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STUDY OF AORTIC ISTHMUS DOPPLER AND OTHER DOPPLER PARAMETERS FOR PREDICTING PERINATAL OUTCOME IN GROWTH RESTRICTED FETUSES

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ABSTRACT

Background: Fetal growth restriction (FGR) affects up to 5-10% of pregnancies. It is associated with increased perinatal mortality and morbidity. Doppler studies identify at-risk fetuses and help in timing interventions and prognosticate outcomes. **Aim:** To find out the predictive value of aortic isthmus Doppler changes and perinatal outcome in growth-restricted fetuses as well comparing the sensitivity and specificity of aortic isthmus Doppler with other Doppler parameters in intrauterine growth restriction. **Methods:** Prospective study of sixty women with singleton pregnancies with gestational age above 28 weeks and detected to have FGR was done. The patients were subjected to Doppler analysis. Abnormal Doppler indices were compared with neonatal outcomes such as NICU admission, and perinatal mortality. **Results:** Elevated umbilical artery PI, abnormal ductus PI, reduced MCA PI, low CP ratio, abnormal aortic isthmus PI were found in 15, 1, 11 and, 15,& 14 fetuses respectively. The sensitivity & specificity in predicting perinatal mortality was 75% ,25%, 25% 75%, 100% & 78.57%, 100%, 82.14%, 85.42% and, 82.14% for umbilical artery PI, ductus PI, MCA PI, CP ratio, aortic isthmus PI respectively. P-value was found to be statistically significant for retrograde flow in aortic isthmus and perinatal mortality (p-value<0.05). Also significant p-value was found for correlation between abnormal CP ratio and adverse perinatal coutcome (p-value<0.05). **Conclusion:** Doppler of aortic isthmus plays an important role in determining at-risk fetuses and their timely management. Retrograde flow in the AoI in growth restricted fetuses strongly correlates with adverse perinatal outcome.

KEYWORDS : Abnormal Doppler indices, FGR (fetal growth restriction), Neonatal morbidity, Aortic isthmus.

INTRODUCTION:

Fetal growth restriction (FGR) is defined as the failure of the fetus to meet its biological growth potential due to a pathological factor[1]The causes are associated with the mother (including malnutrition, high blood pressure, smoking, anemia, and diabetes), genetic diseases such as aneuploidy, and disorders related to the placenta such as placental mosaicism and placental infarction[2,3,4,5].

Since there is no definitive treatment for FGR, accurate clinical monitoring and management are of high significance for determining the best delivery time and preventing fetal complications such as neonatal mortality and perinatal morbidity[6]. There are numerous methods for providing accurate monitoring of the existing conditions. Since the abnormal velocity in the umbilical artery blood flow is significantly associated with FGR, conducting the velocity measurement of the umbilical artery blood flow with Doppler[7] and pulsatility index[8, 9] are the most efficient methods in FGR monitoring.

Apart from umbilical artery Doppler, blood flow indices of other arteries by doppler are also efficient and useful in the management of FGR. The fetal circulatory system includes two distinctive and key parts: A) Brachiocephalic circulatory system that is established by the left ventricle and supplies the blood for the upper half of the fetal body; and B) Subdiaphragmatic placental circulatory system that is established by the right ventricle and supplies the blood for the lower half of the fetal body[10,11,12].

The aortic isthmus is part of descending aorta located between the origin of the left subclavian artery and ductus arteriosus, which is the only real and physiological connection path between the left and right ventricles; in other words, it is located between the two umbilical fetal circulatory systems (brachiocephalic and subdiaphragmatic placental)[10,13,14]. The blood flow indices existing in AoI indicate the output and resistance difference between two fetal circulatory systems[10]. These indices can be measured and monitored by Doppler ultrasound Changes. Nature of AoI blood flow results in hemodynamic disorders in the entire cardiac system[12]. Thus, affecting nutrition and may be associated with FGR. Since few studies have been conducted in this regard, the present study aims to assess the aortic isthmus color Doppler indices in intrauterine growth-restricted fetuses for timely obstetric intervention.

MATERIAL AND METHODS:

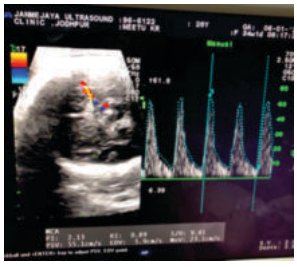
The study included 60 pregnant women with a singleton pregnancy between 28-30 weeks, gestational age confirmed by first-trimester scan and diagnosed to have asymmetrical FGR (FGR, when fetal estimated weight is less than 10th percentile of their expected weight depending on the period of gestation in weeks, calculated through ultrasonography). Pregnancy with gross congenital anomalies in the fetus were excluded from the study. Written informed consent was taken from every patient. Biometry and Doppler ultrasonography was performed by ultrasonography machine. A study of blood vessels including umbilical artery, middle cerebral artery, ductus venosus, and aortic isthmus was performed.

The direction of blood flow in fetal aortic isthmus was studied which may be antegrade, absent, or retrograde flow. It was performed preferably when fetus was immobile or at minimal fetal movement in either the longitudinal aortic arch or the three vessels and trachea view[15] (The three vessel trachea view is obtained at the level of the upper fetal mediastinum in a transverse plane in which the aorta and ductus arteriosus join in a V- shaped vascular structure.). Peak systolic velocity end-

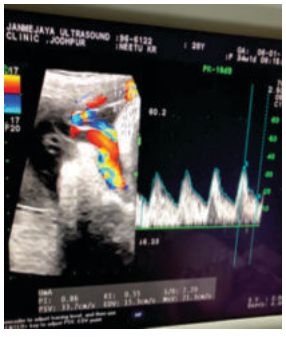
diastolic velocity, S/D ratio, Pulsatility index, Resistance index, were calculated in all studied vessels. S/D ratio and other Doppler parameters of the aortic isthmus were compared to the existing nomogram based on the period of gestation.

The fetal surveillance and Doppler studies were continued once a week or more frequently if required, till the decision for delivery was taken as per the hospital protocol. Following delivery, the birth weight, Apgar score at 1 and 5 min were noted. Perinatal evaluation was done by observing for any complications in the infant and indication of admission in a neonatal intensive care unit (NICU) if any and duration of stay were noted.

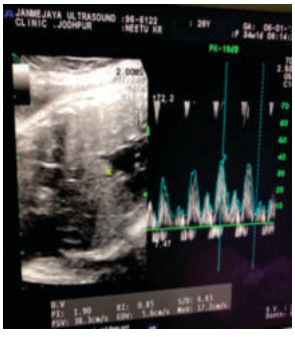
1(a) Normal aortic isthmus waveform



1(b) Normal Middle cerebral artery waveform



1 c) Normal Ductus venosus waveform



1(d) Normal umbilical artery waveform

Fig1: Normal Doppler waveforms

RESULTS:

The study comprised a total of 60 patients.

Table1: Maternal and neonatal parameters.

Variable		No. of patient	%
Age	<20 year	03	5
	20-30 year	40	66.66
	>30 year	17	28.33
Parity	Primi	42	70
	Multigravida	18	30
Mode of delivery	Vaginal	36	60
	LSCS	24	40
Gestational age	>37 weeks	07	11.66
	33-36 weeks	27	45
	<28-32 weeks	26	43.33
Birth Weight	1.5-2.5	55	91.66
	<1.5	5	8.33

In this study, the age of the patient ranged from 19 years to 36 years, of which the majority belonging to the age group of 21-25 years with a mean age of 26.9 years.

The incidence of primigravida (70%) was more than that of multigravida (30%) with maximum number of patients (27) belonged to 33-36 weeks group. In the present study 60% patient with IUGR had normal vaginal delivery while 40% had Caesarean section and, 91.66% patient had birth weight >1.5 Kg while 8.33% had birth weight <1.5 Kg.

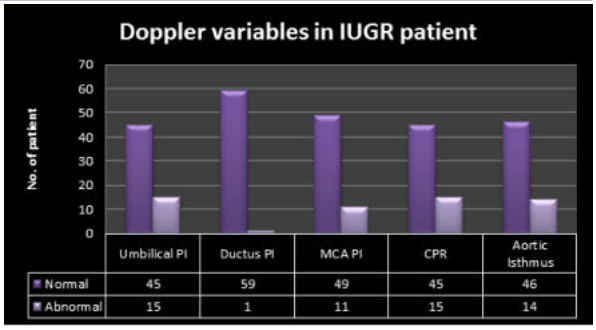


Fig2: In present study, Doppler studies revealed that umbilical artery PI, ductus PI, MCA PI, CPR, and aortic isthmus PI waveforms were found to be abnormal in 25%, 1.66%, 18.33%, 25%, and 23.33% of the patients respectively.

(MCA-Middle Cerebral Artery, CPR-Cerebro-Placental Ratio, PI-Pulsatility index)

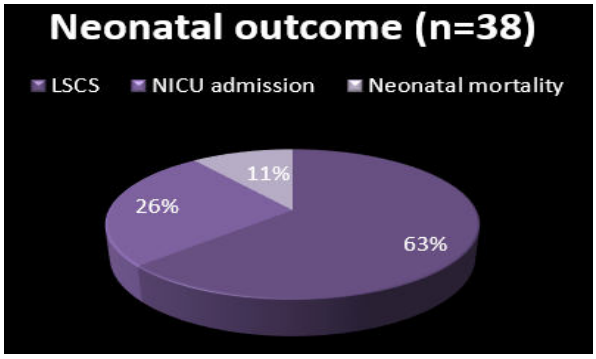


Fig3: Shows the neonatal outcome in growth restricted fetuses. Adverse outcomes were noted in 38 patients. Out of those 38, 24(63%) fetuses were delivered by LSCS, 10(26%) had NICU admission and, 4(11%) had neonatal mortality.

(LSCS- lower segment caesarean section, NICU- neonatal intensive care unit)

Table2: Aortic isthmus direction of flow correlation with fetal outcome.

Fetal outcome	Retrograde flow		Antegrade flow		p-value
	NO. n=2	%	NO. n=58	%	
LSCS	1	50	23	39.65	1.0000
NICU admission	0	0	10	17.24	-
NICU stay >48hrs	0	0	5	8.62	-
Perinatal mortality	2	100	2	3.44	0.0034

In this study it was seen that abnormal aortic isthmus flow i.e retrograde flow was associated with 1 (50%) LSCS and a perinatal mortality rate of 100%. In those cases with a normal antegrade flow, 23 had LSCS, 10 (17.24%) NICU admissions and no perinatal mortality was seen. Retrograde flow had a specificity of 100% in determining perinatal mortality and the p- value was found to be statically highly significant (<0.05).

Table3: Efficacy of various doppler parameters in predicting NICU admission.

Doppler finding	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy	P -value
Umbilical PI	70	84	60	93.34	81.67	0.0013
MCA PI	40	86	36.35	87.76	78.33	0.0743
CPR	60	82	39.99	91.11	78.33	0.0112
Aortic isthmus PI	20	76	14.28	82.62	66.67	1.0000

In our study, Umbilical PI was most sensitive (70%) and MCA PI was most specific (86%) in determining adverse perinatal outcome in form of NICU admission.

Table4: Efficacy of various doppler parameters in predicting perinatal mortality.

Doppler finding	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy	P -value
Umbilical PI	75	78.57	19.98	97.78	78.33	0.0448
Ductus PI	25	100	100	94.92	95	0.0667
MCA PI	25	82.14	9.02	93.88	80	0.5655
CPR	75	85.42	19.98	97.78	78.33	0.0448
Aortic isthmus PI	100	82.14	28.55	100	83.33	0.0021

It was found that aortic isthmus PI changes were most sensitive (100%) in determining perinatal mortality while ductus venosus PI was found to be most specific (100%) for the same.

DISCUSSION:

Fetal growth restriction is a common condition seen during antenatal surveillance, with significant perinatal complications. Apart from fetal biometry, the role of Doppler ultrasound in the study of uteroplacental and fetoplacental circulation is well known and it helps in detecting the extent of placental pathology and also predicts the fetal outcome.

The study of the AoI started as a promising tool to evaluate fetal redistribution in growth-restricted fetuses given its critical location between two different fetal circulations. The presence of reversed diastolic blood flow in the AoI implies the presence of redistribution of fetal circulation as it is a consequence of the decrease of the vascular resistances in the brain together with their increase in the lower body and placenta. Therefore, theoretically, it can be used as an indicator of "brain sparing" when monitoring FGR. No studies so far have evaluated longitudinally the sequence of changes in the AoI in relation to other arterial and venous Doppler parameters. Our results, showing that abnormal AoI-PI is an intermediate step between placental insufficiency-hypoxemia and cardiac decompensation, have interesting pathophysiological and clinical implications.

The present study was conducted to assess the ability of the Doppler study in FGR fetuses to predict neonatal outcomes in the form of NICU admission and length of NICU stay and perinatal mortality.

In the current study, sensitivity in predicting NICU admission for UA PI was 70%, MCA PI was 40% and CP ratio was 60%. The specificity in predicting NICU admission for UA was 84%, MCA was 86% and CP ratio was 82%. In a study by Rekha BR at el, the predictive value for Doppler for detecting abnormal fetal outcome in form of NICU admission, the sensitivity for UA PI, MCA PI, and CPR was 25%, 58%, and 17.9% respectively and specificity was 75%, 62.5%, and 75% respectively[16].

There was a significant correlation between abnormal CPR (<1.0) and adverse perinatal outcomes. NICU admissions, as well as perinatal mortality, were high among the abnormal group ($p<0.05$). However, a study done by Rekha BR abnormal CPR values ($p>0.05$) were not significant for adverse perinatal outcome[16].

In the current study, sensitivity in perinatal mortality for UA PI was 75%, MCA PI was 25% and CP ratio was 75%. The specificity in predicting NICU admission for UA was 78.57%, MCA was 82.14% and CP ratio was 85.42%. In a study by Rekha BR at el, the predictive value for Doppler for detecting abnormal fetal outcome in form of NICU admission, the sensitivity for UA PI, MCA PI, and CPR was 25%, 58%, and 17.9% respectively and specificity was 75%, 62.5%, and 75% respectively[16].

Our study confirms preliminary observations that there is a strong association between retrograde flow in the AoI and adverse perinatal outcome. Sensitivity in predicting perinatal mortality for aortic isthmus retrograde flow was 100% and specificity was 82.14% (p-value 0.0034). In a study by Tantuway B et al, the sensitivity and specificity of the aortic isthmus in predicting perinatal mortality was 66% and 92% respectively[13]. Another study done by K. Abdelrazzaq et al. found significant correlation between retrograde flow in aortic isthmus and perinatal mortality (p-value 0.029).[17]

Among the explanations that can justify why the utility of the AoI remains controversial is that the aortic isthmus is the smallest part of the aortic arch, is relatively short and there are also small vessels in close vicinity, which complicates the recording of pure and good-quality Doppler signals. These technical difficulties explain why the qualitative approach, simply observing the antegrade or reversed flow, is the most commonly used method in the clinical setting. Even though they can be largely overcome by using high-quality equipment in expert hands as was the case in our study.

CONCLUSION:

Our observation was in favor that Doppler imaging of the aortic isthmus can be used in the clinical surveillance of fetuses with FGR, and even the time of termination of the pregnancy can be decided especially in preterm fetuses. This study confirms and expands on previous observations suggesting that the occurrence of retrograde blood flow in the AoI is strongly associated with adverse perinatal outcomes, particularly intrauterine demise Till the flow in the aortic isthmus remains antegrade, the baby can be followed with non-stress testing, every alternate day, but with the occurrence of abnormality in the aortic isthmus, the decision for termination should be taken for preventing neonatal complications. The role of Doppler studies of the AoI as an additional clinical parameter in the routine assessment of hemodynamically compromised growth-restricted fetuses deserves further evaluation in large longitudinal studies.

Changes in ductus venosus occur later and if present is associated with high chances of fetal acidosis and mortality.

DECLARATIONS

Availability of Data and Materials: Not applicable.

Financial support and sponsorship: None

Conflicts of interest: None

Ethical approval and consent to participate:
Approved by Institutional Ethical Committee Dr. Sampurnanand Medical College Jodhpur. Certificate reference number: SNMC/IEC/2020/plan/346

Consent for publication: Not applicable

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