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Original Research Article

Role of colour doppler indices in diagnosing intrauterine growth restriction in high risk pregnancies in second and third trimester

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ABSTRACT

Background: Intrauterine growth restriction (IUGR) is associated with impaired neurological development of child, increased morbidity and increased risk of death during perinatal period. Doppler ultrasound during pregnancy is a useful tool for early detection of IUGR and this helps in early management to prevent further complications associated with IUGR.

Objective: To study efficacy of color doppler in diagnosing Intrauterine growth restriction in high risk pregnancies in second and third trimester.

Materials and Methods: Diagnostic efficacy study was conducted among 100 subjects with high risk pregnancy presenting in second and third trimester. IUGR was suspected when there was a growth lag of >4 weeks between gestational age and fundal height. Further two-dimensional ultrasound was performed. Bi-parietal diameter, Head circumference, Abdominal circumference, Femur length were noted, estimated fetal weight was calculated. IUGR fetuses were identified if abdominal circumference is<5^{th} percentile and estimated fetal weight was<10^{th} percentile for that gestational age. Vessels studied were Uterine artery, Umbilical artery, Middle cerebral artery, Ductus venosus. The doppler indices studied were RI, PI, S/D, Cerebro-Placental ratio (CPR).

Results: Majority were of 22-25 years (52.5%); 53.75% were primigravida; 41.25% presented at 33-37 weeks; 46.25% had gestational hypertension. The overall sensitivity of doppler indices as seen in the present study was good (89.9%) but specificity was only 9.1%. Among the other indices, CPR had the best diagnostic utility with sensitivity=64%; specificity=100% and PPV=100% followed by umbilical artery doppler with sensitivity=55.1%; specificity=81.8% and PPV=96.1%.

Conclusion: The overall color doppler indices are highly sensitive in detection of IUGR and lacks the specificity. CPR and Umbilical artery doppler can be used with more reliability.

1. Introduction

The ultrasonography evidence of less than 10^{th} percentile of fetal weight for gestational age is called Intrauterine growth restriction (IUGR). If the birth weight of less than 10^{th} percentile of the new-born for the gestational age, it is called small for gestational age (SGA). [1]

The definition of low birth weight (LBW) does not take into consideration the any other criteria like gestational age which is used in the definition of the IUGR & SGA. It simply says any child whose weight at the time of the birth is less than 2.5 kg irrespective of any other factors like race, sex, gestational age etc. [2]

It has been estimated that around one third of the babies are born with the low birth weight. The incidence of IUGR is about 6-30% in developing countries whereas it is much lesser in the developed countries which is

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about only 4-8%. In the general population, around 8% of babies have IUGR. It is an important cause of still birth accounting for more than half of the cases of the still birth. 10% of the children with IUGR die during perinatal period as they were not diagnosed with the IUGR at an early stage where intervention was possible and life could have been saved. Important risk factors of IUGR are preeclampsia, hypertension during pregnancy, infections, placental insufficiency, gestational diabetes mellitus, mothers from low social classes. IUGR is the most commonly seen complication of the pregnancy and it has been found that this is associated with impaired neurological development of the child, increased morbidity and increased risk of death during the perinatal period. Doppler ultrasound during pregnancy at regular intervals is a useful tool for early detection of IUGR and this early detection helps in the early treatment and management to prevent further complications associated with IUGR.[3]

Due to presence of risk factors which increase the resistance of the blood flow within the circulation of the placenta; there is reduction in the blood supply to the fetus. This phenomenon is commonly found in diastole. This pathogenesis leads to IUGR. The slowdown of the diastolic flow compared to the systolic flow causes an imbalance or disproportion in doppler indices like pulsatility index and systolic/diastolic ratio. The commonly used Doppler indices for evaluation of the IUGR are "umbilical artery Doppler, Uterine artery Doppler, middle cerebral artery Doppler, ductus venosus Doppler, aortic isthmus Doppler, cerebro placental ratio."[4]

The status of the maternal circulation is known by the doppler study of the uterine artery. Similarly, the status of the fetal circulation is known by the doppler of the middle cerebral artery and umbilical artery. The sensitivity and specificity of the doppler of the uterine artery is limited especially in the third trimester in predicting the IUGR. An increased risk of death during perinatal period can be predicted by doppler of the umbilical artery if the results show the presence of the absent end diastolic flow or the reversal of the end diastolic flow.[5]

High risk pregnancies have more chances of IUGR. Unfortunately, these at-risk mothers are from low social classes and hence due to ignorance they present in the third trimester when the invasive methods are least likely to be applied. Hence non-invasive methods are required and doppler ultrasound of the arteries is one such investigation which is quite sensitive and specific in the diagnosis of the IUGR.[6]

With this background, present study was undertaken to study the efficacy of color doppler indices in diagnosing Intrauterine growth restriction in High Risk Pregnancies in second and third trimester

2. Materials and Methods

This diagnostic efficacy study was conducted in the Department of Radio-diagnosis along with Obstetrics and Gynaecology, at a tertiary care hospital Malla Reddy Institute of Medical Sciences during the period of December, 2019 to December, 2020. A total of 100 subjects were included in the present study. Institutional Ethics Committee permission was obtained. Written informed consent was taken from all study subjects.

2.1. Inclusion criteria

One hundred singleton high risk pregnancies in their second and third trimester complicated with either

1. Hypertension,
2. Severe anaemia,
3. Gestational and overt diabetes mellitus,
4. Heart disease,
5. Thyroid disorders,
6. Rh Isoimmunisation,
7. Previous history of IUGR,
8. Bad obstetric history

2.2. Exclusion criteria

Fetuses with

1. Congenital anomalies and
2. Multiple pregnancies.

Samsung H60 colour doppler machine was used for the study. CA 1-7 AD curvilinear probe was used.

Subjects' name, age, IP No, education status, previous obstetric outcome was noted in detail. Last menstrual period and menstrual history was taken. Patients were examined. IUGR was suspected when there was a growth lag of >4 weeks between gestational age and fundal height. Further the patients were subjected to two-dimensional ultrasound. Bi-parietal diameter, Head circumference, Abdominal circumference, Femur length were noted, estimated fetal weight was calculated. IUGR fetuses were identified if abdominal circumference is $<5^{th}$ percentile and estimated fetal weight was $<10^{th}$ percentile for that gestational age.

2.3. Biparietal diameter (BPD)

For measuring BPD, there should be a correct plane of section and calvaria are smooth and bilaterally symmetrical. The plane passing through thalami and third ventricle is acceptable for measuring BPD. The measurements were taken between outer edge of near calvarial wall and inner edge of far calvarial wall.

2.4. Head circumference

The plane of section through the thalami and third ventricle in the centre, cavum septum pellucidum in the anterior portion and tentorial hiatus in the posterior portion of brain must be visible. A computer-generated ellipse is to be fit to the calvarial margin.

2.5. Abdominal circumference

Abdominal circumference is measured in a position where the transverse diameter of liver is greater and the right and left portal veins are continuous with other. The ellipse is fit to the skin edge after getting the correct plane.

2.6. Femur length

The proper plane of section is obtained by aligning the transducer to the long axis of long bone and is ensured by demonstrating both the femoral head or greater trochanter and femoral condyle simultaneously. The ossified portion of diaphysis and metaphysis are measured and the cartilaginous portions are excluded.

2.7. Estimated fetal weight

The estimated fetal weight is calculated by an inbuilt software in ultrasound machine by using Hadlock formula. Doppler velocity waveforms of various vessels were taken serially with patient lying in semi recumbent position with a lateral tilt. Doppler transducer was placed on the abdominal wall over uterus and manipulated carefully till the signals appropriate for that particular vessels are obtained. Examination is done only during fetal inactivity and apnoea.

The following vessels were studied:

1. Uterine artery
2. Umbilical artery
3. Middle cerebral artery
4. Ductus venosus

2.8. Uterine artery doppler

The main branch of uterine artery can be identified by placing the probe above the inguinal ligament searching for the characteristic sound of uterine artery velocity waveforms. Pulsed wave doppler allows to observe the sampling site. Colour imaging can facilitate the identification of uterine arteries. An alternate easier method for identification of uterine arteries and its branch is by transvaginal approach, placing the transvaginal probe in the lateral fornix.

2.9. Umbilical artery and vein

The measurements are obtained from free loop of umbilical artery in midway between placental and abdominal wall insertion. The fetal end has high resistance and the placental end has the low resistance, and hence the midway vessels were chosen. The umbilical vein is found adjacent to it.

2.10. Middle cerebral artery

The middle cerebral artery is located in transverse plane at the level of lesser wing of sphenoid bone with sample gate near the proximal portion of the vessel.

2.11. Cerebral – umbilical pulsatility ratio

It is calculated by dividing PI of the middle cerebral artery by the PI of umbilical artery.

2.12. Ductus venosus

The ductus venosus can be identified in full length in a midsagittal longitudinal section of the trunk or in an oblique transverse section through the upper abdomen. The signals were recorded for a minimum of 5 to 8 cycles with flow velocity wave forms of equal shape, amplitude and quality and then the image is frozen and measurements were taken.

Doppler indices measured were systolic/diastolic ratio(S/D), Pulsatility index (PI), Resistance index (RI). All patients were kept under surveillance depending upon the findings till delivery. The patients were monitored with fetal kick count, BPP, CTG, Doppler. GHT patients were treated with antihypertensives, severe anaemia patients are transfused with packed cell. A standard proforma was compiled for each patient mentioned the all above parameters and all the details of history, examination, investigations are recorded as per proforma.

2.13. Statistical analysis

True positive, true negative, false positive, false negative values were measured to get the sensitivity, specificity, positive predictive value, negative predictive values of doppler parameters namely uterine artery PI, umbilical artery PI, MCA artery PI, CPR and ductus venosus.

3. Results

The study was done in 100 high risk subjects in their second and third trimester and the following observations were made.

Among the 100 subjects, abnormal doppler indices were found in

1. Uterine artery - 36
2. Umbilical artery - 51
3. Middle cerebral artery – 10
4. CPR – 57
5. Ductus venosus – 1

Among the 100 patients studied, 89 patients had IUGR babies, and the remaining 11 babies had birth weight >2.5kg

out of which 10 had abnormal doppler indices but had normal perinatal outcome.

Among the 89 patients who had IUGR babies, 80 patients had abnormal doppler indices, and 9 patients had normal doppler indices.

Among the 80 IUGR babies with abnormal doppler indices, in

1. Uterine artery - 29
2. Umbilical artery - 49
3. Middle cerebral artery – 9
4. CPR – 57
5. Ductus venosus - 1

Table 1 shows characteristics of study subjects with IUGR. Majority of the patients were in the age group of 22-25 years (52.5%). Majority (53.75%) were primigravida and most of them i.e. 41.25% presented at gestational age of 33-37 weeks. The most common risk factor for IUGR was gestational hypertension in 46.25% of the cases followed by anemia in 20% of the cases.

Table 2 shows distribution of study subjects as per Doppler findings among cases with IUGR (N=80).Uterine artery Doppler was abnormal in 29 cases (36.25%) out of which early diastolic notch with increased uterine artery S/D ratio was seen in eight cases. Umbilical artery Doppler was abnormal in 49 cases (61.25%) out of which AEDV was seen in six cases and REDV was seen in three cases. Middle cerebral artery doppler was abnormal in only nine cases. Cerebro- placental ratio was abnormal in 57 cases while ductus venosus doppler was abnormal in only one case.

Table 3 shows diagnostic utility of various Doppler indices in the diagnosis of IUGR. The overall sensitivity ofdoppler indices as seen in the present study was good (89.9%) but specificity was only 9.1%. Among the other indices, CPR had the best diagnostic utility with sensitivity of 64%; specificity of 100% and positive predictive value (PPV) of 100% followed by umbilical artery doppler with sensitivity of 55.1%; specificity of 81.8% and PPV of 96.1%.

4. Discussion

In the present study majority of the patients were in the age group of 22-25 years (52.5%). Majority (53.75%) were primigravida and most of them i.e. 41.25% presented at gestational age of 33-37 weeks. The most common risk factor for IUGR was gestational hypertension in 46.25% of the cases followed by anemia in 20% of the cases. Uterine artery Doppler was abnormal in 29 cases (36.25%) out of which Early diastolic notch with increased uterine artery S/D ratio was seen in eight cases. Umbilical artery Doppler was abnormal in 49 cases (61.25%) out of which AEDV was seen in six cases and REDV was seen in three cases. Middle cerebral artery doppler was abnormal in only nine cases. Cerebro- umbilical pulsatility ratio was abnormal in 57 cases while ductus venosus doppler was abnormal in only one case. The overall sensitivity of doppler indices as seen in the present study was good (89.9%) but specificity was only 9.1%. Among the other indices, CPR had the best diagnostic utility with sensitivity of 64%; specificity of 100% and positive predictive value (PPV) of 100% followed by umbilical artery doppler with sensitivity of 55.1%; specificity of 81.8% and PPV of 96.1%.

Hugo EJ et al[7] included 572 singleton pregnancies and found that with increase in the resistive index (RI) of the umbilical artery, the incidence of IUGR also increased with 13.2% incidence with RI of $< 75^{th}$ percentile; 39.1% incidence with RI of 75-95^{th} percentile and an incidence of 41.7% with RI of $> 95^{th}$ percentile. They concluded that if the umbilical artery doppler study is normal then the incidence of IUGR is less likely and also the associated complications.

Schulman H et al[8] found a sensitivity of 91% and specificity of 85% for S/D ratio of umbilical artery but in the present study we found that the sensitivity was very less i.e. 55.1% whereas the specificity was comparable.

SOGC[9](Society of Obstetricians and Gynaecologists of Canada) gave following recommendations were made, “Umbilical artery Doppler should be available for assessment of the fetal placental circulation in pregnant women with suspected severe placental insufficiency. Depending on other clinical factors, reduced, absent or reversed umbilical artery end diastolic flow is an indication for enhanced fetal surveillance or delivery. If delivery is delayed to enhance fetal lung maturity with maternal administration of glucocorticoids, intensive fetal surveillance until delivery is suggested for those fetuses with reversed end diastolic flow.”

Alatas C et al[10] observed that the specificity of the pulsatility ratio in the middle cerebral artery was 96.4% and PPV of 80.6% which is comparable to the present study findings of specificity of 90.9% and PPV of 90%. The authors concluded that this information from middle cerebral artery was good enough to predict IUGR in high risk pregnancies.

Guerrero Casillas MA et al[11] studied the correlation between the middle cerebral artery/umbilical artery RI with IUGR and found that it had 100% sensitivity and 91% specificity. For predicting the perinatal death, it had 100% sensitivity and 92% specificity. They concluded that with this good prediction methods, this middle cerebral artery/umbilical artery RI can be used as the method of choice.

Ebrashy A et al[12] found a sensitivity of 64.1%; specificity of 72.7% and PPV of 89.2% with a NPV of 63% for IUGR by using the middle cerebral artery/umbilical artery ratio.

The doppler study of fetal venous blood flow in ductus venosus have raised newer expectations in investigating

Table 1: Characteristics of study subjectswith IUGR (N=80)

Characteristics		Number	%
Age (years)	18-21	26	32.5
	22-25	42	52.5
	26-31	6	7.5
	32-35	5	6.25
	> 36	1	1.25
Gravida	Primi	43	53.75
	Second	30	37.5
	Third	5	6.25
	Fourth and above	2	2.5
Gestational age (weeks)	18-24	5	6.25
	25-28	10	12.5
	29-32	16	20
	33-37	33	41.25
	38-40	16	20
Educational status	Primary	6	7.5
	Middle	10	12.5
	High school	36	45
	Degree	16	20
	Illiterate	12	15
Risk factors for IUGR	Gestational hypertension	37	46.25
	Chronic hypertension	6	7.5
	Anaemia	16	20
	Heart disease	4	5
	Diabetes	2	2.5
	Bronchial asthma	1	1.25
	Hypothyroid	4	5
	Previous h/o IUGR	10	12.5

Table 2: Distribution of study subjects as per Doppler findings (N=80)

Type of Doppler	Finding		Number	%
Uterine artery Doppler	Normal		51	63.75
	Abnormal		29	36.25
	Abnormal type	Only increased uterine artery S/D ratio	21	26.25
		Early diastolic notch with increased uterine artery S/D ratio	8	10
Umbilical artery Doppler	Normal		31	38.75
	Abnormal		49	61.25
	Abnormal type	Reduced diastolic flow	40	50
		Absence of end-diastolic velocities (AEDV)	6	7.5
		Reverse End Diastolic Velocity (REDV)	3	3.75
Middle cerebral artery doppler	Normal		71	88.75
	Abnormal		9	11.25
Cerebro- umbilical pulsatility ratio	Normal		23	28.75
	Abnormal		57	71.25
Ductus venosus doppler	Normal		79	98.75
	Abnormal		1	1.25

Table 3: Diagnostic utility of various Doppler indices in the diagnosis of IUGR

Variables	True positive (a)	False positive (b)	False negative (c)	True negative (d)	Sensitivity	Specificity	Positive predictive value	Negative predictive value
Doppler indices overall	80	10	9	1	89.9%	9.1%	88.9%	10%
Uterine artery doppler indices	29	7	60	4	32.6%	36.4%	80.6%	6.3%
Umbilical artery doppler indices	49	2	40	9	55.1%	81.8%	96.1%	18.4%
Middle cerebral artery doppler indices	9	1	80	10	10.1%	90.9%	90%	11.1%
Cerebral-umbilical pulsatility ratio (CPR)	57	0	32	11	64%	100%	100%	25.6%
Ductus venosus	1	0	88	11	1.1%	100%	100%	11.1%

fetal hemodynamic changes more accurately. Despite of promising results, the application of venous fetal doppler parameters are not yet found widespread application in assessing IUGR fetuses, partly due to technical difficulty and moreover, within the same vessel, it is not which doppler index has the highest discriminative value to predict fetal acidosis. Moreover, venous doppler abnormalities will not precede the deterioration of biophysical profile.[13]

Todros T et al[14] reported that more than 50% of fetuses delivered due to abnormal fetal heart tracings did not have venous doppler abnormalities.

Muller T et al[15] found a significant association between IUGR and "absent or reverse flow in DV along with ADEV and REDV in umbilical artery". They concluded that this is a useful method to predict the IUGR. In the present study, only one case has abnormal ductus venosus study.

5. Conclusion

MCA S/D alone is a poor predictor of IUGR. CPR is the best parameter in detection of IUGR. Ductus venosus reversal flow is ominous sign of academia and has a very poor prognosis. Doppler study helps in early intervention and good outcome. The overall color doppler indices are highly sensitive in detection of IUGR and lack the specificity. Umbilical artery doppler and CPR can be used with more reliability.

6. Conflict of Interest

The authors declare that there is no conflict of interest.

7. Source of Funding

None.

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