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Maternal Body Mass Index on placental morphology and foetal birth weight

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Abstract

Introduction

Placenta is a functional unit between the mother and the foetus. Only eutherian mammals possess placenta. Human placenta is discoid, deciduate, haemochorial, chorioallantoic, labyrinthine and endocrine gland which connects developing embryo by umbilical cord to the endometrium of mother's uterus. It develops from two sources. The fetal component which is the principal component develops from chorion frondosum and the maternal component from decidua basalis. The fetal surface is smooth, covered by amnion and presents the attachment of the umbilical cord close to its centre. The maternal surface is rough, irregular and spongy and is mapped out into 15-20 convex polygonal areas known as lobes or cotyledons which are limited by fissures.

Material and Method: This is a prospective study conducted in the Department of Anatomy at Index Medical College over a period of 1 year. Inclusion Criteria: Totally, 217 healthy mothers who gave birth to uncomplicated singleton pregnancy, and their new-borns were included in the study. Exclusion Criteria: Subjects with diabetes mellitus, hypertension, anaemia, vascular diseases and multiple pregnancies were excluded in this study. Initially the vernier calipers were checked for zero error with jaws closed. The jaws of the calipers were placed on either side of the peripheral margin of the placenta with firm pressure on the placental surface. When both the locking screws of the calipers were tightened the calipers were removed from the placenta and the readings were recorded after the measurement in the main scale of the calipers were read to the nearest tenth of the centimeter.

Results: The New-born body mass index (Kg/m^2) was measured and the majorities (45.16%) of the new-born were within 11-13 followed by 31.33% of the new-born were more than 14 and the lesser proportion of 23.50% was <10 BMI (Kg/m^2). Thirteen (26.53%) of the placentas weigh <400 gm, and 3 (2.2%) weigh >701g. Most of the placentas 116 (94.3%) were of normal weight (400 - 700g). Out of 49 low weight placentas (<400 grams), 26.53% were from underweight mothers. Among 19 placentas with a number of cotyledons below normal, 35.18% of them were from the mothers who were underweight. Most (86.5%) of the placentas had a normal cotyledon count (15-25 cotyledons) and 61.11% of the placentas had

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a normal cotyledon count (< 15 cotyledons). Out of 15 placentas less than 2.0 cm, 53.3% were from underweight mothers. The most (91.7%) had the normal range of thickness of 2 - 4 cm and <2.0 cm (thin) of normal weight was 6 (40.0%). most (96.6%) had a diameter in the normal range of 11 – 22 cm with a mean of 16.86 ±2.359 cm.

Conclusion: Placental morphometry; weight, surface area and volume have exhibited significant and positive relationship with gestation and birth weight. Placental morphometry and sex of the newborn were good predictors of birth weight with sensitivity 75 to 82 percent and specificity around 75 percent. Percentile distributions of birth weight and placental morphometry have been specified by gestation and sex of the baby, which helps in understanding the growth trajectory of foetus. The regression models with good predictive values will help as diagnostic tools in the practice of evidence based medicine (EBM) and to initiate early measures for at risk mothers.

Keywords: Body Mass Index, Placental Morphometric, Newborn's.

Introduction

Placenta is a functional unit between the mother and the foetus. Only eutherian mammals possess placenta. Human placenta is discoid, deciduate, haemochorial, chorioallantoic, labyrinthine and endocrine gland which connects developing embryo by umbilical cord to the endometrium of mother’s uterus. It develops from two sources. [1] The fetal component which is the principal component develops from chorion frondosum and the maternal component from decidua basalis. [2] The fetal surface is smooth, covered by amnion and presents the attachment of the umbilical cord close to its centre. The maternal surface is rough, irregular and spongy and is mapped out into 15-20 convex polygonal areas known as lobes or cotyledons which are limited by fissures [3].

The peripheral margin is continuous with the foetal membrane which consists from outside inwards of fused deciduas parietalis and capsularis, chorion laeve and amnion [4]. The placenta is usually attached to the upper part of the body of the uterus encroaching to the fundus adjacent to the anterior or posterior wall with equal frequency. [5] Placenta separates after the birth of the baby and the line of separation is through the decidua spongiosum. In the first trimester, growth of the placenta is more rapid than of the foetus, but by 17 weeks, placental and fetal weights are approximately equal. It occupies 30% of uterine wall. At term the placental weight is approximately 1/6th of the fetal weight. [6]

Adverse obstetric conditions are associated with either placental growth restriction or placental hypertrophy in relation to birth weight, and even both, based on gestational age at delivery. The majority of the risk factors assessed resulted in increased odds of a PWR ≥90th percentile. [8] This suggests that the placenta may have particular compensatory responses to maternal obstetric conditions, each with a distinct pathophysiologic mechanism, but similar

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PWR outcome. [8] Further research is justified to elucidate the biological mechanisms underlying the associations between anemia, gestational diabetes, hypertensive disease, maternal pre-pregnancy BMI, and umbilical cord complications with abnormal placental growth relative to fetal growth.

Material and Method

This is a prospective study conducted in the Department of Anatomy at Index Medical College over a period of 1 year.

Inclusion Criteria: Totally, 217 healthy mothers who gave birth to uncomplicated singleton pregnancy, and their new-borns were included in the study.

Exclusion Criteria: Subjects with diabetes mellitus, hypertension, anaemia, vascular diseases and multiple pregnancies were excluded in this study.

ANTHROPOMETRIC MEASUREMENTS

1. BIRTH WEIGHT: The Naked birth weight is measured immediately after birth using electronic weighing scale and plotted in WHO Growth curve and based on which babies are classified as AGA, SGA and LGA.

2. BMI Babies: BMI is calculated using formula weight (kg)/ length (meter)2 and based on BMI newborns are classified as malnourished with cut-off

Methods

I. Morphometric values of the placenta was recorded.

1) Shape, diameter and thickness:

i) Shape - was noted and recorded.

ii) Diameter - of the placenta was measured with an inch tape.

iii) Thickness - were noted by vernier calipers.

Initially the vernier calipers were checked for zero error with jaws closed. The jaws of the calipers were placed on either side of the peripheral margin of the placenta with firm pressure on the placental surface. When both the locking screws of the calipers were tightened the calipers were removed from the placenta and the readings were recorded after the measurement in the main scale of the calipers were read to the nearest tenth of the centimeter.

2) Maternal surface: The number of cotyledons were counted and recorded.

3) Placental weight: Weight was recorded using a weighing scale. Babies (conceptus) whose placenta was obtained was also examined for the following facts-

i) Sex of the baby was recorded.

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ii) Weight of the baby recorded by weighing scale.
iii) Maturity of the baby was noted. Preterm conceptus is babies born before 37 weeks of gestation. Term conceptus is babies born from 38 - 40 wks of gestation. Post term conceptus is babies born beyond 40 week of gestation.

4) Fetal surface: Vascular pattern – disperse; magistral and mixed pattern was recorded. Type of insertion of the umbilical cord was noted. Number of umbilical arteries and umbilical vein was noted.

5) Length and diameter of the umbilical cord: Cord was measured in the delivery room with an inch tape and they was recorded. The segments attached to the baby and to the placenta was measured and the results was added. -Diameter of the umbilical cord was recorded by vernier calipers.

6) Spiral turns (twist) of the umbilical cord: The vessels of the cord are wound as cylindrical helices. They remain equidistant from its central axis and retain a constant curvature. In a dextral spiral held vertically the portions of the spiral lying between the axis and observer, as the observer might say, "in front of the axis"-will appear to slant from point above on the right to a point below on the left. In a sinistral spiral so held the reverse will appear; the anterior parts of the spiral will course from left above to right below. In other words, the course 28 of the anterior portion of a dextral spiral was parallel to the right-hand limb of a letter V, while the course of the corresponding portions of a sinistral special was parallel to the left-hand limb of a letter V. This was true no matter in which position a spiral is held for consideration. Spiral turns was counted and recorded.

Presence of true knots and false knots was recorded.

II Histological study of placenta and the umbilical cord:

Two bits of tissues from the placenta and the umbilical cord from normal pregnancy as well as pathological cases such as hypertension, diabetes mellitus, and anaemia was taken. Tissue bits from the animal placenta and cord was also taken. The bits of tissues were fixed with 10% formalin. Dehydration of the tissues were done with ascending grades of alcohol, clearing done with xylol, impregnation and embedding of tissues were done with paraffin wax. Section cutting was done with microtome.

Thin sections of tissues were mounted on the slides by using albumin solution (glycerin + egg white). Fixed section was stained with eosin and haematoxylin stain and mounted on the slide with dpx and the covering was done with a cover slip. The tissues was examined under a microscope and the photographs were taken after examination under photomicroscope with the help of a computer.

III. Silicone Gel Cast technique to study the placental vasculature:

Materials required:
1. Silicone gel 100ml – Black colour -1 & White colour -1.

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2. Heparin Injection (5000) - 1 Amp 3. Butterfly needle No: 17 - 3
4. Caulking gun to instill the silicone gel by shooting with force - 1

Method: Placentae was taken from ward, washed in tap water, and the membranes were trimmed. The umbilical cord was cut close to its site of insertion and the vessels were flushed with first tap water and then with heparinised solution using a butterfly needle. Then 20-30ml of silicone gel black colour for vein and white colour for artery was injected through the butterfly needle with the help of a caulking gun into the vessels one by one. The cast was allowed to set for 24 hrs. The specimens were kept in plastic containers and placed under thin stream of running water for 24 hrs. After 24 hrs the specimens were boiled for three hours in an aluminium vessel. The macerated tissues were removed and the cast was studied.

IV. Contrast study of the placental vasculature by Angiogram:

5 placental specimens were taken to the Anatomy and Radiology department, Index Medical College, Hospital & Research Centre. The specimens were washed thoroughly and blotted dry with cloth. 3 - 17 no: butterfly needle was introduced into each umbilical vessel. 5ml - 10ml of omnipaque (contrast) was injected into each umbilical vessel one by one and then they was clamped. The entire procedure was done under fluoroscopic guidance and serial radiological pictures were taken and studied.

Statistical Analysis

Data management and analysis was performed using Statistical Package for Social Sciences (SPSS) version 25 and the results presented in frequency tables; bivariate analyses were conducted to determine the effects of maternal BMI on placental morphology and foetal birth weight.

Results

In table 1, of the 217 new-borns were 55.76 % male babies and 44.23 % were female babies.

Table 1: Distribution of Babies Gender

Gender	**Frequency**	**Percentage**
Male Babies	121	55.76
Female Babies	96	44.23
Total	217	100

Table 2: Distribution of body mass index of New-born

Body mass index of new-born (Kg/m^2)	**Frequency**	**Percentage**
<10	51	23.50
11-13	98	45.16

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>14	68	31.33
Total	217	100

The New-born body mass index (Kg/m^2) was measured and the majorities (45.16%) of the new-born were within 11-13 followed by 31.33% of the new-born were more than 14 and the lesser proportion of 23.50% was <10 BMI (Kg/m^2) in Table 2.

Table 3: Distribution of Weight of placenta of New-born in gms

Weight of placenta g	**Underweight n %**	**Normal weight n %**	**Overweight n %**
<400	13 (26.53%)	34 (69.38%)	2 (4.08%)
400-700	3 (2.4%)	116 (94.3%)	4 (3.2%)
>701	1 (2.2%)	43 (95.5%)	1 (2.2%)

Thirteen (26.53%) of the placentas weigh <400 gm, and 3 (2.2%) weigh >701g. Most of the placentas 116 (94.3%) were of normal weight (400 - 700g). Out of 49 low weight placentas (<400 grams), 26.53% were from underweight mothers in table 3.

Table 4: Distribution of No. of cotyledons

No. of cotyledons	**Underweight n %**	**Normal weight n %**	**Overweight n %**
<15 (few cotyledons)	19 (35.18)	33 (61.11%)	2 (3.7%)
15-25 (normal no. of cotyledons)	9 (5.5%)	141 (86.5%)	13 (7.9%)

In table 4, Among 19 placentas with a number of cotyledons below normal, 35.18% of them were from the mothers who were underweight. Most (86.5%) of the placentas had a normal cotyledon count (15-25 cotyledons) and 61.11% of the placentas had a normal cotyledon count (< 15 cotyledons).

Table 5: Distribution of Placental thickness

Placental thickness	**Underweight n %**	**Normal weight n %**	**Overweight n %**
<2.0 cm (thin)	8 (53.3%)	6 (40.0%)	1 (6.6%)
2.0-4.0 cm (normal)	9 (4.5%)	182 (91.7%)	7 (3.2%)
≥4.1cm (thick)	0 (0.0%)	2 (75.0%)	1 (25.0%)

In table 5, Out of 15 placentas less than 2.0 cm, 53.3% were from underweight mothers. The most (91.7%) had the normal range of thickness of 2 - 4 cm and <2.0 cm (thin) of normal

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weight was 6 (40.0%).

Table 6: Distribution of Diameter of the placenta

Diameter of the placenta	Underweight n %	Normal weight n %	Overweight n %
11-22 cm (normal)	18 (8.9%)	92 (92.5%)	6 (2.98%)
≥23 cm (large)	0 (0.0%)	6 (85.7%)	1 (14.2%)

In table 6, most (96.6%) had a diameter in the normal range of 11 – 22 cm with a mean of 16.86 ±2.359 cm. Most (86.9%) umbilical cords had a normal length of 32 – 70cm with a mean of 57.102 and ± 11.5739 cm. Most (90.3%) had eccentric umbilical cord insertions in the chorionic plate.

Table 7: Distribution of Weight of placenta of New-born in gms

Cord length	Underweight n %	Normal weight n %	Overweight n %
<31cm (short)	0 (0.0%)	2 (100.0%)	0 (0.0%)
32-70 cm (normal)	17 (8.9%)	167 (87.4%)	7 (3.6%)
>70 cm (long)	1 (4.1%)	23 (95.83%)	0 (0.0%)

Discussion

This study confirms and expands previous observations on birth weight and the placental morphometry. Placental alterations vary with the nutritional availability that leads to variation in placental weight, altered vascular development, diminished angiogenic growth factor expression, and reduced glucose, amino acid, and lipid transport. Placenta responds to exogenous insults and tries to adapt for varying nutritional level of mother. If this response of placenta fails to maintain foetal growth, then it results in Intra uterine growth retarded babies [9]. Therefore, variations in placental morphometry influence the foetal growth resulting in IUGR babies.

Kishwara et al., in their study from Bangladesh mentioned that the placental weight in normal group ranged from 250-560 gm with mean placental weight 406.90 gm and SD 72.64gm [10]. Little et al., in their study from Ukraine observed the placental weight ranging from 100-1000 gm, and mean placental weight of 470 gm [9]. In another study of term pregnancies by Hoseman has mentioned the placental weight ranging from 400-1000 gm [11], whereas in the present study 5^{th} to 95^{th}percentiles of placental weight were from 235 and 586 gm respectively and mean placental weight was 417.9gm with SD 107.3 gm. This indicates that the mean placental weight and its range differs from place to place and also may be influenced by the factors such as the environmental factors, maternal and paternal nutritional

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status, and genetics. Therefore, present study results were similar to that of developing countries [12]. Many studies have reported that placental weight had significant positive correlation with the birth weight ($p< 0.001$) [13] the similar observations were noted in present study.

A study done in Aberdeen analysed that, the placental weight and FPR were reported higher in males as compared to females and also have proved that the effect of placental weight on birth weight by sex was more than parity [14]. In another study the placental weight of female babies for the whole duration of pregnancy was lower as compared to male babies [15]. In contrast to above results another study has concluded that the placental weights of male and female babies were same throughout the pregnancy [16]. However, in present study the placental weight of male babies was lower than females in weight groups less than 3000 gm, thereafter placental weight of male babies were higher than female babies. These findings were not statistically significant.

The surface area of the placenta explains the efficacy of the placenta to transfer the amount of nutrients, oxygen and carbon-di-oxide that passes from the mother to fetus. Placental surface area growth is completed by third trimester, whereas the placental thickness growth occurs till late third trimester [17]. The mean surface area reported by Salafia CM was 247.7sq cm [18]. However, in our study the mean placental surface area was 225.7sq cm, it correlated positively with the weight of the baby ($r=0.61$; $p< 0.001$).Initially the surface area of placenta in male babies was smaller as compared to females, later on as the birth weight increased to more than 3000 gm, it was larger in male babies. The difference in the placental surface area might be due to nutritional status, maternal and paternal anthropometry, genetic constitution, Rh-incompatibility and other environmental factors.

The mean thickness of term placenta reported by Gunapriya et al., was 2.1cm [19], in other study by Hatti AM it was 2.21cm [20] whereas, in the present study the mean placental thickness was 2.1 cm, 5^{th} and 95^{th} percentiles of placental thickness varied from 1.5 to 3.0 cm, with no significant relationship with birth weight.

In the present study mean placental volume was 366.08±1.10ml, with a significant positive correlation between the weight of the baby and the placental volume ($r=0.662$ml; $p<0.001$), this result is consistent with the other study [21].

Conclusion

Placental morphometry; weight, surface area and volume have exhibited significant and positive relationship with gestation and birth weight. Placental morphometry and sex of the newborn were good predictors of birth weight with sensitivity 75 to 82 percent and specificity around 75 percent. Percentile distributions of birth weight and placental morphometry have been specified by gestation and sex of the baby, which helps in understanding the growth

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trajectory of foetus. The regression models with good predictive values will help as diagnostic tools in the practice of evidence based medicine (EBM) and to initiate early measures for at risk mothers.

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