The Egyptian Journal of Hospital Medicine (October 2022) Vol. 89 (2), Page 6596- 6604

Role of Aortic Isthmus Doppler Ultrasound in Fetuses with Intrauterine Growth Restriction

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ABSTRACT

Background: Poor perinatal outcome and cerebral palsy have been linked to intrauterine growth restriction (IUGR). New Doppler metrics, like the aortic isthmus (AoI), can be used to detect and assess the severity of IUGR in fetuses. The aim of the current study is to investigate the better diagnosis of intrauterine growth Restriction using the aortic isthmus Doppler. **Patients and methods**: A cross-sectional study was conducted on 74 women with a singleton pregnancy between 24-34 weeks, with fetal growth restriction and placental insufficiency, between September 2021 and March 2022. Repeated Doppler evaluation of umbilical artery, middle cerebral artery and aortic isthmus artery were assessed until one day before pregnancy termination by 37 weeks. Correlation of Doppler findings with perinatal fetal outcomes was done. **Results:** As regard aortic isthmus artery resistance index (RI), it differed significantly between both groups as first visit, before termination, decrease and % decrease, as well as regard perinatal outcome as general anesthesia at delivery and neonatal ICU admission. Validity (area under the curve (AUC), sensitivity, specificity) for aortic isthmus, middle cerebral artery as well as umbilical artery at RI First visit to prognoses birth weight ≤2 kg where there was statistically significant difference between aortic isthmus, middle cerebral artery as well as umbilical artery (RI) first visit to prognoses birth weight ≤2 kg.

Conclusion: Using Doppler imaging of the aortic isthmus to assess the clinical state of fetuses with fetal growth restriction (FGR) is possible, and even to decide when to terminate the pregnancy in preterm fetuses. Aortic isthmus (AI) Doppler measurements are useful to identify fetal growth restriction (FGR).

Keywords: Aortic Isthmus, Doppler Ultrasound, Intrauterine Growth Restriction, Zagazig University.

INTRODUCTION

To be classified as having intrauterine growth restriction (IUGR), a pregnant woman must be less than 10 percent of the 10th percentile which corresponds with fetal gestational age [1].

Even though they are frequently used interchangeably in the medical community, IUGR and small for gestational age (SGA) have a distinct meaning. No matter how close they are to the 10th percentile for their gestational age when it comes to anticipated birth weight, SGA just considers the weight at birth, but IUGR considers other signs of malnutrition as well [2]**.** Ultrasound measurement of fetal tone, respiratory movements, and body movements, along with amniotic fluid and traditional cardiotocography (CTG), are used to create a biophysical profile (BPP). For the time being, performing a biophysical profile BPP to keep an SGA premature baby under control is not suggested [3]. An index of amniotic fluid (AFI) is a component of the BPP. Due to the lack of evidence supporting oligoamnios' relevance as a predictor of postnatal problems in in-vitro fertilisation (IVF) babies with Doppler monitoring, its inclusion in treatment guidelines is debatable [3]. High-risk pregnancies, particularly fetal growth restriction (FGR), have been shown to reduce perinatal morbidity and death by using Doppler velocimetry of the umbilical artery (UA) and middle cerebral artery. When blood flow to the brain of a fetus is concentrated in the fetal cerebral hemisphere, this is known as cerebroplacental ratio (CPR). The Doppler index (pulsatility index [PI]), resistance index, or systolic/diastolic ratio) of the middle cerebral artery middle cerebral artery (MCA) is divided by that of the umbilical artery (UA) to arrive at the CPR value [4].

In early-onset FGR, ductus venosus (DV) is the most reliable Doppler measure for predicting the short-term risk of fetal mortality. DV flow waveforms become abnormal only at the most severe phases of fetal impairment, according to long-term investigations [5]. Regardless of the gestational age at birth, atrial contractions with absent or reversed velocities are related with perinatal death [6].

The Doppler waveform of isthmus of the aorta is used to find the right amount of brain-to-systemic circulation impedance balance. Diastolic aortic isthmus AoI flow reversed indicates substantial fetal hypoxia degradation; this usually occurs after abnormalities in the umbilical artery (UA) Doppler indices, but before abnormalities in the DV Doppler indices, by an average of one week. Poor neurodevelopmental outcomes are linked to aberrant aortic isthmus (AoI) recordings. In spite of this, the sensitivity was modest, and its genuine relevance in daily clinical practice is still unclear [7].

Longitudinal studies reveal that aortic isthmus AoI changes occur 1 week before DV changes in patients [8]**,** and as a result, it is a poor indicator of the likelihood of a future stillbirth. The opposite appears to be true: aortic isthmus AoI appears to improve the prediction of neurological morbidity [9]. The aim of the study is the better diagnosis of intrauterine growth restriction IUGR using the aortic isthmus Doppler.

PATIENTS AND METHODS

A cross sectional study was conducted between September 2021 and March 2022 at Radiology

Received: 08/07/2022
Accepted: 13/09/2022

Department, Faculty of Medicine, Zagazig University. A total of 74 women with a singleton pregnancy, between 24-34 weeks, with fetal growth restriction and placental insufficiency were included in the study.

Inclusion criteria:

Maternal age between 18- 35 years, with gestational age >32 weeks (fetal maturity) by detecting the last menstrual period, singleton pregnancies suspicious for intrauterine growth restriction (IUGR), and chronic maternal illness (as chronic hypertension, pre-eclampsia, diabetes mellitus. etc.) and Based on abdominal circumference (AC), biparietal diameter (BPD), as well as femur length (FL) in addition to fetal weight of less than 10% of their gestational age was detected by ultrasound.

Exclusion criteria:

Patients outside age group, documented congenital fetal malformations and chromosomal abnormalities known before delivery or multiple gestations were excluded from the study.

All patients were subjected to the following:

Detailed personal, obstetric and medical history including: Personal history, obstetric history, as well as medical history.

Assessment of fetal wellbeing: Umbilical artery Doppler ultrasonography, fetal weight estimation, a Cardiotocography-fetal heart rate (CTG-FHR) pattern, and evidence of uterine activity were all obtained with the use of a pelvic ultrasound.

Ultrasound examination:

While the women were laying supine with their heads elevated at a 45-degree angle, the ultrasounds were being performed.

Using ultrasound U/S machines Mindray N2 and Toshiba Xario 200, Umbilical artery doppler and middle cerebral artery (MCA) doppler was started from 28 weeks of gestation and reexamined again serially according to the local guidelines after 4 weeks then every 2 weeks till 36 weeks then weekly till delivery.

Gestational age was determined on fetal head biometry and Femur Length (FL). The estimated fetal weight (EFW) and fetal heart (FHR) was calculated at each visit. EFW will be calculated from measurements of biparetal diameter (BPD), abdominal circumference (AC) and femur length (FL) based on Hadlock 2 formula. It's important to keep track of everything from the gestational age at delivery to the birth weight to the placenta's weight to the Apgar score of the newborn baby.

Fetal gender couldn't be determined by an ultrasound at the time of evaluation. An advanced ultrasound technician with two years of training performed all of the scans, including multi-vessel fetal Dopplers, on the subject. The average of three measurements was utilized to analyze the data for each parameter. Local protocols and guidelines were used to manage the workforce at that time. There was no way for the obstetricians in charge of the labor to see the ultrasound results. Case notes and electronic patient records contained information on the mother's and baby's outcomes after the birth. Comparisons between the male and female fetal cohorts were made utilizing independent sample t-tests.

The fetal distress diagnosis was done upon cardiotocography (CTG) aberrations (Bradycardia lasting for more than 90 minutes, as well as variability of less than 5 bpm for more than 90 minutes. for a period of three minutes) on fetal blood samples, and/or signs of fetal acidemia (with pH <7.20).

- Gray scale ultrasonography.
- Examinations of the umbilical artery, brain's main artery, and heart's main isthmus by Doppler until one day before delivery by 37 weeks.
- Correlation of Doppler findings with perinatal fetal outcomes.

Lab assessment:

All investigations obtained according to standard protocol of preterm labor (PTL) in our hospital including complete blood count, C-reactive protein (CRP) and grouping, liver enzymes, kidney functions, random blood sugar, urine analysis and culture, high vaginal swap.

Ethical consent:

An approval of the study was obtained from Zagazig University Academic and Ethical Committee (IRB Approval No. (#6671/10-3-2021). Every patient signed an informed written consent for acceptance of participation in the study. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

The collected data were coded, processed and analyzed using the SPSS (Statistical Package for Social Sciences) version 20.0 for Windows® (IBM SPSS Inc, Chicago, IL, USA). Data were tested for normal distribution using the Shapiro Walk test. Qualitative data were represented as frequencies and relative percentages. Chi square test ($\chi 2$) and Fisher's exact test to calculate difference between two or more groups of qualitative variables. Quantitative data were expressed as mean, standard deviation (SD), median, and interquartile range (IQR). Independent samples t-test was used to compare between two independent groups of normally distributed variables (parametric data). P value $\leq$0.05 was considered significant.

RESULTS

The mean birth weight was 2.39 (SD 0.55) kg with range between 1.70 and 3.40. There were 27 (36.5%) cases with birth weight ≤2 kg. and 47 (63.5%) >2 kg. Residence, age, socioeconomic status, comorbidities, parity and gestational age did not differ significantly between the groups (**Table 1**).

Table (1): Comparisons between the studied groups regarding demographic data.

Demographic data	Total (n = 74)		Birth weight ≤ 2 kg				Test of Sig.	P-value
			No (n = 47)		Yes (n = 27)			
	No.	%	No.	%	No.	%		
Residence								
Urban	28	37.8	18	38.3	10	37.0	X^2= 0.012	0.914
Rural	46	62.2	29	61.7	17	63.0		
Age (years)								
Min. – Max.	21 – 35		21 – 35		21 – 35		t= 1.137	0.259
Mean ± SD.	27.76 ± 4.38		27.32 ± 4.25		28.52 ± 4.58			
Median (IQR)	27.5 (24 – 32)		27 (23.5 – 30.5)		29 (24.5 – 33)			
Socioeconomic status								
Low	34	45.9	23	48.9	11	40.7	X^2= 0.484	0.785
Moderate	28	37.8	17	36.2	11	40.7		
High	12	16.2	7	14.9	5	18.5		
Comorbidities								
Non	69	93.2	45	95.7	24	88.9	X^2= 1.279	^{FE}p= 0.348
Hypertension	5	6.8	2	4.3	3	11.1		
Parity								
Primiparous	17	23.0	11	23.4	6	22.2	X^2= 0.014	0.907
Multiparous	57	77.0	36	76.6	21	77.8		
Gestational age (weeks)								
Min. – Max.	32 – 36		32 – 36		32 – 36		t= 0.833	0.407
Mean ± SD.	34.04 ± 1.42		33.94 ± 1.45		34.22 ± 1.37			
Median (IQR)	34 (33 – 35)		34 (33 – 35)		34 (33 – 35.5)			

SD: **Standard deviation** IQR: **Inter Quartile Range** X^2: **Chi square test**, FE**: Fisher Exact**, **t: Student t-test**
P: p-value for comparing between the studied categories

Umbilical artery resistance index (RI) differed significantly between both groups as (first visit, before termination, decrease and % decrease) (**Table 2**).

Table (2): Comparisons between the studied groups regarding umbilical artery resistance index (RI).

Umbilical artery resistance index (RI)	Total (n = 74)	Birth weight ≤ 2 kg		Test of Sig.	P-value
		No (n = 47)	Yes (n = 27)		
First visit					
Min. – Max.	0.46 – 0.87	0.46 – 0.78	0.74 – 0.87		
Mean ± SD.	0.68 ± 0.12	0.61 ± 0.09	0.80 ± 0.03	t= 13.099	<0.001*
Median (IQR)	0.70 (0.57 – 0.78)	0.58 (0.53 – 0.68)	0.79 (0.78 – 0.82)		
Before termination Min. – Max.	0.43 – 0.81	0.43 – 0.74	0.71 – 0.81		
Mean ± SD.	0.64 ± 0.12	0.57 ± 0.09	0.76 ± 0.03	t= 13.476	<0.001*
Median (IQR)	0.66 (0.53 – 0.74)	0.54 (0.50 – 0.64)	0.75 (0.73 – 0.78)		
Decrease					
Mean ± SD.	0.06 ± 0.02	0.07 ± 0.02	0.05 – 0.02	U= 361.50*	0.002*
Median (Min. – Max.)	0.06 (0.02 – 0.12)	0.07 (0.03 – 0.12)	0.05 (0.02 – 0.08)		
% Decrease					
Mean ± SD.	6.0 ± 2.30	6.66 ± 2.35	4.87 ± 1.74	U= 361.50*	0.002*
Median (Min. – Max.)	6.0 (2.44 – 11.54)	6.52 (3.08– 11.54)	4.94 (2.44 – 7.59)		
Z (p_0)	7.513* (<0.001*)	6.001* (<0.001*)	4.561* (<0.001*)		

P: p value for comparing between the studied categories. p_0: p value for comparing between **First visit** and **before termination.**
*: Statistically significant at $p \leq 0.05$.

Middle cerebral artery resistive index RI also differed significantly between both groups as (first visit and before termination) and as regard middle cerebral artery RI, no significant differences were found as (decrease and % decrease) (**Table 3**).

Table (3): Comparison between the two studied groups according to middle cerebral artery resistive index RI

Middle cerebral artery RI	Total (n =74)	Birth weight ≤ 2 kg		Test of Sig	P-value
		No (n =47)	Yes (n =27)		
First visit Min. – Max.	0.67 – 1.03	0.67 – 0.92	0.88 – 1.03		
Mean ± SD.	0.85 ± 0.10	0.79 ± 0.07	0.95 ± 0.04	t= 11.309	<0.001*
Median (IQR)	0.86 (0.77 – 0.91)	0.80 (0.73 – 0.85)	0.96 (0.91 – 0.99)		
Before termination Min. – Max.	0.62 – 0.95	0.62 – 0.85	0.82 – 0.95		
Mean ± SD.	0.79 ± 0.10	0.74 ± 0.07	0.89 ± 0.04	t= 11.728	<0.001*
Median (IQR)	0.81 (0.73 – 0.85)	0.74 (0.68 – 0.79)	0.90 (0.85 – 0.92)		
Decrease Mean ± SD. Median (Min. – Max.)	0.07 ± 0.02 0.07 (0.04 – 0.11)	0.07 ± 0.02 0.07 (0.05 – 0.11)	0.06 ± 0.01 0.06 (0.04 – 0.08)	U= 480.0	0.083
% Decrease Mean ± SD. Median (Min. – Max.)	6.89 ± 1.61 6.59(4.04– 11.43)	7.19 ± 1.75 7.14(4.60– 11.43)	6.36 ± 1.19 6.12 (4.04 – 8.16)	U= 480.0	0.083
Z (p_0)	7.518* (<0.001*)	6.002* (<0.001*)	4.575* (<0.001*)		

P: p value for comparing between the studied categories. p_0: p value for comparing between **First visit** and **before termination.** *: Statistically significant at p ≤ 0.05

Aortic isthmus artery resistive index RI differed significantly between both groups as (first visit, before termination, decrease and % decrease) (**Table 4**).

Table (4): Comparison between the two studied groups according to aortic isthmus artery resistive index RI

Aortic isthmus artery resistive index RI	Total (n =74)	Birth weight ≤ 2 kg		Test of Sig.	P-value
		No (n =47)	Yes (n =27)		
First visit Min. – Max.	0.81 – 0.97	0.81 – 0.91	0.85 – 0.97		
Mean ± SD.	0.87 ± 0.04	0.86 ± 0.03	0.90 ± 0.04	t= 5.405	<0.001*
Median (IQR)	0.87 (0.84 – 0.90)	0.86 (0.83 – 0.88)	0.90 (0.87 – 0.93)		
Before termination Min. – Max.	0.78 – 0.94	0.78 – 0.89	0.84 – 0.94		
Mean ± SD.	0.85 ± 0.04	0.84 ± 0.03	0.88 ± 0.04	t= 5.601	<0.001*
Median (IQR)	0.85 (0.82 – 0.88)	0.84 (0.81– 0.86)	0.88 (0.84 – 0.92)		
Decrease Mean ± SD. Median (Min. – Max.)	0.02 ± 0.01 0.02 (0.01 – 0.04)	0.02 ± 0.01 0.02 (0.01 –0.04)	0.02 ± 0.01 0.01 (0.01– 0.03)	U= 403.50*	0.009*
% Decrease Mean ± SD. Median (Min. – Max.)	2.07 ± 0.92 2.21 (1.06 – 3.70)	2.19 ± 0.93 2.30 (1.11 – 3.70)	1.85 ± 0.87 1.18 (1.06 –3.45)	U= 403.50*	0.009*
Z (p_0)	7.598* (<0.001*)	6.057* (<0.001*)	4.635* (<0.001*)		

P: p value for comparing between the studied categories. p_0: p value for comparing between **First visit** and **before termination.** *: Statistically significant at p ≤ 0.05

Perinatal outcomes differed also significantly between the two studied groups as (Gestational age (GA) at delivery and neonatal intensive care unit (NICU) admission) while no significant differences were found regarding Apgar 1 and Apgar 5 (**Table 5**).

Table (5): Comparison between the two studied groups according to perinatal outcome.

Perinatal outcome	Total (n =74)	Birth weight ≤ 2 kg		Test of Sig.	P-value
		No (n = 47)	Yes (n = 27)		
Gestational age (GA) at delivery Min. – Max.	33.0 – 37.0	35.0 – 37.0	33.0 – 37.0	t= 3.962*	<0.001*
Mean ± SD.	36.07 ± 1.14	36.49 ± 0.62	35.33 ± 1.44		
Median (IQR)	36.0 (36.0 – 37.0)	37.0 (36.0 – 37.0)	36.0 (34.0 – 36.0)		
Apgar 1 Min. – Max.	4.0 – 8.0	5.0 – 8.0	4.0 – 8.0	t= 1.518	0.133
Mean ± SD.	6.24 ± 1.21	6.40 ± 1.12	5.96 ± 1.34		
Median (IQR)	6.0 (5.0 – 7.0)	6.0 (5.50 – 7.0)	6.0 (5.0 – 7.0)		
Apgar 5 Min. – Max.	4.0 – 10.0	5.0 – 10.0	4.0 – 9.0	t= 1.767	0.081
Mean ± SD.	7.19 ± 1.40	7.40 ± 1.33	6.81 ± 1.47		
Median (IQR)	7.0 (6.0 – 8.0)	7.0 (6.50 – 8.0)	7.0 (6.0 – 8.0)		
NICU admission					
No	49 (66.2%)	35 (74.5%)	14 (51.9%)	X^2= 3.921*	0.048*
Yes	25 (33.8%)	12 (25.5%)	13 (48.1%)		

P: p value for comparing between the studied categories. *: Statistically significant at p ≤0.05

Validity (area under the curve (AUC), sensitivity, specificity) for umbilical artery, middle cerebral artery and aortic isthmus artery at resistive index (RI) First visit to prognoses Birth weight ≤2 kg where there was statistically significant difference between umbilical artery, middle cerebral artery and aortic isthmus artery RI First visit to prognoses Birth weight ≤2 kg, validity (AUC, sensitivity, specificity) for umbilical artery, middle cerebral artery and aortic isthmus artery RI before termination to prognoses Birth weight ≤2 kg where there was statistically significant difference between umbilical artery, middle cerebral artery and aortic isthmus artery RI first visit to prognoses birth weight ≤2 kg (**Figures 1, 2**).

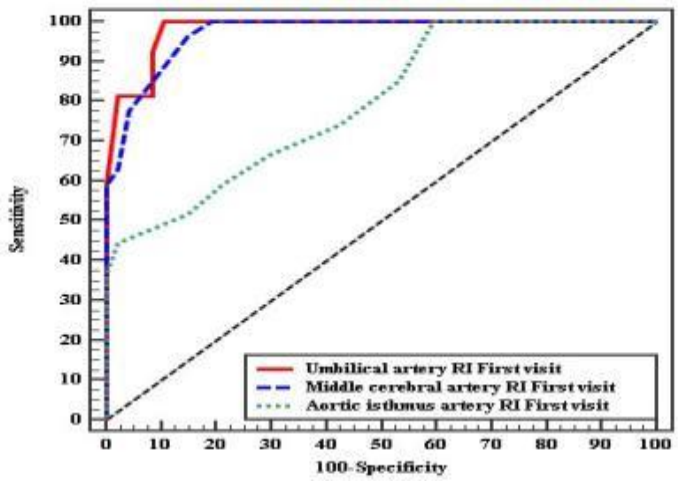


Figure (1): ROC curve for umbilical artery, middle cerebral artery and aortic isthmus artery at RI first visit to prognoses birth weight ≤2 kg patients (n = 27 vs. 47).

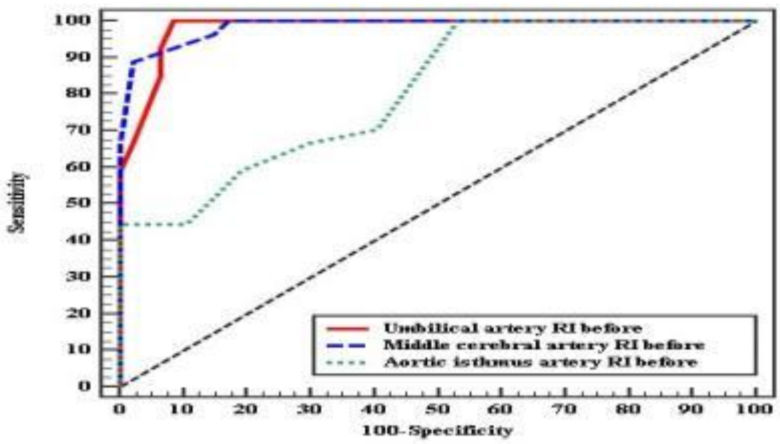
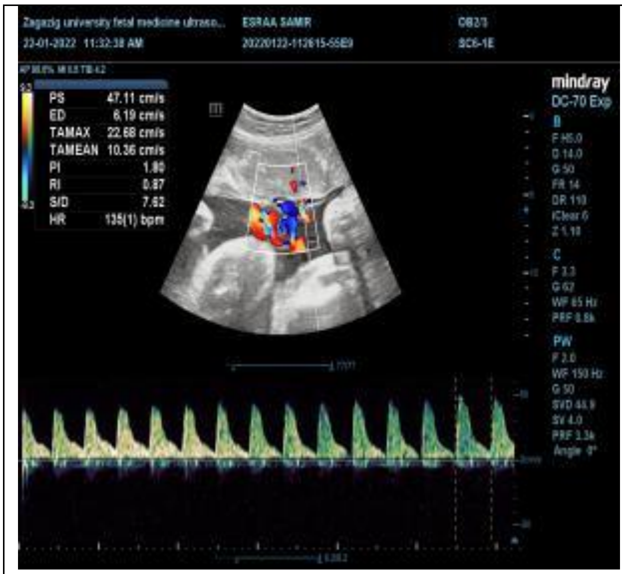
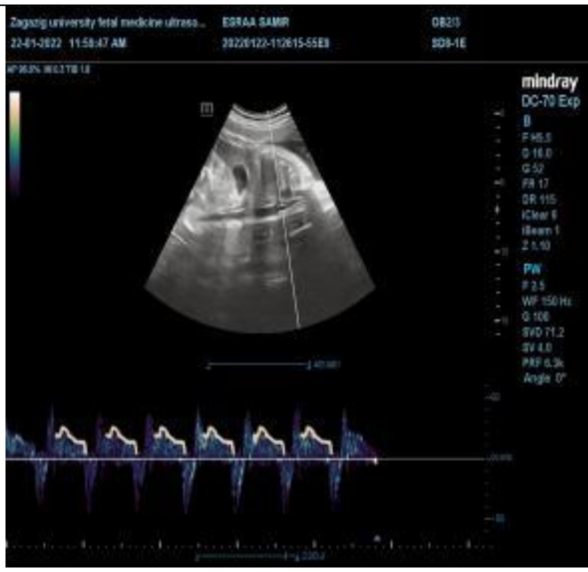


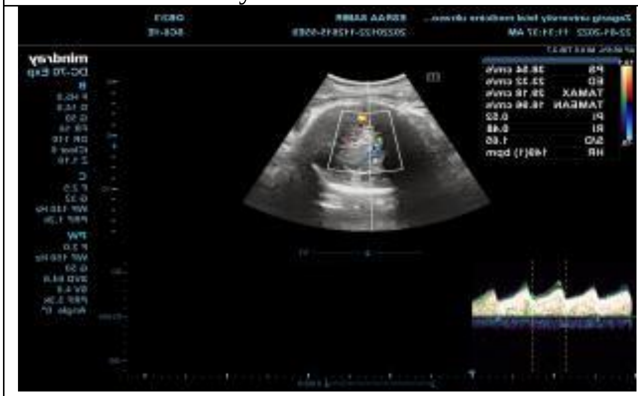
Figure (2): ROC curve for umbilical artery, middle cerebral artery and aortic isthmus artery at RI before to prognoses birth weight ≤2 kg patients (n = 27 vs. 47)



A. Umbilical artery showed low resistance flow

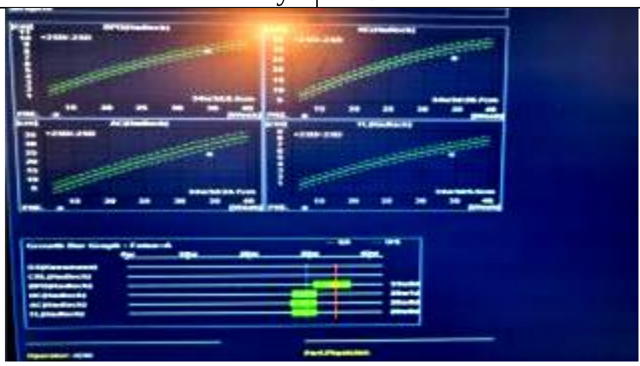


B. Reversed flow of the aortic isthmus waveform



C. Low resistance flow of the middle cerebral artery

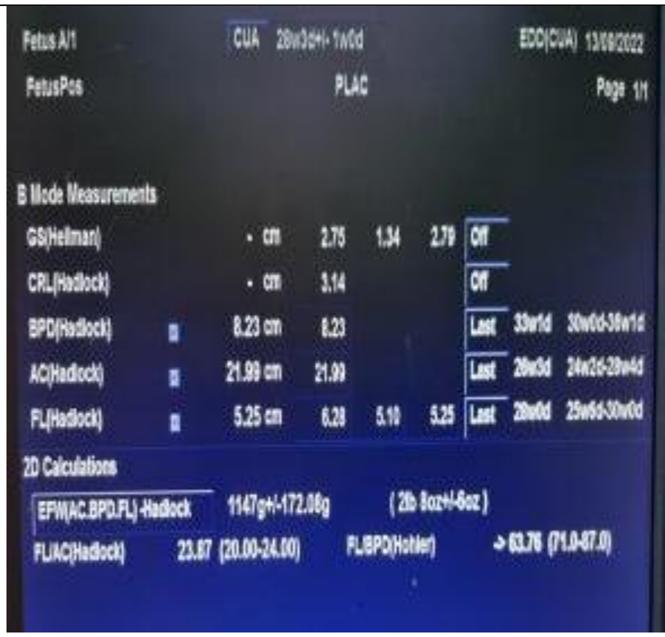
D. Fetal measurement



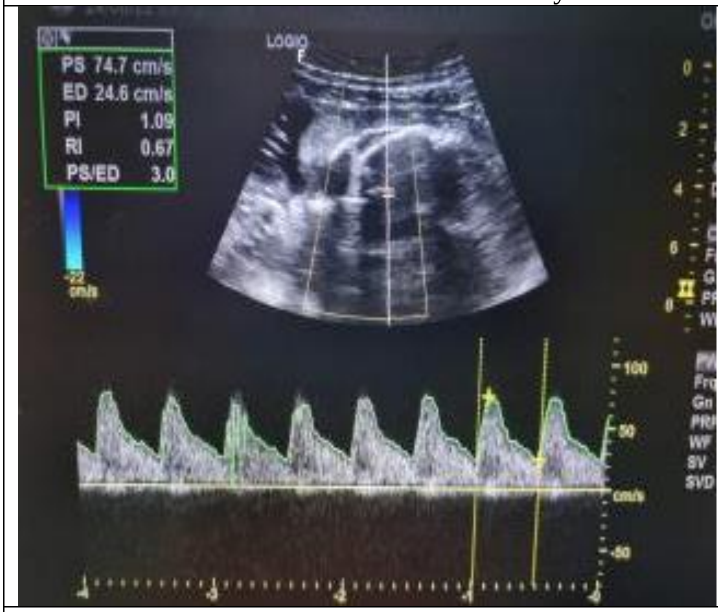
E. Growth bar graph

Figure (3): Pregnant female 25 years old, gravida 2, not diabetic or hypertensive, GA by last menstrual period (LMP) was 34 weeks and 3 days, GA by ultrasound (U/S) was 29 weeks 3 days, estimated fetal weight (EFW) by U/S was 1369±25 grams, middle cerebral artery middle cerebral artery (MCA) RI = 0.45, umbilical artery resistive index umbilical artery (UMB) A RI = 0.87 with reversed flow of the aortic isthmus waveform delivered by cesarean section (CS). The outcome was perinatal death. A case of asymmetrical intrauterine growth restriction IUGR with Doppler examination showed brain sparring effect with reversed flow of the aortic isthmus waveform.

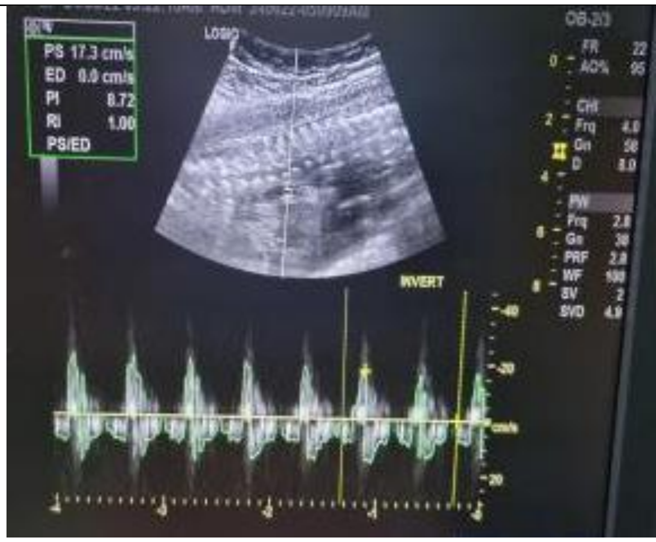
A. Reversed flow of the Umbilical Artery



B. Fetal measurements



C. High resistance Middle cerebral artery waveform



D. Reversed flow of the aortic isthmus waveform

Figure (4): Pregnant female 27 years old, gravida 3, not diabetic or hypertensive, gestational age by LMP was 34 weeks and 2 days, Gestational Age GA by U/S was 28 weeks and 3 days, estimated fetal weight EFW by U/S was 1147 ± 172 grams. Middle cerebral artery resistive index MCA RI = 0.67, Umbilical artery resistive index UMB A RI showed reversed flow and aortic isthmus also showed reversed flow, Amniotic fluid index AFI = 11 (normal), she was delivered by CS. The outcome was NICU admission. A case of asymmetrical IUGR with Doppler examination showed brain sparring effect with reversed flow of the aortic isthmus waveform.

DISCUSSION

Perinatal mortality and morbidity, as well as childhood disabilities, can be attributed to intrauterine growth restriction (IUGR). Sonographically assessed fetal weight 10th percentile for gestational age is considered IUGR by the medical community [10].

Systemic and brain circulation balance could be established via aortic isthmus doppler waveform. Diastolic Aortic isthmus (AoI) flow reversed signals significant fetal hypoxia degradation. This normally occurs after aberrant umbilical artery Doppler indexes, but it usually occurs one week before ductus venosus (DV) recordings. Even though it was highly specific, sensitivity was limited, and its true value in daily clinical practice was not clear. Fetal adaptations to placenta deficiency and hypoxia rely heavily on the heart. Systolic and diastolic cardiac functions can be predicted by myocardial performance index (MPI) [7].

In this study we demonstrated that residence, age, socioeconomic status, comorbidities, parity and gestational age did not differ significantly between the groups.

In the **Fardiazar *et al.*** [11] study, thirty pregnant women with an IUGR neonates were studied as part of a case study at the high-risk pregnancy clinic. Furthermore, the control group included 31 mothers with healthy neonates (as determined by ultrasound scans). Age, gestational age, and gravidity of the mothers in the case and control groups did not differ significantly.

In contrast to the findings of **Jamal *et al.*** [12] researchers in this study disagreed with previous findings indicating older or younger mothers have an increased risk of having a low-birthweight baby. Because of the decreased occurrence of extreme maternal ages in our study compared to theirs, it may have a lesser power to detect an effect.

In this research we found that umbilical artery RI differed significantly between both groups as (first visit, before termination, decrease and % decrease).

In agreement with our results, statistically significant differences between non-intrauterine growth restriction and non-IUGR during the average visit trimester was found by **Hassan and colleagues** [13]**.**

Hennington *et al.* [14] discovered IUGR in his cohort related to increased umbilical artery resistance. Thus, our findings show that maternal undernutrition was not the primary cause of IUGR in their cohort.

In this study we demonstrated that middle cerebral artery resistive index RI also differed significantly between both groups as (first visit and before termination) and as regard middle cerebral artery resistive index RI, no significant differences were found as (decrease and % decrease).

Nimmagadda *et al.* [15] found that in middle cerebral artery, RI of IUGR fetuses was significantly lower than that of normal fetuses (0.0.598±0.12 vs 0.0.742±0.129; p<0.01). Cerebroplacental ratio (MCA RI/UA RI) of IUGR fetuses was significantly lower than that of normal fetuses (0.814±0.20 vs 1.59±0.361; p<0.01).

Khanduri *et al.* [16] found that IUGR patients had significantly lower MCA PI, RI, and S/D values than non IUGR patients on all three visits.

In study in our hands, we found that aortic isthmus artery resistive index RI differed significantly between both groups as (first visit, before termination, decrease and % decrease).

Fetal hemodynamic impairment has been demonstrated to be associated to changes in aortic isthmus AoI Doppler in observational studies conducted in fetuses with IUGR (reported either qualitatively or statistically); the higher the aortic isthmus AoI flow was, the more likely it was that alterations would occur in other vessels. By analyzing the Doppler velocimetry of 100 fetuses with IUGR and an UA-PI > p95, **Fouro *et al.*** [9] reported that aortic isthmus AoI diastolic flow was found to be absent or reversed more frequently than the umbilical artery UA diastolic flow.

Fardiazar *et al.* [11] found that the umbilical artery (UA) color Doppler was abnormal in 43.3% of mothers with IUGR pregnancies, and the middle cerebral artery (MCA) color Doppler was abnormal in 8 instances, according to ultrasonography data (26.7 percent); ductus venosus (DV) color Doppler abnormalities were reported for two of them. The elevated AoI- pulsatility index (PI) and aortic isthmus resistive index AoI-RI values (above the 95th percentile) were seen in 10.30% (33.3%) and 20/30 (66.7%) of IUGR neonates. Healthy neonates were found to have these values: 10/31 (32.3 percent) and 15/31 (48.4 percent).

However, a similar study by **Kennelly *et al.*** [18] comparing Ao-PI levels in 72 AGA, 48 SGA, and 10 IUGR fetuses revealed no significant differences between any of the three study groups. The disagreement may be related to the limited number of patients in the second trial, but at this time, artic isthmus (AoI) cannot be considered a valid criterion to discriminate between fundamentally tiny neonates and those with actual growth restriction.

In this research we illustrated that perinatal outcomes differed also significantly between the two studied groups as (gestational age (GA) at delivery and neonatal intensive care unit (NICU) admission) while no significant differences were found regarding Apgar 1 and Apgar 5. This agrees with **Bardakci et al.** [19] study where mean GA at delivery was 36.21 weeks. Infants with intrauterine growth restriction were studied in a research to evaluate the short-term outcomes of newborns, **Hasmasanu et al.** [20] found that Most of the newborns in both groups had an Apgar score of 7 or above at one minute of age (case group: 77.9 percent; control group: 77.5 percent) the differences between the groups are negligible (p>0.05).

In this study we found that Validity (AUC, sensitivity, specificity) for umbilical artery, middle cerebral artery, and aortic isthmus artery resistive indices (RI) before termination to prognoses birth weight ≤2 kg where there was statistically significant difference between umbilical artery, middle cerebral artery and aortic isthmus artery (RI) First visit to prognoses Birth weight ≤2 kg.

Regarding umbilical artery, Doppler has highly significant predictive value (p <0.001). Agreed with study done by **Lees *et al.*** [21] who concluded the decrease in placental surface area caused by rising PI in the UA is linked to a reduction in the nutrition exchange capability of the fetus, and is reflected in reversed end diastolic flow (EDF).

Using the values of MCA PI and RI, **Khanduri *et al.*** [16] discovered that they were more specific than sensitive. With the same cutoff, **Bano *et al.*** [22] found that MCA PI's specificity was 8.9%, its positive predictive value (PPV) was 100% and its negative predictive value (NPV) was 52.3%. The diagnostic accuracy of MCA PI was 54.4 percent, which is consistent with our findings.

This study has some limitations in which small sample size which may affect our results, so further studies with larger sample size is needed to establish our results.

In conclusion, it is possible to employ Doppler imaging of the aortic isthmus to monitor the clinical status of fetuses with fetal growth restriction (FGR), and even to decide when to terminate the pregnancy in preterm fetuses. AI Doppler measurements are useful to identify fetal growth restriction. FGR can be detected with AI Doppler measures, according to this study. Because of its ability to detect changes in fetuses with FGR earlier than other methods, Doppler monitoring has become an increasingly significant tool for prenatal diagnosis.

Financial support and sponsorship: Nil.
Conflict of interest: Nil.

REFERENCES

1. **Vayssière C, Sentilhes L, Ego A *et al.* (2015):** Fetal growth restriction and intra-uterine growth restriction: guidelines for clinical practice from the French College of Gynaecologists and Obstetricians. Eur J Obstet Gynecol Reprod Biol., 193:10-18.
2. **Sharma D, Shastri S, Sharma P (2016):** Intrauterine Growth Restriction: Antenatal and Postnatal Aspects. Clin Med Insights Pediatr., 10:67-83.
3. **Lalor J, Fawole B, Alfirevic Z *et al.* (2008):** Biophysical profile for fetal assessment in high risk pregnancies. The Cochrane Database of Systematic Reviews, 1: CD000038. doi: 10.1002/14651858. CD000038. pub2.
4. **Vollgraff Heidweiller-Schreurs C, De Boer M, Heymans M *et al.* (2018):** Prognostic accuracy of cerebroplacental ratio and middle cerebral artery Doppler for adverse perinatal outcome: systematic review and meta-analysis. Ultrasound Obstet Gynecol., 51(3):313-322.
5. **Cosmi E, Ambrosini G, D'Antona D *et al.* (2005):** Doppler, cardiotocography, and biophysical profile changes in growth-restricted fetuses. Obstet Gynecol., 106(6):1240-1245.
6. **Schwarze A, Gembruch U, Krapp M *et al.* (2005):** Qualitative venous Doppler flow waveform analysis in preterm intrauterine growth-restricted fetuses with ARED flow in the umbilical artery--correlation with short-term outcome. Ultrasound Obstet Gynecol., 25(6):573-579.
7. **Al Bellehy M, Omar K, Eid S *et al.* (2020):** The Prediction of Adverse Perinatal Outcomes in Intrauterine Growth Restriction using the Doppler Indices of Myocardial Performance and Aortic Isthmus. International Journal of Medical Arts, 2(4):886-897.
8. **Cruz-Martinez R, Figueras F, Hernandez-Andrade E *et al.* (2011):** Changes in myocardial performance index and aortic isthmus and ductus venosus Doppler in term, small-for-gestational age fetuses with normal umbilical artery pulsatility index. Ultrasound Obstet Gynecol., 38(4):400-405.
9. **Fouron J, Gosselin J, Raboisson M *et al.* (2005):** The relationship between an aortic isthmus blood flow velocity index and the postnatal neurodevelopmental status of fetuses with placental circulatory insufficiency. Am J Obstet Gynecol., 192(2):497-503.
10. **Martins J, Biggio J, Abuhamad A (2020):** Society for Maternal-Fetal Medicine Consult Series #52: diagnosis and management of fetal growth restriction (replaces clinical guideline number 3, April 2012). Am J Obstet Gynecol., 223(4):2-17.
11. **Fardiazar Z, Favaedi M, Babahajian A *et al.* (2020):** Aortic Isthmus Color Doppler Indices in intrauterine Growth-Restricted Fetuses (A case control study). Medical Science, 24(101):37-46.
12. **Khan N, Jamal M (2003):** Maternal risk factors associated with low birth weight. J Coll Physicians Surg Pak., 13(1):25-28.
13. **Hassan H, Yosri L, Ali E (2022):** Prediction of fetal growth restriction using combined fetal biometry and maternal serum [Inhibin A] in pregnant women with type 1 diabetes. Journal of Recent Advances in Medicine, 3(1):1-9.
14. **Hennington B, Alexander B (2013):** Linking intrauterine growth restriction and blood pressure: insight into the human origins of cardiovascular disease. Circulation, 128(20):2179-2180.
15. **Nimmagadda H, Kapoor P, Ladwal M (2017):** Evaluation of the Diagnostic Criteria of Ultrasonographic Parameters in the Prediction of Intrauterine Growth Restriction. World Journal of Research and Review, 5(3):262756.
16. **Khanduri S, Chhabra S, Yadav S *et al.* (2017):** Role of Color Doppler Flowmetry in Prediction of Intrauterine Growth Retardation in High-Risk Pregnancy. Cureus, 9(11):e1827. doi: 10.7759/cureus.1827
17. **Esercan A, Karakuş R, Ozgu-Erdinc A (2013):** Aortic Isthmus Doppler For Fetal Assessment. Gynecology Obstetrics and Reproductive Medicine, 19:197-202.
18. **Kennelly M, Farah N, Hogan J *et al.* (2012):** Longitudinal study of aortic isthmus Doppler in appropriately grown and small-for-gestational-age fetuses with normal and abnormal umbilical artery Doppler. Ultrasound Obstet Gynecol., 39(4):414-420.
19. **Bardakci M, Balci O, Acar A *et al.* (2010):** Comparison of modified biophysical profile and doppler ultrasound in predicting the perinatal outcome at or over 36 weeks of gestation. Gynecol Obstet Invest., 69(4):245-250.
20. **Hasmasanu M, Bolboaca S, Baizat M *et al.* (2015):** Neonatal short-term outcomes in infants with intrauterine growth restriction. Saudi Med J., 36(8):947-953.
21. **Lees C, Stampalija T, Baschat A *et al.* (2020):** ISUOG Practice Guidelines: diagnosis and management of small-for-gestational-age fetus and fetal growth restriction. Ultrasound Obstet Gynecol., 56(2):298-312.
22. **Bano S, Chaudhary V, Pande S *et al.* (2010):** Color doppler evaluation of cerebral-umbilical pulsatility ratio and its usefulness in the diagnosis of intrauterine growth retardation and prediction of adverse perinatal outcome. Indian J Radiol Imaging, 20(1):20-25.