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ORIGINAL ARTICLE

Role of Colour Doppler Indices in the Diagnosis of Intrauterine Growth Retardation in High-Risk Pregnancies

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Abstract
Purpose Intra uterine growth retardation (IUGR) due to fetoplacental vascular insufficiency is rampant in developing countries like India. Owing to the lack of awareness, antenatal patients often present in their third trimester for their first ultrasound examination. Alterations in the waveforms and Doppler indices of fetal middle cerebral artery (MCA), umbilical artery and bilateral uterine arteries have been extensively described in various studies in the literature. However, the role of each doppler parameter in actually predicting reduced birth weight (for gestational age) in the third trimester is often debatable and frustrating.
Method A prospective study was done on 100 patients of clinically suspected IUGR/high-risk pregnancies of 31–41 weeks. The cases were followed till delivery; the doppler and grey scale findings were correlated with the birth weight of the baby.
Result The highest sensitivity was found to be of HC/AC ratio, (84.4 %), the highest specificity of oligohydramnios and Cerebral/Umbilical Pulsatility ratio[C/U ratio] (100 %). The sensitivity of C/U ratio was found to be 68.8 %. Fetal MCA had the lowest sensitivity (7.7 %).
Conclusion HC/AC ratio is quite sensitive, and oligohydramnios is a highly specific parameter to diagnose IUGR. However, the former has lower specificity, and the latter has very poor sensitivity. The MCA PI alone is not sensitive at all, and should not be used for screening purposes in IUGR patients. Also, C/U ratio is more sensitive than oligohydramnios and more specific than HC/AC ratio and stands out as the best parameter of all to diagnose IUGR in the third trimester.

Keywords Intra uterine growth retardation · Fetal doppler · Small for gestational age · Placentation and IUGR · Cerebral/umbilical (C/U) pulsatility ratio

Introduction

Pregnancies associated with specific risk factors have high likelihood of complicating into IUGR. Many such patients present in their third trimester for the first time for their antenatal examination. Such patients warrant a highly sensitive and specific diagnostic test which can be non-invasively applied on a large scale. The purpose of this study was to determine the role of ultrasonography in screening high-risk mothers for detection of IUGR, to find out the impact of fetal parameters on the extent of IUGR, correlation between the sonographic pattern of IUGR and

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the birth weight, and to find out the sensitivities of various fetal parameters and their evaluation against each other and against the birth weight.

Materials and Methods

Proper approval from the local ethics committee of our institute was taken.

Study Design

The study was a prospective study done on 118 patients, with their due consents, between June 2010 and Dec 2011, which were scanned for various grey scale and doppler parameters and then followed till delivery. Eighteen patients were lost during follow-up, and hence 100 patients were studied to note the birth weight and mode of delivery. All guidelines prescribed by the Pre Natal Diagnostic Test (PNDT) act, 1994 were strictly followed.

The study was undertaken with the following parameters:

Inclusion Criteria

1. The LMP (Last menstrual period) of the patient was well known.
2. The gestational age of patient was between 31 and 41 weeks (derived from LMP).
3. The pregnancy was single.
4. The patient was a clinically diagnosed case of IUGR (based on findings such as Insufficient weight gain, decrease or no increase in abdominal girth and decrease or no increase in fundal height.)

OR

One of the following risk factors was present in the patient:

Known case of preeclampsia.

Hypertension, i.e. blood pressure of more than 140/90 mmHg as detected after 20 weeks of pregnancy: Gestational hypertension.

Patients with classical features of preeclampsia would have: hypertension, oedema, proteinuria.

OR

Maternal essential hypertension: This was diagnosed if a BP of 140/90 % mm Hg or more existed before 20 weeks of pregnancy without the evidence of previous chronic renal disease.

OR

Previous IUGR: a mother known to have produced a previous growth-retarded infant.

Exclusion Criteria

Exclusion criteria were

(1) Multiple pregnancies; and
(2) Congenital anomalies in the fetus.

Source of Data

Patients who presented to the Obstetric OPD/IPD with clinical symptoms and risk factors, and laboratory data of IUGR, and referred to ultrasound examination to the Department of Radiodiagnosis at Gandhi Medical College and Hamidia Hospital, Bhopal between June 2010 and December 2011.

Method of Collection of Data

Complete evaluation of all patients was done in the following format:

Detailed clinical history,
Laboratory data analysis and
Ultrasonographic evaluation.

Instrumentation

All examinations were performed using GE LOGIC 3 EXPERT scanner with 3.5 MHz transducer.

Preparation of the Patient

The patients were instructed not to evacuate their urinary bladder for at least 3 h before the examination.

Technique of Scanning

Scanning for Biparietal Diameter and Head Circumference

The BPD was measured in the scan which shows the widest diameter at the level of midline echo complex (the interhemispheric fissure), two lateral ventricles and the thalami. The reference point for BPD is the measurement from the inner margin of distal skull interface to outer margin of proximal skull interface. Head circumference was measured in the same plane used for BPD measurement.

Scanning for Abdominal Circumference

The transducer was then placed at right angle to the plane between the heart and the bladder. This assured that the level of the point at which the abdominal circumference was perfectly circular and included the liver, the horizontal portion of the portal vein, as well as the stomach bubble

and the fetal spine. The abdominal circumference was measured using the electronic calipers with maximum diameters using outer to outer technique.

Scanning of Femur Length

Once the femur was located, an attempt was made to define both the ends of the calcified portion of the femur. This is done most accurately if both the soft tissues of the buttock and the knee joint can be seen and which usually avoids tangential section of the bone.

Scanning for Amniotic Fluid

Amniotic fluid volume was estimated by measuring the deepest vertical pocket of liquor amnii which was free of any fetal part or umbilical cord. A measurement of <2 cm was considered as oligohydramnios, 2–8 cm as normal amniotic fluid volume, and >8 cm as polyhydramnios.

Doppler Examination of Blood Flow Velocity Waveforms

The uterine artery was studied by first identifying the placental site. If the placenta was unilateral, then uterine artery of that side was studied. Also the waveform and pulsatility index of contralateral uterine artery were noted for comparison. In case of central placenta, both uterine arteries were evaluated. The main branch of uterine artery is located at cervico-corporal junction, and Doppler velocimetry measurement was performed near this location. The pulsatility index was obtained and the value was noted down.

Next in order to examine the umbilical artery then, a suitable amniotic fluid pocket is chosen with loops of umbilical cord floating in it. Three sites of umbilical cord were chosen at insertion into placenta; at insertion into fetal umbilicus; and at midway. The pulsatility index was obtained, and the values were noted down. An average of these three values was taken.

Next in order to examine the middle cerebral artery (MCA) for measurement of MCA, an axial view of fetal head was obtained at the level of cerebral peduncles; then the colour doppler was used to visualize the circle of Willis, and the Doppler samples were placed within 1 cm of the origin of MCA which was easily identified as a major branch running anterolateral from the circle of Willis towards the lateral edge of orbit. The pulsatility index was obtained, and the values were noted down.

Doppler Indices Measured were Defined as

Pulsatility Index: It requires digitalized waveforms analysis for calculating the mean of the frequencies represented

$$\text{PI} = \frac{\text{S} - \text{D}}{\text{Mean of frequencies}}$$

The cerebral/umbilical pulsatility ratio (C/U ratio): It is the ratio of pulsatility indices of fetal middle cerebral artery and umbilical artery.

Identification of IUGR

These indices were than compared with routine ultrasonic measurements of HC/AC ratio and were also correlated with subsequent birth weight.

The fetuses were regarded as growth retarded when compared to the standard 'Hadlock's Charts of gestational ageing'. If the fetal parameter was within ±2SD, then it was regarded as normal. However, if it was more than 2SD less than the mean gestational age for a particular week of pregnancy, then it was regarded as being abnormal. The BPD, HC, FL and the AC were all tabulated in this manner and compared with the standard charts.

Data Collection

A standard proforma was compiled for each patient documenting the above mentioned parameters. The birth weight of the neonate was noted, and all the details of history, examination and investigations were recorded as per proforma.

Statistical Analysis

This was done by determining the degree of sway from mean gestational age (−2 SD). Sensitivity of each parameter was determined. The statistical analysis was done using *t* test. Probability values (*p* value) <0.05 were considered significant.

True positive, true negative, false positive and false negative values were measured to derive the sensitivity, specificity, positive and negative predictive values of various grey scale and doppler parameters, viz. HC/AC ratio, oligohydramnios, umbilical artery PI, uterine artery PI, fetal MCA PI and C/U ratio.

Observations

All the cases were between 18 and 40 years of age. Most of the cases were between 21 and 25 years of age comprising 47 % of the total number of cases included in this study. Maximum number of cases was those of primipara, i.e. 49 comprising 49 % of the total. A majority of high-risk cases were of PIH which constituted 31 % of total cases; this was followed by 20 % cases with previous history of having given birth to growth-retarded babies. In 11 % of cases, no

risk factor was found. Maximum number of cases with the previous history of IUGR cases were found in the age group of 21–25 years (65 %).

In our group of patients, gestational age at the time of examination in majority of cases was 35.1–37 (31 %) and 33.1–35 weeks (27 %), both groups together comprising 58 % of pregnancies, 20 % cases each were from 31 to 33 weeks and 37.1 to 39 weeks of gestation, 2 % from 39.1 to 41 weeks of gestation.

Regarding location of the placenta, a lateral position of placenta was associated more commonly with SFD cases (21.1 %) than with AFD cases (10 %). An anterior location of placenta was most frequently observed in SFD as well as AFD cases.

88 % of high-risk cases were found to have low birth weight babies. Newborns were classified according to Lubchenco classification:

1. Low birth weight: Weight below 2,500 g
2. Appropriate for date: Weight above 2,500 g.

Indication for LSCS was fetal distress in maximum number of cases.

Maximum no of newborns were found to have birth weight between 2.0 and 2.1 kg (29 %)

The sensitivity of HC/AC in detecting SFD cases was 21.1 % with a specificity of 100 %, a positive predictive value of 100 and a negative predictive value of 12.3.

The association of abnormal HC/AC ratio with an abnormal outcome (SFD) was highly significant (p value < 0.0001).

The sensitivity of oligohydramnios in detecting SFD cases was 21.1 % with a specificity of 100 %, a positive predictive value of 100 and a negative predictive value of 12.3. The association of the presence of oligohydramnios with an abnormal outcome (SFD) was not statistically significant (p value 0.201).

The association of an abnormal uterine artery PI with an outcome of caesarean section was found to be very significant (p value $= 0.0099$).

The association of an abnormal umbilical artery PI with an outcome of caesarean section was not found to be statistically significant (p value $= 0.1399$).

The association of an abnormal fetal middle cerebral artery PI with an outcome of caesarean section was not found to be statistically significant (p value $= 0.1419$).

The association of an abnormal C/U ratio with an outcome of caesarean section was not quite statistically significant (p value $= 0.0927$).

The sensitivity of uterine artery waveform in identifying IUGR in high-risk group was 37.7 % with a specificity of 70 %, a positive predictive value of 91.8 and a negative predictive value of 11.1.

The sensitivity of umbilical artery waveform in identifying IUGR in high-risk group was 64.4 % with a specificity of 80 %, a positive predictive value of 96.6 and a negative predictive value of 20.

The sensitivity of Middle cerebral artery waveform in identifying IUGR in high-risk group was 7.7 % with a specificity of 90 %, a positive predictive value of 87.5 and a negative predictive value of 9.78.

The sensitivity of C/U ratio in identifying IUGR in high-risk group was 68.8 % with a specificity of 100 %, a positive predictive value of 100 and a negative predictive value of 26.3.

The association of abnormal uterine artery PI with an abnormal outcome (SFD) was not statistically significant (p value $= 0.7408$).

The association of abnormal umbilical artery PI with an abnormal outcome (SFD) was statistically significant (p value $= 0.0132$).

The association of abnormal fetal MCA PI with an abnormal outcome (SFD) was not statistically significant (p value $= 0.5834$).

The association of abnormal C/U ratio with an abnormal outcome (SFD) was extremely significant (p value < 0.0001).

Discussion

The present study was done to study the role of ultrasonography in identification of IUGR in high-risk mothers to provide adequate prophylactic antenatal care thus preventing and reducing infant and maternal mortality rates as well as morbidity.

In our study, we undertook those patients who were high risk for IUGR and also those patients who were clinically suspected to have IUGR but had no-risk factors. These patients were followed till delivery; birth weight and mode of delivery of the newborns were recorded.

Young mothers in the age group of 21-25 years, comprised the largest number of total, i.e. 47 %. Only 15 cases (15 %) belong to the age of over 30 years. This observation leads us to believe that most of the high-risk mothers were in the active reproductive age group.

Primipara who constitute 49 % of cases were most significantly associated with IUGR. This was followed closely by mothers who were para I constituting 38 % of total cases. Age-wise distribution of parity shows that primipara and para I in the age group of 21–25 years are at maximum risk for IUGR.

Hence, the age and parity distribution in our study showed a definitive preponderance of primipara in the age group of 21–25 years at increased risk for IUGR. This group should be considered for screening especially by

Table 1 Predictive value of HC/AC ratio for detecting abnormal fetal outcome

Fetal outcome	No. of findings				Sensitivity	Specificity	Predictive value	
	TP (a)	FP (b)	TN (d)	FN (c)	a/(a + c)	d/(b + d)	Positive a/(a + b)	Negative d/(c + d)
SFD	76	1	9	14	84.4 %	90 %	98.7	11.1

Table 2 Predictive value of oligohydramnios for detecting abnormal fetal outcome

Fetal outcome	No. of findings				Sensitivity	Specificity	Predictive value	
	TP (a)	FP (b)	TN (d)	FN (c)	a/(a + c)	d/(b + d)	Positive a/(a + b)	Negative d/(c + d)
SFD	19	0	10	71	21.1 %	100 %	100	12.3

USG if any possibility for high risk is observed by clinical history. In our study, we found that maximum number of cases were PIH comprising 31 % of the total high-risk group. Age-wise distribution of PIH cases shows that a significant number of cases (16 out of 31 cases) were in the age group 21–25 years.

Brain sparing effect of fetal circulation is responsible for more frequent, and severe retardation of body rather than that of head as reported by Kajrak et al. [1] was demonstrated in this study, and AC was found to be a better indicator of IUGR as compared with BPD and HC.

In our study, the sensitivity of HC/AC ratio in the detection of SFD cases was 84.4 % with a specificity of 90 %, a positive predictive value of 98.7 and a negative predictive value of 11.1 (Table 1).

Amniotic Fuid

Manning et al. [2], studied an extensively prescreened sample of patients and found that oligohydramnios was an exceptionally reliable predictor. In contradistinction, the goal of Philipson et al. [3] was to determine how useful ultrasonologically determined oligohydramnios would be in a more useful clinical setting.

In our study, oligohydramnios has been diagnosed when amniotic fluid′s deepest vertical pocket was less than 2 cm. Sensitivity of oligohydramnios for detecting IUGR in our study was 21.1 %. This insensitivity makes detection of oligohydramnios a poor screening method for IUGR (Table 2).

Laurin and Persson [4] found a sensitivity of 64.1 % for IUGR using BPD, FL and AC.

Fetal Outcome

- Most of the cases were delivered by vaginal route (63 %), and 37 % of cases were delivered by LSCS.

Table 3 Distribution of perinatal outcome

S. no.	Perinatal outcome	No of cases	Percentage
1.	Low birth weight (SFD)	88	88
2.	Normal birth weight (AFD)	10	10
3.	Perinatal mortality	02	02
Total		100	100

- The most common indicator of LSCS was the fetal distress.
- 90 newborns have been found to have birth weight of less than 2.5 kg, whereas 10 newborns were found to have birth weight of 2.5 kg of more (Table 3).

In Doppler Study

Uterine Artery Doppler Velocity Waveform

In Doppler ultrasonography, examination of the main branch of uterine artery at the placental site is studied in cases with unilateral placenta, and bilateral uterine arteries are studied in cases with central placenta.

In our study, out of 100 cases of high-risk group, abnormal uterine artery indices were seen in 37 cases among which uterine artery diastolic notch with increased Doppler indices was seen in nine cases, while the rest (28 cases) showed only abnormal uterine artery PI with no diastolic notching. In both these groups, the incidence of caesarian section was significantly more. Out of 37 cases with abnormal uterine artery, 20 cases (54.05 %) had caesarian section. Incidence of abnormal fetal outcome (IUGR, IUFD and perinatal mortality) was higher in this group (Table 4).

Also, all the nine patients showing early diastolic notching resulted in bad outcomes (7 SFD and 2 perinatal

Table 4 Distribution of cases on the basis of normal and abnormal uterine, umbilical and middle cerebral artery indices

S. no.	Doppler Index (P.I.)	Number of cases	Percentage
1.	Normal uterine artery Doppler indices	63	63
2.	Abnormal uterine artery Doppler indices	37	37
	a. Increased Doppler indices	28	28
	b. Increased Doppler indices and diastolic notch	9	9
3.	Normal umbilical artery Doppler indices	40	40
4.	Abnormal umbilical artery Doppler indices	60	60
	a. Reduced end diastolic velocity	31	31
	b. Absent end diastolic velocity	13	13
	c. Reversed end diastolic velocity	2	2
5.	Normal middle cerebral artery Doppler Indices	92	92
6.	Abnormal middle cerebral artery Doppler Indices	8	8
7.	Normal cerebral/umbilical Doppler index	38	38
8.	Abnormal cerebral/umbilical Doppler index	62	62

deaths), suggesting a high degree of positive predictive value of persistence of diastolic notching in late pregnancy for predicting unfavourable outcome. The findings in the present study suggest that the increased Doppler indices in uterine artery with associated diastolic notch and persistence of diastolic notch after 26 weeks constitute an ominous sign and indicate the requirement for timely and intense fetal surveillance, and intervention.

The sensitivity of uterine artery Doppler indices in identifying adverse fetal outcome in the present study was sensitivity of 37.7 % with a specificity 70.0 %, a positive predictive value of 91.8 and a negative predictive value of 11.1 (Table 5).

Umbilical Artery Doppler Waveform

The umbilical artery has been the first and the most studied artery since the introduction of Doppler ultrasound in obstetrics.

The absence of diastolic flow is often associated with adverse outcome of pregnancy, e.g. IUGR and fetal hypoxia (Tannindron et al. [5]). Findings of ARFV (absent or reversed diastolic blood flow velocity) show strong correlation with fetal hypoxia and acidosis (Tannindron et al. [5]).

In our study, in the high-risk group with abnormal umbilical artery Doppler indices (60 cases), 31 cases had reduced end diastolic flow in umbilical artery flow in umbilical artery flow velocity waveforms, out of whom 26 cases (83.87 %) had abnormal fetal outcome. Absent end diastolic flow was present in 13 cases, and 2 cases had reversed end diastolic flow (Table 4).

All patients showing reduced forward diastolic flow went on to SFD outcomes.

Two patients showing reversed diastolic flow went on as perinatal deaths.

Hence, gradual changes in diastolic flow and ultimate reversal may have correlation with severity of fetoplacental insufficiency.

Out of 60 cases, 26 cases had caesarean section, and the incidence of caesarean delivery was 43.3 % with appearance of abnormality in the umbilical artery Doppler waveform.

The sensitivity of umbilical artery Doppler indices in identifying adverse fetal outcome in the present study was 64.4 %, with a specificity of 80.0 %, a positive predictive value of 96.6 and a negative predictive value of 20 (Table 5).

Middle Cerebral Artery Doppler Waveform

Yushimura et al. [6] found a significant association between MCA/UA pulsatility index ratio and HC/AC ratio. They also found a close correlation between MCA/UA PI ratio and birth weight.

Table 5 Predictive value of doppler study for detecting abnormal fetal outcome

S. no.	Doppler indices	No. of findings				Sensitivity	Specificity	Predictive value	
		TP (a)	FP (b)	TN (d)	FN (c)	a/(a + c)	d/(b + d)	Positive a/(a + b)	Negative d/(c + d)
1.	UA Doppler Indices	34	3	7	56	37.7 %	70 %	91.8	11.1
2.	UMA Doppler Indices	58	2	8	32	64.4 %	80 %	96.6	20
3.	MCA Doppler Indices	7	1	9	83	7.7 %	90 %	87.5	9.78
4.	C/U Ratio	62	0	10	28	68.8 %	100 %	100	26.3

TP true positive, *TN* true negative, *FP* false positive, *FN* false negative

Recently Banu [7] measured RI and PI in UA and MCA and also the RI & PI ratios between these arteries. The result of this study indicated that measurement of PI value in the UA is enough to detect IUGR per se, probably due to reflection of decrease placental vascular bed, but the ratio of indices between UA and MCA is more accurate than independent evaluations in identifying fetuses developing distress, reflecting a brain sparing effect as well as feto-placental insufficiency.

In the present study, out of 100 patients of high-risk group, abnormal middle cerebral artery indices were seen in eight cases (8 %), out of which 5 cases were delivered by caesarian section, and the incidence of operative delivery was 62.5 % (Table 4).

The sensitivity of middle cerebral artery indices in identifying adverse fetal outcome in the present study was sensitivity of 7.7 % with a specificity of 90.0 %, a positive predictive value of 87.5 and a negative predictive value of 9.78 (Table 5).

The Cerebral-Umbilical Pulsatility Ratio (C/U)

Recently, the cerebral/umbilical pulsatility ratio (C/U ratio) has been recognized as the more sensitive and specific indicator of likelihood of IUGR and adverse perinatal outcome in high-risk pregnancies.

Shahina et al. [8] concluded that the C/U ratio is a better predictor of SGA fetuses and adverse perinatal outcome than the MCA PI or the UA PI used alone; the UA PI can be used to identify IUGR per se, and the MCA PI alone is not a reliable indicator for predicting fetal distress.

Jurisic et al. [9] concluded that the reliability of C/U ratio in the estimation of fetal condition in preeclamptic patients is high. Very low C/U ratio values in patients with preeclampsia indicate that in these fetuses, fetal acidosis and fetal distress may be expected.

In the present study, we found that out of 100 patients of high-risk group, abnormal C/U ratio was seen in 62 cases (62 %), out of which 27 cases were delivered by caesarian section, and the incidence of operative delivery was 43.5 % (Table 4).

The sensitivity of C/U ratio in identifying adverse fetal outcome in the present study was 68.8 %, with a specificity of 100 %, a positive predictive value of 100 and a negative predictive value of 26.3 (Table 5).

Amongst all indices (grey scale and Doppler), increased HC/AC ratio had the highest sensitivity(84.4 %) in diagnosing an abnormal outcome, while amongst Doppler indices, C/U ratio was the best of all (sensitivity 68.8 %); the presence of oligohydramnios and abnormal C/U ratio had the highest specificity (100.0 % each) in diagnosing an abnormal outcome; presence of oligohydramnios and abnormal C/U ratio had the highest positive predictive value (100 each) in diagnosing an abnormal outcome; the increased HC/AC ratio had the highest negative predictive value(39.13) in diagnosing an abnormal outcome, while amongst Doppler indices, C/U ratio was the best of all (NPV 26.3) (Figs. 1, 2).

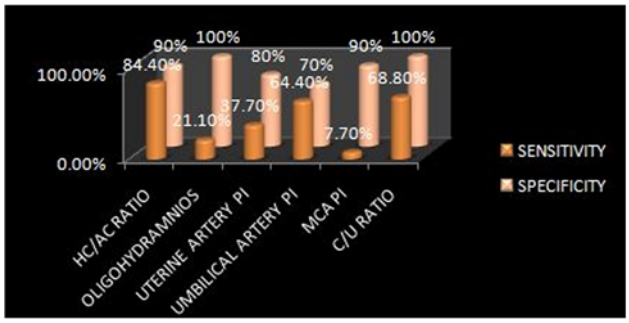

Fig. 1 A comparison of sensitivities and specificities of various gray scale and doppler indices

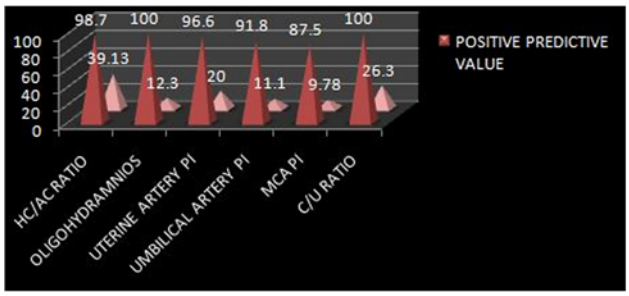

Fig. 2 A comparison of predictive values of various gray scale and doppler indices

Moreover, 43.5 % of cases of abnormal C/U ratio were associated with caesarian delivery, as compared to 40.2 % of abnormal HC/AC ratio. However, even higher (47.3 %) number of oligohydramnios cases went on to caesarian section.

Conclusion

Pregnancy-induced hypertension (PIH), the most common causative factor behind asymmetric IUGR, is the most common in the 21–25-years-age group. The laterality of placenta is more frequently associated with the incidence of IUGR. This factor may be due to supply of placenta by a unilateral uterine artery. The unilateral uterine arterial supply of lateral placentation was further consolidated by the finding that all such cases showed higher forward diastolic flow and lower PI values in ipsilateral uterine artery as compared with the contralateral one. HC/AC ratio is quite sensitive, and oligohydramnios is a highly specific parameter to diagnose IUGR. However, the former has lower specificity, and the latter has very poor sensitivity.

Doppler ultrasound, and especially the C/U ratio is a very sensitive index of the fetal well-being and compromise in PIH. The C/U ratio is a more sensitive, as well as a specific parameter to diagnose and predict adverse perinatal outcome than the umbilical artery PI, which is moderately sensitive and specific for the same purpose. The MCA PI alone is not sensitive at all, and should not be used for screening purposes in IUGR patients. Also, the C/U ratio is more sensitive than oligohydramnios and more specific than the HC/AC ratio for diagnosing IUGR. Gradual changes in diastolic flow and ultimate reversal may have correlation with severity of fetoplacental insufficiency. Thus, identification of these findings creates possibility of early intervention and therapy. Uterine artery colour Doppler may help us to identify the severity of PIH, suggesting a high degree of positive predictive value of persistence of diastolic notching in late pregnancy for predicting unfavourable outcome. Thus, it may contribute to improve maternal well being and fetal health. However, there is an urgent need to standardize Doppler terminology and reference values of Doppler indices to allow direct comparison of studies that are being carried out in increasing number of cases.

Conflict of interest The authors declare that they have no conflict of interest.

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