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Comparative Study of the Morphology, Morphometry and Vascular Pattern of Umbilical Arteries in Placentas of Gestational Diabetes Mellitus and Normal Pregnancies

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ABSTRACT

Introduction: the placenta, which represents the fetus' growing environment inside the uterus, exhibits dramatic changes in its gross morphology as a result of GDM, posing the risk of undesirable pregnancy outcomes.

Materials and Method: the Study was done on the collected and preserved placentas of 50 healthy controls and 50 GDM placentas in the anatomy department, PK Das Institute of Medical Sciences, Vaniamkulam, Palakkad, Kerala. The study protocol was approved by the Institutional Human Ethics Committee of PK Das Institute of Medical Science, Kerala, India with the following IEC number - IEC/01/32/21 on 12/8/2021. Study was conducted for a period of 2 months followed by ethical approval. Morphological features and morphometric parameters of the placenta such as thickness, diameter, circumference, surface area, volume, weight and the number of maternal cotyledons were observed. The data was analyzed using the SPSS 20 version using appropriate statistical tools

Results: in the present study, four different shapes of the placenta were observed viz., discoid, oval, bilobed and irregular. 76% of the placentas of GDM were found to be normal, 14% were circummarginate and 10% were circummvalate. 48% dispersed type of arterial pattern and 52% magestrial type of arterial pattern were observed in GDM placentas. The average number of maternal cotyledons and morphometric parameters in placenta showed more in GDM placentas when compared to normal placentas and statistically significant.

All the results regarding morphometric data were expressed as mean ± SEM. A p-value <0.05 showed a statistical significance.

Conclusion: this study demonstrates the presence of aberrant placental morphometry in GDM, which is brought on by hyperglycemia and may pose many dangers to the fetus's health. Therefore, it is advised to maintain proper management of glycemia when pregnant and one minute observation of placenta will provide valuable insight into fetal health.

Keywords: Maternal cotyledons; Umbilical artery; GDM; Morphometric parameters; Cord insertion.

Introduction

Placenta is a fetomaternal organ. It is deciduate, villous and haemochorial structure seen in higher mammals[1]. It consists of mainly two parts a large foetal part which develops from chorionic sac and a small maternal part formed of endometrium[2]. This connects mother to the foetus and thus acts as an effective interface between the foetus and the mother by facilitating nutrients, oxygen and immunological transport to the foetus[1,3]. It also creates a stable milieu and protects the foetus from maternal and environmental stress[2]. So proper placental development is crucial for uncompromised fetal development. Any Abnormality in the development of this structure will leave an impact on the developing fetus which results complications in pregnancies such as hypertension, Gestational Diabetes Mellitus (GDM), IUGR etc[4].

Diabetes is the most common endocrine disorder of pregnancy having highest feto-maternal morbidity and mortality[5]. 1-20% of all pregnancies worldwide is affected by diabetes[6], thus it has an annual representation of 18 million births. The major risk factors of GDM include overweight/ obesity, westernized diet and micronutrient deficiencies, advanced maternal age and a family history of insulin resistance or diabetes[6]. GDM has been found to be more prevalent in urban areas rather than rural areas[7]. GDM cases are expected to rise to 101.2 million by 2030. The prevalence of GDM was observed to be 15.9% in northern Kerala[8] and 11.2% in southern Kerala[9]. Moreover, it can also lead to long term effects like increased risk for type 2 diabetes (T2DM) and cardiovascular disease (CVD) in the mother as well as to child in future. Thus it generates vicious intergenerational cycle of obesity and diabetes

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that impacts the health of the World population[6], considering this as a universal issue and foreseeing its adverse outcomes, it brings prime interest in this matter.

Gestational diabetics can also lead to abnormal placental environment thus causing structural aberrations of placenta and contributing to its impaired development and functioning[10,11]. Placental functioning depends on its structure, ultrastructure and the functioning of placental exchange barrier. Due to notable ultra-structural difference in placentas of normal and GDM pregnancies it can cause impairment of placental barrier can interfere with fetal development[12].

Normal placental vasculature also plays a major role in the development of fetus. The arterial patterns seen in placenta when subjected to study shows mainly two types Disperse (Dichotomous) and Magesterial (Monopodial). In dispersed variety, the umbilical arteries undergo series of dichotomous division with diminishing calibre, whereas in Magestrial variety, placenta has two arteries that extends till the margin without markable diminishing of calibre. It is of importance as arterial pattern gives a brief peripheral outlook on placental abnormalities[10].

Disease conditions will be reflected in the architecture of the placenta both at macroscopic and microscopic level. Placental examination in such cases gives valuable information and answers to questions concerning pregnancy and management. Morphological and morphometric measurements of the placenta will provide an insight into the aetiology of new-born and maternal complications. Placental dimensions will give a detail description about the entire cumulative development of the foetus from the conception till delivery.

The placental vasculature patterns could be a modality to study and differentiate normal and GDM placentas. The present study was aimed to observe the gross morphological, morphometric assessment and vascular pattern of umbilical arteries in placentas of normal and GDM pregnancies.

Materials and Methods

Examination of placenta: The study was done on collected specimens 50 normal and 50 GDM placentas in the department of Anatomy. Placentas were procured from Obstetrics and Gynaecology department of PK Das Institute of Medical Sciences. The institutional ethical committee clearance was taken before the start of the study.

Morphological study: Morphological features like shape, additional lobe, foetal membrane attachment, umbilical cord attachment and arterial pattern of umbilical arteries on fetal surface were observed.

Morphometric study: The morphometric parameters of the placenta were assessed using different instruments. The morphometric parameters assessed were thickness, diameter, circumference, surface area, volume, placental weight and maternal cotyledons. The thickness of the placentae were measured by inserting a calibrated knitting needle in the centre of the placenta. For measuring the diameter the placenta was kept on a flat tray; the first maximum diameter was measured using a metallic scale calibrated in centimetres (d1) after that the second maximum diameter was measured by keeping the metallic scale perpendicular to the first diameter (d2). The mean of d1 and d2 is considered as the diameter of the placenta. Circumference was calculated by formula $\pi \times d$. Surface area of the placenta was calculated using the formula $\pi d1 \times d2/4$. (Where d1 is the largest diameter and d2 is the smallest diameter). Volume was calculated by formula $(\pi d1 \times d2/4) \times h$. Where 'h' stands for thickness. The weight of the placenta was measured using a digital weighing scale. In order to count the number of maternal cotyledons the placenta was held in the peripheral part using fingers and a small pressure is applied on the foetal part of placenta, this made the cotyledons on the maternal aspect more prominent, the cotyledons were then counted in a loop pattern from any one of the sides and documented.

Ethical consideration

The study protocol was approved by Institutional Human Ethics Committee of P.K Das Institute of Medical Sciences, Kerala, India. (IEC/01/32/21).

Statistical analysis: All the data was coded and entered into MS excel sheet. Data was analysed using SPSS 20 version. Chi square test (categorical variables) and Student t test (noncategorical variables) were used for comparing means of Parameters. All the results regarding morphometric data were expressed as mean ± SEM. A p value <0.05 showed a statistical significance.

Results

Morphological examination of placenta: The morphological parameters such as shape, additional lobes, membrane attachment and arterial supply does not show a significant p value (i.e., p value >0.05). 70% of placentas showed normal membrane attachment, 6% showed circumvallate and 24% showed circummarginate attachment in normal placentas whereas in GDM placentas 76% was found to be normal, 14% circummarginate (figure 1a) and 10% circummvalate (figure 1b).

Dispersed type of arterial supply is shown by 58% of normal and 48% of GDM placentas (figure 2a). Magestrial type of arterial pattern is exhibited by 42% of normal placentas and 52% of GDM placentas (figure 2b).

On the basis of shape of the placenta, it is divided into discoid, oval, bilobed and irregular. Additional

lobes where absent in 98% of both normal and GDM placentas, presence of additional lobes where seen only in 2% of placentas in both cases (figure 3a). In normal placentas 58% was found to be discoid, 38% oval and 4% irregular, whereas in GDM placentas 68% was found to be discoid, 30% oval and 2% bilobed (figure 3b).

A significant p value of 0.025 is shown by a morphological parameter which is umbilical cord attachment. Umbilical cord attachment can be central, eccentric, marginal and velamentous according to the position where it is attached. The normal placenta shows 44% central, 52% eccentric and 4% of marginal cord attachment whereas GDM placentas shows 38%

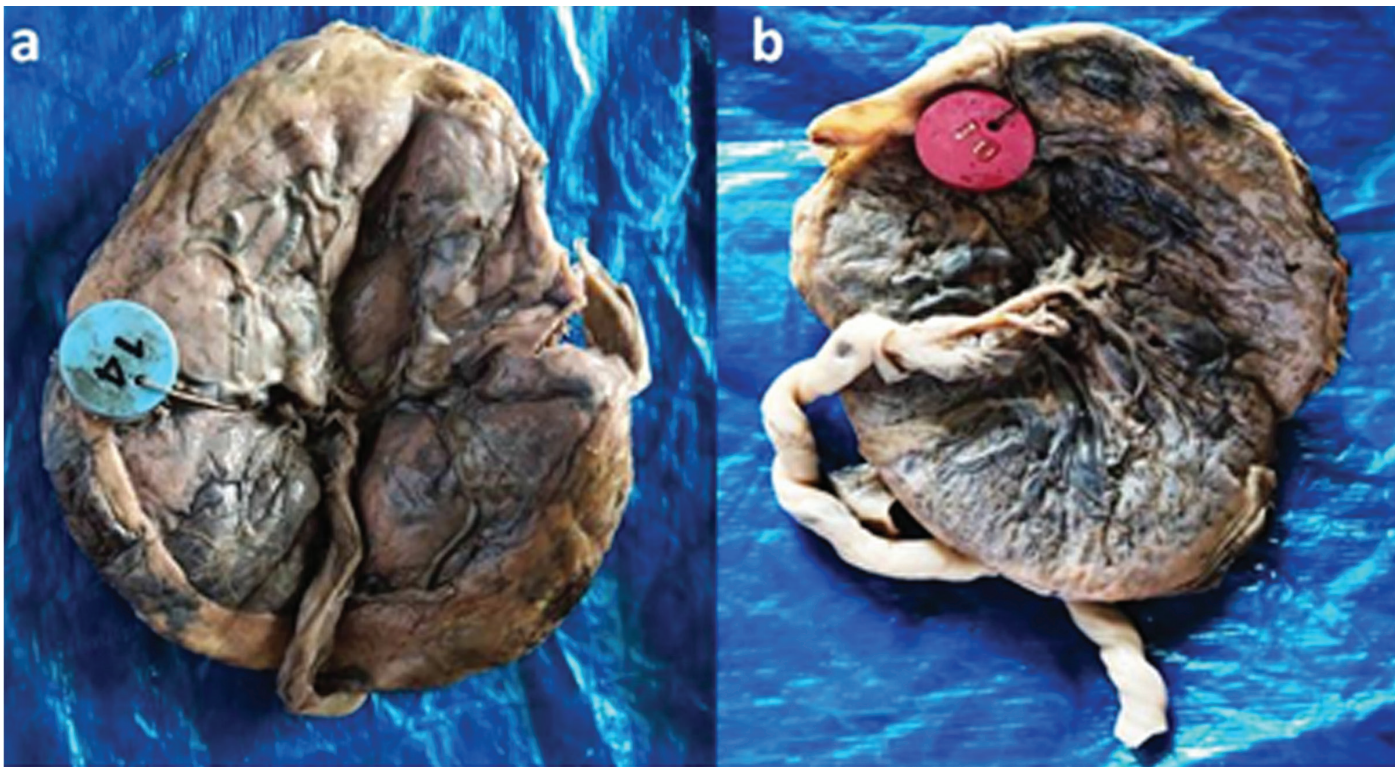

Figure 2. Placenta showing a) dispersed arterial pattern and b) magestrial arterial patter.

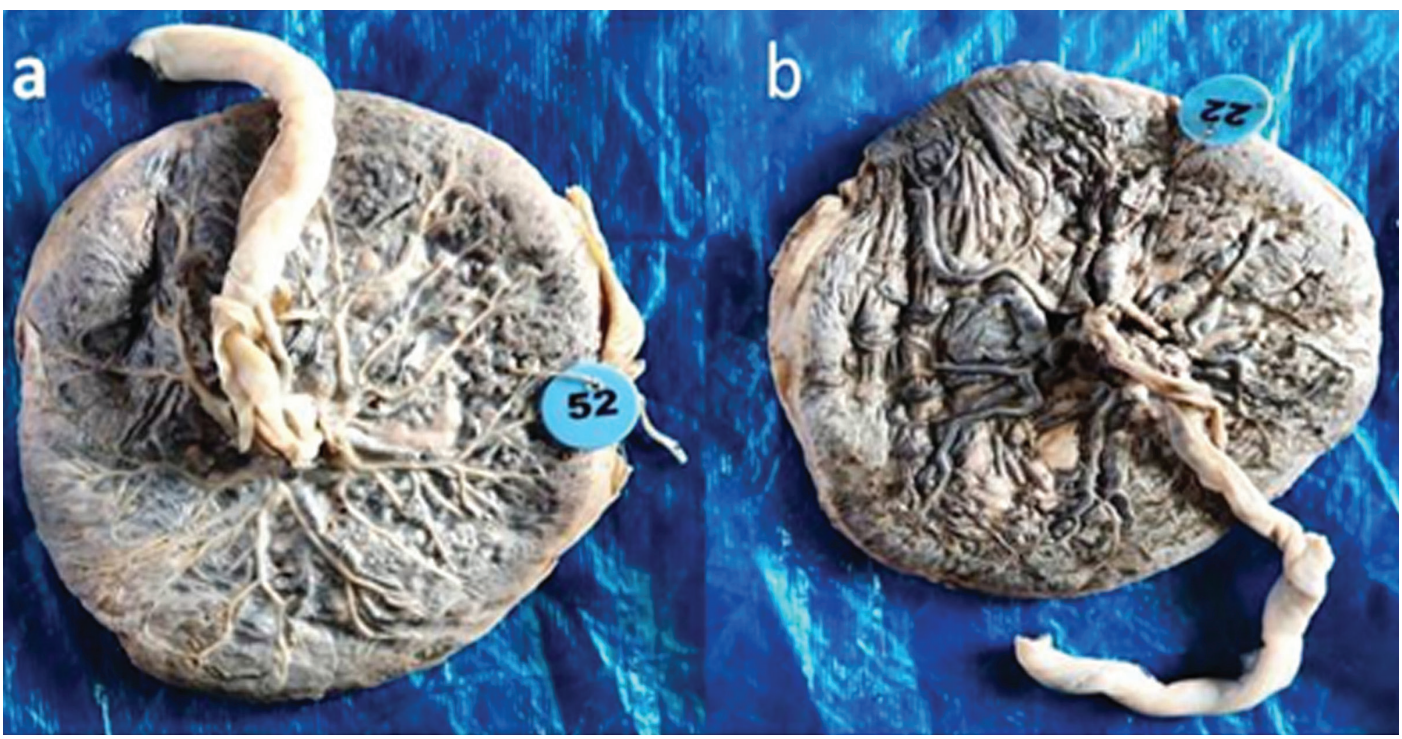

Figure 1. Placenta showing a) cirummarginate membrane attachment and b) circumvallate membrane attachment.

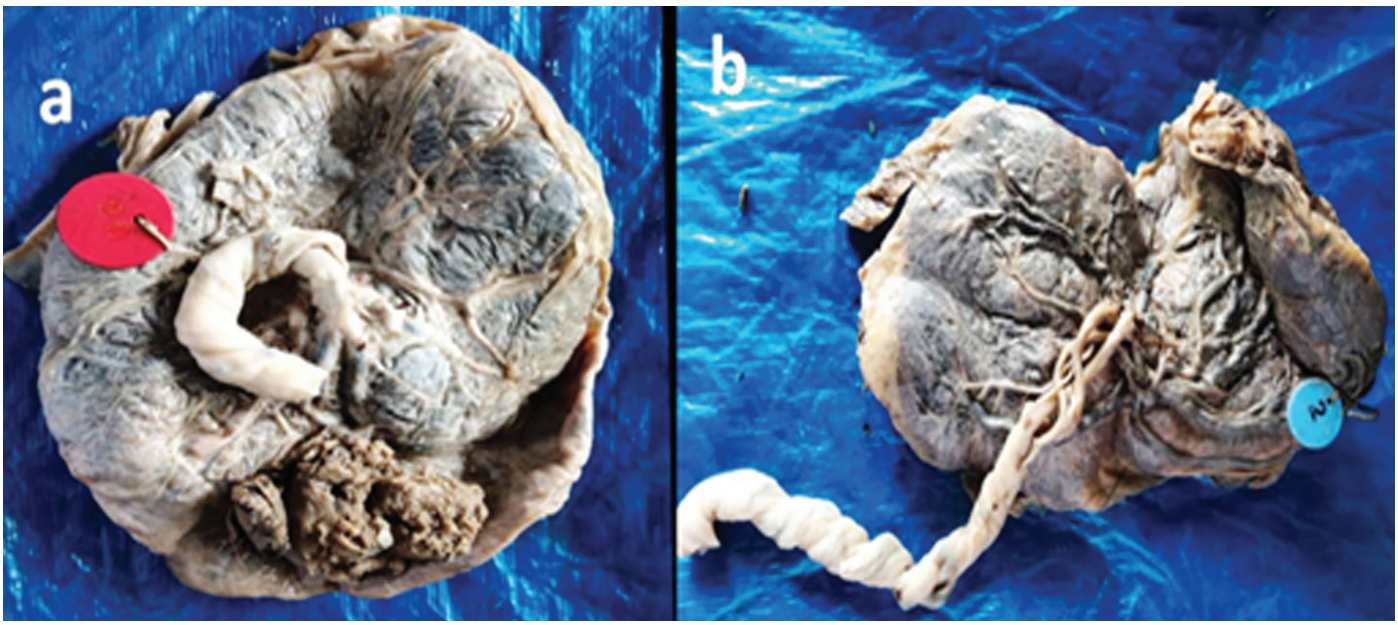

Figure 3. a) Placenta with additional lobe and b) bilobed placenta.

central 54% eccentric and 8% marginal type of cord attachment. (Table 1)

Morphometric examination of placenta: The morphometric parameters such as thickness, diameter, circumference, surface area, volume, placental weight and maternal cotyledon shows significance in p value (i.e., p value <0.05). The mean thickness of normal placenta is 2.416cm whereas GDM placentas showed a mean value of 2.73cm the p value is 0.0001 making it statistically significant. The mean diameter of normal placenta was 15.935cm whereas GDM placentas showed a mean value of 15.286cm the p value is 0.0001 thus diameter is statistically significant. The normal placentas showed a mean circumference value of 50.034cm and GDM placentas showed a mean value of 47.998cm for circumference. Thus, circumference is statistically significant (p value 0.0001). A mean of 199.336 cm2 was observed in surface areas of normal placentas whereas in GDM the mean was found to be 182.912cm2 with a p value of 0.0002 thus making it statistically significant. The mean volume of normal placenta is 481.1729cm^3 whereas GDM placentas showed a mean value of 497.3248cm^3 the p value is 0.0001 making it statistically significant. The normal

Table 1. Comparison of morphological parameters in placentas of normal gestational diabetic pregnancies.

Sl. no.	Parameter	Groups	Normal (total 50)	GDM (total 50)	Chi square value	P value
1	Shape of placenta	Discoid	29 (58%)	34 (68%)	2.628	0.152
		Oval	19 (38%)	15 (30%)		
		Bilobed	-	1 (2%)		
		Irregular	2 (4%)	-		
2	Additional lobes	Absent	49 (98%)	49 (98%)	0.021	0.980
		Present	1 (2%)	1 (2%)		
3	Membrane attachment	Normal	35 (70%)	38 (76%)	1.755	0.095
		Circumvalate	3 (6%)	5 (10%)		
		Circummarginate	12 (24%)	7 (14%)		
4	Umbilical cord attachment	Central	22 (44%)	19 (38%)	5.458	0.025
		Eccentric	26(52%)	27 (54%)		
		Marginal	2 (4%)	4 (8%)		
		Velamentous	-	-		
5	Arterial supply	Dispersed	29 (58%)	24 (48%)	0.278	0.197
		Magestrial	21 (42%)	26 (52%)		

placentas showed an average weight of 480.46kg and GDM placentas showed an average value of 609.117kg. Placental weight is statistically significant with p value 0.0002. The average number of maternal cotyledons in normal and GDM placentas were found to be 10 and 8 respectively, they show a statistically significant p value of 0.001(Table 2).

Discussion

The purpose of the study was to evaluate the morphology and morphometry of placentas from normal and GDM pregnancies. The number of maternal cotyledons, extra lobe presence, membrane attachment, arterial pattern, site of umbilical cord connection, and arterial pattern were all noted. With the exception of the umbilical cord attachment and the quantity of maternal cotyledons, there was no statistically significant variation in the values of the aforementioned criteria between the two categories for GDM placentas.

Between the normal and GDM groups, there was a discernible variation in the pattern of umbilical cord attachment, with GDM showing a higher prevalence of eccentric cord attachment (54%). A considerable decrease in the number of cotyledons was observed in the GDM placentas, which was consistent with the findings of Pooransari *et al*., (2020), who observed that well-treated and well-controlled GDM patients had placental morphology and morphometry that was very comparable to that of the normal group[11]. Similar to Akhter *et al*., the current study was unable to draw any conclusions regarding the existence of any particular, recurring, or consistent pattern of structural abnormality of the placentas in GDM mothers[12]. Therefore, morphological research was unable to establish a reliable link between placental alterations and the mother's diabetic condition during pregnancy. The results of the research concurred with those of Ahmed *et al*., (2018), who found that gestational diabetes had no impact on the shape of the placenta[13].

When analysing placentas from DM women, the greatest challenge for a pathologist is how to distinguish the alterations indicative of hyperglycemic situations. This challenge is brought on by the frequent occurrence of other DM-related pregnancy problems, such as PE, chronic placental insufficiency and gestational arterial hypertension. The severity of carbohydrate problems during pregnancy, in addition to the type of DM, determines the extent of patho-morphological alterations in the placenta. Therefore, "mild" forms of hyperglycemia may not differ from the usual in the placenta's structure. In many earlier studies as well, it was found that the placenta was thicker in the GDM mothers compared to the control mothers. By using an ultrasound scan, it is possible to gradually diagnose an increase in placental thickness at the beginning of the second trimester followed by placentomegaly at the end of the third trimester. When compared to the control subjects, these heavier GDM placentas also showed significant changes in their maternal and foetal surfaces, which was consistent with the current study's observation of 54% eccentric type cord insertion in GDM placentas[14]. We discovered a larger number of round-type placentas in the current study (58% and 68% in normal and GDM, respectively). Guptha *et al*., also found that round placentas were more common than discoid, oval, bilobed, and irregular morphologies and the scattered and magisterial arterial patterns were more evident in round placentas[15].

Table 2. Comparison of morphometric parameters of placentas in normal and gestational diabetic pregnancies.

Sl. no.	Parameter	Groups	Mean	Standard Error	Statistical significance
1	Thickness (cm)	Normal	2.416	0.0567	p value = 0.0001
		GDM	2.73	0.0853	
2	Diameter (cm)	Normal	15.93550	0.262440	p value = 0.0001
		GDM	15.28627	0.175589	
3	Circumference (cm)	Normal	50.034	-	p value = 0.0001
		GDM	47.998	-	
4	Surface Area (cm^2)	Normal	199.3361	6.738	p value = 0.0002
		GDM	182.9126	4.059	
5	Volume (cm^3)	Normal	481.1729	18.589	p value = 0.0001
		GDM	497.3248	17.76	
6	Placental Weight (g)	Normal	480.4650	4.8118	p value = 0.0002
		GDM	609.1176	9.6301	
7	Maternal cotyledons	Normal	10	0.4871	p value = 0.001
		GDM	8	0.2910	

The current study evaluated morphometrical factors such as thickness, diameter, circumference, surface area, volume, and placental weight. All of the morphometrical data were statistically significant, with a p value of 0.05. In agreement with the results of Bhanu *et al*., the current study states that the shape of the placenta was comparable in both groups, but the weight, diameter and thickness in GDM placentas were significantly (P<0.005) higher when compared to that of the normal mothers[16]. This is comparable to our findings, in which we discovered that the morphometric properties of GDM placentas, such as weight, volume, diameter, and thickness, were much higher than those of normal moms. The findings of Saini also advocate that variations in the general morphology of placentas with gestational diabetes mellitus compared to normal pregnancies may be connected with changes in placental physiological functioning and, consequently, foetal outcome[17]. Tandon *et al*., (2018) discovered a positive link between placental weight and neonatal weight, as well as a higher incidence in complex pregnancies when compared to normal pregnancies[18]. This underscored the importance of diabetes pregnancies being detected and treated promptly. Most GDM placentas exhibit diabetes-related histological changes of having such as villous immaturity, enhanced angiogenesis villous fibrinoid necrosis, chorangiosis, etc[19]. Jaleel *et al*., (2019) also discovered that increasing placental weight and central thickness corresponded to an increase in neonatal weight and placental ratio[20]. The morphometric examination of the placenta will be particularly important in the early detection of placental insufficiency and the status of foetal well-being[21]. Early detection of GDM and care with a healthy lifestyle can minimise placental alterations.

According to the study, placentas from women with gestational diabetes mellitus (GDM) had considerably larger thickness, width, circumference, surface area, volume, and placental weight than those from moms without the condition. This emphasises the value of promoting a healthy lifestyle to manage hyperglycaemia in pregnant ladies which is essential in minimising placental changes along with the early monitoring of placental changes and foetal well-being.

Around the third week of intrauterine life placenta is developed and fulfils many equirements of the growing foetus. placental examination in utero as well as after delivery plays a very important role in wellbeing and nutritional status of the growing fetus. Generally it is mandatory to examine the isolated tissues from the patient with certain exceptions being the placental examination which is usually discarded without any examination there exists a multiple etiology which has raised the interest of the researchers for the placental examination. Placenta should be preserved for the first week-post delivery. This will be helpful in medico legal cases if any complications for neonate appear during the initial days and will help clinicians.

Placenta is the mirror of intrauterine existence of baby. Hence, to detect the placental abnormality, to learn and explore the regions and complications of abnormal placenta one should excel with the knowledge about morphological anatomy and vascular pattern of the placenta.

Limitation of the Study

This study is confined to the placenta collected from the south Indian population, so it cannot be generalised. The study period is short, so retrospective and prospective analysis of clinical conditions was impossible, and collected specimens were used for this study.

Conclusion

Examination of placenta will give us an idea about prenatal experience of baby inside the womb and it also give us an idea about the prospective health risks which can arise in mother as well as baby. For proper fetal growth there should be proper placental development. The imbalance between fetal as well as placental development give rise to increased risk of cardiovascular diseases, immunological problems, metabolic disorders etc. Maternal factors will affect placenta and vice versa. Lot of changes happens in placenta during gestational period in morphology, morphometry, thus understanding the predisposing factor will help in early diagnosis, prompt intervention and better management of the condition which lead ultimately to good obstetric care in complicated pregnancies. Placenta is the mirror image of intrauterine life of baby. Examination of placenta also helps to understand the aetiology and pathology of pregnancies which can lead to adverse outcome. So placental examination help in prevention and management of similar condition in subsequent pregnancies. This can help in neonatal-perinatal healthcare, assessment of conditions that can lead to poor pregnancy outcome under medico legal issues. Hence to detect a placental anomaly and vascular structure one should have knowledge about morphology, morphometry and arterial pattern of placenta.

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