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Relation of the Renal Artery Color Doppler With the Umbilical Artery and Amniotic Fluid Index in Fetuses Affected by Intrauterine Growth Retardation

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Abstract

Objectives: This study was performed to investigate the relationship between the renal artery color Doppler with the umbilical artery and amniotic fluid index (AFI) in fetuses affected by intrauterine growth retardation (IUGR).

Materials and Methods: This was a descriptive cross-sectional diagnostic study and the target population included pregnant mothers who were diagnosed to have fetuses with IUGR referring to the Al-Zahra treatment center in Tabriz. At least 40 samples were referred between October 2019 and May 2020. The patients were evaluated using the transabdominal ultrasound of the umbilical artery and fetal renal artery, and then using the color Doppler values of the umbilical artery and fetal renal artery.

Results: The present research was performed on 40 pregnant females with an IUGR fetus with umbilical artery percentile upper that 95% whose minimum to maximum age range was 22-38 years. There is no relationship between umbilical artery and renal artery color Doppler. In addition, umbilical artery color Doppler is not related to amniotic fluid, also renal artery color Doppler demonstrated no significant correlation with amniotic fluid index.

Conclusions: Based on our results, the PI of the umbilical artery had no significant correlation with that of the renal artery. In addition, there was no significant correlation with the PI of the renal artery and AFI.

Keywords: Color Doppler, IUGR, Umbilical artery, AFI, Renal artery

Introduction

The efficiency of the maternal-fetal exchange of nutrients, fluid, and waste can become suboptimal when there is a decrease in substrate transporters, an increase in the diffusion distance between maternal and the fetal compartments, a reduction in the exchange area, or increased impedance to blood flow in maternal and fetal compartments in the placenta. Fetal hypoxemia occurs when uterine oxygen delivery is less than a critical value and fetal oxygen uptake represents a decline. Vascular and metabolic disturbances within the placenta lead to alterations in many fetal organ systems, and as a result, the placenta and the fetus do not reach their growth potential. The combination of fetal starvation, a modified endocrine milieu, and deficient tissue stores limits fetal growth and affects cellular and functional differentiation in many target organs and causes intrauterine fetal growth restriction (IUGR). In addition, changes in fetal blood flow are related to placental resistance, fetal oxygenation, organ autoregulation, and vascular reactivity. In the compensated hypoxemic state, peripheral arteries constrict and truncal resistance increases (including umbilical artery, thoracic, and descending aorta Doppler resistance indices) and thus enhance blood flow to individual organs such as the myocardium, adrenal glands, spleen, and liver. Then, blood flow resistance in several vessels such as kidneys increases for improving the distribution of well-oxygenated blood to vital organs. Abnormal umbilical flow patterns indicate an increased risk of hypoxemia and acidemia proportional to the severity of Doppler abnormality. Further, decreasing the blood flow of the kidney causes a decrease in the amniotic fluid volume after long-standing redistribution.

If placental dysfunction is progressive or sustained, the adaptive mechanisms become exhausted and decompensation begins accordingly. Furthermore, multiple-organ failure as a result of placental dysfunction is caused by the metabolic milieu and the regulatory loss of cardiovascular homedynamic.

Nowadays, diagnosing high-risk pregnancies is one of the most important issues in modern obstetrics and gynecology. Moreover, IUGR is one of the most common causes of placental insufficiency and fetal and neonatal mortality, as well as the cause of the baby's physical and mental disabilities after birth (1-3). It should be noted that mortality and fetal complications in IUGR fetuses are about 4-6 times those of normal fetuses. Additionally, the short-term side effects of IUGR in the future life of the fetus include polycythemia, hypoglycemia, and

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Key messages

- IUGR is one of the most common causes of placental insufficiency and fetal and neonatal mortality, as well as the cause of the baby's physical and mental disabilities after birth
- Doppler of umbilical artery and renal artery and AFI are measured and compared with each other in fetuses with IUGR.

meconium aspiration, and long-term side effects are learning difficulties and cardiovascular problems (2,3). Different methods have been proposed to diagnose IUGR, the best of which is the use of ultrasound. However, after suspected fetal growth retardation, a detailed ultrasound study is performed, which includes abdominal circumference, femur length, biparietal diameter, head circumference, and amniotic fluid index (AFI), as well as the Doppler examination of the umbilical cord and middle cerebral arteries. Although these parameters are measured in fetuses with IUGR, a limited number of studies have directly compared such parameters. In addition, very few studies have focused on fetal renal arteries. There is no consensus on the validity of this parameter (4,5). The term IUGR refers to fetuses that weigh less than the 10% normal percentile of gestational age (6-8). Uterine arteries can now be examined by the Doppler ultrasound, and high-risk pregnancies can be evaluated to a large extent by analyzing the available indicators (9). So far, having an angiogram has been the only way to examine renal arteries. However, the Doppler ultrasound is now known as available alternative in many cases because it is a low-cost non-invasive procedure that provides valuable information about hemodynamics in addition to showing vascular anatomy. In addition, the ultrasound examination of renal arteries performs a variety of criteria, the most important of which are resistive index, renal/aortic ratio, pulsatility index (PI), and acceleration index (9,10). According to a search of databases, no study was found to compare the wave of the umbilical artery with that of the renal artery in fetuses with IUGR (10). Therefore, the present study aimed to evaluate the relationship between the renal artery PI and the umbilical artery in fetuses with IUGR.

Materials and Methods

Study Design

This descriptive cross-sectional diagnostic study was conducted in the Al-Zahra treatment center in Tabriz, Iran from October 2019 and May 2020. The target population included pregnant women with the diagnosis of fetuses with IUGR and PI percentile of the umbilical artery >95. In addition, 40 pregnant women (using the sample volume formula including 5% alpha, the optimal *P* value, which was equal to half, and the error coefficient of sixteen hundredths) were included in the study. Further, the color Doppler values of the umbilical artery and fetal renal artery of these patients were evaluated by transabdominal ultrasound and compared with each other. Furthermore, the normal PI value for the umbilical artery and the renal artery was obtained using the corresponding tables. Moreover, all sonographic examinations were done by one examiner by the SonoSite MicroMaxx machine (SonoSite, Inc. Bothell, WA 98021 USA) equipped with a 5-MHZ convex array sector transducer. Setting the device in each case has always been the largest and clearest possible wave, and therefore, the points that need consideration are the maximum power Pulsed Doppler, the minimum velocity scale, the minimum possible wall filter, the sample volume = 2 mm, and the Doppler angle less than 30 degrees. Additionally, the PI of renal artery flow was measured at the separation site of renal arteries from the aorta.

The Entering Criteria

1. Pregnant women with the fetal diagnosis of IUGR with estimated fetal weight (EFW) <10 %;
2. Fetal age of 26-37 weeks;
3. People's willingness to participate in the study;
4. PI percentile of the umbilical artery >95.

The Exit Criteria

1. The presence of fetal abnormalities;
2. People's reluctance for participating in the study;
3. Maternal infections with TORCH (*Toxoplasma gondii*, rubella virus, cytomegalovirus, and herpes viruses);
4. Existence of umbilical cord abnormalities.

Statistical Analyses

The obtained data were analyzed using SPSS statistical software, version 19, and data normality was assessed using the Kolmogorov-Smirnov test and the plot Q-Q diagram. Frequency (percentage) was used to describe qualitative data, and in the case of data normality, the average (standard deviation) was applied for quantitative data. On the other hand, moderation (percentages 25 and 75) was utilized in the case of non-normality. Eventually, the chi-square test and the indicators of sensitivity, specificity, and positive and negative news value were used to analyze the strength of the diagnosis.

Results

The present research was performed on 40 pregnant women with IUGR fetuses. The mean age of the participants was 29.6 years (22-38 years) in all 40 patients. In addition, the average fetal weight based on gestational age was under 10%. Further, there were 7, 10, 10, 8, and 2 patients with 2%, 3%, 4%, 5%, and under 2%, respectively. Furthermore, the assessment of gravidity in the present research showed that 12 (30%) participants were pregnant for the first time. Table 1 presents the number of para, abortion, and alive fetuses.

The Pulsatility Index of Renal Artery

The Relationship Between the PI of the Umbilical Artery and Renal Artery

Among 40 patients with the PI of the umbilical artery of >95%, 20 cases had a PI of the renal artery of <95%. The assessment of the relationship between the PI of the umbilical artery and that of the renal artery demonstrated a 12% correlation, which had not significant correlation ($P = 0.06$) (Table 2).

Results of the Amniotic Fluid Index

The AFI measurement in the present study showed that this index was normal in 26 (65%) patients. While, it was under 5% in 35% of them, indicating oligohydramnios (Table 3).

Results of Amniotic Fluid Index Reports as the Mean

The Relationship Between the PI of the Umbilical Artery and Renal Artery With AFI

The evaluation of the relationship between the PI of the renal artery and AFI showed that correlation was not significant ($P = 0.04$). The correlation of the umbilical artery and AFI revealed non-significant correlations ($P = 0.975$) (Table 4).

Table 1. Demographic Information of Participants in the Study

Participant	Age	Gestational Age	EFW	Percentile of EFW (%)	Gravid	Para	Abortion	Alive
1	23	37	2303	3	4	2	1	2
2	29	28	639	2	2	1	0	1
3	36	27	671	3	2	1	0	1
4	32	31	1455	4	3	1	1	1
5	29	33	1783	5	1	0	0	0
6	36	31	1421	4	2	1	0	1
7	30	30	1390	3	1	0	0	0
8	33	34	2010	5	2	1	0	1
9	33	29	1090	2	3	2	0	2
10	32	30	723	2	1	0	0	0
11	28	33	1950	4	2	1	0	1
12	30	34	2017	4	3	2	0	2
13	33	32	1596	3	2	1	0	1
14	27	26	640	2	1	0	0	0
15	28	37	2294	3	1	0	0	0
16	38	41	1306	5	1	0	0	0
17	26	34	1614	2>	3	2	0	2
18	22	36	2990	3	3	2	0	2
19	36	34	1821	4	1	0	0	0
20	23	32	2190	4	3	2	0	2
21	28	29	2440	7	1	0	0	0
22	27	36	2510	6	3	1	0	1
23	30	34	1890	7	2	1	0	0
24	34	30	2221	5	3	2	0	2
25	28	32	1491	4	2	0	1	0
26	32	33	1500	5	1	0	0	0
27	22	31	1410	3	2	1	0	1
28	35	37	2015	5	1	0	0	0
29	26	33	2009	4	1	2	0	2
30	25	34	2015	5	3	1	0	1
31	34	36	1140	4	2	1	1	1
32	30	33	1819	8	3	1	0	1
33	32	30	2025	8	3	0	0	0
34	33	35	2045	5	2	0	0	0
35	27	32	1581	6	1	1	0	2
36	31	30	1480	3	3	2	0	1
37	29	30	1668	6	2	1	0	0
38	32	34	1590	3	1	2	0	1
39	28	33	1890	6	2	1	0	0
40	26	34	2210	7	2	1	0	1

Note. EFW: Estimated fetal weight (g); Gestational age based on pregnancy week.

Table 2. The Relationship Between PI of the Umbilical Artery and Renal Artery

		N	Correlation	*P* Value	Bootstrap for Correlation			
					Bias	Std. Error	95% Confidence Interval	
							Lower	Upper
Pair 1	PIRA & PIUA	40	12.0%	0.06	0.011	0.74	1.33	1.86

Note. PI: Pulsatility index; PIRA: Pulsatility index of renal artery, PIUA: Pulsatility index of umbilical artery.

Discussion

Intrauterine growth restriction or IUGR is a condition in which the fetus grows extremely slowly, resulting in extremely less weight compared to the normal weight of the fetus during the week of pregnancy (9, 11). This problem can be caused by an infection or the lack of delivering sufficient food and oxygen to the fetus. The intrauterine growth restriction can have many causes the most common of which is placental insufficiency (11). The placenta is the tissue that connects the mother and the fetus, delivering oxygen and nutrients to the fetus and removing waste products from the fetus. Additionally, intrauterine growth restriction may occur due to several problems in the mother, including advanced diabetes, high blood pressure or heart disease, kidney or lung disease, malnutrition or anemia, sickle cell disease, smoking, alcohol or drug use, and infections such as rubella, cytomegalovirus, toxoplasmosis, and syphilis. Fetal problems such as chromosomal abnormality and multiple pregnancies may also cause this complication (12-14). Based on the results of one study, oxidative stress had an important role in IUGR (8).

The main symptom of this complication is smaller than the normal size of the fetus, especially if the estimated weight of the fetus is less than that of 90% of other fetuses in the same period. Depending on the limitations of intrauterine growth, the baby may be small or pale and have dry and loose skin. The fetal umbilical cord is usually thin and dull instead of thick and shiny, but not all babies born small at birth will have intrauterine growth restrictions (15). Obstetricians and gynecologists have different ways of estimating the size of the fetus during pregnancy. One of the simplest and most common methods is to measure the distance between the upper part of the uterus and pubis bones (9). The doctor usually monitors the progress of the pregnancy in this way during pregnancy examinations. The size of this gap in centimeters after the 20th week of pregnancy is normally equal to the number of pregnancy weeks (16). If this number is lower than expected, it may indicate poor fetal growth. Other applied methods for diagnosing intrauterine growth restrictions and assessing fetal health include ultrasound, Doppler ultrasound, and weight measurement fetal monitoring.

The present study used the Doppler color ultrasound to examine fetuses with IUGR and then measured the PI of umbilical and renal arteries. The AFI level was assessed as well.

Given that measurements revealed that the PI of the umbilical artery can increase in fetuses with IUGR, it can be one of the reasons for the increase in arterial resistance, leading to a decrease in the rate of blood supply to the fetus. The fetus is disturbed and its natural growth is prevented as well. On the other hand, the increase in pressure and resistance of the umbilical artery in severe cases led to increases in the resilience information of the renal artery and thus the reduction of blood flow to the kidney tissue and its damage, thereby subsequent decreasing of the amount of fetal urine. Moreover, the amount of amniotic fluid decreased as a result of decreased fetal urine, resulting in a decline in the AFI (10).

In this context, Levytska et al found that the PI of the umbilical artery was high in patients with IUGR and this index was related to IUGR (10). Based on the findings of previous research, the IUGR led to an increase in the PI of the renal artery (17). Finally, an increase in the PI in renal and umbilical arteries led to a reduction in the AFI, which resulted in a reduction in urine production and amniotic fluid (18).

Table 3. Result of AFI

Percentile of AFI	n	Percent	Mean AFI
<5	14	35	6.35
5-50	20	50	10.20
50-95	6	15	14.2

Note. AFI: Amniotic fluid index.

Conclusions

The results of the present study showed that the PI of the umbilical artery had not significant correlation with

Table 4. The Relationship Between the PI of the Umbilical Artery and Renal Artery With AFI

		N	Correlation	*P* Value	Bootstrap for Correlation			
					Bias	Std. Error	95% CI	
							Lower	Upper
Pair 1	PIRA & AFI	40	25.%	0.004	0.012	0.44	-6.49	-4.66
Pair 1	PIUA & AFI	40	10.0%	0.975	0.005	0.47	-8.16	-6.24

Note. AFI: Amniotic fluid index, PIRA: Pulsatility index of renal artery, PIUA: Pulsatility index of umbilical artery.

that of the renal artery. On the other hand, the PI of the renal artery was not significantly correlated with the AFI that of the umbilical artery demonstrated no significant correlation with AFI.

Authors' Contribution

NSh, ShA and ZF contributed to the conception and design of the study and literature review. SM collected all data and contributed to data interpretation and manuscript drafting. FS drafted the first manuscript. All authors reviewed and approved the final version of the article.

Conflict of Interests

Authors declare that they have no conflict of interests.

Ethical Issues

This study was approved by the ethical committee of Tabriz University of medical Sciences (Ethics No. IR.TBZMED.IEC.1999.313).

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References

1. Goldenberg RL, Cliver SP. Small for gestational age and intrauterine growth restriction: definitions and standards. Clin Obstet Gynecol. 1997;40(4):704-714. doi:10.1097/00003081-199712000-00004
2. Barker DJ, Bull AR, Osmond C, Simmonds SJ. Fetal and placental size and risk of hypertension in adult life. BMJ. 1990;301(6746):259-262. doi:10.1136/bmj.301.6746.259
3. Cater J, Gill M. The follow-up study: medical aspects. In: Illsley R, Mitchell RG, eds. Low Birth Weight, a Medical Psychological and Social Study. Chichester: John Wiley: 1984:191–205.
4. Owen P, Khan KS. Fetal growth velocity in the prediction of intrauterine growth retardation in a low risk population. Br J Obstet Gynaecol. 1998;105(5):536-540. doi:10.1111/j.1471-0528.1998.tb10155.x
5. James DK, Parker MJ, Smoleniec JS. Comprehensive fetal assessment with three ultrasonographic characteristics. Am J Obstet Gynecol. 1992;166(5):1486-1495. doi:10.1016/0002-9378(92)91624-j
6. Skovron ML, Berkowitz GS, Lapinski RH, Kim JM, Chitkara U. Evaluation of early third-trimester ultrasound screening for intrauterine growth retardation. J Ultrasound Med. 1991;10(3):153-159. doi:10.7863/jum.1991.10.3.153
7. Villar J, de Onis M, Kestler E, Bolaños F, Cerezo R, Bernedes H. The differential neonatal morbidity of the intrauterine growth retardation syndrome. Am J Obstet Gynecol. 1990;163(1 Pt 1):151-157. doi:10.1016/s0002-9378(11)90690-5
8. Schneider D, Hernández C, Farías M, Uauy R, Krause BJ, Casanello P. Oxidative stress as common trait of endothelial dysfunction in chorionic arteries from fetuses with IUGR and LGA. Placenta. 2015;36(5):552-558. doi:10.1016/j.placenta.2015.02.003
9. Mureşan D, Rotar IC, Stamatian F. The usefulness of fetal Doppler evaluation in early versus late onset intrauterine growth restriction. Review of the literature. Med Ultrason. 2016;18(1):103-109. doi:10.11152/mu.2013.2066.181.dop
10. Levytska K, Higgins M, Keating S, et al. Placental pathology in relation to uterine artery Doppler findings in pregnancies with severe intrauterine growth restriction and abnormal umbilical artery Doppler changes. Am J Perinatol. 2017;34(5):451-457. doi:10.1055/s-0036-1592347
11. Poudel R, McMillen IC, Dunn SL, Zhang S, Morrison JL. Impact of chronic hypoxemia on blood flow to the brain, heart, and adrenal gland in the late-gestation IUGR sheep fetus. Am J Physiol Regul Integr Comp Physiol. 2015;308(3):R151-162. doi:10.1152/ajpregu.00036.2014
12. Romo A, Carceller R, Tobajas J. Intrauterine growth retardation (IUGR): epidemiology and etiology. Pediatr Endocrinol Rev. 2009;6 Suppl 3:332-336.
13. Longo S, Bollani L, Decembrino L, Di Comite A, Angelini M, Stronati M. Short-term and long-term sequelae in intrauterine growth retardation (IUGR). J Matern Fetal Neonatal Med. 2013;26(3):222-225. doi:10.3109/14767058.2012.715006
14. Fu Q, Yu X, Callaway CW, Lane RH, McKnight RA. Epigenetics: intrauterine growth retardation (IUGR) modifies the histone code along the rat hepatic IGF-1 gene. FASEB J. 2009;23(8):2438-2449. doi:10.1096/fj.08-124768
15. de Onis M, Blössner M, Villar J. Levels and patterns of intrauterine growth retardation in developing countries. Eur J Clin Nutr. 1998;52 Suppl 1:S5-15.
16. VandenBosche RC, Kirchner JT. Intrauterine growth retardation. Am Fam Physician. 1998;58(6):1384-1390.
17. Singh N, Tyagi S, Tripathi R, Mala YM. Maternal and fetal outcomes in pregnant women with Takayasu aortoarteritis: does optimally timed intervention in women with renal artery involvement improve pregnancy outcome? Taiwan J Obstet Gynecol. 2015;54(5):597-602. doi:10.1016/j.tjog.2015.08.014
18. Gutaj P, Wender-Ozegowska E. Diagnosis and management of IUGR in pregnancy complicated by type 1 diabetes mellitus. Curr Diab Rep. 2016;16(5):39. doi:10.1007/s11892-016-0732-8