Original Article

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Placental Morphometry Determines the Birth Weight

Anatomy Section

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ABSTRACT

Background: Placental morphometry determines the foetal development and adulthood disease pattern. Hence, in the present study the influence of placental weight, volume, surface area, and thickness were studied in different groups of birth weight by sex of the newborn.

Material and Methods: Present study was conducted on 164 consecutive singleton deliveries from a teaching hospital of Northern Karnataka, India. Multivariate linear regression models were constructed by maximum likelihood method after checking the linearity. The sensitivity, specificity and predictive values of regression models were computed to exhibit their utility for physicians.

Results: Gestational age exhibited positive relationship with birth weight. Placental parameters showed a positive and significant relationship ($p<0.001$) with birth weight and higher values in males. The birth weight was estimated by regression models using sex of the newborn and placental morphometry; weight ($R^2=0.474$), surface area ($R^2=0.420$), and volume ($R^2=0.477$) at 95% confidence interval. Low birth weight babies in the study were correctly identified by placental weight, surface area, volume and sex of the newborn. Their sensitivity, specificity and predictive values have been specified.

Conclusion: Placental morphometry: weight, surface area, volume and sex of the baby determined the birth weight efficiently to initiate the corrective measures for planning better maternal care and to pacify mothers and their relatives.

Keywords: Regression models, Sex of the newborn

INTRODUCTION

The wellbeing of the fetus is affected by many factors but a healthy placenta is the single most important factor in producing a healthy baby. Pregnancy outcome depends on placental morphology, and its efficiency to transfer nutrients, gases, waste products, heat, hormones, and other regulatory molecules. It also prevents the rejection of the fetal allograft. Placental morphology, blood flow, and nutrient transport functions primarily determine the growth trajectory of the fetus [1–3]. The adverse pregnancy outcomes are associated with either placental growth restriction or placental hypertrophy. It indicates that placenta has its own compensatory response to adverse maternal obstetric conditions, a regulatory path-physiologic mechanism [4].The birth weight of female babies and their feto-placental ratio (FPR) are more responsive to changes in the chorionic surface area, than the male babies; as a result of greater female resilience and male vulnerability to gestational stresses [5].Therefore, all the variables of placental morphometry influence the foetal growth in different pattern in male and female babies. Many studies have been done on placental weight in relation to birth weight of newborn and on feto-placental ratio. There is an area specific literature paucity, regarding the influence of placental morphometry (weight, volume, surface area, thickness) in different birth weight groups by gender, hence present study attempts to address the lacuna and helps to evaluate the relationship of placental morphometry in different birth weight groups by gender.

MATERIAL AND METHODS

Present study was carried out in Dr Prabhakar Kore Hospital and Medical Research Centre, Belgaum (Northern Karnataka, India) for duration of five months. Study was conducted on 164 placentae and neonates from Obstetrics and Gynecology unit. The study was approved by the Institutional Ethical Clearance Committee. Informed and written consent was obtained from mothers. Study included the placentae from consecutive singleton normal deliveries and cesarean sections. Mothers of the age group 18-40 years and gestational age ranging from 28-41 weeks were included. The data about demographic and clinical parameters of mother, placenta and their offspring were recorded in a standard pre-designed and pre-tested proforma. All the instruments were used with proper standard operating procedures.

Measurement of Placental Morphology

Placentae were collected immediately after delivery, examined thoroughly and washed under running tap water thereafter; membranes were trimmed and stored in 10% formalin container. The weight of placenta was determined by using Digital baby weighing scale CS-8316 (CE certified). Placental maternal surface area was calculated using the formula [4]:

$$\text{Surface area} = \varpi \times dl \times ds/4,$$ (dl: largest diameter, ds: smallest diameter).

Volume of the placenta was measured by water displacement method [6]. Thickness was measured by inserting a calibrated Knitting needle at the center of placenta and measured in centimeter, with accuracy of 0.1 cm.

Assessment of Newborn Parameters

Gestational age was recorded from last menstrual period (LMP) and further confirmed by Ultrasonography (USG) and grouped in four groups 28-32, 33-36, 37-40, and more than 41 weeks (Wk). Birth weight (Bwt) was measured by Digital baby weighing scale CS-8316(CE certified) and grouped into four categories; less than 2000, 2000-2499, 2500-2999, and 3000 gm or more. For computing sensitivity and specificity birth weight was further categorized as less than 2500 and 2500 gm or more.

STATISTICAL METHODS

The differences in birth weight and gestational age by gender were tested by Chi-square. The one way analysis of variance was used to study the placental morphometry in different groups of birth weight. Linear regression analysis was carried out to estimate birth weight using placental morphometry and sex of the newborn.The sensitivity, specificity and predictive values of regression models were computed to exhibit their utility for physicians.Box plots were used to assess the locational measures of placental morphometry in different groups of birth weight by sex of the newborn. Analysis of data was carried out by using SPSS V. 16.

RESULTS

[Table/Fig-1-9].

Birth weight / Sex	Gestation Groups		Total (%)	Percent
	<37 (%)	37+ (%)		
Male; Chi square (df=1)=5.36; p<0.05				
<2500	6 (20.70)	23 (79.30)	29 (100.00)	67.78
2500+	2 (3.30)	59 (96.70)	61 (100.00)	32.22
Total	8 (8.90)	82 (91.10)	90 (100.00)	100.00
Female; Chi square (df=1)=6.48; p<0.01				
<2500	7 (20.60)	27 (79.40)	34 (100.00)	52.78
2500+	0 (0.00)	38 (100.00)	38 (100.00)	47.22
Total	7 (9.70)	65 (90.30)	72 (100.00)	100.00
G.Total; Weighted Chi square (df=1)=13.65; p<0.001				
<2500	13 (20.63)	50 (79.37)	63 (100.00)	38.89
2500+	2 (2.02)	97 (97.98)	99 (100.00)	61.11
G.Total	15 (9.26)	147 (90.74)	162 (100.00)	100.00

[Table /Fig-1]: Birth weight by gestation and sex
Note: Outcome of 2 pregnancies were excluded as there gestational age was <28 wk.

Birth weight***.*/ Sex(n)	Placental morphometry			
	Weight(gm)***	Surface area (sq.cm)***	Volume (ml)***	Thickness (cm)*
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Male (90)	426.86±108.16	228.68±51.94	374.78±112.82	2.09±0.39
Female (72)	406.71±105.83	221.95±53.12	355.22±107.65	2.10±0.50
G.Total (162)	417.90±107.27	225.69±52.41	366.09±110.64	2.10±0.44
a. <2000 gm				
Male (7)	294.71±87.22	165.14±43.73	212.86±81.59	1.91±0.38
Female (15)	296.93±135.18	178.03±63.83	248.67±136.17	1.79±0.53
Total (22)	296.23±119.82	173.93±57.45	237.27±120.64	1.83±0.48
b. 2000-2499 gm				
Male (22)	363.23±85.46	185.80±29.97	310.46±74.10	2.09±0.36
Female (19)	396.00±62.31	217.57±38.13	347.90±60.05	2.16±0.42
Total (41)	378.41±76.52	200.53±37.19	327.81±69.73	2.12±0.39
c. 2500-2999 gm				
Male (32)	432.31±70.62	236.91±38.79	385.63±73.35	2.08±0.41
Female (26)	441.27±70.71	240.88±46.36	382.15±83.09	2.14±0.45
Total (58)	436.33±70.18	238.69±42.01	384.07±77.18	2.10±0.42
d. ≥3000				
Male (29)	501.00±106.19	267.45±41.68	450.69±114.23	2.15±0.39
Female (12)	486.00±70.79	242.79±42.24	441.67±64.50	2.33±0.54
Total (41)	496.61±96.54	260.23±42.84	448.05±101.47	2.20±0.44

[Table/Fig-2]: Placental morphometry in birth weight groups by sex of the newborn
Note: *p<0.05; ***p<0.001 by birth weight groups. Outcome of 2 pregnancies were excluded due to gestational age <28 wk

Placental morphometry	Coefficients B***	SE(B)	95% C I for B	
			Lower	Upper
Placental weight (R^2=0.474)				
(Constant)	775.47	151.91	475.47	1075.46
Placental weight	3.90	0.35	3.20	4.59
Sex(M=1,F=0)	259.54	77.91	105.67	413.42
Surface area (R^2=0.420)				
(Constant)	741.45	173.16	399.49	1083.41
Surface area	7.31	0.74	5.84	8.78
Sex (M=1,F=0)	286.53	81.62	125.34	447.72
Volume (R^2=0.477)				
(Constant)	1002.92	132.54	741.18	1264.66
Volume	3.81	0.34	3.14	4.49
Sex (M=1,F=0)	266.41	77.67	113.03	419.80

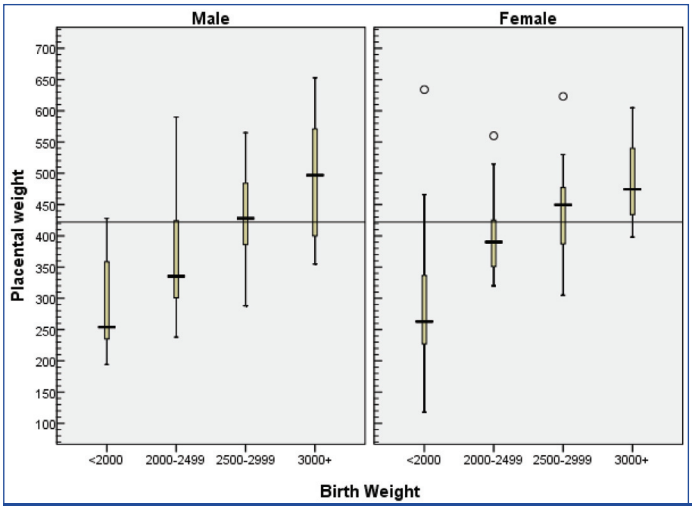
[Table/Fig-3]: Linear regression models to estimate birth weight using placental morphometry and sex of the newborn
Note: ***; p<0.001

Constants	Weight		Surface area		Volume	
	Estimate	SE	Estimate	SE	Estimate	SE
Sensitivity	76.90	5.23	81.50	4.82	75.40	5.34
Specificity	74.70	4.37	74.70	4.37	73.70	4.42
Positive Predictivity	66.67	5.44	67.95	5.28	65.33	5.50
Negative Predictivity	83.15	3.97	86.05	3.74	82.02	4.07

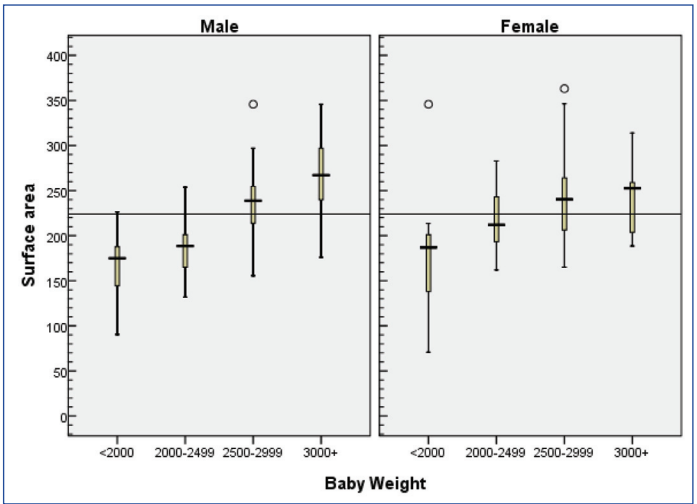
[Table/Fig-4]: Sensitivity and specificity of regression models to estimate low birth weight using placental morphometry and sex

Percentiles	Birth weight (gm)	Placental Morphometry			
		Weight (gm)	Surface area (sq cm)	Volume (ml)	Thickness (cm)
5	1300	235	139	190	1.5
10	1545	283	165	240	1.5
25	2300	352	189	300	1.8
50	2600	421	224	380	2
75	3000	491	255	430	2.5
90	3300	559	295	500	2.5
95	3500	586	314	554	3.0

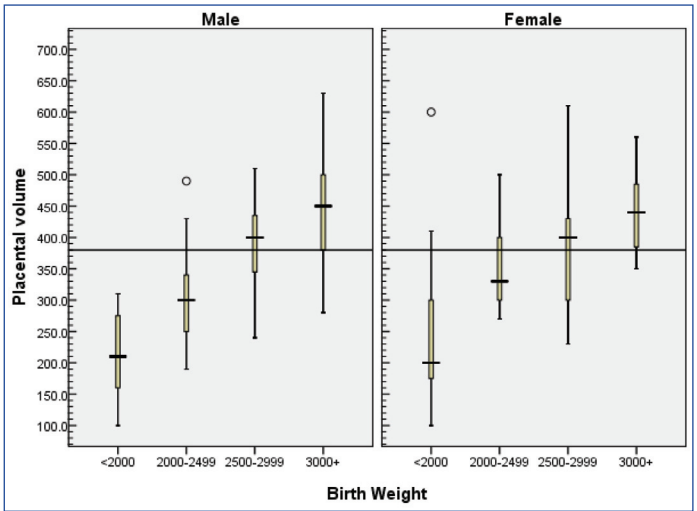
[Table/Fig-5]: Percentile distribution of birth weight and placental morphometry
Percentile distribution of birth weight and placental morphometry, reveals that birth weight's 5th and 95th percentiles were 1300 and 3500 gm respectively, the similar figures for placental morphometry have been specified



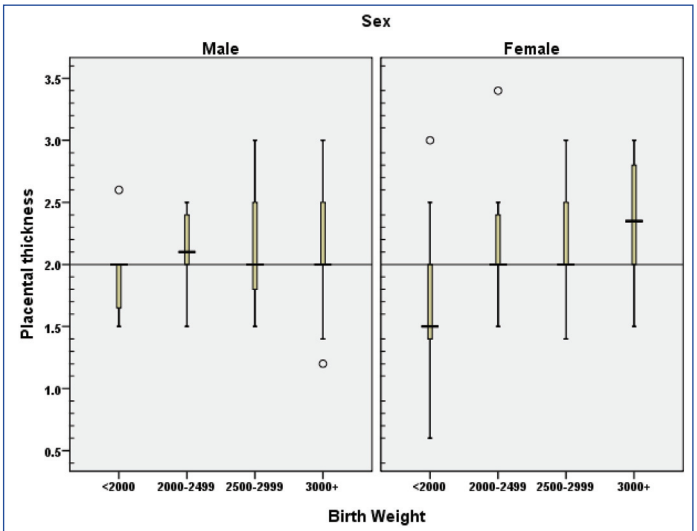
[Table/Fig-6]: Box plot showing the locational measures of placental weight by birth weight and sex



[Table/Fig-7]: Box plot of locational measures of placental surface area in birth weightgroups by sex



[Table/Fig-8]: Box plot of locational measures of placental volume in birth weight groups by sex



[Table/Fig-9]: Box plot of locational measures of placental thickness in birth weight groups by sex

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 [7]. 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 [8]. 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 [10], whereas in the present study 5th to 95thpercentiles 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 status, and genetics. Therefore, present study results were similar to that of developing countries [8,9]. Many studies have reported that placental weight had significant positive correlation with the birth weight ($p< 0.001$) [11–13] 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 [3]. The mean surface area reported by Salafia CM was 247.7sq cm [12]. 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 [17], in other study by Hatti AM it was 2.21cm [18] whereas, in the present study the mean placental thickness was 2.1 cm, 5th and 95th 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 [19].

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.

LIMITATION

Findings of the study are based on data from a teaching hospital, hence may need validation for other settings.

Many of the observations are showing consistent trends along with gestation but not statistically significant, hence a larger number of subjects may be necessary for generalisation.

REFERENCES

[1] Van den Broek, N Ntonya C, Kayira E, White S, Neilson JP. Preterm birth in ruralMalawi: high incidence in ultrasound-dated population. *Human Reproduction.* 2005;20: 3235-37.

[2] Anthony RV, Scheaffer AV, Wright CD, Regnault TR. Ruminant models of renatalgrowth restriction. *Reproduction Suppl*. 2003; 61: 183-94.

[3] Salafia CM, Charles AK, Mass EM. Placenta and fetal growth restriction. *Clin Obstet Gynecol.* 2006; 49 (2): 236-56.

[4] Baptiste KR, Salafia CM, Nicholson WK, Anne D, Wang NY, Brancati FL. Maternal risk factor for abnormal placental growth: The National Collaborative Perinatal Project. *Pregnancy and Child Birth.* 2008; 8: 44

[5] Misra DP, Salafia CM, Miller RK, Charles AK. Non-linear and gender-specific relationships among placental growth measures and the fetoplacental weight ratio. *Placenta.* 2009; 30:1052-57.

[6] Scherle WF, A simple method for volumetry of organ in quantitative stereology. *Mickroskopie*.1970; 26: 57-60.

[7] Blake KV, Gurrin LC, Beilin LJ, Stanley FJ, Landau LI, Newnham JP .Placental weight and placental ratio as predictors of later blood pressure in childhood. *J Hypertension.* 2001; 19:697-702.

[8] Kishwara S, Nurunnabi ASM, Begum M, Abu Rayhan K, Ara S. Effect of maternalpreeclampsia on the weight of the placenta. *Bangladesh Journal of Anatomy.* 2010;8(2):69-71.

[9] Little RE, Zadorozhnaja TD, Hulchiy OP, Mendel NA, Shykyryak-NyzhnkZA,Chyslovska N, et al. Placental weight and its ratio to birthweight in a Ukrainian city. *Early Hum Dev* 2003; 71:117-27.

[10] Hoseman H. Duration of pregnancy and weight of the placenta. *Archives of Gynecology.* 1946; 176: 453.

[11] ManopJanthanapan, OunjaiKor-anantakul, Alan Geater .Placental Weight and its Ratio to Birth Weight in Normal Pregnancy at Songkhlanagarind Hospital. *J MedAssoc Thai.* 2006; 89 (2): 130-37.

[12] Salafia CM, Misra DP, Yampolsky M, Charles AK, Miller Rk. Allometric metabolic scaling and fetal and placental weight. *Placenta.* 2009; 30:355-60.

[13] Virupaxi RD, Potturi BR, Shirol VS, Desai SP Hukkeri VB. Morphology of placenta and its relation with small for date babies in 950 Live births. *Recent Research in Science and technology.* 2011; 3(2): 123-26.

[14] Wallace JM, Bhattacharya S, HorganGW. Gestational age, gender and parity specific centile charts for placental weight for placental weight for singleton deliveries in Aberdeen, UK. *Placenta.* 2013;34(3):269-74.

[15] Thomson J, Irgens L, Skjaerven R, Rasmussen S. Placenta weight percentile curves for singleton deliveries. *BJOG.* 2007; 114: 715-20.

[16] Bleker OP, Bumier M, Vander PJ, Vander VF. Ted (GJ), Kloosterman: On intrauterine growth. The significance of prenatal care. Studies on birth weight, placental weight and placental index, *Placenta.* 2006; 27: 1052-54.

[17] Gunapriya R, Vijaylaxmi, Varsha S. A study on the morphology and the morphometry of the human placenta and its clinical relevance in a population in Tamilnadu. *JCDR.* 2011; 5: 282-86.

[18] Hatti MA, Imran SS, Ashwini H. Effect of birth order on placental morphology and its ratio to birth weight. *Int J Biol Med Res.* 2013; 4(1): 2765-71.

[19] Ghodke S, Dharwadkar S. Hypertensive disorders affecting the morphometry of placenta. *Journal of Scientific Society.* 2012; 39: 17-18.

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