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The effect of previous deliveries on second-trimester uterine artery Doppler parameters

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Abstract

Objective: This study investigates the effects of previous vaginal deliveries and cesarean sections, as well as their repetitions, on uterine artery (UtA) Doppler parameters in subsequent pregnancies.

Methods: The study included 300 healthy pregnant women between 20 and 24 weeks of gestation. Pregnant women were compared in terms of UtA Doppler parameters according to previous delivery type and number

Results: Once compared according to delivery methods, UtA pulsatility index (PI), PI percentile, PI multiple of median (MoM), and systole/diastole (S/D) values were similar in nulliparous, vaginal delivery (VD) group and cesarean delivery (CD) group (p values 0.191, 0.374, 0.284, and 0.152, respectively). UtA resistance index (RI) was significantly higher in the CD group (p=0.010). Once UtA Doppler parameters were compared according to the delivery method and repetitions, it was determined that all indices were significantly different between the groups (p=0.013 for UtA PI, p=0.041 for UtA PI percentile, p=0.016 for UtA PI MoM, p=0.001 for UtA RI, p=0.019 for UtA S/D). Regression analysis showed a statistically significant effect of parity on the UtA RI variable (p=0.007).

Conclusion: Cesarean deliveries may alter UtA Doppler parameters in subsequent pregnancies, and furthermore, increasing numbers of cesarean and vaginal deliveries may impact all UtA Doppler parameters.

Keywords: Cesarean delivery, Doppler ultrasonography, parity, uterine artery, vaginal delivery

Introduction

Doppler sonographies of fetal and maternal vessels during pregnancy have been used frequently in recent years to evaluate the physiology of the feto-maternal unit. Advancing ultrasonography technology and vast knowledge of Doppler ultrasonography have provided substantial achievements. Reliable and non-invasive methods are the primary achievements.

During pregnancy, a set of changes occur in the maternal uterine arteries (UtA) to accommodate the increased blood supply to the placenta. Maternal UtA Doppler ultrasound allows the evaluation of these changes that occur in the uteroplacental circulation from the first trimester of pregnancy.[1] Doppler sonography of UtA is a proven noninvasive method to evaluate abnormal placentation and impaired uteroplacental circulation.[2] Particularly in recent years, UtA Doppler ultrasound has been used as a screening tool to evaluate the risk of preeclampsia, fetal growth restriction, abruptio placentae, and stillbirth.[3,4] The most commonly used parameters to evaluate UtA flow rate waveforms are the pulsatility index (PI), resistance index (RI), and systole/diastole (S/D) ratio.[5]

Cesarean section rates are increasing worldwide. Adverse outcomes such as postpartum infection, hemorrhage, and thromboembolism are frequent due to the increased rate of cesarean deliveries.[6,7] It has been demonstrated that devascularization and scar formation in the uterine tissue increase after cesarean section. This

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condition is likely to affect blood flow to the placenta. Certain studies report that there is a change in the UtA Doppler pattern in the postpartum period. A few of these studies included women who gave birth by cesarean section.[8,9] It has been proven in some studies that regardless of the method of delivery, parity can also affect UtA Doppler parameters due to changes in uterine tissues.[10-12]

To our knowledge, there is no study investigating the effects of both the previous delivery method and the number of births on uteroplacental circulation in subsequent pregnancies. In this study, we aimed to test the hypothesis that the previous delivery method and the number of repetitions can change UtA Doppler parameters and to investigate the effect on these parameters.

Methods

Study design

This retrospective case-control study was conducted in a tertiary center between January 2022 and April 2023. The study included healthy pregnant women who had their UtA Doppler parameters checked during fetal anatomical scanning between the 20th and 24th weeks of gestation. The study was approved by local ethics committee (Decision no: 2023/237) and informed consent was obtained from all participants.

Patient selection

Women who had a previous vaginal delivery (VD) or cesarean delivery (CD) history were considered as two separate study groups, and those who had no previous delivery history were considered as the nulliparous group. In the same period, the groups were formed by including healthy pregnant women, whose gestational age was matched, without obstetric pathology, any maternal medical complication, or autoimmune disorder history. Study groups were further divided into subgroups according to the method and number of deliveries: nulliparous group, single VD group (one VD story), multiple VD group (more than one VD story), single CD group (one CD story), and multiple CD group (more than one CD history). Exclusion criteria have been over 40 years of age, multiple pregnancies, fetal structural and chromosomal anomalies, hypertension, preeclampsia, vascular disease, smoking-alcohol use, heparin or aspirin use, history of uterine surgery other than cesarean section, history of UtA and hypogastric artery ligation, and placental invasion anomalies.

The main data collected for analysis are age and obstetric histories, maternal weight, height and body mass index (BMI), gestational week, UtA PI, PI percentile, PI multiple of the median (MoM), UtA RI and, UtA S/D ratio. The gestational week was calculated according to the last menstrual period of pregnant women or according to fetal ultrasonography measurements in the first trimester for those who did not recall the last menstrual period.

Measurements

UtA Doppler ultrasonography evaluations were performed by a single Gynecology and Obstetrics Specialist (YD) who received training and had proven experience in fetal Doppler sonography. A Samsung HS60 ultrasound machine (SAMSUNG MEDISON CO., LTD. Seoul, Korea) with a 2–5 Mhz convex probe was used for all measurements. Doppler measurements were carried out according to The International Society of Ultrasound in Obstetrics and Gynecology (ISUOG) guidelines (5). For UtA Doppler sonography, a midsagittal section of the uterus and cervical canal was taken and the transducer was moved laterally up to the point that paracervical veins were visible. UtA's were defined as crossing with the external iliac artery. The insonation angle was set to zero degrees or the minimum (<30 degrees) if it could not be adjusted at zero degrees. UtA Doppler indices were measured on both sides just proximal to the point where UtA's prominently intersect with the external iliac artery. Both UtA PI values were calculated using the software package in the ultrasonography device, and then the average UtA PI value was determined. Both UtA RI and, S/D ratio were calculated with the same method and their average values were taken (Figure 1). PI MoM (patient's PI values/median PI values based on gestational age) values were calculated for each patient to standardize the difference between weeks of gestation.[13]

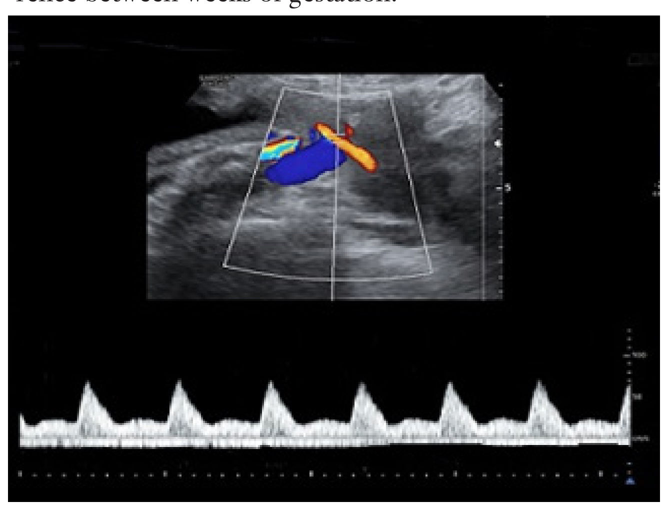

Fig 1. Uterine artery Doppler sonography. Doppler sonography of the crossing of the uterine artery with the iliac artery in transabdominal ultrasonography and uterine artery wave pattern

Statistical analysis

Statistical Package for the Social Sciences (Version 22, SPSS Inc., Chicago, IL, USA) was used to analyze the data. Kolmogorov–Smirnov test, Shapiro–Wilk test and histograms were used to evaluate the normality of distributions. In the analysis of the data, the mean and standard deviation, median, minimum, and maximum values of the characteristics were used while performing the continuous data statistics. One Way ANOVA and Kruskal Wallis test statistic were used to compare independent group means. If a difference was determined between the averages in group measurements, pairwise comparisons were evaluated with the Bonferroni-corrected Mann-Whitney U test and the post-hoc Bonferroni test. Regression analysis was performed to determine the effects on the UtA RI variable. The statistical significance level was taken as p<0.05.

Results

Three hundred pregnant women who met the inclusion and exclusion criteria were included in the study. 107 pregnant women who did not give birth before (nulliparous group), 80 pregnant women with a history of VD (VD group), and 113 pregnant women with a history of CD (CD group) were compared.

According to the comparison of the sociodemographic data of the groups according to the delivery methods (Table 1), the difference between the average maternal age of the groups was statistically significant (p = 0.001). The average age of the nulliparous group (26.64±4.48) was lower than the average age of the VD group (29.64±5.08) and CD group (30.65±5.18), and this difference was statistically significant in the subgroup analysis (p values 0.001, 0.001, respectively). The gravida median value of the nulliparous group was found to be (1, 1–4), and the gravida median value of the VD group and CD group was found to be (3, 2–6). This difference is statistically significant (p = 0.001). In the subgroup analysis, it is the nulliparous group that makes the significant difference (p values 0.001, 0.001, respectively). The parity median value of the nulliparous group was found to be (0, 0–0), and the parity median value of the ND group and CD group was found to be (1, 1–5). This difference is statistically significant (p = 0.001). In the subgroup analysis, it is the nulliparous group that makes the significant difference (p values 0.001, 0.001, respectively). There was no statistically significant difference between the groups in terms of abortion numbers (p = 0.792). Based on the comparison of maternal body weight, the average of the nulliparous group was 65.79±11.70, the average of the VD group was 69.86±12.08, and the average of the CD group was 70.01±12.88. Body weight was less in the nulliparous group than in the other groups. This difference is statistically significant (p = 0.020). In the subgroup analysis, the difference between the nulliparous group and the CD group was found to be statistically significant (p = 0.033). There was no statistically significant difference between the groups in terms of maternal height (p = 0.489). In terms of the average BMI, the average of the nulliparous group was 25.03±4.59, the average of the VD group was 26.56±4.38, and the average of the CD group was 26.57±4.50. BMI was lower in the nulliparous group compared to the other groups. This difference is statistically significant (p=0.019). In the subgroup analysis, the difference between the nulliparous group and the CD group was found to be statistically significant (p = 0.035). The average weeks of gestation were similar between the groups, and the difference was not statistically significant (p = 0.285).

Table 1. Comparison of the sociodemographic data of the groups according to the delivery methods

	Nulliparous group(n=107)	VD group(n=80)	CD group(n=113)	P value
Age (year)	26.64 ± 4.48	29.64 ± 5.08	30.65 ± 5.18	**0.001[a]**
Gravidity	1 (1 – 4)	3 (2 – 6)	3 (2 – 6)	**0.001[b]**
Parity	0 (0 – 0)	1 (1 – 5)	1 (1 – 5)	**0.001[b]**
Abortion	0 (0 – 3)	0 (0 – 3)	0 (0 – 3)	0.792[b]
Weight (kg)	65.79 ± 11.70	69.86 ± 12.08	70.01 ± 12.88	**0.020[a]**
Height (cm)	161.39 ± 5.39	162.23 ± 6.03	162.24 ± 6.06	0.489[a]
BMI (kg/m^2)	25.03 ± 4.59	26.56 ± 4.38	26.57 ± 4.50	**0.019[a]**
Gestational week	20.96 ± 1.02	21.05 ± 1.10	20.82 ± 1.01	0.285[a]

Abbreviations: kg, kilogram; cm, centimeter; kg/m^2, kilogram/square meter; [a]One way ANOVA (mean ± SD), bonferroni post hoc test in subgroup analysis; [b]Kruskal - Wallis test [median (min-max)], Mann Whitney U test with bonferroni correction in subgroup analyzes; Significant at the p<0.05 level. Bold p values indicate statistically significant.

Based on the comparison of the UtA Doppler parameters of the groups according to the delivery methods (Table 2), the average of the UtA PI of the nulliparous group was 1.02±0.34, the average of the UtA PI of the VD group was 1.06±0.28, and the average of the CD group was 1.11±0.43. This difference was not statistically significant (p = 0.191). Once UtA PI percentiles were compared among the groups, the UtA PI percentile value of the nulliparous group was 35 (1–100), the UtA PI percentile value of the VD group was 46.5 (1–96), and the UtA PI percentile value of the CD group was 47 (1–100). This difference was not statistically significant (p = 0.374). The average UtA PI MoM of the nulliparous group was 0.96±0.32, the average of the UtA PI MoM of the VD group was 1.01±0.27, and the average of the CD group was 1.03±0.39, and the difference was not statistically significant (p = 0.284). Once the average UtA RI of the groups were compared, the average of the nulliparous group was determined as 0.58±0.10, the average of the UtA RI of the VD group was determined as 0.61±0.11, and the average of the CD group was determined as 0.65±0.23. This difference is statistically significant (p = 0.010). UtA RI value was lower in the nulliparous group than in the other groups. In the subgroup analysis, the difference between the nulliparous group and the CD group was statistically significant (p = 0.008). Once the average UtA S/D values were compared, the average UtA S/D value of the nulliparous group was 2.51±0.72, the average of the UtA S/D value of the VD group was 2.69±0.76, and the average of the UtA S/D value of the CD group was 2.66 ± 0.70. This difference was not statistically significant (p = 0.152).

Table 2. Comparison of the uterine artery Doppler parameters of the groups according to the delivery methods

	Nulliparous roup (n=107)	VD group (n=80)	CD group (n=113)	P value
UtA PI	1.02 ± 0.34	1.06 ± 0.28	1.11 ± 0.43	0.191 [a]
UtA PI percentile	35 (1 – 100)	46.5 (1 – 96)	47 (1 – 100)	0.374[b]
UtA PI MoM	0.96 ± 0.32	1.01 ± 0.27	1.03 ± 0.39	0.284 [a]
UtA RI	0.58 ± 0.10	0.61 ± 0.11	0.65 ± 0.23	**0.010** [a]
UtA S/D value	2.51 ± 0.72	2.69 ± 0.76	2.66 ± 0.70	0.152 [a]

Abbreviations: PI, pulsatility index; MoM, multiple of median; RI, resistance index; S/D, systole/diastole ratio; [a]One way ANOVA (mean ± SD), bonferroni post hoc test in subgroup analysis; [b] Kruskal - Wallis test [median (min-max)], Mann Whitney U test with bonferroni correction in subgroup analyzes; Significant at the p<0.05 level. Bold p values indicate statistically significant.

When comparing the UtA Doppler parameters of the groups according to the method and number of deliveries (Table 3), the UtA PI value differed significantly between the groups (p = 0.013). The PI value was higher in the multiple VD group and the multiple CD group than in the other groups. According to the subgroup analysis, significant differences were determined, particularly between the nulliparous group and multiple CD groups (p = 0.023) and between the single VD group and multiple CD groups (p = 0.044). The UtA PI percentile value also differed significantly between the groups (p = 0.041). Significant differences were determined, especially between the nulliparous group and single CD groups, between the nulliparous group and multiple CD groups, and between single VD group and multiple VD groups (p values of 0.020, 0.043, and 0.032, respectively). UtA PI MoM value differed significantly between groups (p = 0.016). In the subgroup analysis, the difference was determined between the nulliparous group and the multiple CD groups, and the difference was statistically significant (p = 0.045). The UtA RI value demonstrated a statistically significant difference between the groups (p = 0.001). The UtA RI value was higher in the multiple CD group. For UtA RI value, it was the values between the multiple CD group and the nulliparous group, the single VD group, and the single CD group that created a statistically significant difference in the subgroup analysis (p values were 0.001, 0.009, and 0.003, respectively). The UtA S/D value differed significantly between the groups (p = 0.019). The S/D value was higher in the multiple VD group and multiple CD group. In subgroup analysis, between the nulliparous group and multiple VD group (p = 0.006), between the nulliparous group and multiple CD group (p = 0.019), between the single VD group and multiple VD group (p = 0.025), and between the single VD group and single CD group (p = 0.033), a significant difference was determined.

According to the results of the regression analysis of the effects on the UtA RI variable (Table 4), the variables of maternal age, gravida, BMI, and gestational week did not have a statistically significant effect on the dependent variable (recorded as p=0.099, p=0.325, p=0.612, p=0.306, respectively). However, the parity variable has a statistically significant effect (p = 0.007). These results indicate that the effects of maternal age, gravida, BMI, and gestational week variables on the estimation of the dependent variable examined are weak. However, the parity variable can play an essential role in estimating the dependent variable.

Table 3. Comparing the uterine artery Doppler parameters of the groups according to the method and number of delivery

	Nulliparous group(n=107)	Single VD group(n=39)	Multiple VD group(n=41)	Single CD group(n=69)	Multiple CD group (n=44)	P value
UtA PI	1.02±0.34	0.99±0.25	1.13±0.29	1.04±0.37	1.22±0.50	**0.013[a]**
UtA PI percentile	35 (1 – 100)	43 (1 – 93)	55 (1 – 96)	40 (1 – 100)	53 (1 – 100)	**0.041[b]**
UtA PI MoM	0.96±0,32	0.94±0,25	1.07±0.27	0.97±0,34	1.13±0.45	**0.016[a]**
UtA RI	0.58±0.10	0.60±0.11	0.63±0.11	0.60±0.14	0.71±0.31	**0.001[a]**
UtA S/D value	2.51±0.72	2.51±0.60	2.87±0.86	2.57±0.66	2.81±0.74	**0.019[a]**

Abbreviations: PI, pulsatility index; MoM, multiple of median; RI, resistance index; S/D, systole/diastole ratio; [a]One way ANOVA (mean ± SD), bonferroni post hoc test in subgroup analysis; [b] Kruskal - Wallis test [median (min-max)], Mann Whitney U test with bonferroni correction in subgroup analyzes; Significant at the p<0.05 level. Bold p values indicate statistically significant.

Table 4. Effects on the uterine artery RI variable: Regression Analysis

Independent variable	B Coefficient	p value	95% Confidence Interval (Lower Bound)	95% Confidence Interval (Upper Limit)
Constant	0.718	0.000	0.322	1.114
Age (year)	0.003	0.099	-0.001	0.007
Gravidity	-0.015	0.325	-0.045	0.015
Parity	0.048	0.007	0.013	0.083
BMI (kg/m²)	-0.001	0.612	-0.005	0.003
Gestational week	-0.009	0.306	-0.026	0.00

Abbreviations: kg/m^2, kilogram/square meter; B Coefficient, Standardized Coefficients Beta; Significant at the p<0.05 level. Bold p values indicate statistically significant.

Discussion

It is acknowledged that the method and number of birth cause changes in uterine anatomy and vascular structures. Such changes are likely to cause changes in the UtA current. Studies evaluating uteroplacental circulation in pregnancy are available in the literature. However, there is no study available in the literature investigating the effects of more than one cesarean section and vaginal delivery and the number of deliveries on uterine artery Doppler parameters. In our study, it was found that the UtA RI value was higher in those with a history of CD, and as the number of VD and CD increased, other parameters (UtA S/D and UtA PI) also increased.

There are a number of studies in the literature on how UtA Doppler parameters change in pregnant women with or without a history of CD. There are conflicting results in these studies. In a study, UtA PI values were found to be similar between pregnant women with and without CD at 22 to 24 weeks of gestation period. However, UtA RI values were significantly higher in the CD group.[14] In the study conducted by Yapan et al., UtA PI MoM, UtA RI MoM, and UtA S/D MoM values were compared in pregnant women with and without CD, and it was observed that there was no significant change between the groups.[15] According to a study that included 153 pregnant women between their 18 and 24 weeks of the gestation period, UtA PI MoM values were significantly higher in the CD group. There was no significant difference between the groups in UtA mean PI, RI, and S/D values .[16] However, in the study conducted by Torabi et al., UtA PI value was significantly higher in the CD group compared to pregnant women with a history of VD.[13]

In our study, the RI value of UtA Doppler parameters was found to be higher in the CD group than in the nulliparous and VD groups, and other indices were similar. It was determined that there was no difference in indices between the nulliparous and VD groups. The groups were also compared according to the method and number of births. We determined that the mean UtA PI values were significantly higher in the multiple CD group compared to the nulliparous and single ND groups. UtA PI values were similar in those with one or more CDs and those with more than one VD. We determined that the UtA PI percentile value was significantly higher in those with a history of more than one VD or CD compared to nulliparous. We observed that the CD number and UtA PI percentile value did not change, but changed significantly as the VD number increased. The UtA PI MoM value was significantly higher in patients with a history of multiple CDs compared to nulliparous groups and was similar in other groups. Those with a history of multiple CDs had a significantly higher UtA RI compared to those with a history of one VD or CD. UtA RI value was similar in those with a history of more than one VD or CD. We found that the UtA S/D value increased in those with a history of more than one VD or CD, and this increase was significant compared to nulliparous patients. We observed that the type and number of delivery affect the second-trimester UtA Doppler indexes. These findings suggest that there may be some permanent changes in UtA after pregnancy and that these changes may alter uteroplacental flow in subsequent pregnancies. We think that parity and mode of delivery should also be taken into consideration when evaluating UtA Doppler parameters used in screening for the risk of preeclampsia and fetal growth restriction.

In our study, we determined that the UtA Doppler indices changed as the number of CDs increased. In the regression analysis performed to determine the variable that has an effect on UtA RI, we found that parity had a significant effect. Studies investigating the effect of parity on UtA Doppler parameters are also available in the literature. In a study, a strong positive correlation was determined between parity and UtA PI, and a slight positive correlation with RI was specified.[11] In the study conducted by Prefumo et al., it was concluded that parity had a significant effect on UtA RI and wave forms.[12] There are studies in the literature demonstrating that parity does not affect UtA Doppler parameters. In a study including 1102 pregnant women, it was observed that the UtA PI value was similar in the first and second pregnancies.[17] In the study of Göynümer et al., nulliparous women and women who gave birth previously were compared, and a significant decrease was found in UtA PI values between 19 and 24 weeks of gestation. However, parity did not affect the average UtA PI.[10]

The limitations of our study are related to its retrospective design and the inability to compare with the first and third-trimester UtA Doppler indices. Although it seems like a weakness of the study that it is single-centered and cannot be compared with pregnant women from different regions, it eliminates the differences due to Doppler measurements. The fact that the UtA PI reference values can vary according to the societies may be the weakness of the study. The strengths of the study are that the study was carried out in a tertiary center and Doppler measurements were made by a single sonographer. The coherence of sample size is another strength of the study.

Conclusion

In our study, we found that UtA Doppler parameters changed particularly among women with a history of more than one CD, and these parameters could also change in those with a history of more than one VD. It does not lead to the conclusion that these changes can completely affect the current pregnancy negatively. However, further prospective studies, including other possible risk factors, may be useful to confirm these results.

References

1. Jurkovic D, Jauniaux E, Kurjak A, Hustin J, Campbell S, Nicolaides KH. Transvaginal color Doppler assessment of the uteroplacental circulation in early pregnancy. Obstet Gynecol. 1991;77(3):365-9.
2. Albaiges G, Missfelder-Lobos H, Lees C, Parra M, Nicolaides KH. One-stage screening for pregnancy complications by color Doppler assessment of the uterine arteries at 23 weeks' gestation. Obstet Gynecol. 2000;96(4):559-64. [PubMed][CrossRef]
3. Gómez O, Martínez JM, Figueras F, Del Río M, Borobio V, Puerto B, et al. Uterine artery Doppler at 11-14 weeks of gestation to screen for hypertensive disorders and associated complications in an unselected population. Ultrasound Obstet Gynecol. 2005;26(5):490-4.[PubMed][CrossRef]
4. Papageorghiou AT, Yu CK, Bindra R, Pandis G, Nicolaides KH. Multicenter screening for pre-eclampsia and fetal growth restriction by transvaginal uterine artery Doppler at 23 weeks of gestation. Ultrasound Obstet Gynecol. 2001;18(5):441-9. [PubMed][CrossRef]
5. Bhide A, Acharya G, Baschat A, Bilardo CM, Brezinka C, Cafici D, et al. ISUOG Practice Guidelines (updated): use of Doppler velocimetry in obstetrics. Ultrasound Obstet Gynecol. 2021;58(2):331-9. [PubMed][CrossRef]
6. Cavazza S, Rainaldi MP, Adduci A, Palareti G. Thromboprophylaxis following cesarean delivery: one site prospective pilot study to evaluate the application of a risk score model. Thromb Res. 2012;129(1):28-31.[PubMed][CrossRef]
7. Silver RM. Implications of the first cesarean: perinatal and future reproductive health and subsequent cesareans, placentation issues, uterine rupture risk, morbidity, and mortality. Semin Perinatol. 2012;36(5):315-23. [PubMed][CrossRef]
8. Tekay A, Jouppila P. A longitudinal Doppler ultrasonographic assessment of the alterations in peripheral vascular resistance of uterine arteries and ultrasonographic findings of the involuting uterus during the puerperium. Am J Obstet Gynecol. 1993;168(1 Pt 1):190-8. [PubMed][CrossRef]
9. Nakai Y, Imanaka M, Nishio J, Maeda T, Ozaki A, Sun TT, et al. Uterine blood flow velocity waveforms during early postpartum course following caesarean section. Eur J Obstet Gynecol Reprod Biol. 1997;74(2):121-4. [PubMed][CrossRef]
10. Goynumer G, Yayla M, Arisoy R, Durukan B. The effect of parity on midgestational uterine artery Doppler findings in uncomplicated and low-risk pregnancies. Gynecol Obstet Invest. 2009;68(3):191-5. [PubMed][CrossRef]
11. Oloyede OA, Iketubosin F. Uterine artery Doppler study in second trimester of pregnancy. Pan Afr Med J. 2013;15:87. [CrossRef]

12. Prefumo F, Bhide A, Sairam S, Penna L, Hollis B, Thilaganathan B. Effect of parity on second-trimester uterine artery Doppler flow velocity and waveforms. Ultrasound Obstet Gynecol. 2004;23(1):46-9. [PubMed][CrossRef]
13. Torabi S, Sheikh M, Fattahi Masrour F, Shamshirsaz AA, Bateni ZH, Nassr AA, et al. Uterine artery Doppler ultrasound in second pregnancy with previous elective cesarean section(). J Matern Fetal Neonatal Med. 2019;32(13):2221-7. [PubMed][CrossRef]
14. Flo K, Widnes C, Vårtun Å, Acharya G. Blood flow to the scarred gravid uterus at 22-24 weeks of gestation. Bjog. 2014;121(2):210-5. [PubMed][CrossRef]
15. Yapan P, Tachawatcharapunya S, Surasereewong S, Thongkloung P, Pooliam J, Poon LC, et al. Uterine artery Doppler indices throughout gestation in women with and without previous Cesarean deliveries: a prospective longitudinal case-control study. Sci Rep. 2022;12(1):20913. [PubMed][CrossRef]
16. Işıkalan MM, Yeniçeri H, Toprak E, Güleroğlu FY, Acar A. Effect of previous cesarean sections on second-trimester uterine artery Doppler. J Obstet Gynaecol Res. 2020;46(9):1766-71. [PubMed][CrossRef]
17. Hafner E, Schuchter K, Metzenbauer M, Philipp K. Uterine artery Doppler perfusion in the first and second pregnancies. Ultrasound Obstet Gynecol. 2000;16(7):625-9. [PubMed][CrossRef]