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Abdel-Monem Mohamed Zakaria
Department of Obstetrics and Gynecology, Faculty of Medicine for boys, Al-Azhar University, Cairo, Egypt

Yasser Mohamed Said Diab
Department of Obstetrics and Gynecology, Faculty of Medicine for boys, Al-Azhar University, Cairo, Egypt

Asser Tarek Ibrahim Khatab
Department of Obstetrics and Gynecology, Faculty of Medicine for boys, Al-Azhar University, Cairo, Egypt, dr.asertarek@gmail.com

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ORIGINAL ARTICLE

Efficacy of Doppler Ultrasound on Spiral Arterioles to Predict the Outcome of Cases of First Trimester Threatened Abortion

Abdel-Monem Mohamed Zakaria, Yasser Mohamed Said Diab, Asser Tarek Ibrahim Khatab*

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

Abstract

Background: **Miscarriage is the spontaneous loss of fetus before 20 weeks of pregnancy. Pregnancy losses after the 20 weeks of pregnancy are called stillbirths. Miscarriage is naturally occurring unlike medical or surgical abortion. The placenta is the most common source of bleeding during the first trimester.**

Aim: **To evaluate spiral artery circulation in the primary three months of pregnancy in cases of threatened abortion.**

Patients and methods: **This cohort research was executed in Obstetrics and Gynecology Department, Al-Azhar University Hospitals, from December 2021 till February 2023. This study was performed on a total of 100 pregnant women in their first trimester with threatened abortion who were willing to participate and were distributed into double collections: Group A: (Abortion group): 19 patients who were exposed to miscarriage. Group B: (Continued Pregnancy): 81 patients who had no complications and continued pregnancy.**

Results: **Doppler Ultrasound findings among the studied cases. Mean ± SD of pulsatility index (PI), Resistive index (RI) and Systolic/diastolic (S/D) ratio was 0.94 ± 0.22, 0.46 ± 0.07 and 2.18 ± 0.29, respectively. Abortion did not correlate with any statistically significant changes in age, BMI, location, or number of children. Aborted cases had statistically elevated values of PI, RI, and systolic/diastolic (S/D) ratio. In predicting abortion, the RI performed somewhat well statistically, but the PI and S/D ratio performed poorly.**

Conclusion: **Doppler ultrasound examination of the uterine arteries (transvaginal) can detect trophoblastic invasion abnormalities in early pregnancy without causing any harm to the infant (4−8 weeks).**

Keywords: Doppler, Spiral artery, Threatened abortion

1. Introduction

The placenta connects the fetus' circulatory system to the mother's one, making it an important organ for embryonic growth and development. Proper placental development necessitates not only trophoblast invasion of endometrial tissues[1] but also integrated renovation of the maternal and fetal circulation systems in order to keep those two blood flow systems in close contact with each other.[2]

Intrauterine growth restriction (IUGR) and preeclampsia are two pathological diseases that can develop when these mechanisms are disrupted.[3] A miscarriage is the loss of an unplanned infant before the 20th week of pregnancy. This is also called a spontaneous abortion. At least half of all early pregnancy losses are caused by problems with the embryo or fetus's chromosomes. This is the furthermost popular reason for unplanned abortion in the first trimester.[4]

In addition to vascular diseases like lupus, this condition can also be caused by hormonal problems, infections, and abnormalities in the uterus. Maternal age and a woman's history of spontaneous abortions are the most important factors that can make a woman more likely to have a spontaneous abortion. Accidental trauma can also a trigger for

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* Corresponding author at: Faculty of Medicine, Mansoura University, Cairo, Egypt.
E-mail address: dr.asertarek@gmail.com (A.T.I. Khatab).

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spontaneous abortion, also, a miscarriage that occur by subjecting the pregnant woman to stress or trauma which called is called induced abortion or feticide.[5]

Most cases of preterm bleeding can be returned to the placenta. It can have a wide range of immediate and long-term consequences for the progression and fate of the pregnancy.[6]

Short-term effects are extensive and early beginnings of maternal blood flow and substantial oxidative degeneration due to compromised placenta-decadal interface development. Miscarriage can occur through this process, or through direct pressure and disruption of the placenta. It is now generally believed that defects in early trophoblast invasion and continuously rising spiral artery's resistance are the primary causes of the most common pregnancy problems.[7]

2. Patients and methods

This cohort research was executed in the Obstetrics and Gynecology Department, Al-Azhar University Hospitals, from December 2021 till February 2023. This study was performed on a total of 100 Pregnant women in their first trimester with threatened abortion who were willing to participate and were divided into two groups: Group A: (Abortion group): which included 19 patients who were exposed to miscarriage. Group B: (Continued pregnancy): which included 81 patients who had no complications and continued pregnancy.

The Inclusion criteria were: Age of women from 18 to 35 years old, Gestational Age between 6 and 12 weeks, Transvaginal and abdominal ultrasounds detect a single gestational sac inside the uterus. Signs of a possible miscarriage include vaginal spotting or bleeding, together with or without abdominal pain. Verifiable menstrual cycles (26–30 days): The gestational age will be calculated using the mother's last menstrual period, the date of conception, and whether or not ovulation was induced.

The Exclusion criteria were: Individuals who could not recall their most recent menstrual period or whose periods were historically dysfunctional during the preceding six months, Advanced systemic or medical disorders e.g., SLE, RA, Anti-Phospholipid Syndrome, Pregnancy after in vitro fertilization/intracytoplasmic sperm injection, Molar pregnancies, and patients when there has been a string of miscarriages, Females with an ectopic pregnancy, Those who have uterine abnormalities or fibroids; women who have a clinically apparent vaginal or cervical abnormality that may be the source of their bleeding, Individuals whose spiral arteries could not be properly examined, or whose examinations took more than 10 min, Individuals with a bleeding disorder.

2.1. Ethical approval

The Al-Azhar University Faculty of Medicine's Ethical Research Board (ERB) in Cairo, Egypt, approved the study. Prior to the start of the study, all patients provided informed consent after a clear description of the potential adverse outcomes.

2.2. Study procedure

All patients underwent: Complete detailed history; complete examination; complete blood count, urine analysis; liver enzymes, creatinine; imaging assessment.

3. Results

Table 1.

Mean ± SD of Pulsatility index (PI), Resistive index (RI) and Systolic/diastolic (S/D) ratio was 0.94 ± 0.22, 0.46 ± 0.07 and 2.18 ± 0.29 respectively (Table 2).

This table shows: There are no statistically significant variations in age, body mass index, gravidity, or parity between those who had or did not have an abortion Aborted cases had statistically higher results for the PI, RI, and S/D ratio (Table 3).

This table shows: Only Resistive index had statistically significant correlation with week of abortion (Table 4, Fig. 1).

This table shows that the diagnostic performance of the RI was moderately significant, whereas that of the PI and the S/D ratio was statistically low (Table 5, Fig. 2).

This table shows: RI ≥ 0.49 had increased diagnostic features in expecting the abortion; it had high specificity and negative predictive value but low other characteristics (Table 6).

This table shows: when it comes to predicting abortion, the RI performed rather well statistically,

Table 1. Spiral arterioles Doppler ultrasound findings among the studied cases and shows: spiral arterioles Doppler ultrasound findings among the studied cases.

Doppler items	Mean ± SD	Range
Pulsatility Index (PI)	0.94 ± 0.22,	0.43–1.61
Resistive Index (RI)	0.46 ± 0.07	0.34–0.65
Systolic/diastolic (S/D) ratio	2.18 ± 0.29	1.64–2.84

Total = 100.

Table 2. Comparison according to abortion.

Variables	Aborted ($N = 19$)	Continued ($N = 81$)	P value
Age (years)	25.3 ± 4.5	26.8 ± 3.5	[a]0.125
BMI (kg/m^2)	30.3 ± 1.9	29.6 ± 2.2	[a]0.182
GA (weeks)	9.32 ± 1.1	8.9 ± 1.4	[a]0.280
Parity			
Nulli	7 (36.8%)	31 (38.3%)	[b]0.908
Parous	12 (63.2%)	50 (61.7%)	
Pulsatility index (PI)	1.06 ± 0.23	0.88 ± 0.23	[a]0.002[c]
Resistive index (RI)	0.55 ± 0.07	0.44 ± 0.05	[a]<0.001[c]
Systolic/diastolic (S/D) ratio	2.38 ± 0.26	2.13 ± 0.28	[a]<0.001[c]

[a] Independent *t*-test.
[b] Chi square test.
[c] Significant.

Table 3. Correlation between week of abortion and spiral arterioles Doppler ultrasound findings.

Doppler findings	R (correlation coefficient)	P value
Pulsatility index (PI)	−0.188	0.441
Resistive index (RI)	−0.694	0.001[a]
Systolic/diastolic (S/D) ratio	−0.113	0.645

Pearson correlation test.
[a] Significant.

but the PI and S/D ratio performed poorly (Table 7, Fig. 3).

This table shows:RI ≥ 0.45 had the highest diagnostic characteristics in predicting IUGR; it had high specificity and negative predictive value but low other characteristics.

4. Discussion

At a gestational age of 20 weeks, with a closed cervical os, and with complaints of abdominal pain and vaginal bleeding or spotting, a pregnancy is considered to be a threatened abortion. Abortions are 2.6 times more common among threatened women than among unthreatened women.[8]

No statistically significant changes in age, BMI, GA, or parity were found in relation to abortion in the current study (P value: 0.125, 0.182, 0.280 and 0.908 respectively).

Table 4. Diagnostic performance of spiral arterioles Doppler ultrasound findings in predicting abortion.

Doppler findings	AUC	SE	P value	95% CI	Cut point
Pulsatility index (PI)	0.693	0.064	0.009[a]	0.568–0.819	≥0.97
Resistive index (RI)	0.879	0.052	<0.001[a]	0.777–0.981	≥0.49
Systolic/diastolic (S/D) ratio	0.735	0.064	0.001[a]	0.610–0.860	≥2.25

AUC, Area under curve; CI, Confidence interval; SE, Standard error.
[a] Significant.

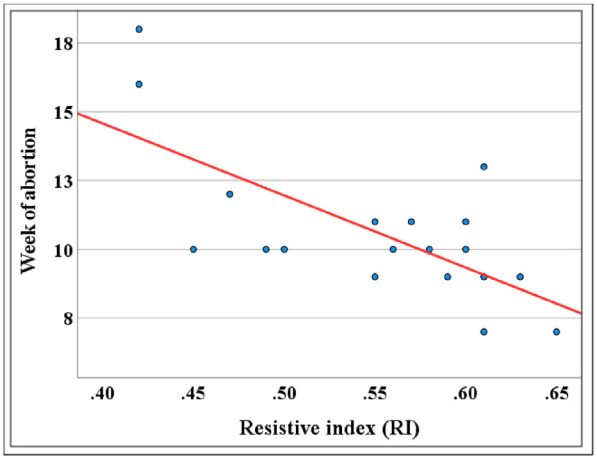

Fig. 1. Correlation between week of abortion and resistive index.

As regards Doppler Ultrasound Findings, the current study results revealed that PI, RI and S/D ratio statistically were remarkably elevated in the aborted cases (P value < 0.001) while only RI had statistically significant correlation with weeks of abortion (P value = 0.001).

These results are in line with those of a previous cross-sectional study by **Bhoil *et al.*,**[7] which included 50 pregnant women to assess and compare spiral artery flow at the midpoint of the first trimester 4–8 weeks if threatening abortion and in normal pregnancies, finding significant differences in the spiral artery Doppler values of RI and PI between the two groups, with higher values in abortion cases (P value = 0.003, 0.041 respectively). While there was a trend towards higher S/D values in one group in comparison with the other, there was no statistically significant variance (P value = 0.147).

Impairment in vascular remodelling due to a lack of normal trophoblastic invasion at placentation may account for the rise in UARI that occurs between weeks 5 and 6 of pregnancy, which may induce spontaneous abortion. **Zkan *et al.***[9]

Later on, similar findings were reported by other investigators, **CAO Jing**[10] 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).

This is consistent with previous work that **Ozkaya *et al.***[11] Doppler sonography was used to look at the blood flow between the uterus and the placenta in

Table 5. Diagnostic features of spiral arterioles Doppler ultrasound cut points in predicting abortion.

Characters	Pulsatility index (PI) ≥0.97		Resistive index (RI) ≥0.49		Systolic/diastolic (S/D) ratio ≥2.25	
Sensitivity	68.4%	43.4%–87.4%	78.9%	54.4%–93.9%	73.7%	48.8%–90.9%
Specificity	56.8%	45.3%–67.8%	90.1%	81.5%–95.6%	65.4%	54.0%–75.7%
DA	59.0%	48.7%–68.7%	88.0%	80.0%–93.6%	67.0%	56.9%–76.1%
YI	25.2%	1.7%–48.7%	69.1%	49.6%–88.5%	39.1%	16.8%–61.5%
PPV	27.1%	15.3%–41.8%	65.2%	42.7%–83.6%	33.3%	19.6%–49.5%
NPV	88.5%	76.6%–95.6%	94.8%	87.2%–98.6%	91.4%	81.0%–97.1%
LR+	1.58	1.07–2.35	7.99	3.98–16.06	2.13	1.43–3.19
LR-	0.56	0.28–1.11	0.23	0.10–0.56	0.40	0.19–0.87
DOR	2.85	0.98–8.24	34.22	9.12–128.43	5.30	1.73–16.23

CI, Confidence interval; DA, Diagnostic accuracy; NPV, Negative Predictive values; PPV, Positive Predictive values; YI, Youden's index. Positive likelihood ratio, LR-: Negative likelihood ratio, LR: Diagnostic odds ratio.

105 pregnant women between weeks 6 and 12. This was done to determine whether early spectral Doppler measures from the bilateral uterine, arcuate, radial, and spiral arteries were associated with a poor pregnancy outcome. Compared to women who had healthy pregnancies, those who did not had considerably higher PI and RI levels in the uterine artery. There was also an increase in the PI and RI values of the spiral artery, but this was not statistically significant. According to their findings, transvaginal Doppler screening (during the first trimester) can identify hemodynamic alterations in uteroplacental circulation that are linked to unfavorable birth outcomes.

Both complex and simple pregnancies at 8–12 weeks were studied by **Nagy and Gardo,**[12] and their Doppler values for the spiral artery were compared. Complex pregnancies had higher peak systolic velocity, RI, and PI than normal controls. To evaluate trophoblast invasion abnormalities without causing the fetus any harm, they suggested a Doppler study of the spiral artery.

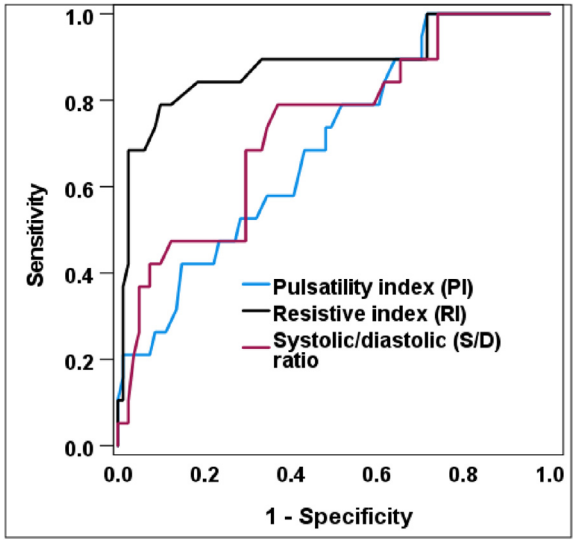

Fig. 2. Receiver operating characteristic (ROC) Spiral Arterioles Doppler Ultrasound findings in predicting abortion.

Table 6. Diagnostic performance of spiral arterioles Doppler ultrasound findings in predicating IUGR.

Doppler findings	AUC	SE	*P* value	95% CI	Cut point
Pulsatility index (PI)	0.546	0.064	0.652	0.421–0.672	≥0.90
Resistive index (RI)	0.714	0.094	0.037*	0.530–0.898	≥0.45
Systolic/diastolic (S/D) ratio	0.633	0.071	0.194	0.495–0.772	≥2.14

*: P < 0.05 = Significant.

As regards 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 significant low diagnostic performance. RI ≥ 0.49 had highest Diagnostic characteristics in predicting abortion; it had high specificity (90.1%) and negative predictive value (94.8%) but low other characteristics.

As regards Diagnostic performance of Doppler Ultrasound findings in predicating IUGR, the current study results revealed that in predicting IUGR, the resistive index performed somewhat well statistically, but the PI and S/D ratio performed poorly. RI ≥ 0.45 had the highest diagnostic characteristics in predicting IUGR; it had high specificity (70.8%) and negative predictive value (94.4%) but low other characteristics. Most of the physiological vascular changes that occur during the first trimester of pregnancy are concentrated in the vascular bed formed by the uterine arteries. Because of this, the S/D ratio in the uterine artery may be the best predictor of a future miscarriage.[13]

Sharma *et al.*[13] focused on the elevated Negative Predictive value (94%) of the color Doppler exam due to its beneficial results for practitioners when considering unnecessary and expensive therapy. The exam's sensitivity is also known as the true positive rate, which calculates the proportion of

Table 7. Diagnostic characteristics of characteristics of spiral arterioles Doppler ultrasound cut points in predicting IUGR.

Characters	Pulsatility index (PI) ≥0.90		Resistive index (RI) ≥0.45		Systolic/diastolic (S/D) ratio ≥2.14	
	Value	95% CI	Value	95% CI	Value	95% CI
Sensitivity	88.9%	51.8%–99.7%	66.7%	29.9%–92.5%	77.8%	40.0%–97.2%
Specificity	47.2%	35.3%–59.3%	70.8%	58.9%–81.0%	47.2%	35.3%–59.3%
DA	51.9%	40.5%–63.1%	70.4%	59.2%–80.0%	50.6%	39.3%–61.9%
YI	36.1%	12.6%–59.7%	37.5%	5.0%–70.0%	25.0%	−4.5%–54.5%
PPV	17.4%	7.8%–31.4%	22.2%	8.6%–42.3%	15.6%	6.5%–29.5%
NPV	97.1%	85.1%–99.9%	94.4%	84.6%–98.8%	94.4%	81.3%–99.3%
LR+	1.68	1.23–2.31	2.29	1.27–4.11	1.47	0.98–2.22
LR-	0.24	0.04–1.52	0.47	0.18–1.20	0.47	0.14–1.64
DOR	7.16	0.85–60.22	4.86	1.11–21.25	3.13	0.61–16.11

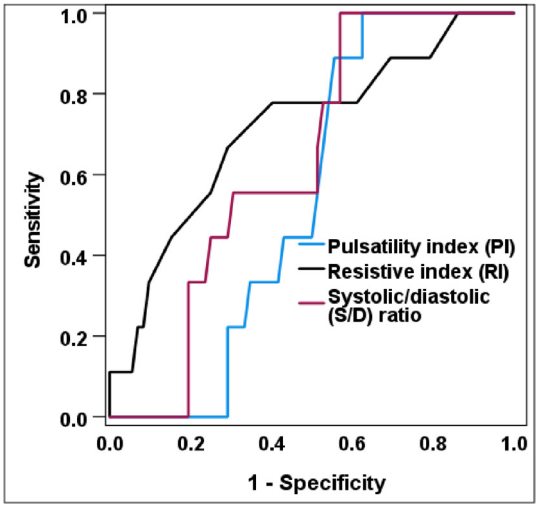

Fig. 3. Receiver operating characteristic (ROC) of Spiral Arterioles Doppler Ultrasound findings in predicating IUGR.

positives that are also correctly known. As a result, color Doppler of the uterine artery is a reliable test when the Doppler is normal, as it is rarely normal when the outcome is bad.

However, atypical Doppler is ineffective for screening a negative outcome. Specificity (also known as the true negative rate) which evaluates the proportion of normal Doppler results that had normal outcomes. As a result, a normal Doppler can correctly reject any abnormality.

4.1. Conclusion

Doppler ultrasound examination of the uterine arteries (transvaginal) can detect trophoblastic invasion abnormalities in early pregnancy without causing any harm to the infant (4–8 weeks).

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.

Conflicts of interest

The authors declared that there were NO conflicts of Interest.

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