

Color Doppler sonography of the aortic isthmus in intrauterine growth-restricted fetuses and normal fetuses

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Abstract

Intrauterine growth restriction is associated with a significant increase in morbidity and perinatal mortality, and increases the likelihood of fetal death, asphyxia, meconium aspiration, hypoglycemia, and neonatal hypothermia. The aim of this study was to determine aortic isthmus flow difference by using color doppler sonography in Intrauterine growth restriction and normal fetuses. The data presented were obtained from 30 mothers, who referred to the radiology department of Akbarabadi Hospital of Tehran with a diagnosis of intrauterine growth restriction. An ultrasound was performed to determine the status of placenta, fetus, and amniotic fluid. The umbilical arterial doppler assessment was used to confirm diagnosis of intrauterine growth restriction. Thirteen (43.3%) were nulliparous mothers and 17 (56.7%) were multiparous mothers. 30 pregnant women with healthy fetuses were enrolled as control group. According to the ultrasound findings, Dactus Venus wave type was recorded in intrauterine growth restriction fetuses, which was reported as normal (26 subjects; 86.7%) and abnormal (4 subjects; 13.3%). All together, this study provides appropriate guidance to use doppler for delivery timing and to control risk factors.

Key Words: Color Doppler ultrasound, fetal aortic isthmus, Doppler flow, Intrauterine growth restriction.

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Intrauterine growth restriction (IUGR) is associated with a significant increase in morbidity and perinatal mortality,^{1,2} and the likelihood of some emerging risks and problems such as fetal death, birth asphyxia, meconium aspiration, hypoglycemia, neonatal hypothermia, and abnormal development of nervous system can be increased.^{3,4} Identifying fetuses with inappropriate growth is still difficult. Growth failure case identification is sometimes not possible even in the neonatal nursing unit, that shows this difficulty more than ever. However, there are clinical methods and more sophisticated technologies that help to diagnose maternal constraint of fetal growth.⁵⁻⁷ Determining the serial fundal height measurement is a safe, and relatively accurate screening method for the diagnosis of a large number of small fetuses for gestational age.⁸⁻¹⁰ However, the main disadvantage of this method is its low inaccuracy. In several studies, it was found that symphysial fundal height measurement (SFH) detects only 40% of these cases. Therefore, small fetuses for gestational age are both neglected and over-detected. In

spite of this, these results do not reduce the importance of SFH as a simple screening method.¹¹⁻¹³ The abnormality of fetal umbilical artery flow velocity has a unique association with IUGR. The abnormal result of this test is the absence or reduction of diastolic blood flow, which implies an increase in impedance. The use of Doppler velocity measurement has been suggested as a contributing method to other fetus assessments.¹⁴ It is worth noting that the aortic isthmus is the part of aorta located between the origin of the left subclavian artery and the ductus arteriosus. The timely and accurate diagnosis of IUGR cases leads to the necessary measures for the health of the fetus and the mother. Therefore, alternative methods for suspected cases of IUGR help to manage maternal and fetal statuses and provide access to appropriate diagnostic and therapeutic outcomes. Due to the different results of aortic isthmus from IUGR fetuses and lack of research in Iran, the present study was performed to evaluate color Doppler sonography of the aortic isthmus in normally grown and growth-restricted fetuses.

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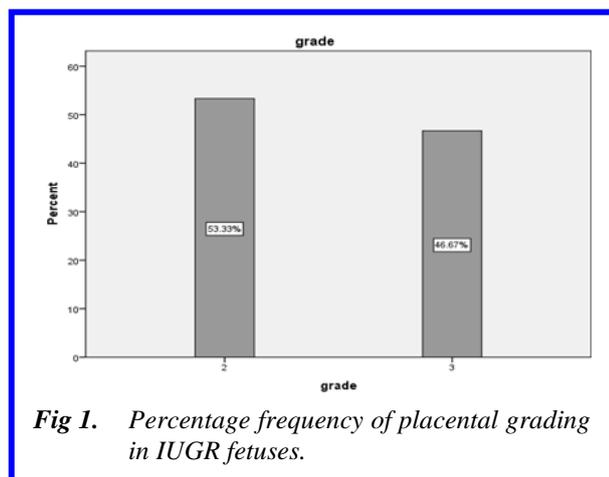


Fig 1. Percentage frequency of placental grading in IUGR fetuses.

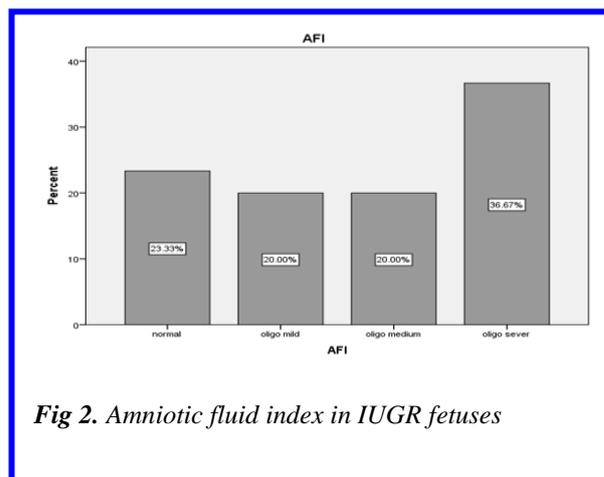


Fig 2. Amniotic fluid index in IUGR fetuses

Materials and Methods

This analytical cross-sectional study was conducted among mothers who referred to the radiology department of Akbar Abadi Hospital in Tehran during 2013-2014 with a diagnosis of IUGR from 25 to 37 weeks of gestation. The study was explained to enrolled persons and an informed consent was obtained before analyses. Standard sonography was performed to determine the status of placenta, fetus and amniotic fluid. Umbilical arterial Doppler assessment was used for definitive diagnosis of IUGR. Doppler evaluation of fetal aortic isthmus blood flow was also performed. In the prenatal care initial diagnosis of IUGR was performed on the basis of clinical examination and fundal height measurement. For this purpose, the area of the abdominal arc was measured using a tape (in cm) from the top of the symphysis pubis to the uterine fundus with an empty bladder. Then, the percentile of the fetus was calculated, which was confirmed if it was below the 10th percentile. Pregnant mothers who did not have risk factors for IUGR and referred to the clinic of Akbar Abadi Hospital for prenatal care were included as control group. These mothers were evaluated by clinical examination, weight assessment, umbilical arterial Doppler assessment, as well as Doppler test of fetal aortic isthmus blood flow. Patient information such as fetal age, pregnancy status, parity and maternal age were also recorded in a data collection form. Doppler findings of the fetal aortic isthmus blood flow were determined in IUGR and healthy fetuses. The data of all the subjects who participated in this study remained strictly confidential. The analyses did not impose health system related costs to the subjects.

Sample size

Regarding the small number of available samples, we tried to use a census sampling for all subjects that were referred to this center during one year. Sample size included all patients diagnosed with IUGR in the Department of Radiology, Akbar Abadi Hospital.

Case group consisted of 30 subjects; 30 healthy subjects were included in the study as control group with healthy fetuses.

Data analysis

Data analysis was performed using IBM SPSS 22 software. Descriptive analysis was presented as mean, standard deviation and frequency percentage for underlying variables. Statistical analyses were performed using T-test and chi square tests. Values of $P < 0.05$ were considered to be statistically significant.

Results

In this study, 30 pregnant women who referred to the radiology department of Akbarabadi Hospital in Tehran at 34 and 36 weeks of gestation were diagnosed with IUGR and 30 pregnant women with healthy fetuses were enrolled as control group. In the case group, the mean gestational age was 32.4 (SD = 3.2) weeks. The minimum and maximum gestational age were determined to be 27 weeks and 37 weeks, respectively. Thirteen (43.3%) were nulliparous mothers and 17 (56.7%) were multiparous mothers. For all mothers, standard ultrasonography was performed to evaluate the placenta, fetal weight, and IUGR. Sixteen mothers of the case group (53.3%) showed grade II placenta, followed by grade III placenta (46.7%) (Figure 1). Amniotic fluid index was normal in 7 (23.3%) cases, followed by 6 cases of mild oligohydramnios (20%), 6 cases of moderate oligohydramnios (20%) and 11 cases of severe oligohydramnios (36.7%), (Figure 2). The fetal weight was recorded in 19 cases (63.3%) of mothers (with IUGR fetuses) to be below the 3rd percentile, while 11 cases (36.7%) were below the 10th percentile, so the diagnosis of IUGR was confirmed in all cases. According to the ultrasound findings of the, the Dactus Venus wave type (DV) was recorded in IUGR fetuses, which was reported as normal (26 subjects; 86.7%) and abnormal (4 subjects; 13.3%), (Fig. 3). In the IUGR fetuses, the mean RI of the umbilical artery was 0.86 (SD = 0.09), where the lowest and highest were recorded as 0.68 and 1, all items were

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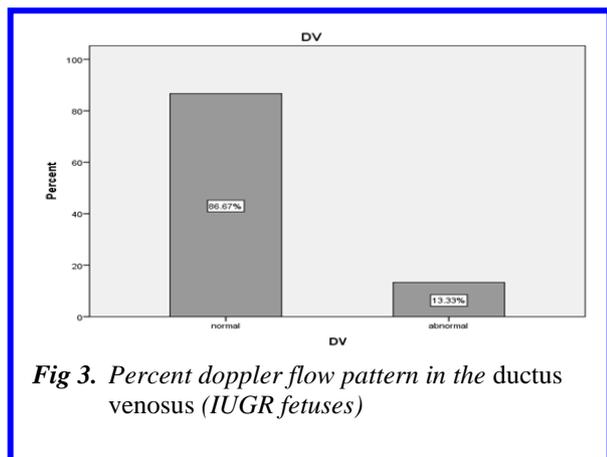


Fig 3. Percent doppler flow pattern in the ductus venosus (IUGR fetuses)

above the 95th percentile. In IUGR fetuses, the mean RI of the fetal aortic isthmus was calculated as 0.89 (SD = 0.02), with the lowest and highest rate (0.82 and 0.94; fig 4). Furthermore, the mean RI of the fetal aortic isthmus in the control group was calculated as 0.87 (SD = 0.04), comparing the highest with the lowest scores (0.78 and 0.94; Table 1). Based on the one sample K-S test, the distribution of RI of the fetal aortic isthmus was non normal distribution. As a result, nonparametric test was employed for comparing the two groups. Based on the results of Mann-Whitney test, there was no significant difference in the mean of RI in the case and control group (P = 0.08), (Fig. 5).

Discussion

IUGR occurs in 15% of the second pregnancy due to utero-placental failure and is one of the major cause of fetal and neonatal morbidity and long-term health problems.^{16,17} This is a progressive vascular disorder associated with vascular malformations of the third villi that initiates hemodynamic disorders and abnormalities in multiple fetuses vessels. In the absence of effective intrauterine therapies, the timing of delivery and the birth of a baby become crucial. The main goal of controlling the delivery of the baby is at a time when the risk of intrauterine death and irreversible complications of organ function in the context of prolonged pregnancy

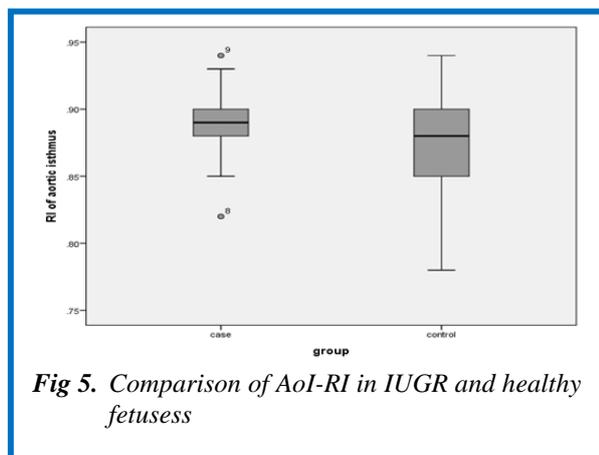
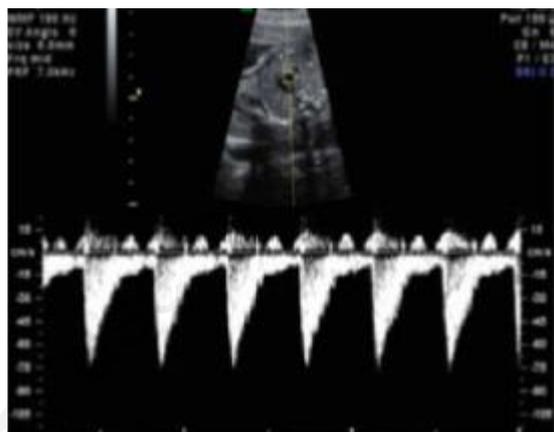


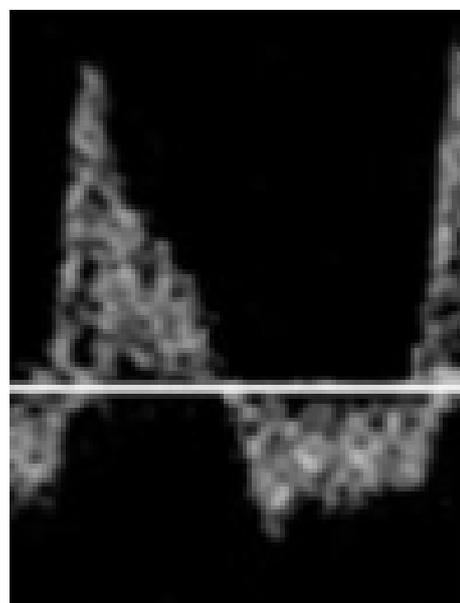
Fig 5. Comparison of AoI-RI in IUGR and healthy fetuses



a. Arrow indicates point distal to the left subclavian artery and typical blood flow velocity waveforms.



b. Three vessel views with cursor placed on AoI at point proximal to ductus arteriosus joining the descending aorta.



c Reversed blood flow during diastole and antegrade flow during systole.

Fig 4. The fetal aortic isthmus at week 20 of pregnancy.

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Table 1. Mean standard deviation and range of RI in both case and control groups

group		N	Minimum	Maximum	Mean	Std. Deviation
case	RI of aortic isthmus	30	.82	.94	.89	.02
	Valid N (listwise)	30				
control	RI of aortic isthmus	30	.78	.94	.87	.04
	Valid N (listwise)	30				

is greater than the preterm birth risk. Longitudinal data show a consistent pattern of hemodynamic changes which forms the basis of surveillance and follow-up with Doppler in the IUGR.¹⁸⁻²¹ So far, several longitudinal studies have been performed on measurement of aortic isthmus in uncomplicated pregnancies, but data are still incomplete.²¹ A previous study indicated that peak systolic velocity (PSV) and AoI pulsatility index (PI) can be markedly elevated in AGA fetuses by increasing gestational age. Furthermore, afford mentioned study demonstrated noremarkable mean difference in measurements of AoI-PI or AoI-PSV based on the intra- and interoperator variability. In addition, AoI-PI and AoI-PSV from SGA fetuses were not considerably different from those of AGA or IUGR fetuses.²² A study evaluated features and correlation with perinatal outcome of AoI circulation using Doppler method in IUGR fetuses with placental insufficiency. Adverse perinatal outcome has been found to be markedly linked to elevated AoI-PI (Retrograde flow in the AoI). On the other hand, it has been revealed that retrograde blood flow in the AoI could be correlated with adverse perinatal outcome. Furthermore, AoI-PSV and AoI-TAMXV have been determined to be < 5(th) centile in 78% and 94% of subjects, respectively; where AoI-PI has been revealed to be > 95(th) centile in 41% of cases. Aforementioned study suggested the key role of Doppler imaging of the AoI for severe IUGR surveillance. In another study conducted in Italy in 2008, AoI-PI was measured in 70 fetuses (20 cases of IUGR and 50 normal cases) at 24-36 weeks' gestation whereas all measurements were performed in both the LAA and 3V views, and compared with each other. The results of mentioned study exhibited a high degree of reliability between PI values achieved from LAA and 3V views in both IUGR and normal fetuses. In addition, the 3V view has been remarkably recorded to be less time-consuming, when comparing with those from the LLA view, where higher intra-observer reproducibility has been revealed in this regard.^{23,24} In our study, we also compared RI values

obtained from LAA and 3V views in both IUGR and normally grown fetuses. The mean RI of aortic isthmus in the IUGR fetuses was determined as 0.89 (SD = 0.02), comparing the highest with the lowest scores (0.82 and 0.94). The mean RI of the fetal aortic isthmus in the control group was obtained to be 0.87 (SD = 0.04), comparing the highest with the lowest scores (0.78 and 0.94). Given Mann-Whitney test, mean RI of isthmic aorta did not exhibit a significant difference in case and control groups (P = 0.08). Regarding to the previous studies in this area, the accepted protocol has not been achieved for the clinical surveillance of the IUGR fetuses based on the use of Doppler imaging. In this regard, longitudinal and observational studies would show more information about the natural history and pathophysiology of intrauterine growth-restricted fetuses in relation to Doppler indexes. A randomized clinical trial on the blood flow of UA and embryo in Europe (TRUFFLE study), have evaluated the fetuses' heart with a change in the latency of the DV stream using three randomized arms cardiocotography. The data from this study and other studies provide appropriate guidance regarding the role of doppler in the timing of delivery and control of effective factors. Regarding to available evidence, the evaluation of Doppler waveforms of the AoI can be an important element in the evaluation of fetuses with the IUGR, where they have an abnormal Doppler of UA. However, prior to entering these indexes into clinical practice for preventing premature birth, more prospective studies are needed in relation to AoI indexes and other arterial Doppler indexes with perinatal outcomes.^{25,26}

List of acronyms

AFI – amniotic fluid index
 AGA - appropriate for gestational age
 AoI - aortic isthmus
 DV - Dactus Venus
 IUGR - Intrauterine growth restriction
 PI - pulsatility index
 PSV - peak systolic velocity

RI - resistive index
SFH - symphysial fundal height
TAMXV - time-averaged maximum velocity

Author's contributions

LY, MGH, ZS, and GHA equally participated in experimental design, data collection, writing and revision of the manuscript.

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Conflict of Interest

The authors declare no conflicts of interests.

Ethical Publication Statement

We confirm that we have read the Journal's position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.

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