

DOPPLER ASSESSMENT OF THE AORTIC ISTHMUS AND ITS UTILITY IN MANAGEMENT OF INTRAUTERINE GROWTH RESTRICTED FOETUSES

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ABSTRACT

BACKGROUND

Cardiovascular Doppler indices have long been demonstrated to have an association with the risk of perinatal death. Recent studies have investigated whether the aortic isthmus (AoI) could contribute to the prediction of mortality.¹ The isthmus, located between the origin of the left subclavian artery and the aortic end of the DA, establishes communication between the two arterial outlets that perfuse in parallel the upper and lower body of the foetus.²

Objectives of this study were to evaluate the aortic isthmus doppler changes and its utility in management of growth-restricted foetuses.

MATERIALS AND METHODS

Prospective observational study, recruiting 50 women with singleton pregnancy at or beyond 28 weeks of gestation presenting to the tertiary referral hospital between June 2015 to January 2016 with intra uterine growth restricted foetus based on grey scale ultrasound findings and obstetric Doppler Ultrasound showing umbilical artery pulsatility index >95th percentile. Doppler parameters of umbilical artery, middle cerebral artery and aortic isthmus were recorded and compared to the reference values.

RESULTS

Out of 50 IUGR foetuses, 36(72%) showed antegrade aortic isthmus net flow whereas 14 (28%) showed retrograde aortic isthmus net blood flow. Median gestational age at inclusion and at delivery was 34.5 & 35.6 weeks in antegrade blood flow group and 30 weeks & 33 weeks in retrograde blood flow group respectively. 46% of patients had pregnancy-induced hypertension. IUGR with anaemia complicating pregnancy (sickle cell anaemia & beta thalassemia trait included) was present in 6% of cases. Bad obstetric history was seen in 4%. The postnatal complications were higher in retrograde aortic isthmus net blood flow group as compared to the antegrade net blood flow group.

CONCLUSION

Absence/reversal of diastolic flow in Aortic Isthmus carries grave prognosis and high mortality. Doppler imaging of the aortic isthmus could be used as a screening tool in clinical surveillance of foetus with IUGR. This might be of clinical relevance in improving the detection and management of intrauterine growth restriction.

KEYWORDS

Aortic Isthmus, Doppler, IUGR.

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BACKGROUND

The incidence of IUGR in a population where the mothers are generally healthy and well-nourished is estimated to be about 3-5%. In a population of women with hypertension or previous growth restricted foetus however the incidence increases to 15- 20% or higher.³ IUGR babies are prone to develop still birth, Intrapartum foetal acidosis, perinatal asphyxia, Meconium aspiration syndrome, Hypoglycaemia, Hypocalcaemia, Hypothermia and Hypoxic ischemic

encephalopathy etc. The uteroplacental and fetoplacental circulation give information on the placental resistance whereas evaluating the foetal circulation using Doppler ultrasound could non-invasively assess the foetal response to hypoxia.

Cardiovascular Doppler indices have long been demonstrated to have an association with the risk of perinatal death. Recent studies have investigated whether the aortic isthmus (AoI) could contribute to the prediction of mortality.

The isthmus, located between the origin of the left subclavian artery and the aortic end of the DA, establishes communication between the two arterial outlets that perfuse in parallel the upper and lower body of the foetus. The greater the reverse isthmic flow, the lower is the ISTMUS FLOW INDEX and the higher should be the risk of prenatal cerebral damage.⁴ This study aims at establishing the IFI level corresponding to impending decompensation; At this level, delivery of an IUGR foetus would be rationally

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indicated before the appearance of signs of central nervous system impairment.⁵

The primary objective of this study was to evaluate the aortic isthmus doppler changes and its utility in management of growth-restricted fetuses. We evaluated the relationship between quantitative (absolute velocities, impedance indices) and qualitative (retrograde blood flow) changes in the Aortic isthmus and arterial and venous circulations and the perinatal outcome in growth restricted fetuses.

Aim of the Study

The primary objective of this study was to evaluate the aortic isthmus doppler changes and its utility in management of growth-restricted fetuses.

MATERIALS AND METHODS

Study Population

This study was a non-interventional Prospective observational study, recruiting 50 women with singleton pregnancy at or beyond 28 weeks of gestation presenting to the tertiary referral hospital with intra uterine growth restricted foetus based on grey scale ultrasound findings and obstetric Doppler Ultrasound showing umbilical artery pulsatility index >95th percentile. Gestational Age of all patients was confirmed by first trimester sonography.

Women with multiple pregnancy and/or pregnancies with antenatally diagnosed congenital anomalies, were excluded. Informed written consents were obtained from all participants. Institutional Ethical Committee clearance was obtained prior to the study commencement. During data collection, medical conditions and medication taken at the time of booking were recorded. Demographic data (e.g. age), pregnancy related characteristics (e.g. parity, and gestational age) and perinatal risk factors were noted. Antenatal presentation was detailed, blood pressure was recorded, followed by a detailed BPP.

Ultrasound Examination

All patients were scanned on Philips HD 11 or Siemens Acuson X500 using a 2-5 MHz sector having colour Doppler and spectral capabilities. Ultrasound examination included a complete morphological examination and foetal weight and amniotic fluid index calculations. During each examination Doppler measurements were obtained from the umbilical artery (UA) and from both uterine arteries and middle cerebral artery.

Aortic Isthmus Velocimetry

Assessment of foetal Aortic isthmus Doppler velocimetry done in either the longitudinal aortic arch (LAA) or the three vessels and trachea view (3VT), as both sonographic planes of this vascular segment have been shown to provide reproducible Doppler parameters. The 3VT view was obtained at the level of the foetal mediastinum by moving the transducer cephalad from the four-chamber view. At this 3VT view, the pulmonary trunk, ductus arteriosus, aortic arch, AoI and superior vena cava are clearly demonstrated, with the aortic and ductal arches forming a V configuration

pointing to the posterior spine⁶. At least three Doppler waveforms were obtained for each measurement and the most representative one was included for analysis. Follow up Doppler studies were performed, if clinically indicated to determine a favourable or a worsening trend in the Doppler indices. However only the results of the last Doppler ultrasound performed within 72 hrs of delivery were used for analysis of perinatal outcome. Foetuses were stratified into two groups according to the direction of the diastolic blood flow in the aortic isthmus: antegrade flow or retrograde flow. Foetal heart rate patterns were obtained on twice weekly basis and foetal lung maturation was accelerated by maternal steroid application before timed delivery when indicated and always before 34 weeks of gestation.

Outcome

Neonatal evaluation included assessment of Apgar scores, birth weight and birth weight centiles as charted against local reference values of gestational age and gender. Umbilical cord arterial pH and blood gases were obtained at delivery. Poor perinatal outcome was defined as one or all of the following: poor APGAR score, need for resuscitation, neonatal acidosis perinatal asphyxia requiring interventions, meconium stained liquor, NICU admission.

Delivery

Timing of delivery of uncomplicated IUGR foetuses was through induction of labour at 38 – 40 weeks' gestation after maternal steroid application. Delivery of IUGR foetuses with abnormal umbilical artery Doppler was considered in cases of abnormal foetal heart rate pattern, reversed flow in the umbilical artery, abnormal biophysical profile, was at the discretion of the managing obstetrician⁷. In these cases, mode of delivery was by emergency Caesarean section.

RESULTS

Flow velocity waveforms of the uterine, umbilical, middle cerebral arteries, & aortic isthmus were obtained from all the 50 cases and were analysed.

All of our patients ranged from 19 to 30 years of age. The average age of the patients was 25.19 ± 3.19 years.

The gestational age at the time of Doppler examination ranged between 28 - 40 weeks. 62% of the antenatal mothers examined were between 30 to 38 weeks of gestation, 12 % were between 28-30 weeks' gestation and 26% with gestational age between 38- 40 weeks.

46% of patients had pregnancy-induced hypertension. IUGR with anaemia complicating pregnancy (sickle cell anaemia & beta thalassemia trait included) was present in 6% of cases. Bad obstetric history was seen in 4%.

In aortic isthmus Doppler study 25 foetuses (50%) showed Increased aortic isthmus RI, 22 foetuses (44%) showed decreased aortic isthmus PI, 30 foetuses (60%) showed decreased aortic isthmus PSV. 30 foetuses (60%) showed decreased aortic isthmus EDV.

Out of 50 IUGR foetuses, 36 showed antegrade flow in aortic isthmus whereas 14 showed retrograde blood flow.

Value	Number	Percentage
Antegrade	36	72
Retrograde	14	28
Total	50	100

Table 1. Distribution of Aortic Isthmic Net Blood Flow

	Antegrade Aortic Flow	Retrograde Aortic Flow
Perinatal Death	1	2
Postnatal Complications	0	10
PVH/IVH	0	0
Bronchopulmonary Dysplasia	0	0
Respiratory Distress Syndrome	2	2
Necrotizing Enterocolitis	0	0
Sepsis	0	2
NICU Stay>7 days	5	8

Table 2. Aortic Isthmus Net Blood Flow and Perinatal Outcome

(The complications were not exclusive,) The postnatal complications were higher in retrograde aortic isthmus net blood flow group as compared to the antegrade net blood flow group.

	Antegrade (n = 36)	Retrograde (n = 14)
GA Diagnosis	34.5 weeks	30 weeks
GA Delivery	37.6 weeks	33 weeks
Birth Weight	1.99 Kg.	1.68 Kg.
Apgar 5 min <7	3 (8.3%)	3 (21.4%)
Vaginal Delivery	26 (63.83%)	5 (35.17%)
Caesarean Section	10 (36.17%)	9 (64.28%)

Table 3. Short Term Outcome of Neonates

IUGR fetuses with retrograde blood flow were more frequently born by caesarean section because of the foetal compromise (64.3% in retrograde blood flow v/s. 27.8% in antegrade blood flow).

Type of Delivery	Flow		Total
	Anterograde	Retrograde	
LSCS	10	9	19
	27.8%	64.3%	38%
VAGINAL	26	5	31
	72.2%	35.7%	62%
Total	36	14	50
	100%	100%	100%

Table 4. Aortic Isthmus Net Blood Flow & Type of Delivery

DISCUSSION

Numerous studies with varying results have been published and difficult to compare. Yet no universally accepted standard for defining an abnormal Doppler flow velocity waveform as well as the pregnancy outcome measure, so conflicting observations might continue to emerge.

It is observed that the maximum number of pregnant women were in the age group of 21-25 years (48%). This can be attributed probably to increased pregnancy rate in these age groups

In this study all patients underwent Doppler study in the third trimester of their pregnancy with 64% being investigated between 31-35 weeks of gestation.

The earliest study was done at 29th week of gestation. Hence most pregnancies were monitored between 31-35 weeks, when the foetus would have begun developing sufficient lung maturity to survive outside the uterus.

Figeuras et al⁷ studied Doppler of umbilical, middle cerebral artery, ductus venosus & aortic isthmus in 46 small-for-gestational foetuses requiring delivery before 34 weeks. The median gestational age at inclusion was 28.9 (range, 23.6–33.4) weeks and delivery occurred at a median gestational age of 30.5 (range, 25.9–33.9) weeks. Six (13%) cases of perinatal mortality occurred. Aortic isthmus Doppler became abnormal on average 13 days before delivery.

Symmetrical IUGR accounts for 20-30% and asymmetrical IUGR accounts for 70-80%. In asymmetrical IUGR insult begins later than symmetrical IUGR, usually after 28 weeks of gestation. Hence 31-35 weeks of gestation probably could be more common.⁸

Cruz Martinez et al⁹ evaluated AoI and DV pulsatility indices (PI) every 1–7 days in a cohort of IUGR fetuses with abnormal umbilical artery Doppler PI (>95th percentile) delivered before 34 weeks’ gestation. AoI-PI and DV-PI showed increases with the progression of foetal deterioration throughout the follow-up study period. On average, AoI-PI and DV-PI crossed the 95th percentile at 12 days and 5 days before delivery, respectively.

The redistribution calculated from the ratio of the PI in the MCA to PI in umbilical artery showed 64% of the fetuses to redistribute their cardiac output than either umbilical artery PI (60%) or middle cerebral artery (44%) alone. The sensitivity of MCA PI / Umb PI of our study is 87.5% in predicting perinatal outcome. These results are slightly higher to D Gramellini et al study (68%), probably this may be attributed to small sample size.¹⁰

The aortic isthmus flow index provided a better predictor of intrauterine growth restriction and adverse perinatal outcome than either aortic isthmus RI or PI or PSV alone. Absent end diastolic flow/ reversal of aortic isthmus flow is an ominous sign since it carries a grave prognosis and a high mortality.¹¹

Prediction of Perinatal Outcome

In the present study, there was a statistically significant increase in perinatal mortality and morbidity in retrograde aortic net blood flow group.¹² An interesting finding was that neonates with aortic isthmus retrograde net flow were more

frequently born by caesarean section because of suspected foetal compromise ($p = 0.017$).

Neonates born with the retrograde aortic blood flow had lower birth weights (mean 1.68 kg) as compared with neonates in normal aortic blood flow (mean 1.99 kg).

NICU admission rate was overall high, however neonates with the retrograde blood flow had prolonged NICU stay ($p < 0.01$).

No significant differences for respiratory distress syndrome, intraventricular haemorrhage, necrotizing enterocolitis were found.

Summary

We studied 50 pregnancies with IUGR. Mean birth at delivery was 1.90 kg. 28% neonates in retrograde blood flow group had mean birth weight of 1.68 kg. 70% of neonates had at least one adverse event. Remaining 30% had favourable outcome. There were 3 perinatal deaths in retrograde net blood flow, whereas there were no deaths in antegrade aortic isthmus blood flow group. ($p < 0.01$). Of the remaining 47, 32 were admitted to NICU. 4 neonates had Apgar score less than 7 and 19 babies were born by emergency caesarean section.

The sensitivity & specificity of PI of aortic isthmus was 78.85% and 66.67%. This was comparable to the RI of aortic isthmus as sensitivity of 71.76% & specificity of 72.41%. The sensitivity & specificity of PSV of aortic isthmus was 74.29% and 73.33%.

The aortic isthmus flow index provided a better predictor of intrauterine growth restriction and adverse perinatal outcome than either aortic isthmus RI or PI or PSV alone. absent end diastolic flow/ reversal of aortic isthmus flow is an ominous sign since it carries a grave prognosis and a high mortality.

CONCLUSION

The umbilical-placental and cerebral vascular beds are directly involved in the hemodynamic adjustments of foetal growth restriction.¹³ A doppler index that reflects both these areas can be useful for identifying foetuses with increased placental and/or cerebral resistance.

Assessment of both the uteroplacental circulation and the fetoplacental circulations together is more sensitive to predict to perinatal outcome, than assessment of each alone. Aortic isthmus doppler measurements are useful for identifying decompensated growth restricted foetuses before deterioration occurs, to plan optimal timing of delivery.¹⁴

Absence/reversal of diastolic flow in Aortic Isthmus carries grave prognosis and high mortality.

Doppler imaging of the aortic isthmus could be used as a screening tool in clinical surveillance of foetus with IUGR after confirmation in large prospective trial.

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