Evaluation of Fetal Growth by Transcerebellar Diameter, Head Circumference to Abdominal Circumference Ratio

Original Article

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ABSTRACT

Objective: To analyze if trans-cerebellar diameter/abdominal circumference ratio (TCD/AC) and head circumference/ abdominal circumference ratio (HC/AC) values remained constant throughout the gestational age (GA) and to determine the cut-off values.

Patient and Methods: In this observational prospective study, we enrolled 305 pregnant females above 20 weeks with singleton low-risk pregnancy attending outpatient clinic (OPC) or admitted to Obstetrics and Gynaecology department Mansoura University Hospitals over a period of 12 months .Using (Samsung UGEO H60&GE Logiq F6) to measure fetal biometry and assess GA including: HC(mm),TCD(mm)and AC(mm) then calculation of TCD/AC ratio [TCD was divided by AC and then multiplied by 100] and HC/AC ratio [dividing HC by AC] .

Results: Both ratios (TCD/AC and HC/AC) are relatively stable parameters that can be used for early detection of abnormal fetal growth, particularly when GA is unknown. The cut-off values of TCD/AC and HC/AC ratios to predict IUGR are 13.7 and 1.2 respectively.

Conclusion: The TCD/AC and HC/AC ratios are almost consistent and independent of gestational age. They are therefore very useful for anticipating IUGR beyond 20 weeks of gestation. TCD/AC and HC/AC ratio cut-off values are 13.7 and 1.2, respectively. Elevated any of both ratios above these cut-off values may predict IUGR at any gestational age.

Key Words: Abdominal circumference (AC), head circumference (HC), IUGR, trans-cerebellar diameter (TCD).

Received: 19 September 2024, **Accepted:** 22 November 2024

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ISSN: 2090-7265, 2025, Vol. 15

INTRODUCTION

Monitoring the fetus's well-being and growth is a fundamental goal of prenatal care[1]. IUGR is a prominent cause of perinatal-neonatal morbidity and death, it contributes to long-term chronic disorders[2]. As a result, accurate prediction and prevention of IUGR could be a key component of a public health strategy aimed at avoiding the adult implications of antenatal growth restriction[3].

However, there is no universal agreement on FGR diagnosis criteria. Because race, fetal gender, and geographic region all have an effect on fetal growth, it is challenging to achieve a clinically acceptable criteria for SGA and FGR[4].

In IUGR fetuses, reduction of liver glycogen and subcutaneous fat stores causes a drop in fetal AC, making AC an early and sensitive parameter for predicting asymmetrical IUGR[5].

In chronic asphyxia, blood flow is primarily directed to the brain, cardiac tissue, and adrenal glands. This redistribution to the brain (i.e. brain sparing effect) leads to both an average head size and body wasting, as demonstrated by a high HC/AC ratio[6].

Because of cardiac output redistribution, cerebellar blood flow is not changed. TCD is measured from the posterior cranial fossa, which has strong bony walls and is generally resistant to external compression. Also, it is less influenced than the HC, implying a preferential mechanism favouring cerebellar growth preservation in comparison to other brain structures[7].

TCD was found comparable among fetuses of normal growth and those with IUGR without a significant difference, establishing that cerebellar growth was not affected in small for gestational age fetuses. That could assist in prediction of gestational age[8].

DOI:10.21608/EBWHJ.2024.322420.1360

TCD is the least altered biometric measure, whereas AC is the most influenced; TCD/AC ratio may be a sensitive approach for diagnosing asymmetrical IUGR at any GA[9]. Thus, increased TCD/AC ratio might aid in the early identification of IUGR[10].

A further parameter that is only marginally impacted by alterations in growth or by external factors that can cause distortion of the head of the foetus is HC. HC is slightly superior to BPD in predicting SGA and FGR fetuses[11].

Campbell and Thoms were the first to propose using the HC/AC ratio for screening for IUGR[12].

There is a link between elevated HC/AC ratio greater than the 95th percentile and poor obstetric outcomes (e.g. preterm delivery, low birth weight, caesarean section due to fetal distress and newborn morbidity)[13].

As a result, the investigated ratios can be abnormal early in the course of IUGR and thus can identify the pregnancy that necessitates close monitoring of fetal growth[14].

PATIENT AND METHOD

This observational prospective study involved 305 pregnant women above 20 weeks with singleton pregnancy attending outpatient clinic (OPC) or admitted to Obstetrics and Gynecology department in Mansoura University Hospitals over a period of 12 months (From May 2022 to May 2023).

Inclusion criteria

1. Maternal age is 18-35 years.
2. Singleton pregnancies.
3. Gestational age above 20 weeks.
4. Accurate gestational age (sure about last menstruation or having 1st trimester scan).
5. Biometric parameters of the fetus are within normal range.

Exclusion criteria

1. Maternal age is <18 or >35 years old.
2. Multiple pregnancy.
3. Gestational age (GA) below 20 weeks.
4. Maternal co-morbidities (High blood pressure, diabetes, kidney disease, heart disease, etc.).
5. Congenital anomalies in the fetus.

Using (Samsung UGEO H60&GE Logiq F6) to rule out multiple pregnancy, rule out congenital anomalies and to measure biometric parameters of the fetus to evaluate GA including: BPD(mm), HC(mm), TCD(mm), AC (mm), FL(mm) and EFW(gm) then TCD/AC ratio [TCD is divided by AC and then multiplied by 100] and HC/AC ratio were calculated [dividing HC by AC] .

On an axial scan, the measurements of BPD and HC were performed at the level of thalamus and cavum septum pellucidum.

When the transducer is rotated slightly below the thalamic plane, posterior fossa with the butterfly-shaped cerebellum can be observed. On an axial scan, TCD was measured as the maximal diameter from the outer margin of the right cerebellar hemisphere to the outer margin of the left cerebellar hemisphere.

Measurement of AC was obtained in the transaxial view (circular section rather than oval) of fetal abdomen from the utermost aspects of fetal soft tissues. AC is measured at the level of the liver, using the umbilical part of the left portal vein as a landmark with the fetal stomach is at the same level. Kidneys and umbilical cord insertion should not be visible.

The next (Figures 1,2,3) belong to Mansoura Feto-Maternal Unit (MFMU) by Samsung UGEO H60:

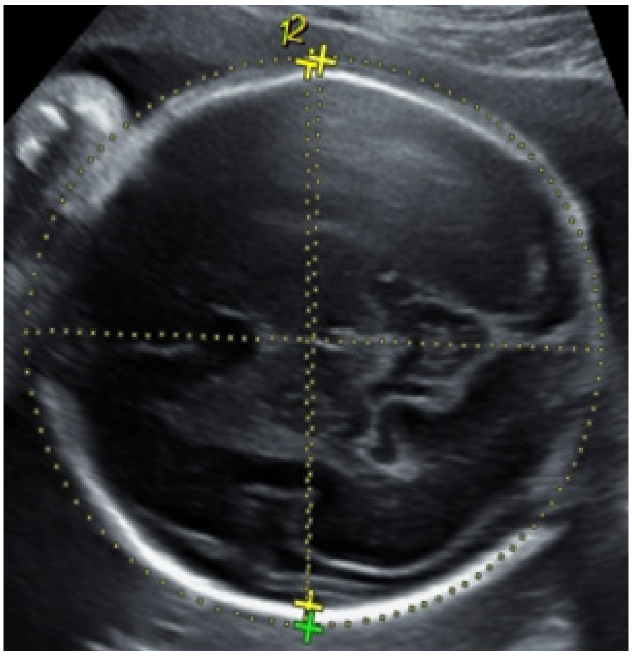

Fig. 1: BPD & HC

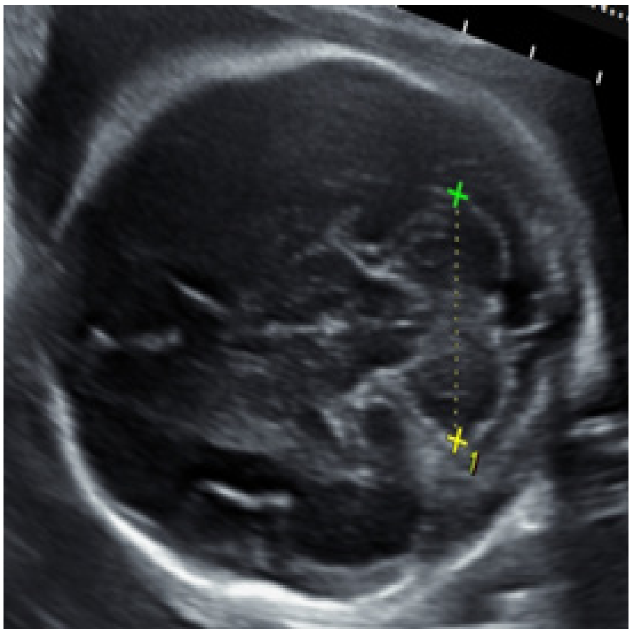

Fig. 2: TCD

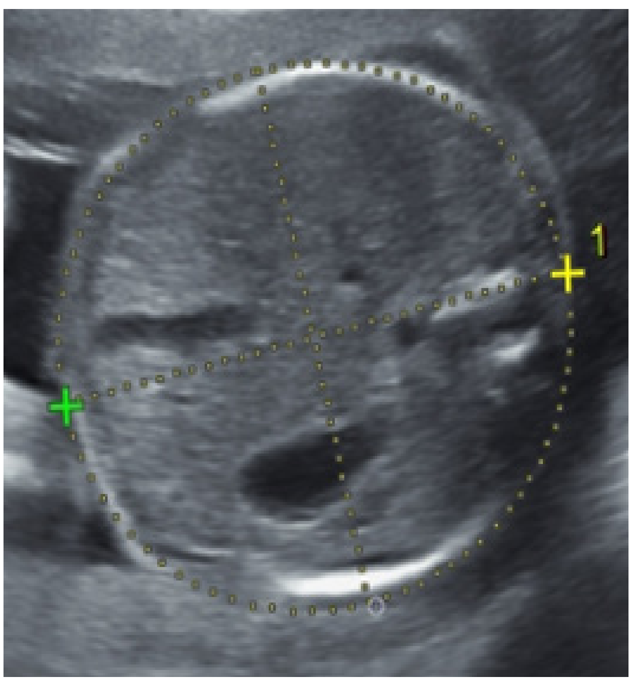

Fig. 3: AC

RESULTS

(Table 1) demonstrates that mean age (SD) of the studied cases is 26.2(4.8) years (range between 18 and 35 years). Mean (SD) of gestational age is 34.6 (4.4) weeks ranging from 20 to 40 weeks. Median number of parity is 1 ranging from 0 to 5, median previous cesarean section is 1 ranging from 0 to 5, median number of abortion is 0 ranging from 0 to 5.

Table 1: Medical and Obstetrical history of the studied group

	n	%
Age (years)	(18 - 35)	
18-29	216	70.8
30-35	89	29.2
Mean ±SD	26.2 ±4.8	
Gestational age (weeks)	(20 - 40)	
20-30	58	19.0
31-40	247	81.0
Mean ±SD	34.6 ±4.4	
Parity	1 (0-6)	
Nullipara	58	19.0
Primipara	98	32.1
Multipara	149	48.9
Previous Cesarean section	1 (0-5)	
None	101	33.1
1 - 2 times	162	53.1
>2 times	42	13.8
Previous abortion	0 (0-5)	
None	213	69.8
1 - 2 times	81	26.6
>2 times	11	3.6

Parameters described as mean±SD (min-max), median (min-max)

(Table 2) shows ultrasound findings of the studied cases with mean ±SD of Biparietal diameter (BPD) is 84.6 ±9.9 mm ranging from 45.1 to 94.8 mm , mean ±SD of Transcerebellar diameter (TCD) is 36.7 ±4.9 mm ranging from 20.9 to 45.9 mm . mean ±SD of Head circumference (HC)is 312.5 ±35.3mm ranging from 172.3 to 361.1 mm, mean ±SD of Abdominal circumference (AC) is 298.5 ±43.2 ranging from 143.7-351.3 mm , mean ±SD of Femur Length (FL) is 66.4 ±9.5 ranging from 32.1-78.6 mm. Mean±SD of Estimated fetal weight (EFW)is 2483.3 ±848.5gm , mean±SD of TCD / AC ratio is 12.3 ±0.6 ranging from 11.04 – 15.19 and mean±SD of HC / AC ratio is 1.1 ±0.05 ranging from 0.97 – 1.39 (Table 3).

Table 2: Transabdominal ultrasound scanning assessment of the study group

	Range	Mean ±SD
Biparietal diameter (BPD) (mm)	45.10 – 94.80	84.6 ±9.9
Transcerebellar diameter (TCD) (mm)	20.90 – 45.90	36.7 ±4.9
Head circumference (HC) (mm)	172.30 – 361.10	312.5 ±35.3
Abdominal circumference (AC) (mm)	143.70 – 351.30	298.5 ±43.2
TCD/AC ratio	11.04 – 15.19	12.3 ±0.6
HC/AC ratio	0.97 – 1.39	1.1 ±0.05
Femur Length (FL) (mm)	32.10 – 78.60	66.4 ±9.5
Estimated fetal weight (EFW) (g)	315.00 – 3709.00	2483.3 ±848.5

Table 3: The 3rd, 50th, and 97th percentiles of the TCD/AC ratio and HC/AC ratio of the entire study group

	TCD/AC ratio	HC/AC ratio
3rd percentile	11.45	0.99
50th percentile	12.26	1.04
97th percentile	13.68	1.17

(Table 4) demonstrates non-significant association between TCD/AC ratio and all subgroups and non-significant association between HC/AC ratio and maternal age or parity, but there is a statistically significant association between HC/AC ratio and gestational age (Figures 4,5,6,7,8,9,10,11).

Table 4: Comparison of TCD/AC and HC/AC ratios between subgroups

	Age groups			Student's t test	
	18-29 (years)		30-35 (years)	t	*p*
TCD/AC	12.3 ±0.6		12.3 ±0.5	0.523	0.601
HC/AC	1.05 ±0.05		1.05 ±0.06	0.412	0.681
	Gestational age groups			Student's t test	
	20-30 (weeks)		31-40 (weeks)	t	*p*
TCD/AC ratio	12.3 ±0.7		12.2 ±0.5	0.047	0.828
HC/AC ratio	1.1 ±0.05		1.0 ±0.03	14.285	<0.001
	Parity groups			One-Way Anova	
	Nullipara	Primipara	Multipara	F	*p*
TCD/AC	12.3 ±0.5	12.3 ±0.7	12.3 ±0.6	0.337	0.714
HC/AC	1.05 ±0.04	1.06 ±0.05	1.05 ±0.06	0.791	0.454

Fig. 4: Correlation between TCD/AC ratio and HC/AC ratio in the entire study group

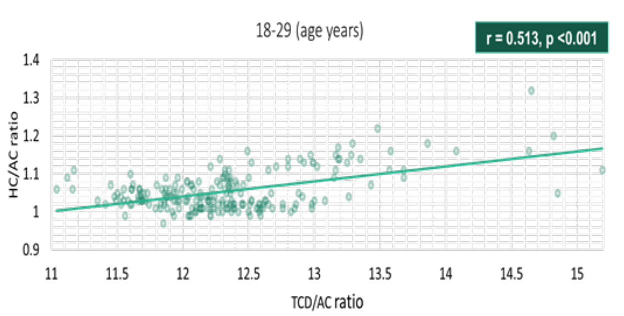

Fig. 5: Correlation between TCD/AC ratio and HC/AC ratio in the 18-29 years age subgroup

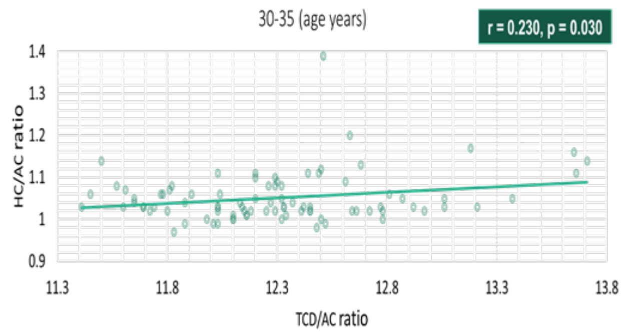

Fig. 6: Correlation between TCD/AC ratio and HC/AC ratio in the 30-35 years age subgroup

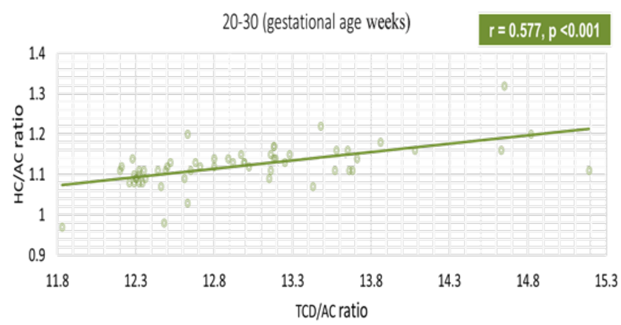

Fig. 7: Correlation between TCD/AC ratio and HC/AC ratio in the 20-30 weeks gestational age subgroup

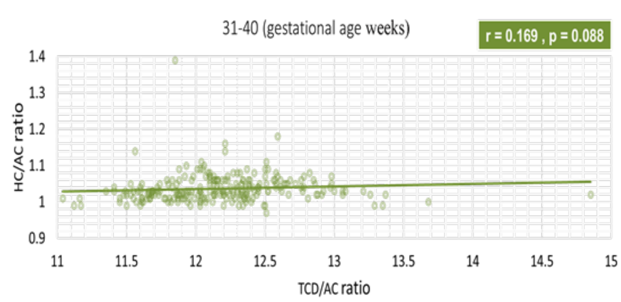

Fig. 8: Correlation between TCD/AC ratio and HC/AC ratio in the 31-40 weeks gestational age subgroup

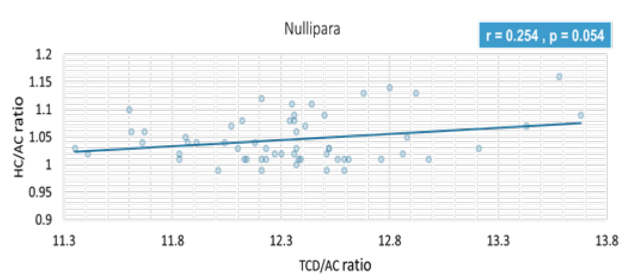

Fig. 9: Correlation between TCD/AC ratio and HC/AC ratio in the nullipara subgroup

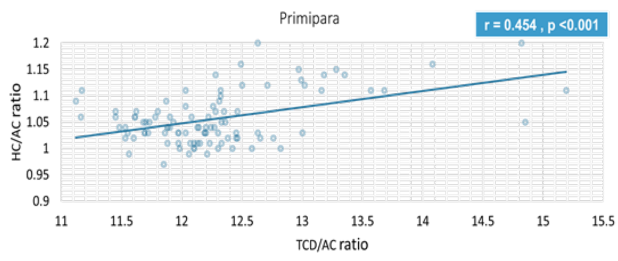

Fig. 10: Correlation between TCD/AC ratio and HC/AC ratio in the primipara subgroup

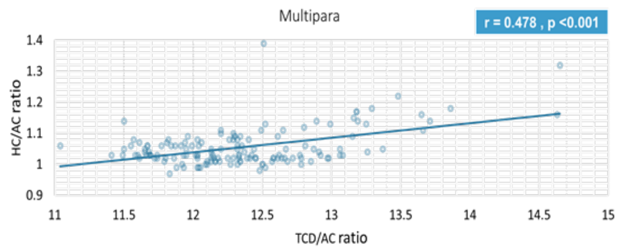

Fig. 11: Correlation between TCD/AC ratio and HC/AC ratio in the multipara subgroup

(Table 5) demonstrates that cut-off values of TCD/AC and HC/AC ratios in entire study population are 13.7 and 1.2, respectively.

Table 5: Cut off values of TCD/AC ratio and HC/AC ratio of the entire study group and subgroups

	TCD/AC ratio	HC/AC ratio
Entire study population	13.7	1.2
Age groups		
18-29 (years)	13.5	1.15
30-35 (years)	13.3	1.17
Gestational age groups		
20-30 (weeks)	13.7	1.2
31-40 (weeks)	13.5	1.06
Parity group		
Nullipara	13.3	1.13
Primipara	13.7	1.16
Multipara	13.5	1.17

DISCUSSION

The cornerstone of an obstetrician's antepartum care and management ability is an accurate knowledge of GA. Iatrogenic preterm, which is associated with higher perinatal morbidity and death, can arise from failure in accurate knowledge of GA. Throughout the first and second trimesters, ultrasound measurement of the fetus is very trustworthy; however, as gestation progresses, the reliability of these ultrasonography measurements is significantly decreased. The third trimester presents challenges for the reliability of any ultrasonography parameter[15].

Ultrasonography remains the gold standard for evaluating the growth of the fetus. The growth parameters that are most frequently utilized include biparietal diameter, HC, AC, and femur length. Nevertheless, the dependence of these factors on gestational age restricts their applicability at growth extremes[16].

Several studies have reported TCD/AC ratio as a growth parameter that is independent of age[17].

A fetus with IUGR has an elevated TCD/AC ratio because AC is clearly impacted while TCD is not. Thus, even in the case of an undetermined date, an elevated TCD/AC ratio may be a predictor of IUGR at any GA[18].

Another ratio that compares the preserved organ in a starved fetus to its most susceptible organ and is useful for diagnosing asymmetric growth restriction is HC/AC[11].

In this observational prospective study, we enrolled 305 pregnant women above 20 weeks with singleton low-risk pregnancy attending outpatient clinic (OPC) or admitted to Obstetrics and Gynaecology department Mansoura University Hospitals.

Regarding TCD/AC ratio, our results revealed that TCD/AC ratio remained relatively constant throughout the GA (mean=12.3± 0.6) and cut-off value 13.7

Our results went hand in hand with many studies[11,16,18–20] in which TCD/AC ratios were independent of GA after 20 weeks of pregnancy and remained relatively constant.

Compared to this study, Hussain *et al.*,[21] studied 200 low-risk obstetric patients and showed that TCD/AC value dispersed normally with mean (±SD) 14.01 (±0.74) and cut-off value of 15.49

Also, Yang,[22] studied 784 low-risk obstetric patients and showed that TCD/AC readings varied regularly, with a mean (±SD) of 13.2 (±0.59), and a cutoff of 14.2.

Our results went hand in hand with Hassan Ahmed Mohamed Ibrahim *et al.*,[23] studied 100 pregnant women (50 AGA fetuses and 50 IUGR) and showed that cutoff of TCD/AC ratio was 13.75 .

Similarly, consistent with our investigation, Mohammed *et al.*,[24] studied 75 pregnant women (46 AGA fetuses and 29 IUGR) and reported that cut-off value of TCD/AC ratio ≥13.77 to predict IUGR.

Our results were not in agreement with El Nafrawy *et al.*,[25] conducted on 300 pregnant females (Group A : 242 females with normal fetuses and Group B : 58 patients with IUGR) which demonstrated that cutoff of TCD/AC ratio was 13.2 .

Moreover, El Garhy,[26] included 500 pregnant females (Group A : 415 females with normal fetuses and Group B: 85 patients with IUGR) showed that cutoff of TCD/AC ratio was 13.

Regarding HC/AC ratio, the current results revealed that the HC/AC ratio was relatively constant throughout the GA (mean =1.1±0.05) and cutoff value 1.2 .

The current study was supported by Peleg *et al*.,[27] that demonstrated that HC/AC ratio is relatively constant between 20 and 36 weeks of pregnancy, and linearly drops from 1.2 to 1 .

Compared to this study, Quinton *et al*.,[28] studied 41 patients (20 having AGA neonates and 21 having SGA neonates) and established a cutoff value for HC/AC ratio of 1.067.

Additionally , Toyama *et al*.,[29] studied 177 patients (118 having AGA neonates and 59 having SGA neonates) and showed that HC/AC ratio of 1.15 predicted the risk of SGA at birth.

Also, our results were not in agreement with Mohammed *et al*.,[24] studied 75 pregnant women (46 AGA fetuses and 29 IUGR) and reported that cut-off of HC/AC ratio ≥1.04 for prediction of IUGR.

Variation in TCD/AC & HC/AC ratios can be explained by the study's diverse populations, and thus cut-off values were different compared to other studies[11]. Maternal race, age, nutrition, prenatal BMI, educational level, parity, and fetal sex are examples of factors found to be strongly related to fetal growth[30].

In the current study, we classified the studied group into three subgroups according to maternal age (18-29/30-35), parity (nullipara / primipara / multipara) and gestational age (20-30/31-40) to evaluate the relationship between the investigated ratios and these three factors.

Our results revealed a non-significant association between TCD/AC ratio and maternal age, parity and gestational age.

Conversely, our findings demonstrated a non-significant association between HC/AC ratio and maternal age or parity, but there is a statistically significant association between HC/AC ratio and GA.

HC/AC ratio was higher in group with gestational age (20-30) weeks than (31-40) weeks. Mean(±SD) of HC/AC ratio is 1.1 (±0.05) in GA of 20-30 weeks with cut-off value 1.2, while Mean(±SD) in gestational age between 31-40 weeks is 1.0 (±0.03) with cut-off value 1.06 (*P value* <0.001).

This is significant association may be explained by Chang *et al*.,[31] which reported that till the 36 week of gestation, the HC is > AC; hence, HC/AC ratio is >1. However later on, AC grows at a quicker rate, thus HC/AC ratio at term becomes <1.

Additionally, Hiersch & Melamed,[14] found that early in pregnancy, HC/AC ratio is roughly 1.2; it then falls linearly to reach around 1.0 at full-term.

As a result, TCD/AC ratio is more constant than HC/AC ratio throughout gestational age. Furthermore , Maryi *et al*.,[7] studied 200 pregnant women (100 normal antenatal cases &100 clinically detected IUGR cases) to compare between both ratios and found that TCD/AC and HC/AC were independent of GA; thus might be utilized for accurate detection of IUGR. TCD/AC ratio, on the other hand, demonstrated superior diagnostic validity and accuracy in predicting asymmetric IUGR than HC/AC ratio.

The main advantage of our study is helping to establish cut-off values of TCD/AC & HC/AC ratios, which in turn helps obstetricians with early prediction of IUGR at any gestational age particularly patients whose dates are uncertain. This can help decide the frequency of prenatal surveillance, adequate risk management (as treatment of maternal disease - good nutrition- cessation of substance abuse), additional assessment (as doppler ultrasound or detailed scan for fetal anomalies) and optimal delivery timing.

IUGR not only increases perinatal morbidity and mortality but also, in the long run, affect adult health. Therefore, identification of IUGR is a crucial purpose of antenatal care since appropriate assessment and management can improve the outcome.

The major limitation of this study was that, it was necessary to validate the efficacy of these ratios in multicentric larger patient population, with longer follow-up of pregnancy outcome and in patients with IUGR fetuses. Also, using the studied ratios combined with other methods (e.g. doppler study) aims to reach a proper diagnosis of IUGR.

CONFLICT OF INTERESTS

There are no conflicts of interest.

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