

Comparison of Umbilical and Uterine Artery Doppler Indices with Placental Shear Wave Elastography and Superb Microvascular Imaging Findings in Pregnancies Beyond 20 Weeks: A Retrospective Study

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Abstract

Objectives: Placental insufficiency is closely associated with alterations in the uterine and umbilical artery (UA) waveforms, which are considered early indicators of impaired placental function and underscore the clinical importance of obstetric Doppler ultrasonography. However, conventional Doppler ultrasonography provides limited information regarding placental morphology and microvascular alterations. Recent advances in ultrasound technology have introduced shear wave elastography (SWE) and superb microvascular imaging (SMI) as promising non-invasive techniques for assessing placental stiffness and microvascular architecture. This study aimed to investigate the relationship between obstetric Doppler indices and placental SWE and SMI measurements.

Methods: This retrospective study included 66 pregnant women aged ≥ 18 years with gestational age ≥ 20 weeks and anterior placental localization. Placental stiffness (kilopascals) was measured using SWE, while the vascular index (%) was obtained using SMI from both central and peripheral placental regions. The associations between Doppler indices and imaging parameters were analyzed.

Results: Significant negative correlations were identified between uterine and UA Doppler indices and placental SMI measurements obtained from both central and peripheral regions. In addition, significant differences were observed in central SMI ($p=0.027$) and peripheral SMI ($p=0.012$) according to subcutaneous adipose tissue thickness. Comparisons between obese and non-obese pregnant women also demonstrated significant differences in central SWE measurements ($p=0.049$) and peripheral SMI values ($p=0.028$).

Conclusion: These findings suggest that multimodal ultrasonographic evaluation combining grayscale ultrasonography, SWE, SMI, and conventional Doppler ultrasonography may improve placental assessment and contribute to better clinical management of placental insufficiency. Furthermore, SMI may detect placental microvascular alterations earlier than measurable stiffness changes identified by SWE.

Keywords: Obstetric doppler ultrasonography, placenta, superb microvascular imaging, shear wave elastography

Introduction

Accurate assessment of placental health is essential for predicting maternal and fetal complications during pregnancy. Placental insufficiency is strongly associated with adverse obstetric outcomes such as intrauterine growth restriction (IUGR), preeclampsia (PE), and perinatal mortality, highlighting the critical role of Doppler ultrasonography in modern obstetric practice.¹ Doppler evaluation of the uterine artery, umbilical artery (UA), ductus venosus (DV), and

middle cerebral artery (MCA) is widely used to assess fetal-placental hemodynamics and fetal well-being.

In pregnancies complicated by IUGR, UA pulsatility index (PI) values are typically elevated, whereas MCA PI values are reduced, resulting in a decreased cerebroplacental ratio (CPR), which is generally defined as <1.08 or below the 5th percentile.² A reduced CPR is considered an early marker of uteroplacental insufficiency, while absent or reversed end-diastolic flow in the UA and abnormal venous Doppler findings are

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regarded as late-stage signs associated with severe fetal compromise and the need for therapeutic delivery.^{3,4}

Physiologically, increased resistance to flow and early diastolic notching may persist in the uterine arteries until approximately the 24th week of gestation. Therefore, uteroplacental vascular resistance is commonly assessed by the resistance index (RI), PI, and diastolic notching. Following the second trimester, uterine artery PI values greater than 1.45 and RI values above 0.58 are considered pathological and have been associated with an increased risk of PE and IUGR.^{5,6} Among Doppler parameters, elevated RI values are considered among the most reliable indicators of IUGR in high-risk pregnancies.

Although obstetric Doppler ultrasonography has long been accepted as the standard imaging modality for evaluating placental perfusion, its ability to assess placental microvascularization and tissue characteristics remains limited. In recent years, advances in ultrasound technology have introduced novel non-invasive imaging techniques such as shear wave elastography (SWE) and superb microvascular imaging (SMI), which provide additional information regarding placental structure and function. SWE quantitatively evaluates tissue stiffness, whereas SMI enables detailed visualization of low-velocity microvascular blood flow.

Over the last decade, several studies have investigated placental elasticity using SWE in both healthy pregnancies and pregnancies complicated by PE, gestational diabetes mellitus (GDM), and IUGR.⁷⁻¹¹ These studies consistently demonstrated a significant increase in placental stiffness in pathological pregnancies compared with healthy controls, suggesting that placental elasticity may reflect underlying pathological changes.

Conventional Doppler ultrasonography has limitations in detecting low-velocity blood flow in small-caliber vessels because wall filters suppress low-frequency signals to eliminate motion artifacts from surrounding tissues.¹² SMI (SMI; Canon Medical Systems, Otawara, Japan) is an advanced Doppler-based imaging technique capable of separating true blood flow signals from tissue motion artifacts, thereby enabling high-resolution visualization of microvascular structures and slow blood flow.¹³ SMI has already shown promising results in the assessment of microvascular perfusion in various glandular tissues, including the breast.¹⁴ Furthermore, Sun et al.¹⁵ reported that SMI was superior to conventional color Doppler ultrasonography in detecting low-flow placental vessels and evaluating placental microcirculation.

In light of these findings, the present study aimed to investigate the relationship between conventional obstetric Doppler indices and placental SWE and SMI measurements in pregnancies beyond 20 weeks of gestation.

Methods

Study Design and Patient Population

This retrospective, descriptive study was conducted in the Department of Radiology at Bursa Uludağ University Faculty of Medicine following approval from the Bursa Uludağ University Medical Research Ethics Committee (approval no: 2022-16/43, date: 08.11.2022).

Pregnant women aged 18 years or older who underwent obstetric ultrasonography at Bursa Uludağ University Faculty of Medicine Hospital at a gestational age of 20 weeks or greater between November 1, 2021, and May 1, 2022, were evaluated for study inclusion. During the study period, a total of 250 pregnant women underwent obstetric ultrasonographic examinations, which were retrospectively reviewed.

Grayscale ultrasonographic images archived in the hospital Picture Archiving and Communication System, obstetric Doppler findings including UA and uterine artery Doppler indices, and placental measurements obtained using SWE and SMI techniques were analyzed retrospectively.

Patients were excluded if they were younger than 18 years of age, had a gestational age below 20 weeks, or had fetal congenital anomalies, oligohydramnios, posterior placental localization, a multiple pregnancy, or incomplete or technically inadequate Doppler ultrasonography, SWE, or SMI examinations. Following the application of exclusion criteria, 184 pregnant women were excluded from the study. Consequently, the final study population consisted of 66 pregnant women with anterior placental localization.

Imaging Methods

All ultrasonographic examinations were performed using a Canon Aplio i600 ultrasound system (Canon Medical Systems, USA). Grayscale ultrasonography, color Doppler ultrasonography, spectral Doppler assessment of the uterine and umbilical arteries (UA), and placental SWE were conducted using a 1-6 MHz convex transducer (6C1 probe; Model PVT-375BT, Canon Medical Systems, USA). Placental SMI evaluations were performed using the same ultrasound system equipped with a 5-14 MHz linear transducer (14L5 probe; Model PLT-1005BT, Canon Medical Systems, USA).

All examinations were performed with the pregnant women in the supine position. Initially, grayscale ultrasonographic evaluation of the placenta was performed, including assessment of placental localization, morphology, echogenicity, and the subplacental space. Subsequently, obstetric Doppler ultrasonography was performed.

Doppler Ultrasonography

For uterine-artery Doppler assessment, spectral Doppler measurements were obtained immediately distal to the point at which the uterine artery crossed the external iliac artery (Figure 1). Doppler analysis was performed using three consecutive uniform waveforms selected from a sequence of 5-15 regular cardiac cycles. Bilateral PI and RI values were recorded for analysis.

Subsequently, the placental insertion site of the umbilical cord was identified, and Doppler measurements of the UA were obtained from the segment closest to the insertion site (Figure 2). UA PI and RI values were then recorded.

Shear Wave Elastography

Placental SWE assessment was performed in both the central (defined as within 2 cm of the umbilical cord insertion site) and peripheral placental regions (Figure 3). All SWE examinations were conducted in the transverse plane without applying external compression.

Measurements were obtained using a dual-display mode combining grayscale ultrasonography and elastography imaging. Homogeneous placental areas suitable for analysis were identified on grayscale images prior to elastographic evaluation. Quantitative SWE measurements were then acquired from automatically generated color-coded elastography maps using a standardized 3-mm region of interest (ROI). For each region, four consecutive measurements were obtained, and the arithmetic mean was recorded. Elastography data were expressed in kilopascals (kPa).

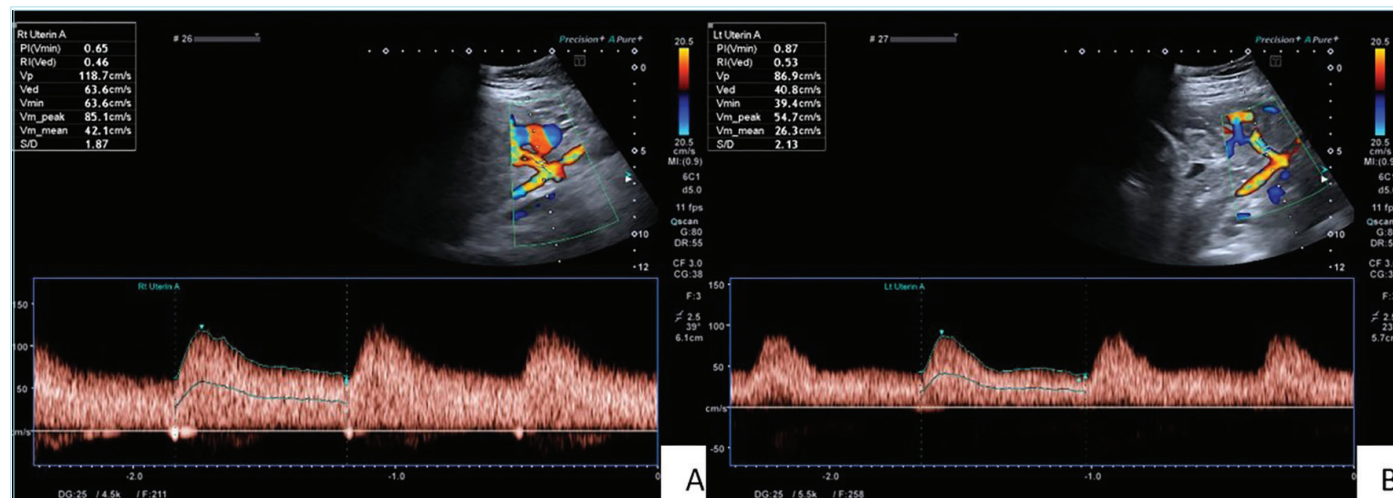


Figure 1. A) Doppler evaluation of the right uterine artery and B) Doppler evaluation of the left uterine artery

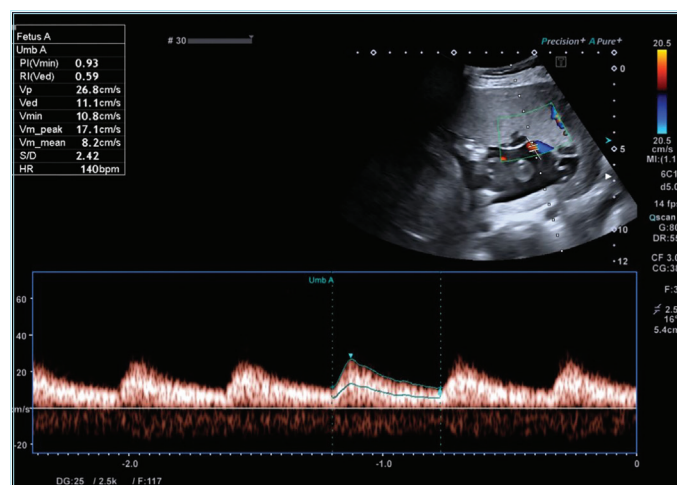


Figure 2. UA Doppler evaluation

UA: Umbilical artery

Superb Microvascular Imaging

Placental SMI assessment was performed using a high-frequency linear transducer. Measurements were obtained from both the central and peripheral placental regions corresponding to the areas evaluated using SWE (Figure 4). Prior to each examination, gain and wall filter settings were standardized to ensure measurement consistency. During image acquisition, patients were instructed to remain motionless to minimize motion artifacts.

Color SMI (cSMI) vascular imaging was performed using the maximum achievable magnification. The ROI was standardized at 0.75 cm², as recommended by the manufacturer. Within the ROI, vascular flow was automatically quantified using the vascular index algorithm in cSMI mode. The vascular index was calculated as the proportion of color signal pixels representing parenchymal blood flow relative to the total number of color and grayscale pixels within the ROI. Vascular index values were expressed as percentages.

For each placental region, four consecutive measurements were obtained, and the arithmetic mean values were recorded for analysis.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics software version 28.0 (IBM Corp., Armonk, NY, USA). The normality of the distribution of continuous variables was assessed using the Shapiro-Wilk test. Variables with normal distribution were expressed as mean $\pm$ standard deviation, whereas non-normally distributed variables were presented as median (minimum-maximum) values.

Comparisons among three independent groups were performed using the Kruskal-Wallis test for non-normally distributed variables. Comparisons between two independent groups were performed using the Independent Samples t-test for normally distributed variables and the Mann-Whitney U test for non-normally distributed variables. Correlations between variables were evaluated using Spearman's correlation analysis. Categorical variables were expressed as frequencies and percentages. A p value < 0.05 was considered statistically significant.

Results

A total of 66 pregnant women were included in the study. The median maternal age was 28 years (range, 18-46 years). All participants had a gestational age of 20 weeks or greater; the median was 22.21 weeks (range, 20.22-28.14 weeks). Only pregnancies with anterior or anterolateral placental localization were included. Placental localization was anterior in 57 cases (86.4%), right anterolateral in 6 cases (9.1%), and left anterolateral in 3 cases (4.5%).

Regarding gravidity, 27 women (40.9%) were in their first pregnancy. Ten patients (15.2%) were in their second pregnancy; 21 (31.8%) in their third; 5 (7.6%) in their fourth; and one patient each (1.5%) in their fifth, sixth, and ninth pregnancies. Regarding parity, 31 pregnant women (47.0%) had no previous live births, 18 (27.3%) had one, 15 (22.7%) had two, and 2 (3.0%) had three.

All pregnancies included in the study resulted in live births. Among neonates, 32 (48.5%) were female and 34 (51.5%) were male. The median gestational age at delivery was 38.85 weeks (range, 33.28-41.85 weeks), and the median birth weight was 3250 g (range, 2450-4750 g). Median Apgar scores were 9 (range 7-10) at 1 minute and 10 (range 9-10) at 5 minutes.

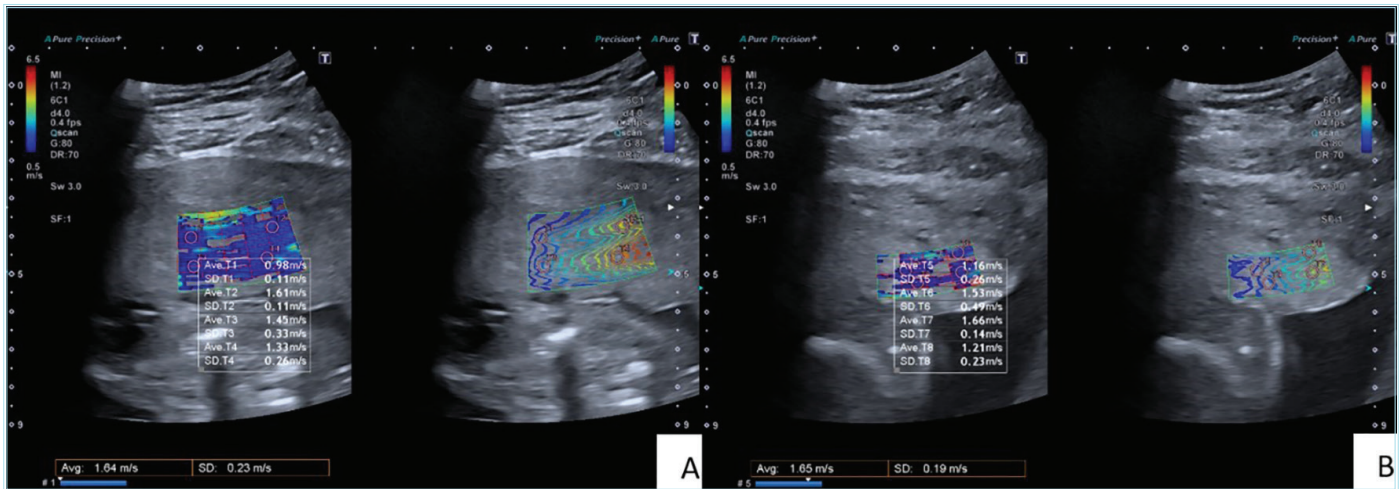


Figure 3. A) Central placenta and B) peripheral placenta SWE evaluation

SWE: Shear wave elastography

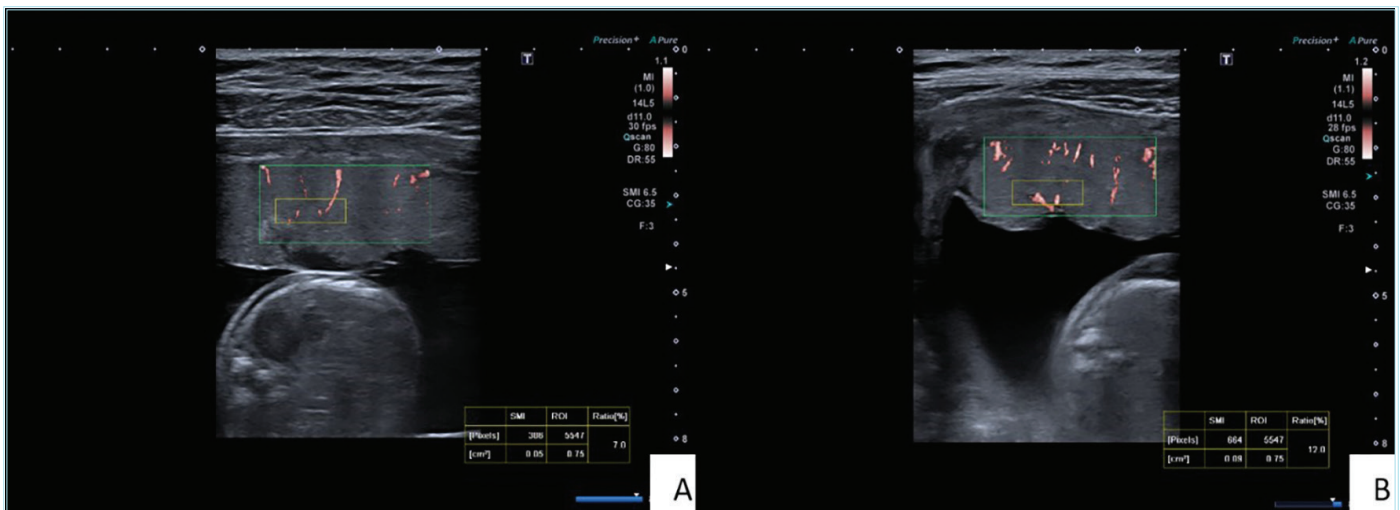


Figure 4. A) Central placenta and B) peripheral placenta SMI evaluation

SMI: Superb microvascular imaging

Thirteen pregnant women (19.7%) with a body mass index (BMI) ≥ 30 kg/m² were classified as obese, while 53 women (80.3%) had a BMI < 30 kg/m². In addition, participants were categorized into three groups according to subcutaneous adipose tissue thickness measured at the level where elastography and SMI assessments were performed (Table 1). Group 1 consisted of 16 pregnant women (24.2%) with subcutaneous adipose tissue thickness between 0-10 mm, Group 2 included 38 women (57.5%) with thickness between 10-20 mm, and Group 3 included 12 women (18.1%) with thickness ≥ 20 mm. The median subcutaneous adipose tissue thickness among all participants was 14 mm (range, 5-35 mm).

It was observed that at least one of the central or peripheral SMI measurements was recorded as "0" in pregnant women classified in Group 3. This finding was attributed primarily to reduced examination sensitivity caused by decreased penetration of high-frequency ultrasound waves as subcutaneous adipose tissue thickness increased, rather than to a direct association between subcutaneous adipose tissue thickness and placental vascularization. Therefore, to minimize the risk of misleading statistical results, SMI measurements obtained from Group 3 were excluded from comparative statistical analyses.

Pairwise comparisons between Group 1 and Group 2 demonstrated significant differences in both central and peripheral SMI measurements ($p=0.027$ and $p=0.012$, respectively).

The mean Doppler ultrasonography measurements were as follows: right uterine artery PI, 0.95 ± 0.33 ; right uterine artery RI, 0.55 ± 0.10 ; left uterine artery PI, 0.97 ± 0.29 ; left uterine artery RI, 0.55 ± 0.09 ; UA PI, 1.07 ± 0.18 ; and UA RI, 0.65 ± 0.06 .

The median SWE value measured from the central placental region was 6.15 kPa (range, 2.40-40.00 kPa), whereas the median peripheral SWE value was 6.95 kPa (range, 2.20-86.30 kPa). The median of the mean placental SWE values was 6.40 kPa (range, 2.30-19.70 kPa). Median SMI measurements were 5.65% (range, 0.1-19.70%) in the central placental region and 3.60% (range, 0.1-15.80%) in the peripheral placental region.

Correlation analyses demonstrated significant negative correlations between Doppler indices and placental SMI measurements. A significant negative correlation was observed between right uterine artery PI and peripheral SMI values ($r=-0.332$, $p=0.014$). Right uterine artery RI values showed significant negative correlations with both central

Table 1. Comparison based on fat tissue thickness (FTT)

Variables	FTT ≤10 mm (n=16)	FTT >10-20 mm (n=38)	FTT >20 mm (n=12)	p value
PI right uterine artery	0.87 (0.47-1.86)	0.90 (0.34-1.99)	0.84 (0.65-1.32)	0.603 ^a
RI right uterine artery	0.53 (0.34-0.72)	0.56 (0.26-0.79)	0.51 (0.44-0.67)	0.405 ^a
PI left uterine artery	0.87 (0.62-1.58)	0.92 (0.48-1.79)	1.00 (0.60-1.72)	0.341 ^a
RI left uterine artery	0.53 (0.39-0.74)	0.56 (0.37-0.80)	0.59 (0.43-0.73)	0.158 ^a
PI umbilical artery	1.05 (0.66-1.48)	1.12 (0.77-1.55)	0.99 (0.70-1.34)	0.064 ^a
RI umbilical artery	0.63 (0.48-0.78)	0.66 (0.55-0.83)	0.62 (0.51-0.76)	0.146 ^a
Central elastography (kPa)	5.70 (2.40-21.20)	6.30 (2.40-40.00)	7.30 (2.60-9.70)	0.587 ^a
Peripheral elastography (kPa)	5.00 (2.20-9.90)	6.50 (2.60-86.30)	7.80 (4.60-11.80)	0.102 ^a
Average elastography (kPa)	5.20 (2.30-14.60)	6.40 (3.00-63.20)	7.30 (5.20-10.80)	0.161 ^a
Central SMI (vascular index)	7.20 (4.00-19.40)	6.05 (0.10-19.70)	0 (0-13.30)	0.027 ^b
Peripheral SMI (vascular index)	6.70 (1.80-15.80)	3.65 (0.10-14.80)	0 (0-1.90)	0.012 ^b

Data are presented as median (minimum-maximum). ^a: Obtained from Kruskal-Wallis test comparing all three groups (FTT ≤10 mm vs. FTT >10-20 mm vs. FTT >20 mm). ^b: Obtained from Mann-Whitney U test performing pairwise comparison strictly between the FTT ≤10 mm and FTT >10-20 mm groups. SMI measurements for the FTT >20 mm group were excluded from this specific statistical comparison due to technical ultrasound penetration limitations in obese patients. Statistically significant p values (<0.05) are highlighted in bold

FTT: Fat tissue thickness, PI: Pulsatility index, RI: Resistance index, kPa: Kilopascals, SMI: Superb microvascular imaging

Table 2. Correlation between uterine artery and UA Doppler indices and elastography and SMI measurements

		Central elastography (kPa)	Peripheral elastography (kPa)	Average elastography (kPa)	Central SMI (vascular index)	Peripheral SMI (vascular index)
PI right uterine artery	r	0.236	-0.123	0.161	-0.219	-0.332
	p value	0.056	0.324	0.244	0.112	0.014
RI right uterine artery	r	0.201	-0.056	0.155	-0.273	-0.330
	p value	0.145	0.689	0.263	0.046	0.015
PI left uterine artery	r	0.112	-0.112	0.036	-0.209	-0.351
	p value	0.418	0.422	0.794	0.129	0.009
RI left uterine artery	r	0.151	-0.036	0.102	-0.230	-0.396
	p value	0.275	0.796	0.464	0.094	0.003
PI umbilical artery	r	0.032	-0.119	-0.035	-0.409	-0.375
	p value	0.817	0.393	0.800	0.002	0.005
RI umbilical artery	r	-0.093	-0.121	-0.108	-0.393	-0.319
	p value	0.504	0.382	0.439	0.003	0.019

PI: Pulsatility index, RI: Resistance index, kPa: Kilopascals, SMI: Superb microvascular imaging, UA: Umbilical artery

and peripheral SMI measurements (central SMI: $r=-0.273$, $p=0.046$; peripheral SMI: $r=-0.330$, $p=0.015$). Similarly, left uterine artery PI ($r=-0.351$, $p=0.009$) and RI ($r=-0.396$, $p=0.003$) values were negatively correlated with peripheral SMI measurements.

In addition, UA PI values demonstrated significant negative correlations with both central and peripheral SMI measurements (central $r=-0.409$, $p=0.002$; peripheral $r=-0.375$, $p=0.005$). UA RI values were also negatively correlated with central SMI ($r=-0.393$, $p=0.003$) and peripheral SMI ($r=-0.319$, $p=0.019$). No significant correlations were identified between central, peripheral, or mean SWE measurements and uterine or UA Doppler indices (Table 2).

Pregnant women with a BMI ≥ 30 kg/m² were classified as obese. Doppler ultrasonography, SWE, and SMI measurements were compared between obese and non-obese participants. A statistically significant difference in central SWE measurements was observed between the two groups ($p=0.049$). Although no significant difference was identified in central SMI values between obese and non-obese pregnant women ($p=0.954$),

peripheral SMI measurements differed significantly between the groups ($p=0.028$). No statistically significant differences were found in the uterine artery and UA Doppler indices, peripheral SWE measurements, or mean SWE values.

Correlation analysis demonstrated a significant negative relationship between gestational age and both the right uterine artery PI ($r=-0.263$, $p=0.033$) and RI ($r=-0.269$, $p=0.029$). Similarly, gestational age showed a significant negative correlation with left uterine artery PI values ($r=-0.262$, $p=0.034$). However, no significant correlation was observed between gestational age and the left uterine artery RI values ($r=-0.214$, $p=0.084$). In addition, no significant correlations were identified between gestational age and UA PI or RI values.

No significant association was found between gestational age and central, peripheral, or mean SWE measurements. A significant positive correlation was observed between gestational age and peripheral SMI measurements ($r=0.365$, $p=0.003$), whereas central SMI values were not significantly associated with gestational age ($r=0.179$, $p=0.151$).

Birth weight demonstrated significant negative correlations with right uterine artery PI ($r=-0.246$, $p=0.046$), right uterine artery RI ($r=-0.283$, $p=0.021$), left uterine artery PI ($r=-0.338$, $p=0.005$), and left uterine artery RI ($r=-0.310$, $p=0.011$). However, no significant correlations were identified between birth weight and UA PI, UA RI, central SWE, peripheral SWE, mean SWE, central SMI, or peripheral SMI measurements.

Discussion

Obstetric Doppler ultrasonography is widely used in clinical practice for the assessment of placental insufficiency. In general, elevated PI and RI values reflect increased vascular resistance, whereas lower values indicate reduced vascular resistance within the placental circulation.¹ Histopathological studies in pregnancies complicated by PE and GDM have demonstrated intervillous thrombosis, inflammatory changes within the placental vascular bed, arterial narrowing secondary to sclerotic alterations, and areas of placental infarction.¹⁶⁻²⁰ These pathological alterations lead to impaired placental vascularization, while inflammation-related extracellular matrix accumulation contributes to increased placental stiffness and reduced tissue elasticity.²¹

Several previous studies have investigated the relationship between placental elastography findings and Doppler ultrasonography parameters. Cimsit et al.²² reported a correlation between strain elastography (SE) findings and uterine artery notching, suggesting that elastographic changes may serve as a positive predictive factor for PE. Similarly, Kılıç et al.⁸ demonstrated a weak correlation between uterine artery RI and PI values and placental SE measurements in patients with PE. Ertekin et al.²³ reported an inverse correlation between SE measurements and UA RI values. In contrast, Akbas et al.¹⁰ observed a positive correlation between point SWE (pSWE) values and uterine artery as well as AU RI and PI indices in pregnancies complicated by IUGR, suggesting that increased placental stiffness and elevated vascular resistance may represent different manifestations of the same underlying pathophysiological process.

In the present study, however, no significant correlation was identified between SWE measurements and uterine or UA Doppler indices. This discrepancy may be explained by differences in patient populations, gestational ages, ultrasound techniques, or by the relatively small number of pathological pregnancies included in our cohort.

Previous studies by Kılıç et al.⁸, Akbas et al.¹⁰, and Arioğlu Habibi et al.¹¹ demonstrated a significant negative correlation between placental SWE values and birth weight. Although our study similarly demonstrated significant negative correlations between birth weight and uterine artery Doppler indices, no significant relationships were observed between birth weight and the central, peripheral, or mean SWE measurements. These findings may indicate that Doppler parameters are more sensitive than placental stiffness measurements in reflecting fetal growth impairment in relatively low-risk populations.

Altunkeser et al.⁷ reported significant associations between two-dimensional SWE measurements and maternal age and BMI, whereas no significant relationship was found with gravidity, parity, or gestational age. Consistent with these findings, our study demonstrated a significant association between obesity and central SWE measurements; no significant correlations were identified between SWE values and gravidity, parity, or gestational age.

Regarding SMI findings, Sun et al.¹⁵ demonstrated a significant negative correlation between maternal weight and placental SMI measurements.

Placental villous vascularization is largely regulated by vascular endothelial growth factor (VEGF), and previous studies have shown that the syncytiotrophoblast response to VEGF may be impaired in pregnant women with obesity.²⁴ In line with these findings, our results demonstrated a significant negative association between obesity and peripheral SMI measurements, whereas no significant relationship was observed between obesity and central SMI values.

Importantly, our study demonstrated significant negative correlations between uterine and UA Doppler indices and placental SMI measurements. These findings suggest that decreased placental microvascularization may be associated with increased uteroplacental vascular resistance. Furthermore, SMI may detect placental microvascular alterations associated with increased uteroplacental vascular resistance before measurable changes in placental stiffness become apparent on SWE. Therefore, SMI may provide additional information regarding placental microcirculation beyond conventional Doppler ultrasonography.

Study Limitations

The present study has several limitations. First, its retrospective single-center design inherently limits causal interpretation. Second, the number of pregnant women with comorbid conditions was relatively small. In addition, using a high-frequency linear transducer for SMI examinations reduced image penetration and the sensitivity of the examination in patients with excessive subcutaneous adipose tissue thickness or deeply located placentas. Posteriorly located and deeply seated placentas were excluded because optimal ultrasonographic assessment could not be achieved.

Conclusion

The present study demonstrated significant correlations between uterine and UA Doppler indices and placental SMI measurements, suggesting a relationship between placental microvascularization and uteroplacental vascular resistance. Although no significant association was observed between SWE measurements and Doppler indices, optimizing SWE examination protocols and evaluating SWE in larger study populations may yield more reliable and clinically meaningful results. Previous studies have similarly supported the potential value of SWE for placental assessment.

Our findings suggest that a multimodal ultrasonographic evaluation that combines grayscale ultrasonography, SWE, and SMI, and conventional Doppler ultrasonography may improve diagnostic performance in placental assessment and provide additional clinical benefits for patient management in obstetric practice. Furthermore, these findings suggest that SMI may detect placental microvascular alterations earlier than stiffness changes measurable by SWE. Further prospective studies with larger patient cohorts are needed to clarify the clinical utility and reproducibility of these advanced ultrasonographic techniques.

Ethics

Ethics Committee Approval: Approval was obtained from the Bursa Uludağ University Medical Research Ethics Committee (approval no.: 2022-16/43, date: 08.11.2022).

Informed Consent: Because the study was designed retrospectively no written informed consent form was obtained from the patients.

Footnotes

Authorship Contributions

Concept: T.A., N.B.T., Design: T.A., E.K., E.T., Ö.T., Data Collection or Processing: T.A., N.B.T., B.E.G., Analysis or Interpretation: T.A., N.B.T., B.E.G., Literature Search: T.A., N.B.T., B.E.G., Writing: T.A., E.K., E.T., Ö.T.

Conflict of Interest: No conflict of interest was declared by the authors.

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