Chron Precis Med Res 2023; 4(3): 226-231
DOI: 10.5281/zenodo.10018911

ORIGINAL ARTICLE
ORİJİNAL ARAŞTIRMA

Evaluation of Placental Elasticity in Fetuses with Single Umblical Artery

Tek Umblikal Arterli Fetuslerde Plasental Elastisitenin Değerlendirilmesi

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ABSTRACT

Aim: In this study, we aimed to figure out whether there were differences in placental Shear Wave Elastography (SWE) data between isolated instances with a single umbilical artery and pregnancies with healthy pregnancies.

Material and Method: For placental Shear Wave Elastography (SWE) measurements, the study used a Samsung RS80A Prestige 2014 instrument. Fetal biometry, placental assessment, and amniotic fluid analysis were all covered by ultrasound examinations. To lessen the influence of fetal movement, placental SWE values were collected from the thickest non-cord insertion region. The examination included two SWE measurements in each of the three placental portions (inner, middle, and outside). The Thermal and Mechanical Index values were kept under control.

Results: 44 patients were examined in the study, equally divided by the number of umbilical arteries. Biometric measurements and patient characteristics were noted. In terms of sociodemographic characteristics or health, there were no appreciable differences between groups. Shear Wave parameters didn't differ significantly. Notably, placental thickness and Shear Wave Max (SWM) had a negative correlation while fetal weight and Shear Wave Mean (SWF) had a positive correlation. Within the Shear Wave parameters, there were positive correlations.

Conclusion: In terms of sociodemographic characteristics or health, there were no appreciable differences between groups. Notably, placental thickness and SWM had a negative correlation, while fetal weight and SWF had a positive correlation. Within the Shear Wave parameters, there were positive correlations.

Keywords: Fetus, placental elasticity, single umblical artery

ÖZ

Amaç: Bu çalışmada, tek umbilikal arterli izole vakalar ile sağlıklı gebelikler arasında plasental Shear Wave Elastografi (SWE) verilerinde farklılık olup olmadığını ortaya çıkarmayı amaçladık.

Gereç ve Yöntem: Plasental Shear Wave Elastography (SWE) ölçümleri için Samsung RS80A Prestige 2014 cihazı kullanıldı. Fetal biyometri, plasental değerlendirme ve amniyotik sıvı analizinin tümü ultrason muayeneleri kapsamındaydı. Fetal hareketin etkisini azaltmak için plasental SWE değerleri kordun girmediği en kalın bölgeden toplanmıştır. Muayene, üç plasental bölümün (iç, orta ve dış) her birinde iki SWE ölçümünü içeriyordu. Termal ve Mekanik İndeks değerleri kontrol altında tutulmuştur.

Bulgular: Çalışmada 44 hasta incelendi ve umbilikal arter sayısına eşit olarak bölündü. Biyometrik ölçümler ve hasta özellikleri not edildi. Sosyodemografik özellikler veya sağlık açısından gruplar arasında kayda değer bir fark yoktu. Shear Wave parametreleri anlamlı farklılık göstermedi. Özellikle, plasental kalınlık ve Shear Wave Max (SWM) negatif korelasyona sahipken, fetal ağırlık ve Shear Wave Mean (SWF) pozitif korelasyona sahipti. Shear Wave parametreleri içinde, arasında pozitif korelasyonlar vardı.

Sonuç: Sosyodemografik özellikler veya sağlık açısından gruplar arasında kayda değer bir fark yoktu. Özellikle, plasental kalınlık ve SWM negatif korelasyona sahipken, fetal ağırlık ve SWF pozitif korelasyona sahipti. Shear Wave parametreleri arasında pozitif korelasyon vardı.

Anahtar Kelimeler: Fetüs, plasental elastikiyet, tek umblikal arter

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Başvuru Tarihi/Received: 23.08.2023
Kabul Tarihi/Accepted: 23.09.2023

INTRODUCTION

The umbilical cord, also known as the navel string, birth cord, or funiculus umbilicalis, serves as a connection between the growing embryo or fetus and the placenta in placental animals. The umbilical cord, which in humans typically has two arteries (the umbilical arteries) and one vein (the umbilical vein), hidden under Wharton's jelly, is physiologically and genetically connected to the fetus throughout prenatal development. Blood from the placenta that is oxygenated and nutrient-rich is sent to the fetus through the umbilical vein. In contrast, the fetal heart returns low-oxygen, nutrient-poor blood to the placenta through the umbilical arteries (1).

The umbilical cord develops between days 13 and 38 after conception. Normally, it has one vein and two arteries that are encased in Wharton's jelly. The abnormality of a single umbilical artery (SUA), which is defined by the presence of one artery and one vein in the cord, is the most prevalent variant. In singleton pregnancies, the incidence of SUA anomaly varies from 0.25 to 1 percent, however, it can reach up to 4.6% in twin pregnancies. Additional structural abnormalities (renal, cardiovascular, gastrointestinal, and central nervous system) can be seen at a rate of 13-50% in cases of SUA abnormality. Additionally, hereditary diseases including Meckel-Gruber syndrome, Zellweger syndrome, and the VATER complex (vertebral deformity, imperforate anus, tracheoesophageal fistula, radial dysplasia, and renal dysplasia) can all be linked to single umbilical artery abnormality. Because of this, invasive genetic testing must be used in situations when SUA and other structural defects are present. Genetic testing is not required in cases of isolated SUA because the risk of chromosomal anomaly is very low (1%). However, in these circumstances, potential negative outcomes like intrauterine fetal growth restriction, intrauterine or intrapartum mortality, and preterm birth should be taken into account. From the 28th week of pregnancy until delivery, careful monitoring of fetal growth should be done. Additional co-pathologies that could contribute to fetal growth restriction (such as preeclampsia, prior fetal growth restriction in a previous pregnancy, and low PAPP-A levels) should be evaluated (2-4).

Negative fetal and maternal outcomes in isolated SUA have been linked in the literature to abnormal placental function, fetal perfusion issues, abnormalities in the cord's insertion, placenta previa, and cord knots (5, 6).

A non-invasive dynamic ultrasound technique called Shear Wave Elastography (SWE) is based on creating transverse shear wave propagation (Shear Wave) within tissues through mechanical vibrations. This method depends on the tissue producing shear waves that spread laterally between two points in the examination area. Detectors track the motion of the shear wave generated in the tissue, and the SWE velocity measurement is carried out. The SWE velocity measurement unit is m/s, but depending on the user's preference, it can be automatically converted to kilopascals using Young's modulus. Measurements of tissue stiffness can be made without invasive procedures thanks to shear-wave elastography. The SWE velocity values increase along with the tissue stiffness. In clinical settings, elastography is used to image soft tissues like the liver, breast, prostate, thyroid gland, and more recently, the placenta, among others. This makes it possible to distinguish between tissue fibrosis, malignancy, and inflammation. However, elastography is not used as frequently in vivo in the placenta as it is in other organs (7-10).

Contrary to placentas from normal pregnancies, placentas from high-risk pregnancies, such as those involving intrauterine growth restriction, gestational diabetes, and preeclampsia, exhibit distinctive placental histologies. Therefore, these histological variations may be responsible for the variations in placental stiffness levels. To aid in the early diagnosis and selection of appropriate treatments for placenta-related problems, elastography may offer additional information about mechanical changes in the placenta in problematic pregnancies. There are a few studies in the literature that show pregnancies with preeclampsia, gestational diabetes, and fetal anomalies are associated with higher levels of placental stiffness (11-13).

In this study, we sought to determine if placental Shear Wave Elastography SWE measurements in isolated single umbilical artery cases varied from those in healthy pregnancies.

MATERIAL AND METHOD

The present investigation was launched as a prospective study after receiving approval Canakkale Onsekiz Mart University Ethics Committee (Date: 10.02.2021, Decision No: 2020-02). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

All prospective patients provided their written, informed consent. The selection process included expecting women who were gathered from the Obstetrics and Gynecology Department at Mehmet Akif Ersoy Hospital.

An expert radiology professional measured the placental shear wave elastography (SWE) using a Samsung RS80A Prestige 2014 device. Fetal biometry, placental evaluation, and amniotic fluid analysis were all done during the ultrasound examination. To lessen the impact of fetal movement, measurements of the placental SWE were taken from the thickest portion of the placenta, which was located away from the cord insertion site. Three equal sections of the placenta—the inner (fetal side), middle (central), and outer (maternal side)—were each examined. Two measurements of placental SWE were taken from each of the maternal and fetal sections.

During the measurements, the placenta was not compressed in any way. The pregnant person was instructed to hold their breath for 5 seconds while the SWE was being measured. The entire SWE measurement process took only a brief amount of time—about 5 minutes. The Thermal Index (TI) and Mechanical Index (MI) values were monitored throughout the SWE measurements to make sure they stayed below 0.7 and 1.0, respectively (the maximum allowed TI and MI values are 1 and 1.3, respectively, per FDA guidelines).

The study excluded people with pre-pregnancy diagnoses of diabetes or hypertension, multiple pregnancies, people with a history of prior ultrasound anomalies, pregnant people with a history of preeclampsia-eclampsia, and smokers. Additionally, due to the difficulties in examining tissues at such depths, pregnant women with placentas posteriorly located and deeper than 8 cm were also excluded. The study did not include pregnant women whose screening ultrasound revealed significant anomalies. The study included cases with minor anomalies such as choroid plexus cysts and echogenic findings, as well as other minor anomalies like cardiac focus, increased fetal bowel echogenicity, and mild to moderate pyelectasis.

Statistical Analysis

The IBM SPSS Statistics version 25 software was utilized for all analyses, and a significance level of $p < 0.05$ was considered as statistically significant. The normality assumptions of the variables were examined using the Shapiro-Wilk test. In cases where continuous variables did not follow a normal distribution, the Mann-Whitney U test was employed for comparing two groups, while the Independent Samples t-test was used when the assumption of normality was met. Relationships between continuous variables were analyzed using Spearman's correlation analysis (Spearman's rho).

RESULTS

The study involved a total of 44 patients, with 22 from each group divided into groups according to whether they had 1 or 2 umbilical arteries. **Table 1** lists the sociodemographic and medical details of the patients who were included. **Table 1** displays the average age, height, weight, and body mass index (BMI) of all patients. The average age was 30.73±3.65 years, the average height was 161.66±5.70 cm, the average body weight was 69.43±7.88 kg, and the average BMI was 26.62±3.24. According to all patients, the mean values for gravidity, parity, and abortions were 2.41±1.51, 0.70 0.93, and 0.70 1.05, respectively. The mean gestational age was 21.48±1.39 weeks based on the Last Menstrual Period (LMP), while 21.82±1.47 weeks based on biometry. Mean values for the biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL) were 21.55, 1.47, 21.45, 1.28, 21.25, and 1.57, respectively. The mean placental thickness was 2.3±0.19 cm, and the mean fetal weight was 402.32 76.60 grams. The final mean values were 5.68±1.53, 1.36±0.19, 3.83±1.49, and 1.11±0.22 for Shear Wave Max (SWM) in kPa, Shear Wave Max (SWM) in m/s, Shear Wave Mean (SWF) in kPa, and Shear Wave Mean (SWF) in m/s, respectively.

Table 1. Sociodemographic and medical characteristics of the patients included in the study

Parameter	n	Mean.±SS.	Median (Min.-Max.)
Age	44	30.73±3.65	30.50 (24.00-40.00)
Height (cm)	44	161.66±5.70	161.50 (150.00-175.00)
Body weight (kg)	44	69.43±7.88	67.50 (57.00-90.00)
Body mass index (BMI)	44	26.62±3.24	26.64 (19.27-34.29)
Gravida	44	2.41±1.51	2.00 (1.00-10.00)
Parity	44	.70±.93	.00 (.00-4.00)
Abortus	44	.70±1.05	.00 (.00-5.00)
The gestational week according to LMP	44	21.48±1.39	21.00 (20.00-24.00)
The gestational week according to biometry	44	21.82±1.47	22.00 (18.00-24.00)
BPD	44	21.55±1.47	21.00 (19.00-24.00)
HC	44	21.45±1.28	21.00 (19.00-24.00)
AC	44	21.25±1.57	21.00 (18.00-24.00)
FL	44	21.48±1.50	21.00 (18.00-24.00)
Fetal weight (gr)	44	402.32±76.60	397.00 (265.00-655.00)
Placental thickness (cm)	44	2.37±.19	2.32 (1.67-2.73)
SWM kPa	44	5.68±1.53	5.70 (2.60-7.95)
SWM msn	44	1.36±.19	1.38 (.94-1.62)
SWF kPa	44	3.83±1.49	3.53 (1.70-6.50)
SWF msn	44	1.11±.22	1.08 (.76-1.47)

* LMP: last menstrual period,BPD:biparietal diameter, HC: head circumference, FL: femur length, SWM: Shear Wave Max

As shown in **Table 2**, the sociodemographic and medical characteristics of the patients were compared between patients with umbilical artery numbers 1 and 2 and no significant difference was found for any parameter (p>0.05).

As shown in **Table 3**, WM kPa, SWM msec, SWF kPa and SWF msec parameters were compared between patients with umbilical artery number 1 and 2 and no significant difference was found for any parameter (p>.05).

Table 2. Comparison of sociodemographic and medical characteristics between patients with single umbilical artery and double umbilical artery

Parameter	Single umbilical artery		Double umbilical artery		p
	Ort.±SD.	Median (Min.-Max.)	Ort.±SD.	Median (Min.-Max.)	
Age	30.64±3.54	30.00 (24-40)	30.82±3.84	31 (240-38)	.871*
Height (cm)	161.68±5.38	160.00 (155-168)	161.64±6.12	162.50 (150-175)	.979*
Body weight (kg)	70.05±6.95	67.00 (57-80)	68.82±8.82	69 (57-90)	.611*
Body mass index (BMI)	26.84±2.83	26.64 (23.73-32.05)	26.41±3.66	25.50 (19.27-34.29)	.680**
Gravida	2.32±.72	2 (1-3.)	2.50±2.04	2.00 (1-10)	.604**
Parity	.59±.80	.00 (.00-2)	.82±1.05	.50 (.00-4.)	.524**
Abortus	.73±.88	.00 (.00-2.00)	.68±1.21	.00 (.00-5)	.541**
The gestational week according to LMP	21.73±1.28	21.50 (20-24)	21.23±1.48	20.50 (20-24)	.149**
The gestational week according to biometry	22.23±1.41	23.00 (19-24)	21.41±1.44	21.00 (18-2)	.058**
BPD	21.41±1.65	21.00 (19-24)	21.68±1.29	21.50 (20-24)	.433**
HC	21.23±1.34	21.00 (19-23)	21.68±1.21	22.00 (19-24)	.203**
AC	20.91±1.38	20.50 (18-24)	21.59±1.71	22.00 (18-24)	.092**
FL	21.32±1.59	20.50 (19-24)	21.64±1.43	21.50 (18-23)	.332**
Fetal weight (gr)	392.36±84.12	382.50 (265-655)	412.27±68.79	401.50 (265-545)	.169**
Placental thickness (cm)	2.38±.11	2.38 (2.22-2.63)	2.35±.24	2.32 (1.67-2.73)	.823**

*Independent Sample t test; **Mann Whitney Test, * LMP: last menstrual period,BPD:biparietal diameter, HC: head circumference, FL: femur length, SWM: Shear Wave Max

Table 3. Comparison of SWM kPa, SWM msec, SWF kPa and SWF msec parameters between patients with single umbilical artery and patients with double umbilical artery

Parameter	Single umbilical artery		Double umbilical artery		p
	Ort.±SD.	Median (Min.-Max.)	Ort.±SD.	Median (Min.-Max.)	
SWM kPa	5.72±1.62	5.80 (2.60-7.80)	5.64±1.47	5.65 (2.60-7.95)	.655*
SWM msn	1.37±.21	1.38 (.94-1.62)	1.36±.19	1.37 (.94-1.62)	.638*
SWF kPa	3.61±1.43	3.05 (1.85-6.50)	4.05±1.55	3.80 (1.70-6.50)	.390*
SWF msn	1.08±.21	1.00 (.79-1.47)	1.14±.23	1.13 (.76-1.47)	.358*

*Mann Whitney Test

As shown in **Table 4**, there was a significant positive correlation between fetal weight and SWF kPa (p=.003) and SWF msn (p=.004). In other words, as fetal weight increased, SWF kPa and SWF msn increased or as SWF kPa and SWF msn decreased, fetal weight decreased. In addition, a significant negative correlation was found between placental thickness and SWM kPa (p=.001) and SWM msn (p=.002). In other words, as placental thickness increases, SWM kPa and SWM msec decrease or as SWM kPa and SWM msec decrease, placental thickness increases. Moreover, a significant positive correlation was found between SWM kPa and SWM msec (p<.001). Finally, a significant positive correlation was found between SWF kPa and SWF msec (p<.001).

Table 4. Spearman Correlation Coefficients between Fetal Weight, Placental Thickness, SWM kPa, SWM g, SWF kPa, and SWF g

		1	2	3	4	5	6
1. Fetal weight	r	-					
	p	-					
2. Placental thickness (cm)	r	.288	-				
	p	.058	-				
3. SWM mean kPa	r	.088	-.467	-			
	p	.568	.001	-			
4. SWM mean msn	r	.094	-.457	.999	-		
	p	.545	.002	<.001	-		
5. SWF mean kPa	r	.435	.135	.180	.182	-	
	p	.003	.383	.242	.238	-	
6. SWFmean msn	r	.427	.081	.157	.160	.990	-
	p	.004	.600	.309	.299	<.001	-

DISCUSSION

This study which included 44 cases, compared data from SUA cases and healthy pregnancies using SWE. In the current investigation, placental thickness and SWM showed a negative correlation, whereas fetal weight and SWF showed a positive correlation. Furthermore, the Shear Wave parameters themselves showed positive correlations.

According to our knowledge, Arslan et al. (2) from Turkey published the first study in 2019, in which the placental elasticity of fetuses with and without SUA is compared. With our research, we hoped to contribute to the body of knowledge.

Ultrasound was used for fetal biometry, placental evaluation, and amniotic fluid analysis. Measurements of placental SWE were made away from the location of cord insertion. The anatomical parameters of the umbilical cord and the Doppler blood flow properties of several fetal and extrafetal arteries within fetuses afflicted by SUA have been the subject of numerous prior studies (13-18). Researchers Persutte and Lenke (17) have noted that the SUA generally has bigger diameters than the arteries found in ordinary umbilical cords. In contrast to umbilical cords with the traditional three-vessel structure, Raio et al. (13) have shown evidence of both the artery's and the vein's extension in umbilical cords with SUA. According to Lacro et al.'s research (18), In contrast to umbilical cords from three-vessel babies, SUA-affected fetuses had less coils in their umbilical cords,

According to the research by Raio et al. (19), there is a noticeable difference between fetuses with an SUA and those with a typical three-vessel umbilical cord arrangement in terms of the blood flow pattern within the ductus venosus. Circulation in the umbilical and placental systems, as well as heart function, all have a profound impact on blood flow through the ductus venosus. Therefore, it is important to interpret the observed decrease in blood flow velocity at the level of the ductus venosus over the whole cardiac cycle in fetuses with SUA carefully. The unusual structure of the umbilical cord itself may be the source of these hemodynamic properties rather than any underlying heart malfunction. According to Raio et al.'s study (19), umbilical cords with a SUA display more than merely adaptive arterial dilation, which has been previously shown by other researchers (15,17). Raio et al.'s research revealed that the umbilical vein has grown in size (19). This finding is consistent with a previous study the same research team conducted on a particular population (20), in which 11 of 22 fetuses with SUA had an umbilical vein area that was greater than two standard deviations from the mean for their gestational age. Umbilical artery Doppler US findings were examined in a study by Baron et al. (21), and it was discovered that fetuses with and without SUA had significantly different UA (umbilical artery) PI (pulsatility index) values. The SUA group was found to have a lower PI, which indicated a lower level of resistance. Because the SUA will have a larger diameter than normal umbilical cords, the lower resistance of the umbilical artery in SUA may be explained.

In a prior study from Turkey (2), 40 pregnant women were involved (20 with a single umbilical artery and 20 with three-vessel cords). At the fetal edge of single umbilical artery placentas, lower SWV scores were seen. Between the groups, there was a significant difference in the measurement of placental stiffness (p=0.021). The stiffness values for the central and outer placental regions, however, showed no discernible differences. According to the study, this finding might be a reflection of tissue elasticity, and the VTTQ method might help in identifying markers for future pregnancy-related complications in single umbilical artery fetuses (2). According to our study, fetal weight and SWF have a positive correlation while placental thickness and SWM have a negative correlation. According to our theory, these correlations might show that SUA pregnancies have a compensatory mechanism to support fetal growth. As our study pioneers its exploration in this context, more research is necessary to delve into this concept.

Limitations

Our study possesses several kinds of limitations. The first was the small number of those who participate. Additionally, the evaluation only considered measurements made during the second trimester of pregnancy. Last but not least, research indicates that measurements made using the Virtual Touch Tissue Quantification method may be influenced by placental depth.

CONCLUSION

In conclusion, this study found no appreciable differences in the examined groups' sociodemographic characteristics or health status. Shear Wave parameters showed similar levels between groups. Notably, fetal weight and SWF showed a positive correlation while placental thickness and SWM showed a negative correlation. Moreover, within the Shear Wave parameter set, there were discovered to be positive correlations. These discoveries advance our knowledge of fetal and placental health indicators.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Canakkale Onsekiz Mart University Ethics Committee (Date: 10.02.2021, Decision No: 2020-02).

Informed Consent: All patients signed the free and informed consent form.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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