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Original Article

Comparison of anthropometric measurements of foetuses in normal, gestational diabetes-affected, and hypertensive pregnancies

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الملخص

أهداف البحث: تقوم القياسات الأنثروبومترية للجنين بتقييم ومراقبة نمو الجنين وتقدير الحالة التغذوية للجنين النامي. وهي مؤشر حيوي لنمو الجنين الطبيعي أو غير الطبيعي داخل الرحم. وأكثر العلامات ذات الصلة في القياسات الأنثروبومترية للجنين هي القطر الثنائي، ومحيط الرأس، ومحيط البطن، وطول الفخذ. يعد داء سكري الحمل وارتفاع ضغط الدم الحملي من الأسباب الرئيسة للاختلافات في نمو الجنين. وتقارن هذه الدراسة قياسات الجسم البشري للجنين باستخدام الموجات فوق الصوتية بين حالات الحمل العادية، وسكري الحمل، وحالات ارتفاع ضغط الدم الحملي.

طرق البحث: في هذه الدراسة، تم إجراء ما مجموعه ٦١٥ عملية مسح للشذوذ بين أعمار الحمل من ١٨ إلى ٢٢ أسبوعا من ٢٠١٦ إلى ٢٠١٨. تم جمع بيانات المرضى من سجل غرفة فحص الحالات الشاذة. ضم قياس العلامات القياسات البشرية للجنين القطر الثنائي ومحيط الرأس ومحيط البطن وطول الفخذ.

النتائج: كانت جميع القياسات بما فيها القطر الثنائي ومحيط الرأس ومحيط البطن أقل في حالات ارتفاع ضغط الدم الحملي، وكانت جميع القياسات بما فيها طول الفخذ أعلى في حالات داء سكري الحمل مقارنة بحالات الحمل العادية. وأظهر تحليل ما بعد المخصص باستخدام اختبار توكي أن كل معلمة جنينية لها ارتباط كبير ضد الأمراض المصاحبة المرتبطة بالحمل.

الاستنتاجات: يتضح من دراستنا أن أجنة الأمهات المصابات بداء سكري الحمل أظهرت تباينا ثابتا بمقدار ١٠ ملم فوق المتوسط الطبيعي في قياسات القطر الثنائي ومحيط الرأس ومحيط البطن وطول الفخذ. ولدى أجنة الأمهات المصابات بارتفاع ضغط الدم الحملي متوسط أقل من المعدل الطبيعي للقطر الثنائي ومحيط الرأس ومحيط البطن.

الكلمات المفتاحية: نمو الجنين؛ سكري الحمل؛ حمل؛ ارتفاع ضغط الدم الناجم عن الحمل؛ الموجات فوق الصوتية

Abstract

Objectives: Foetal anthropometry evaluates and monitors foetal development and assesses the nutritional state of the developing foetus. It is a vital indicator of the normalcy of foetal development in-utero. The most relevant parameters in foetal anthropometry are biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL). Gestational diabetes mellitus (GDM) and gestational hypertension (GHTN) are the major reasons for variations in foetal development. In this study, we compare foetal anthropometric measurements taken using ultrasounds of normal, gestational diabetes-affected, and hypertensive pregnancies.

Method: In this study, a total of 615 anomaly scans were done between the gestational ages of 18–22 weeks from 2016 to 2018. The patients' data were collected from the register of the anomaly scanning room. The foetal anthropometric parameters measured BPD, HC, AC, and FL.

Results: All the measurements including BPD, HC, and AC were lower in foetuses affected by GHTN, and all the measurements, including FL, were higher in foetuses affected by GDM than in normal pregnancies. A post-hoc analysis using Tukey's test showed that each foetal parameter had a significant correlation with pregnancy-related co-morbidities (p-value < 0.05).

Conclusion: It is clear from our study that the foetuses of mothers with GDM showed a consistent variation of 10 mm above the normal average in terms of the BPD, HC, AC, and FL measurements. The GHTN-affected foetuses had averages that were lower than normal for BPD, HC, and AC.

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Keywords: Foetal development; Gestational diabetes; Pregnancy; Pregnancy-induced hypertension; Ultrasonography

Introduction

The term 'anthropometry', per the accepted definition of the World Health Organization (WHO), is 'the quantitative measurement of human individuals'.[1] These measurements are usually taken to maintain a record of standard values among a defined population regarding characteristics and dimensions, and they help physicians recognise deviations from the norm.[2] Anthropometry also makes it easier to compare and analyse physical similarities among people of various ethnic and cultural groups.[2] Anthropometry includes, but is not limited to, the systemic measurement of the physical dimensions of the human body, like height, weight, girth, skin-fold thickness, BMI, etc.[1] It can also be an indicator of health in pregnancy and in children. The measurements thus obtained can provide us with vital information about the general well-being of a patient, and they can be used as diagnostic criteria.[1] Anthropometric measurements are related to two categories, body size and body composition. The measurements related to body composition, such as head circumference, weight, and height, in new-borns and infants, help to establish the nutritional state of the individual.[3]

Foetal anthropometry is, however, a relatively new science in which the proportions and measurements of a developing foetus are measured in-utero. This is done through standard ultrasonography.[4] Measurements are typically taken around the second and third trimesters and are studied for the progression of foetal growth through the growth curve.[4] Foetal anthropometry gives clinicians a chance to evaluate and monitor foetal development and assess the nutritional state of a developing foetus. It is considered a vital indicator of the normalcy of foetal development in-utero.[5]

Maternal nutrition is closely related to foetal well-being and growth.[5] The accepted parameters for foetal growth in every trimester are correlated with maternal nutrition.[5] Malnutrition and disorders of metabolism, such as GDM and GHTN, are major reasons for variations in foetal development, subsequent birth weight, and complications in pregnancy.[5]

The most relevant parameters in foetal anthropometry are BPD, HC, AC, and FL. They are relevant because they determine the rate of growth of a foetus and their specific organs depending on nutrition and the internal environment beginning at 13–14 weeks of gestation. Most obstetricians rely on these parameters to get an estimate of foetal well-being or intra-uterine growth restriction (IUGR).[6]

The rate of foetal growth is determined by interactions between several maternal, foetal, and environmental mechanisms. Achieving an accurate estimation of in-utero foetal anthropometry parameters is important for the early identification and clinical management of the metabolic disorders that can arise during pregnancy, like GDM and GHTN; hence, it is associated with promoting the survival and well-being of a foetus.[7] There are several intra-partum foetal weight estimation methods, of which ultrasound-based estimation is the most reliable and widely used.[8] An ultrasound scan, also known as a foetal anomaly scan, is performed to look for major foetal abnormalities early in pregnancy, at 18–20 weeks of gestation.[9]

The foetal biometric parameters, like BPD, HC, AC, and FL, can be used to obtain an estimated foetal weight (EFW).[10] Achieving a precise estimation of gestational age is a criterion for determining whether the size of a foetus is appropriate-for-gestational-age (AGA).[10] Small-for-gestational-age (SGA) and large-for-gestational-age (LGA) foetuses are generally at increased risk of suffering from a range of adverse maternal and perinatal outcomes.[10] Abnormal biometry can be a result of various maternal factors and their associated management (hypertension, diabetes, infection exposure).[10]

Thus, the aim of our study is to collect foetal anthropometric measurements for normal, GDM-affected, and hypertensive pregnancies using an ultrasound at 20–22 weeks of gestation. The objective is to identify any deviations in foetal growth from normal pregnancies during GDM-affected and hypertensive pregnancies.

Materials and Methods

A retrospective study was conducted based on data from 2016 to 2018 (two years). The anomaly scans that we examined were done on foetuses between the gestational ages of 18–22 weeks from 2016 to 2018 at the Department of Obstetrics and Gynaecology. Of the scans, 615 were selected according to inclusion criteria for our study.

a) Inclusion criteria: pregnant women with normal pregnancies, women with a history of pre-pregnancy diabetes/hypertension, diagnosed pre-eclampsia, diagnosed GDM.
b) Exclusion criteria: pregnancies with anomalies, pregnancies before 18 weeks or after 24 weeks of gestation.

Of the 615 patients, 137 were confirmed as having GHTN, 102 of the expectant mothers were confirmed as having GDM, and the rest had normal pregnancies. The age range of the patients was 19–46 years.

The patient data and hospital numbers were collected from the register maintained in the scanning room of the Department of Obstetrics and Gynaecology. The following measurements were recorded from the register:

1) Biparietal diameter (BPD),
2) Head circumference (HC),
3) Abdominal circumference (AC), and
4) Femur length (FL).

The Data collected were then verified against the patient-provided and antenatal information from the labour room registry of all the women who had vaginal or LSCS

deliveries. The collected data were then segregated into hypertensive, gestational diabetes-affected, and normal categories based on the entry comments in the labour room registry.

Later, the data were analysed using the following statistical methods: ANOVA and post hoc Tukey's test.

Table 1: Distribution of pregnancies as per co-morbidities.

Co-morbidity	No of patients
Gestational hypertension	137
Gestational diabetes	102
Normal	376
Total	615

Results

The sample for the study consisted of 615 pregnant females. The distribution of pregnancies according to co-morbidities is shown in Table 1.

All measurements of biparietal diameter (BPD), head circumference (HC), and abdominal circumference (AC) were lower in GHTN-affected pregnancies than in normal ones. Femur length (FL), however, was not significantly affected. The mean values for BPD, HC, AC, and FL in GTHN-affected pregnancies were 32.5, 150, 124, and 26 mm. In normal pregnancies, the values were 45mm, 165mm, 135mm, and 29 mm.

All measurements of biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL) were higher in GDM-affected pregnancies than in normal ones. The mean values of BPD, HC, AC, and FL in GTHN-affected pregnancies were 52.5, 185, 143, and 35 mm.

It was observed that all the measurements except FL were almost 10–15 mm lower in GHTN-affected pregnancies than in normal ones, while all the measurements were almost 10–15 mm greater in GDM-affected pregnancies than in normal ones.

A comparison of all the parameters for GHTN-affected, GDM-affected, and normal pregnancies is shown in Figures 1-4.

The results of a one-way ANOVA test show that the biparietal diameter (BPD), head circumference (HC),

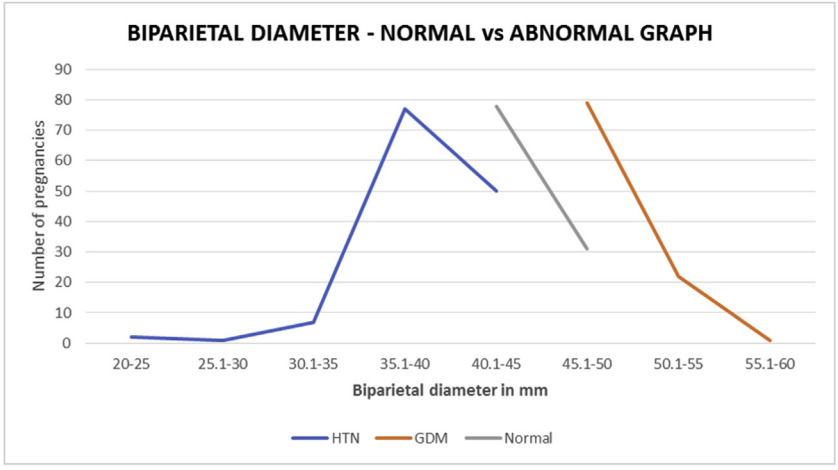

Figure 1: Measurements of BPD in normal and abnormal pregnancies.

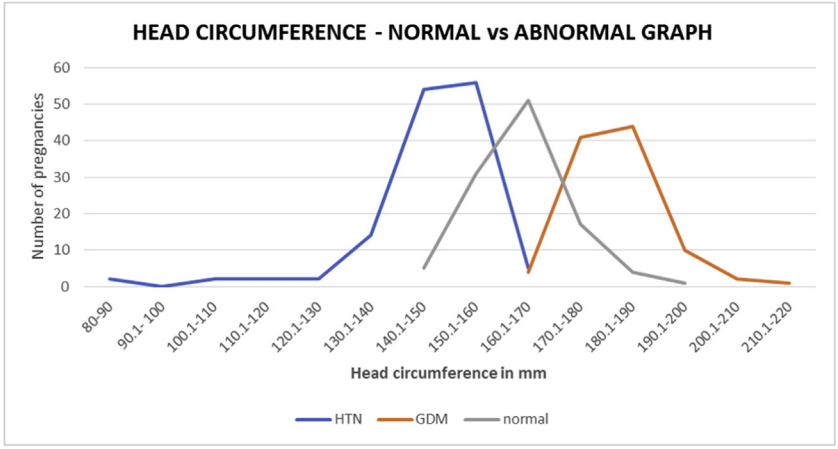

Figure 2: Measurements of HC in normal and abnormal pregnancies.

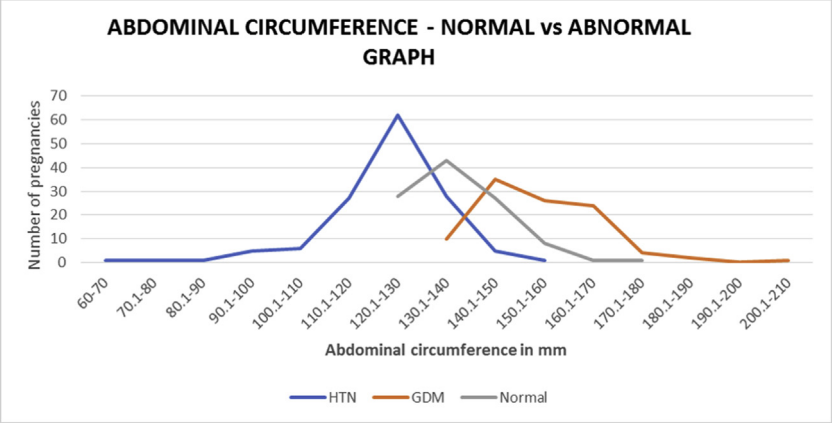

Figure 3: Measurements of AC in normal and abnormal pregnancies.

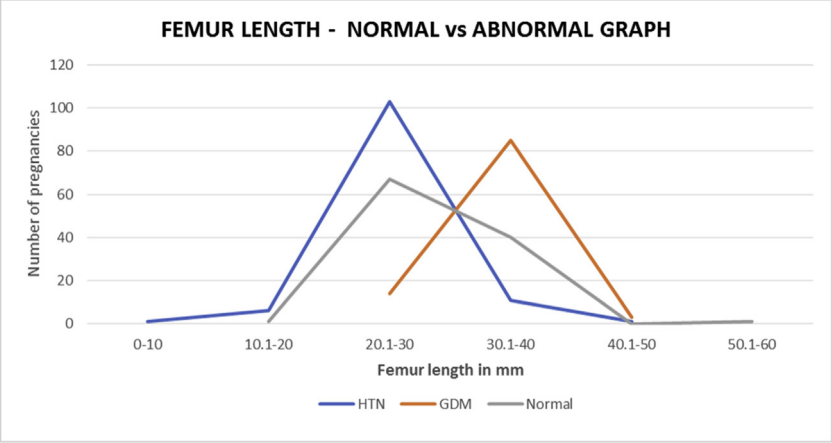

Figure 4: Measurements of FL in normal and abnormal pregnancies.

abdominal circumference (AC), and femur length (FL) were found to be significant in all the parameters evaluated between the groups, as the P-values were <0.05 for all the measurements, as shown in Table 2.

The results of the Tukey's test show that each foetal parameter had a significant correlation with pregnancy related co-morbidities, as the P-values were <0.05 for all the measurements, as shown in Table 3.

Table 2: Showing the comparison of all parameters using anova test.

		Sum of Squares	Mean Square	F*	Sig.
BPD	Between Groups*	6639.812	3319.906	845.238	<0.001
	Within Groups*	2403.798	3.928		
	Total	9043.611			
HC	Between Groups	69,725.593	34,862.797	272.560	<0.001
	Within Groups	78280.216	127.909		
	Total	148005.809			
AC	Between Groups	56304.138	28152.069	218.524	<0.001
	Within Groups	78842.795	128.828		
	Total	135146.933			
FL	Between Groups	3151.575	1575.788	85.504	<0.001
	Within Groups	11278.844	18.429		
	Total	14430.419			

*Within groups variation measures how much the each parameter vary from their group mean. *Between groups variation measures how much the group means vary from the overall mean.
*f is Test statistics.

Table 3: Showing the correlation of each foetal parameter against pregnancy related co-morbidities using Post Hoc Test - Tukey HSD.

Post Hoc Test - Tukey HSD						
Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval
						Lower Bound
BPD	HTN	GDM	−10.52749*	.25919	<0.001	−11.1364
		NORMAL	−5.53884*	.19778	<0.001	−6.0035
	GDM	HTN	10.52749*	.25919	<0.001	9.9185
		NORMAL	4.98865*	.22126	<0.001	4.4688
	NORMAL	HTN	5.53884*	.19778	<0.001	5.0742
		GDM	−4.98865*	.22126	<0.001	−5.5085
HC	HTN	GDM	−34.16604*	1.47907	<0.001	−37.6410
		NORMAL	−17.75754*	1.12864	<0.001	−20.4092
	GDM	HTN	34.16604*	1.47907	<0.001	30.6911
		NORMAL	16.40849*	1.26261	<0.001	13.4421
	NORMAL	HTN	17.75754*	1.12864	<0.001	15.1059
		GDM	−16.40849*	1.26261	<0.001	−19.3749
AC	HTN	GDM	−30.77386*	1.48438	<0.001	−34.2613
		NORMAL	−15.65993*	1.13269	<0.001	−18.3211
	GDM	HTN	30.77386*	1.48438	<0.001	27.2864
		NORMAL	15.11393*	1.26714	<0.001	12.1369
	NORMAL	HTN	15.65993*	1.13269	<0.001	12.9988
		GDM	−15.11393*	1.26714	<0.001	−18.0910
FL	HTN	GDM	−7.23031*	.56143	<0.001	−8.5494
		NORMAL	−3.89200*	.42841	<0.001	−4.8985
	GDM	HTN	7.23031*	.56143	<0.001	5.9113
		NORMAL	3.33831*	.47927	<0.001	2.2123
	NORMAL	HTN	3.89200*	.42841	<0.001	2.8855
		GDM	−3.33831*	.47927	<0.001	−4.4643

Discussion

Physiologically, foetal growth spurts are typically seen in the second semester, with an increase in birth weight, BPD, FL, AC, and HC corresponding to foetal age.[11] In a normal pregnancy uncomplicated by GDM or GHTN, the foetal growth curve traced would match the national standard for each country's foetal birth chart, which is variable depending on ethnicity and nationality.[12]

However, regardless of differences in ethnicity and nationality, every previous study on foetal growth curves has showed a strong correlation between pregnancy-related co-morbidities and a deviation from the standard foetal growth curve that occurs from approximately 18 weeks of pregnancy onwards.[13] Several studies conducted by various independent researchers have consistently established that the foetal anthropometry parameters of AC, FL, and HC specifically were marginally increased from 18 weeks onwards in pregnancies involving GDM.[14] This increase in foetal anthropometry parameters maintained an upward incline throughout pregnancy in patients with untreated GDM, resulting in the birth of large-for-gestational-age (LGA) infants (those with a body weight exceeding the 90th percentile).[14] These LGA infants later presented with postnatal complications, such as low Apgar scores, poor feeding habits, increased blood sugar levels with insulin resistance, and obesity. They also suffered from early cardiovascular disease later in life and were at increased future risk of various cancers, such as leukaemia, breast, prostate, and colon cancer.[15]

Similarly, hypertension, either with or without eclampsia, causes constriction of placental blood vessels, leading to decreased placental blood flow and hence less nutrition for the developing foetus.[15] This invariably leads to a decrease in AC, HC, and FL and hence an overall drop in the foetal growth curve compared to normal pregnancies.[16] GHTN-affected pregnancies showed a slightly greater risk of intra-uterine death due to growth retardation. Unmonitored and untreated hypertension during pregnancy can lead to eclampsia during delivery, further endangering an already compromised foetus.[16]

In their study, SF Wong et al. found that BPD was higher in the foetuses of diabetic mothers than in the low-risk population from 26 weeks of gestation onwards. In our study, we also found that BPD was higher in pregnancies involving GDM than in normal ones.[11]

EAAEI Fattah conducted a study on pregnant women in their second trimester. He found that BPD and AC were statistically significant indicators of the likelihood of GDM occurrence. In our study, we also found, based on the results of the Tukey's test, that BPD and AC showed a significant correlation with GDM.[17]

H Venkataraman et al. conducted a study on normal pregnancies and pregnancies involving GDM. They found that BPD and HC were lower in GDM-affected mothers than in the controls. In our study, however, we found that BPD and HC were higher in pregnancies involving GDM than in normal ones.[18]

In their study, KJ Vedavathi et al. found that HC was significantly higher in GDM-affected patients than in those

with normal pregnancies.[19] We also found the same results in our study. DP Eviston et al. conducted a study focused on normal pregnancies and pregnancies involving preeclampsia. In their study, they found that HC increased at a greater rate in pregnancies with preeclampsia than in the controls. They explained their findings by referring to altered foetal exposure to neurotrophins in pregnancies involving hypertension.[20] In our study, however, the HC measurements of the foetuses of mothers with hypertension were almost 10 mm lower than in normal pregnancies.

The AC of foetuses of mothers with GTHN showed a marked decline compared to normal pregnancies. This is consistent with the fact that maternal hypertension causes a marked drop in the umbilical venous (UV) volume flow, which leads to decreased foetal cardiac output and a smaller amount of glycogen reserves in the liver and thus a decreased liver size, resulting in a drop in AC. In contrast, the foetuses of the diabetogenic mothers in our study showed increased AC levels, as glucose oversupply from early pregnancy causes hypertrophy and hyperplasia of the pancreas and increased glycogen reserves in the liver.

Julio Mateus et al. stated that 'women with severe GHTN when compared with those without GHTN had notably smaller foetal AC.'[21] Our results echoed this statement. P Quaresima et al. conducted a study on consecutive singleton pregnancies. They found that AC was significantly higher in women diagnosed with GDM at 24–28 weeks of gestation than in normal glucose-tolerant women.[22]

JS Brand et al. conducted a study and found that the foetuses of women subsequently diagnosed with GDM were smaller at 12–16 weeks of gestation but grew faster so that, from 24 weeks up to delivery, they had greater AC levels than foetuses not exposed to GDM.[23]

HA Al Rawi et al. conducted a study on 160 pregnant women. They inferred that macrosomic infants had higher AC and FL levels than infants in normotensive pregnancies at 20 weeks of gestation.[24] This result echoes the findings of our study. In our study, also we found, based on the results of the Tukey's test, that AC and FL levels showed a significant correlation with GDM.

There was no marked difference in the FL levels of foetuses of mothers with GHTN and foetuses in normal pregnancies, with the FL levels of foetuses in hypertensive pregnancies falling well within the range of those in uncomplicated pregnancies. On the other hand, ultrasound scans of diabetogenic mothers revealed that the FL levels of these foetuses were greater than normal. This significantly contributed to the prevalence of large-for-gestational-age (LGA) infants with weights above the 90th percentile/macrosomic infants (weighing more than 4,000 gm).[25] FL levels are likely strongly dictated by genes; hence, maternal nutrition alone does not contribute significantly to wide variations in foetal FL levels.[26]

As normal foetal growth determines, to a large extent, whether a pregnancy is healthy and impacts the perinatal outcome as well as the long-term health of the offspring, common adult diseases in pregnancy, such as type 2 diabetes and cardiovascular conditions like hypertension, have been linked to abnormal foetal growth, especially foetal growth restriction (FGR).

As foetal growth discrepancies begin as early as 18 weeks of gestation, paying attention to small deviations and closely monitoring foetal growth can contribute greatly to preventing morbid perinatal outcomes and can provide sufficient scope for early interventions, ensuring optimal maternal and foetal health. This comparison can help physicians monitor foetal growth during early pregnancy and understand its relationship with GDM and GHTN.

Conclusion

Our results show that, when we compare the foetal growth parameters, namely BPD, HC, AC, and FL, in normal and GDM-affected pregnancies, we can observe that the foetuses of mothers with GDM have higher values for BPD, HC, AC, and FL than in normal pregnancies.

When we compare the foetal growth parameters, namely BPD, HC, AC, and FL, in normal and GHTN-affected pregnancies, we can observe that the foetuses of mothers with GHTN have lower values for BPD, HC, and AC than in normal pregnancies. Femur length, however, is not significantly affected.

Recommendations

It can be observed that foetal growth during pregnancies affected by GDM is greater than normal foetal growth, while foetal growth during hypertensive pregnancies is lower than in a normal pregnancy. Thus, it is recommended that foetal anthropometric parameters be checked early in a pregnancy to look for deviations from the foetal growth norms. The foetal parameters in anomaly scans can be used for early identification of, and intervention in, hypertensive and GDM-affected pregnancies and thus can be used to prevent complications.

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Conflict of interest

The authors have no conflicts of interest to declare.

Ethical approval

Ethical clearance was received from the Institutional Ethics Committee on 14.1.2020 (IEC no. - IEC 11/2020).

Authors' contributions

CG conceived and designed the study, provided research materials, and wrote the initial draft of the article. RL conducted research, collected and organised the data, and analysed and interpreted the data. CG and RP composed the final draft and provided logistic support. All authors have critically reviewed and approved the final draft and are

responsible for the content and similarity index of the manuscript.

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