

Efficacy of Fetal Transverse Cerebellar Diameter/Abdominal Circumference (AC) Ratio versus Head Circumference/AC Ratio in Predicting Intrauterine Growth Retardation

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Abstract

Background: The study was planned to compare the accuracy of transverse cerebellar diameter/abdominal circumference (AC) with head circumference (HC)/AC in predicting intrauterine growth retardation.

Methods: This study was conducted as a hospital-based prospective observational study at Department of Radio diagnosis, NSCB Medical College and Hospital Jabalpur (M.P.) who were referred from the Department of Obstetrics and Gynecology to the our department for antenatal ultrasound. With ultrasonogram, the HC, TCD, and AC of fetus were measured in addition to anomaly scanning, routine biometric parameters, and liquor volume. The HC/AC ratio and TCD/AC ratio was calculated. These women were informed about the results of the scan.

Results: Sensitivity and, positive predictive value (PPV), of TCD/AC ratio in diagnosing intrauterine growth retardation (IUGR) were 90.91% and 97.56%, respectively. Sensitivity and PPV of HC/AC ratio in diagnosing IUGR were 82.22% and 97.37%, respectively. Overall, the accuracy of TCD/AC is higher (89%), than that of HC/AC (82%) in predicting IUGR antenatally. Our study documented a significant correlation of gestational age with TCD, HC as well as AC.

Conclusions: TCD shows linear correlation with the advancing gestational age. TCD/AC and HC/AC ratio remains content throughout the gestational age. However, ratio increased in cases of growth restricted fetuses (due to brain sparing effect). TCD is least affected in the process of growth restriction, while HC is affected less frequently. However, AC is the most affected parameter, and hence, TCD/AC and HC/AC ratio is increased in the cases of IUGR. As TCD/AC and HC/AC ratio remains constant throughout in normal pregnancy, hence, they becomes gestational age in-dependent parameter for diagnosing IUGR, even in pregnancies of unknown dates. Hence, both methods can be used to screen the cases of IUGR, antenatally. However among the two discussed method above, TCD/AC is better parameter for screening of IUGR cases.

Key words: Abdominal circumference, Diagnostic accuracy, Head circumference, Intrauterine growth retardation, Transcranial diameter

INTRODUCTION

The process of birth is the most dangerous journey an individual undertakes. A healthy new born is the goal of

every expectant mother and her treating obstetrician. The high incidence of intrauterine growth retardation (IUGR) in general obstetric population (~10%) and its low recognition (< 40%) together lead to increasing risk of perinatal morbidity and mortality. Regular surveillance and timely management decisions are the goal for optimum outcome in these cases, which rely mainly on accurate determination of gestational age.^[1] Chances of *in utero* fetal demise, meconium aspiration, birth asphyxia, neonatal hypoglycemia, and hypothermia are all increased in the fetus showing growth restriction. In addition, it has been also found that

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Month of Submission : 05-2022
Month of Peer Review : 06-2022
Month of Acceptance : 06-2022
Month of Publishing : 07-2022

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these growth restricted infants have higher 1-year infant mortality rate and abnormal neurological development.^[2] The desire to prevent such maloccurrences during pregnancy has prompted the clinician to develop various methods of assessing the fetal condition in utero itself as early as possible with accuracy. Best investigation ideally must be simple, safe, reproducible, reliable, non-invasive, and accurate and should cause no damage to the mother and her fetus.^[3] Prenatal ultrasonography fulfills almost all these prerequisites and, hence, plays a crucial role in antepartum fetal surveillance. A near accurate determination of gestational age, identification of major anatomical congenital anomalies up to possible level, evaluation of fetal growth, and assessment of fetal well-being and maturity are all possible due to the availability of good quality ultrasound.^[2,3]

The assessment of fetal growth is important to the provision of optimum prenatal care. As the clinical estimation of the fetal growth is not reliable, prenatal USG provides an opportunity to more accurately assess the fetal growth. The most commonly used parameters to evaluate fetal growth are biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL). Of all the ultrasound derived biometric parameters, the AC seems to be the best predictor of fetal growth restriction (FGR). However, all these parameters can be correlated only if gestational age is accurately known. However, uncertainty of the gestational age (either by known accurate last menstrual period (LMP) or availability of dating ultrasound) occurs frequently and makes four the differentiation between the appropriate for gestational age (AGA) and the small for gestational age fetus difficult and challenging. Transverse cerebellar diameter (TCD) is the maximum transverse diameter of the fetal cerebellum. The fetal cerebellar hemispheres are located in the posterior cranial fossa which is resistant to external pressure and growth deviations^[1] that are not affected in FGR, because the – brain sparing effect – thus making it a better indicator for determination of gestational age.^[3]

Measurement of TCD is an near accurate method of estimating gestational age in cases of uncertain dates and even in dolicocephaly or brachycephaly, where biparietal diameter could not be used accurately. In contrast to TCD, fetal AC is the earliest affected parameter in the process of impaired fetal growth.^[4] Thus, a ratio of TCD/AC which is gestational age independent is very useful in predicting IUGR. Hence, TCD/AC ratio increases in FGR which fairly remains constant throughout normal pregnancy.^[5] HC is another parameter which remains minimally affected by external pressure effects causing deformation of fetal head and by 5 growth alterations. Hence, HC/AC ratio is another gestational age independent parameter which may be used in predicting IUGR. Hence, as the both parameters were gestational age

independent criteria for the determining the IUGR, the study was planned to compare the accuracy of TCD/AC with HC/AC in predicting intrauterine growth retardation.

MATERIALS AND METHODS

This study was conducted as a hospital-based prospective observational study at the Department of Radio diagnosis, NSCB Medical College and hospital Jabalpur (M.P.) during the study period of January 2019–August 2020 on 50 clinically suspected cases of IUGR who were referred from the department of obstetrics and Gynecology to the our Department for Antenatal Ultrasound. Any gravid women with singleton pregnancy, history of regular menstrual cycle, presenting after 20 weeks of gestation (preferably third trimester), and suspected for IUGR (according to the ACOG guideline OR estimated fetal weight below the 10th percentile of the gestational age according to the USG) with lack of interval growth as compared to the LMP OR Previous USG with accurately determined gestational age by LMP or by dating ultrasound were included in the study. However, anomalous pregnancies and pregnant females not willing to participate in the study were excluded from the study.

Antenatal women were enrolled after written informed consent. A detailed history of the patients was taken. A thorough systemic and obstetric examination was made in the referring department. All preliminary investigations were done. The antenatal women were made aware of the benefits of ultrasonogram. The scans were carried out by the single trained sonologist. All the 50 patients underwent antenatal ultrasound scan on MINDRAY DC 30 ultrasound and color Doppler system with a curvilinear probe of frequency 2–6 MHz, optimized according to the gestational age of the fetus for optimum contrast and better visualizations [Figure 1].

With ultrasonogram, the HC, TCD, and AC of fetus were measured in addition to anomaly scanning, routine biometric parameters, and liquor volume. The HC/AC ratio and TCD/AC ratio was calculated. These women were informed about the results of the scan.

The patients were followed up until delivery for fetal birth weight. All babies at birth were assessed by the neonatologist and grouped as AGA or FGR according to birth weight 10th–90th percentile and <10th percentile for gestational age, respectively. The cutoff of value of TCD/AC and HC/AC ratio for diagnosing FGR is taken according to the previous studies. In addition, we also perform uterine artery Doppler, UA Doppler, MCA Doppler, and DV Doppler study on all the cases and all relevant parameters such as RI, PI, and S/D were calculated. Grades of Doppler changes assigned accordingly.

Statistical Analysis

Data were compiled using Microsoft Excel and analyzed using IBM SPSS software version 20 (IBM; Illinois Chicago). Categorical and continuous data were expressed as frequency (proportion) and mean (standard deviation), respectively. Diagnostic accuracy of TCD/AC and HC/AC was calculated and expressed as percentage in terms of sensitivity, specificity, positive predictive value (PPV), and negative predictive value. Correlation of TCD, AC, and HC with gestational age was done using Pearson Correlation Coefficient. $P < 0.05$ was considered statistically significant.

RESULTS

A total of 50 suspected cases of IUGR pregnancy were included in our study. Majority of the study subjects were below the age of 30 years. About 44% were below the age of 25 years. Out of all antenatal women, 54% were primigravida. Approximately 56% were associated with Preeclampsia, while in 24% of cases, no identifiable risk factor was found. In our study, we found 36% severe growth restricted births. In the present study, 90% cases were delivered as IUGR babies. Any grade of Doppler changes are associated with the 50% of cases, in the present study [Table 1]. In the present study, 52% subjects had Grade II changes, followed by 20%, 16%, and 12% cases with Grade III, IV, and V changes, respectively [Table 2].

Out of total cases with cutoff of TCD/AC% of >16.50 , 60% show any grade of Doppler changes and with cutoff of HC/AC of >1.10 , 61.50% show any grade of Doppler changes [Table 3]. TCD/AC ratio is able to diagnose 41 true cases of IUGR among the 45 actual cases. At the same time, this ratio over diagnosed one case. HC/AC ratio accurately diagnosed 37 cases out of the 45 actual cases of IUGR, and accurately exclude the four normal cases out of five cases [Table 4].

Sensitivity and, PPV, of TCD/AC ratio in diagnosing IUGR were 90.91% and 97.56%, respectively. Sensitivity and PPV of HC/AC ratio in diagnosing IUGR were 82.22% and 97.37%, respectively [Figure 2]. Overall, the accuracy of TCD/AC is higher (89%), than that of HC/AC (82%) in predicting IUGR antenatally. Our study documented a significant correlation of gestational age with TCD, HC, as well as AC [Table 5].

DISCUSSION

IUGR refers to the condition, in which a fetus is unable to achieve the genetically endorsed growth. A fetus is termed growth restricted if weight is below the 10th percentile for that gestational age.^[6] In the present study, there are total

50 pregnant woman were included, having high suspicion of intrauterine growth restriction, who were fulfilling the



Figure 1: MINDRAY DC 30 ultrasound and color Doppler system

Table 1: Distribution according to maternal and fetal factors

Maternal and fetal factors	Number of cases (n=50)	Percentage
Age (years)		
20–25	22	44
25–30	19	38
>30	9	18
Parity		
Primi	27	54
Multi	23	46
Risk factor		
No associated risk factor	12	24
Pre-eclampsia	28	56
Chronic hypertension	1	2
Pre-eclampsia with GDM	3	6
Preeclampsia with chronic HTN	6	12
Oligohydramnios		
Normal liquor ($>10^{\text{th}}$ centile)	9	18
Oligohydramnios ($<10^{\text{th}}$ – 5^{th} percentile)	34	68
Severe oligohydramnios ($<5^{\text{th}}$ percentile)	7	14
Birth weight		
$>10^{\text{th}}$ percentile	5	10
$<10^{\text{th}}$ percentile	27	54
$<5^{\text{th}}$ percentile	18	36
Fetal growth retardation		
Normal	5	10
FGR	45	90
Associated Doppler changes		
Present	25	50
Absent	25	50

FGR: Fetal growth restriction

Table 2: Grading of IUGR according to Doppler changes

Grades		Cases	Percentage
Grade II	Moderate increased resistance, no redistribution	Cerebro placental ratio (cpr) <p5 or/and uterine artery pi >p95	13 52
Grade III	Severely increased resistance and/or redistribution	Absent end diastolic flow in umbilical artery and mca pi <p5	5 20
Grade IV	Severe hemodynamic alteration	Reverse end diastolic flow in umbilical artery	4 16
Grade V	High risk of death	Reverse a flow in ductus venosus	3 12

IUGR: Intrauterine growth retardation

Table 3: Distribution of cases with respect to Doppler changes in case of TCD/AC and HC/AC%

Parameters	Number of cases	Cases shows Doppler changes (of any grade)
TCD/AC%		
<16.50	20 (40%)	35%
>16.50	30 (60%)	60%
HC/AC%		
<1.10	24 (48%)	37.5%
>1.10	26 (52%)	61.5%

TCD/AC: Transverse cerebellar diameter/Abdominal circumference, HC/AC: Head Circumference/Abdominal circumference

Table 4: Diagnostic accuracy of TCD/AC and HC/AC for IUGR

Parameters	True positive	False positive	True negative	False negative
	Cases	Cases	Cases	Cases
TCD/AC	41	1	4	4
HC/AC	37	1	4	8

IUGR: Intrauterine growth retardation, TCD/AC: Transverse cerebellar diameter/Abdominal circumference, HC/AC: Head circumference/Abdominal circumference

Table 5: Correlation of gestational age with TCD, HC and AC

Correlation	TCD	HC	AC
Pearson's correlation	$r = 0.7185$	$r = 0.7887$	$r = 0.634$
Coefficient of correlation	$r^2 = 0.5162$	$r^2 = 0.622$	$r^2 = 0.402$
P value	<0.00001	<0.00001	<0.00001

TCD: Transverse cerebellar diameter, HC: Head circumference, AC: Abdominal circumference,

inclusion criteria and with informed written consent. In the present study, 45 (90%) fetuses were found with IUGR, while 5 (10%) were born normal, according to the their birth weight. This is not in-line with general incidence^[7] of IUGR, which might be due to the patient selection criteria in the present study.

In this study, 82% of the patients were found to have Oligohydramnios, and 18% had adequate liquor (according to AFI). Of the patients having low liquor, 34 cases that are 68% cases were classified as moderate Oligohydramnios (AFI < 10th percentile to > 5th percentile), while seven cases as severe Oligohydramnios (AFI < 5th percentile). Therefore, a strong correlation was found between reduced amount of liquor and FGR in the present study. Results were similar to the study conducted by the Chauhan *et al.*^[8]

There is linear increase in the TCD with the advancing gestational age with a strong positive correlation ($r = 0.7213$) between Gestational Age and TCD in present study ($P < 0.00001$, significant at $P < 0.05$). This is in-line with study conducted by Haller *et al.*, where they found a positive correlation between the same of $r = 0.955$.^[9] Furthermore, there is the strong positive correlation exist between gestational age determined by LMP and the HC obtained at ultrasound ($r = 0.7887$), with the $P = 0.00001$, highly significant (significant <0.05). TCD remains unaffected by the growth restriction and serves as the age independent criteria for estimating the gestational age.^[9] Similar findings could be observed in our study, where we documented that TCD is very less affected in the process of IUGR.

Our study showed a significant positive correlation exist between the gestational age determined by the LMP and AC at the time of ultrasound ($r = 0.634$) with $P < 0.00001$ (significant below the level of 0.05). In the study conducted by Heller *et al.*, there was strong correlation exist between gestational age and AC ($r = 0.9453$), which is similar to our study.^[9]

The sensitivity of TCD/AC ratio in diagnosing IUGR antenatally is 90.91% with specificity of 80.00%, PPV is 97.56%, and negative predictive value (NPV) is 50.00%, which is comparable to the study conducted by the Meyer *et al.*, in which sensitivity, specificity, and PPV, respectively, are 83.9%, 96.8%, and 94.5%.^[10] However, NPV is not comparable with our study, possibly due to selection criteria of patient in present study. Similar study conducted by Bhimmarao *et al.* and found, the sensitivity, specificity, and PPV are 88%, 93.5%, and 77.1% which are similar to the present study.^[11] Results were also comparable with the study conducted by Campbell *et al.*, where sensitivity, specificity, and PPV were found to be 71%, 77%, and 79%, respectively.^[12]

According to the present study, the sensitivity, specificity, PPV, and NPV of the HC/AC in diagnosing IUGR was 82.22%, 80%, 97.30%, and 33.33%, respectively. This is quite comparable with the study of Bhimmarao *et al.*^[11] and Benson and Doubilet,^[13] Where they found that sensitivity, specificity, and PPV are 84%, 92%, and 77.1% and 82%, 94%, and 62%, respectively. Cabbad *et al.*, in another study

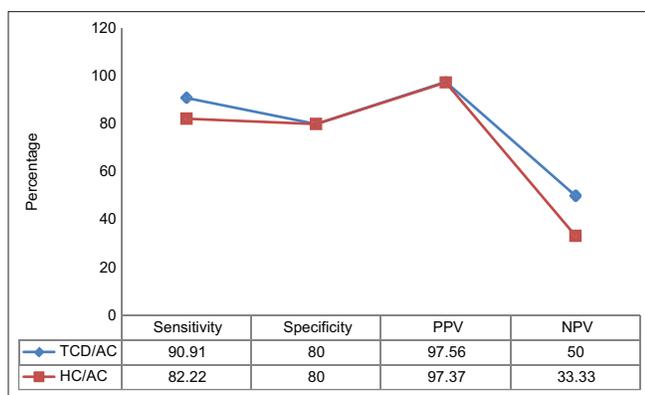


Figure 2: Diagnostic accuracy of transverse cerebellar diameter/abdominal circumference and head circumference/abdominal circumference for diagnosis of fetal growth restriction

with suspected IUGR, demonstrated that, fetal weight is affected at greatest extent in the process of IUGR, while TCD affected least. Hence, the discordance between TCD and fetal weight can diagnostic of almost all IUGR fetuses with sensitivity of 95.6 % and specificity of 96.3%. In contrast, HC/AC remains normal in about more than 50% of fetuses.^[14] Comparable results are drawn from our study, where the birth weight kept as the diagnostic criteria for IUGR, TCD/AC ratio perform good than HC/AC ratio with positive likely hood ratio of 4.5 and 4.11, respectively. We also found that higher the discordance between TCD and fetal weight, higher the severity of growth restriction.

Khan *et al.*, in their study, involved 30 high-risk patients, with known accurate gestational age and singleton pregnancy found that raise of TCD/AC ratio was observed in 15 patients, that is, in 50% cases with sensitivity of 77.8%, which was comparable to our study, where sensitivity is 90.91%.^[15]

Cutoff value of TCD/AC ratio for diagnosing IUGR, in our study, was 14.83 (13.63+1.2), which is (derived from) similar to the study of Ghazala *et al.*,^[16] where ratio was (14.06 ± 0.59). Furthermore, studies conducted by Bhimarao *et al.*^[11] and Khan *et al.*,^[15] the cutoff values for diagnosing FGR were 13.63 and 16.03, respectively, which were closure to present study cutoff values.

As regards HC/AC in prediction of IUGR, in our study, cutoff value was taken as 1.09 (from 1.04 ± 0.05), which was similar to the (derived from) cutoff value of HC/AC for SGA infants of the study conducted by the Takoka *et al.*,^[17] is 1.15.

In the present study, the efficacy of the TCD/AC ratio is proven more, than HC/AC ratio in diagnosing IUGR, with diagnostic accuracy is 89.80% and 82%, respectively. It is similar to the study conducted by the Bhimarao *et al.*,^[11]

where the diagnostic accuracy found to be 92.4% and 90.4 %, respectively. In the present study, we also perform Doppler correlation on selected cases and found that, cases having TCD/AC % ratio < 16.50, only 35% show any grade of Doppler changes, while cases having TCD/AC % ratio > 16.50, 60% show positive Doppler changes. However, we observed that out of cases with HC/AC ratio < 1.10, 37.5% cases show any grade of Doppler changes and out of cases HC/AC ratio > 1.10, 61.5% had any grade of Doppler changes. These findings suggested that as both ratio (TCD/AC% ratio and HC/AC ratio) increases, the doppler changes tend to increase suggesting redistribution of blood to save the vital organs.

CONCLUSIONS

TCD shows linear correlation with the advancing gestational age. TCD/AC and HC/AC ratio remains constant throughout the gestational age. However, ratio increased in cases of growth restricted fetuses (due to brain sparing effect). TCD is least affected in the process of growth restriction, while HC is affected less frequently. However, AC is the most affected parameter, and hence, TCD/AC and HC/AC ratio is increased in the cases of IUGR. As TCD/AC and HC/AC ratio remains constant throughout in normal pregnancy, hence, they becomes gestational age in-dependent parameter for diagnosing IUGR, even in pregnancies of unknown dates. Hence, both methods can be used to screen the cases of IUGR, antenatally. However, among the two discussed method above, TCD/AC is better parameter for screening of IUGR cases.

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How to cite this article: Panwar S, Agrawal R, Parmar V, Sharma P. Efficacy of Fetal Transverse Cerebellar Diameter/Abdominal Circumference (AC) Ratio versus Head Circumference/AC Ratio in Predicting Intrauterine Growth Retardation. *Int J Sci Stud* 2022;10(4):25-30.

Source of Support: Nil, **Conflicts of Interest:** None declared.