: negative predictive value, AUC: area under the curve.

RI can significantly predict abortion (P-value<0.001 and AUC=0.949) at cut-off >0.47 with 82.35% sensitivity, 96.36% specificity, 82.4% PPV and 96.4% NPV, (table 5; figure 6).

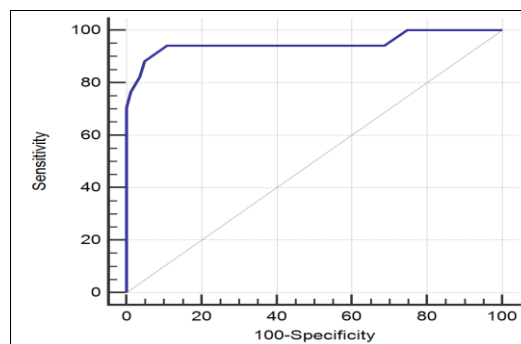


Figure 6. ROC curve of RI in prediction of abortion.

Table 6. Role of PI in prediction of abortion.

CUT-OFF	SENSITIVITY	SPECIFICITY	PPV	NPV	AUC	P-VALUE
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PPV: positive predictive value, NPV: negative predictive value, AUC: area under the curve.

PI can significantly predict abortion (P-value=0.001 and AUC=0.745) at cut-off>0.96 with 64.71% sensitivity, 83.13% specificity, 44% PPV and 92% NPV, (table 6; figure 7).

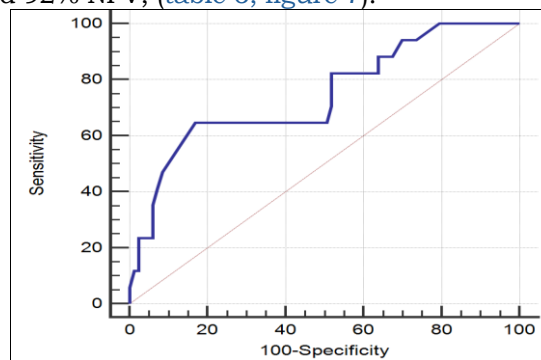


Figure 7. ROC curve of PI in prediction of abortion.

4. Discussion

The development of transvaginal ultrasound greatly improved the evaluation of early pregnancy in threatened abortion cases. Fetal loss occurs in approximately 15% of cases when a woman experiences a threatened abortion and a live baby in the first trimester. This highlights the significant impact of ultrasound on obstetrics and gynecology practice.⁶

In the short term, there is a lot of blood flow to the mother at the beginning of the pregnancy, which can lead to oxidative damage and potentially a miscarriage. In the long run, the placenta can be directly compressed and disrupted, or there can be problems with early trophoblast invasion and the resistance of the spiral artery, which are thought to be the main causes of most pregnancy complications.⁷

Regarding demographic characteristics, our study groups showed no significant differences in terms of age, weight, height, BMI, and GA, indicating well-matched study populations. The

mean age was 27.6 ± 2.88 years in the threatened abortion group and 28.4 ± 4.07 years in the control group ($p=0.259$). This homogeneity in baseline characteristics strengthens the validity of our findings regarding the Doppler parameters.

In harmony, Bhoil et al.,⁷ sought to assess and compare the spiral artery flow in the middle of the first trimester (4-8 weeks) in women experiencing threatened abortion versus those in healthy pregnancies. The participants' ages ranged from 16 to 35 years, with a mean of 26.8 years. Neither the age nor the body mass index of the participants was significantly different between the two groups.

In our study, a crucial finding was the significant difference in abortion rates between groups, with 26% in the threatened abortion group compared to 8% in the control group ($p=0.031$).

This aligns with findings by Saleh et al.,⁶ of those who reported having an abortion during their most recent pregnancy were more likely to have had an abortion during their most recent pregnancy (13.3 vs. 1.2%).

In addition, Benton et al.,⁸ attributed a greater incidence of pregnancies with complications to placental malfunction, namely to implantation insufficiency leading to placental ischemia in the first trimester and subsequent termination.

The group that was threatened with abortion had substantially higher impedance indices, according to the results of the Doppler ultrasound that we conducted. In the threatened abortion group, the mean S/D ratio was significantly higher (2.32 ± 0.28) than in the control group (1.95 ± 0.24 , $p<0.001$).

This finding corresponds with research by Zakaria et al.,⁹ who revealed that PI, RI, and S/D ratio statistically were remarkably elevated in the aborted cases ($P\text{-value}<0.001$).

In our study, the RI showed marked differences between groups (0.45 ± 0.08 vs. 0.26 ± 0.08 , $p<0.001$). Similarly, the PI was significantly higher in the threatened abortion group (0.96 ± 0.06 vs. 0.55 ± 0.23 , $p<0.001$).

These results are in line with Uysal et al.,¹⁰ research has shown that compared to fertile women, those experiencing unexplained infertility had a substantially higher resistance of spiral artery blood flow.

Bhoil et al.,⁷ advocate for the non-invasive assessment of trophoblastic invasion abnormalities in early pregnancy (4-8 weeks) using spiral artery Doppler investigation (transvaginal). Patients exhibiting symptoms of a possible miscarriage had substantially higher PI and RI than those with normal pregnancies, according to the findings. Our investigation is in

agreement with these results.

Similar findings were reported by other investigators, Jing,¹¹ who conducted a retrospective study that included 60-pregnant women with threatened abortion in early pregnancy to determine if transvaginal color Doppler ultrasound can aid in the differential diagnosis of pregnancies if abortion is threatened, and found that the abortion group had a higher PI and RI of the uterine spiral artery and luteal blood flow than the control group ($P<0.05$).

Perhaps the most clinically relevant findings relate to the predictive value of these Doppler parameters. The RI emerged as the strongest predictor of abortion with an impressive AUC of 0.949 at a cut-off value >0.47 , demonstrating 82.35% sensitivity and 96.39% specificity.

In our study, the S/D ratio showed moderate predictive value (AUC=0.799) at a cut-off >2.13 , with 70.59% sensitivity and 66.27% specificity. While less robust than RI, these values still indicate useful clinical applicability.

In our study, the PI demonstrated the lowest predictive value among the three parameters (AUC=0.745) at a cut-off >0.96 , though still maintaining good specificity (83.13%), but lower sensitivity (64.71%).

The notably high negative predictive values (NPV) for all three parameters (91.7% for S/D ratio, 96.4% for RI, and 92% for PI) suggest these measurements could be particularly valuable in identifying pregnancies likely to continue successfully. This aspect is especially relevant for clinical practice, as it could help reassure patients with threatened abortion but normal Doppler findings.

The lower positive predictive values (30% for S/D ratio, 82.4% for RI, and 44% for PI) indicate that while these parameters are useful screening tools, they should be interpreted in conjunction with other clinical findings rather than used as sole predictors of pregnancy outcome.

This observation aligns with Zakaria et al.,⁹ revealed that, as regards the diagnostic performance of Doppler Ultrasound findings in predicting abortion, the current study results revealed that in predicting abortion, the resistive index performed moderately well, while PI and S/D ratio statistically had significantly low diagnostic performance. $RI>0.49$ had the highest Diagnostic characteristics in predicting abortion; it had high specificity (90.1%) and negative predictive value (94.8%) but low other characteristics.

4. Conclusion

Circular artery anomaly Pregnancies in which a miscarriage is imminent are more likely to end in abortion if certain Doppler indices are elevated, such as the S/D ratio, RI, and PI. The predictive

accuracy of these Doppler parameters, particularly the RI with its high sensitivity and specificity, suggests they may serve as valuable early indicators of miscarriage risk. Our findings support the potential clinical utility of Doppler ultrasound in the first trimester as a predictive tool for identifying pregnancies at higher risk of adverse outcomes, allowing for early intervention and management.

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

Funding

No Funds : Yes

Conflicts of interest

There are no conflicts of interest.

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