Research Article

Maternal determinants of placental morphometry and birth weight

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Abstract

Background: Pregnancy outcome is determined from sociodemographic characteristics to genetic factors of the mother. Hence, any imbalance in the equilibrium of maternal health, placental morphometry, or fetus leads to adverse pregnancy outcome and long-term risk of chronic diseases in the newborn.

Objective: This study was carried out to explore the effect of maternal social factors such as age, education, parity, consanguineous marriages, and prepregnancy body mass index (BMI), and clinical factors such as fetal presentation, mode of delivery, and gestational age, birth weight, and placental morphometry.

Materials and Methods: This study was carried out on 161 placentae of singleton newborns from a teaching hospital of north Karnataka.

Results: The mean and standard deviation of placental morphometry; weight, volume, surface area, and thickness were 419.8 ± 104.9 g, 367.1 ± 109.0 ml, 226.7 ± 51.1 cm^2, and 2.1 ± 0.4 cm, respectively, with birth weight 2570.1 ± 631.8 g. Placental morphometry and birth weight increased significantly with gestation. Increase in maternal age and BMI showed significant increase in birth weight and placental volume. BMI also had a positive and significant relationship with placental weight and thickness. In the pregnant women, factors such as education of <6 years, primipara, fetal presentation with oblique lie, and emergency cesarean delivery were associated with low birth weight and lesser placental weight, volume, and surface area, but the variations were not statistically significant.

Conclusion: This study will help clinicians to identify at-risk mothers with suboptimal social and clinical factors resulting in adverse pregnancy outcome and to pacify mothers for the needed care.

KEY WORDS: Placental weight, placental surface area, birth weight, consanguineous marriages

Introduction

Placenta is a transient embryonic organ of communication between the mother and the fetus during pregnancy, the only source of nutrient transfer to the fetus. Hence, healthy placenta is essential for fetal growth and development.[1] Human placenta is described as hemochorial, discoid, and deciduate; at term, mean placental weight is 470 g, diameter ranges from 200 to 220 mm, and thickness is 25 mm.[2]

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Placental hypertrophy is due to adaptive responses to adverse intrauterine environment conditions such as lower socioeconomic status and anemia. Placental growth restriction is reported to be caused due to poor nutrition and oxygen supply to placenta, leading to intrauterine growth restriction in babies.[3–5] A large placenta and a low birth weight have been reported as strong independent risk factors for adulthood cardiovascular diseases.[6]

Placental weight is a gross summary, which is unable to explain the biological mechanism of fetal growth. The assessment of different parameters, such as surface area and thickness, provides a multidimensional measure of placental growth. This knowledge reveals the underlying mechanism of fetal adaptation and the changes occurring in placenta during gestation.[7] Hence, the assessment of placental surface area,

volume, and thickness along with placental weight is also important to assess the fetal growth.

Many studies have assessed the effects of maternal sociodemographic and clinical factors on placental weight and its ratio with birth weight. There is an area-specific paucity of literature regarding the influence of basic maternal factors on the placental morphometry (i.e., weight, volume, surface area, and thickness) and birth weight. Hence the present study attempts to address the lacuna and helps evaluate the effect of different sociodemographic and clinical factors associated with pregnant women on the placental morphometry and birth weight.

Materials and Methods

This study was conducted on 164 placentae of consecutive deliveries from Obstetrics and Gynaecology unit of Dr Prabhakar Kore Hospital and Medical Research Centre, Belgaum, north Karnataka, India, from September 2012 to January 2013. The approval of the institutional ethics clearance committee was taken. Informed written consent was obtained from the subjects. Study included mothers with consecutive singleton deliveries of gestational age 28 weeks and above. The subjects without antenatal checkup during first trimester and with history of prepregnancy systemic and chronic diseases were excluded. Pilot study was conducted on 10 mothers. The maternal characteristics, placental morphometry, and newborn parameters were recorded on a predesigned and pretested pro forma.

Methods of Specimen Collection, Preparation, and Assessment of Placental Morphometry

- Placentae were collected soon after separating the baby from the umbilical cord. The collected placentae were examined thoroughly and washed under running tapwater, thereafter, membranes were trimmed.
- The specimens were tagged with numbers for identification and were transported to the skill lab by placing them in a container with 10% formalin.
- The weight of each placenta was determined by a digital baby weighing scale (CS-8316; CE certified) and recorded with accuracy of 1 g.
- The maternal surface area of the placenta was calculated using the following formula:[7]
  Surface area= π dl × ds/4, (where dl is the largest diameter and ds is the smallest diameter)
  The surface area was recorded with accuracy of 1 cm^2.
- The volume was recorded using water displacement method, with accuracy of 1 ml.[8]
- The thickness was measured by inserting a calibrated Knitting needle at the center of placenta and measured in centimeter with accuracy of 0.1 cm.

Parameters of Mother Assessed

Information regarding the sociodemographic factors such as age, education, height, weight, consanguineous marriage, and parity of mothers were recorded from in-patient records. Age was classified into four groups; <20 years, 20–24 years, 25–29 years, and ≥30 years. Education was grouped into three categories by years of schooling; <6 years, 6–10 years, and 10 or more years. Prepregnancy body mass index (BMI) was computed from first trimester height and weight measurements. BMI was grouped into three categories; underweight (<18.5), normal (18.5–22.9), and overweight (23.0–24.9).[9] The marriages occurring within blood relations were classified as consanguineous marriages. Parity was classified in two groups: primipara and multipara.

Fetal presentation was classified into four groups—vertex, breech, oblique lie, and face presentation. Mode of delivery was classified into four classes—normal (vaginal), assisted vaginal delivery (suction or ventouse), elective, and emergency caesarean deliveries.

Parameters of Newborn Baby Assessed

- Gestational age, weight of the baby, any visible anomalies, live birth/still birth
- The gestational age was recorded from last menstrual period and further confirmed by ultrasonography; grouped as 28–34, 35–36, 37+ weeks (wk).
- Birth weight was measured by using the digital baby weighing scale (CS-8316; CE certified) with an accuracy of 10 g. Birth weight was grouped into two categories: <2500 or ≥2500.

Statistical analysis was carried out using SPSS, version 16. The differences in means were tested using analysis of variances and comparisons of means were studied by *t*-test. Differences were considered statistically significant at *p*-values less than 0.05, 0.01, and 0.001. The box plots were prepared to study the relative distributions of placental morphometry and birth weight by period of gestation.

Results

Maternal characteristics, placental morphometry, and birth weight of the newborn are assessed in different tables and graphs.

Table 1 shows that 39% of the newborn are low birth weight (<2500 g), whereas 21% are preterm. Placental morphometry increased consistently and significantly ($p < 0.001$) by birth weight groups except placental thickness. Placental morphometry showed a highly positive relationship with gestation. The placental weight, volume, and thickness increased significantly at $p < 0.001$ whereas surface area increased significantly at $p < 0.01$ with increasing gestational age groups.

Figure 1 shows the locational measures of median, quartiles 1 and 3 of birth weight in different gestational groups. The medians of birth weight increase consistently with gestation age. The overall median reference line of birth weight (2600 g) has been specified to explain the variations in median birth weight of different gestational groups.

Table 1: Placental morphometry by birth weight and gestational age

Variables	*n* (%)	Placental morphometry				
		Birth weight (g)	Weight (g)	Volume (ml)	Surface area (cm2)	Thickness (cm)
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Total	161 (100)	2570.1 ± 631.8	419.8 ± 104.9	367.7 ± 109.0	226.7 ± 51.1	2.1 ± 0.4
Birth weight in g (n = 161): ***, p < 0.001						
<2500	62 (39)	1987.3 ± 539.6***	353.5 ± 97.3***	299.4 ± 97.4***	193.2 ± 44.4***	2.0 ± 0.4
2500+	99 (61)	2935.1 ± 348.0***	461.3 ± 86.9***	410.6 ± 93.1***	247.6 ± 43.5***	2.1 ± 0.4
Gestation in weeks (n = 161): **, p < 0.01;***, p < 0.001						
28–34	19 (12)	1691.8 ± 721.9***	322.6 ± 127.1***	265.3 ± 149.7***	196.7 ± 65.4**	1.7 ± 0.4***
35–36	15 (9)	2275.3 ± 464.0***	378.0 ± 101.6***	331.3 ± 89.6***	209.6 ± 49.5**	2.0 ± 0.6***
37+	127 (79)	2736.3 ± 504.1***	439.2 ± 92.3***	387.4 ± 94.1***	233.1 ± 47.1**	2.2 ± 0.4***

Figure 2 shows the locational measures of median, quartiles 1 and 3 of placental weight in different gestational groups. The medians of placental weight increase consistently by gestation. The overall median reference line of placental weight (420 g) has been specified to explain the variations in median placental weight of different gestational groups.

Figure 3 shows the locational measures of median, quartiles 1 and 3 of placental volume in different gestational groups. The medians of placental volume increased consistently with gestation. The overall median reference line of placental volume (380 ml) has been specified to explain the variations in median placental volume of different gestational groups.

Figure 4 shows the locational measures of median, quartiles 1 and 3 of placental surface area in different gestational groups. The medians of placental surface area increased

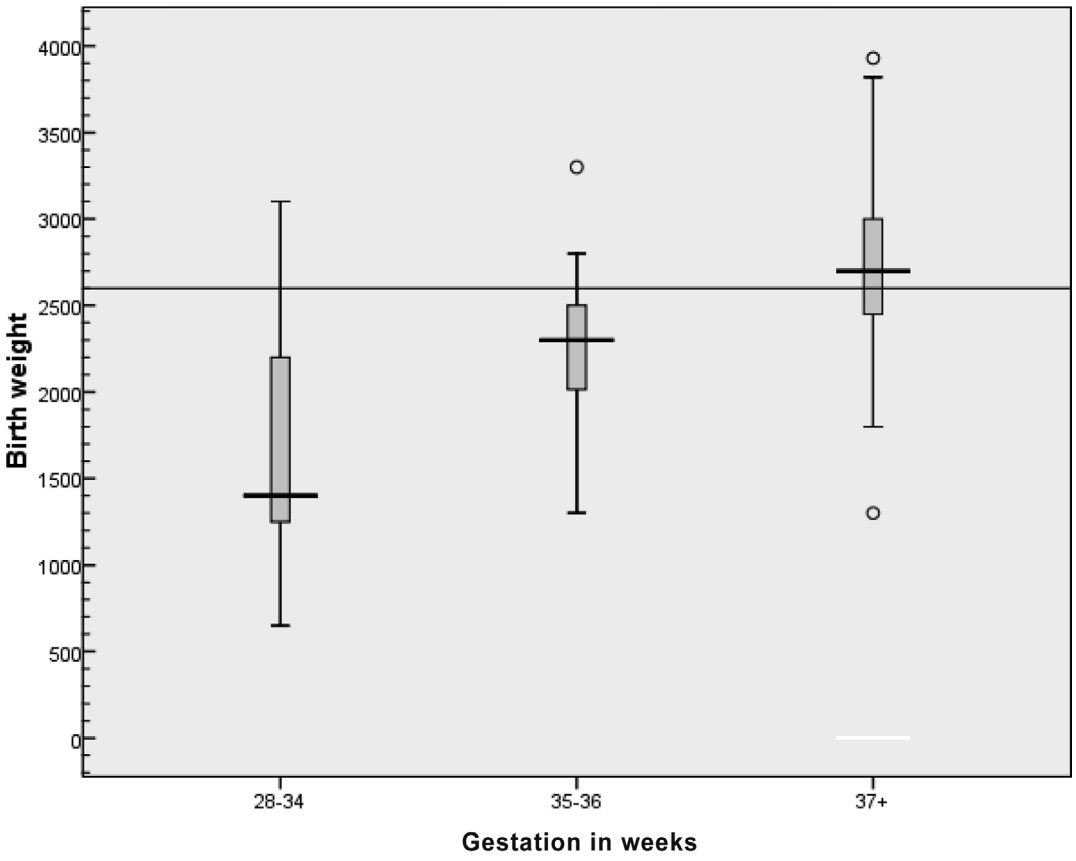

Figure 1: Box plot showing the locational measures of birth weight by gestational age.

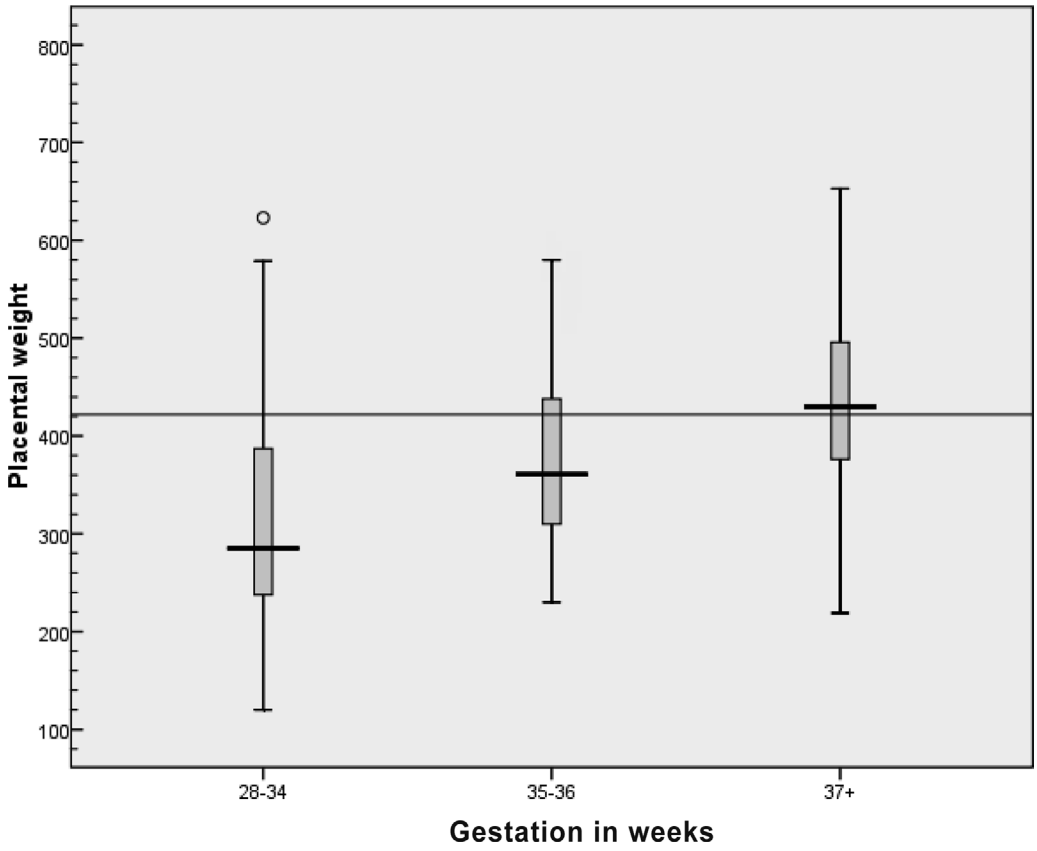

Figure 2: Box plot showing the locational measures of placental weight by gestational age.

consistently with gestation. The overall median reference line of placental surface area (225 cm^2) has been specified to assess the variations by gestational groups.

Table 2 shows that overall mean birth weight is 2570 g with SD 630, the similar figure for placental weight is 420 g with SD 105, volume 368 ml with SD 109, surface area 226 cm^2 with SD 50, and thickness 2.1 cm with SD 0.4.

Two percent of babies were born in age group <20 years whereas 10% were born in age group 30 years and above. The birth weight increased significantly ($p < 0.01$) and consistently from 2450 g in age group <20 years to 3089 g in age group 30 years and above. Placental morphometry increased consistently with maternal age. However, the placental weight increased by age groups significantly at $p < 0.05$ and volume at $p < 0.01$, whereas surface area and thickness did not show any statistical significant difference by age groups [Table 2a]. Birth weight increased consistently in the three groups of schooling, from 2377 g in <6 years of schooling to 2741 g in 10 years or more ($p < 0.05$). However, education of mother did not show any consistent and significant relation with placental morphometry [Table 2b]. Undernourished group of mothers had lower placental weight, volume, surface area, and thickness as compared to normal and obese groups. The increase in placental morphometry was consistent and significant ($p < 0.05$) except in placental surface area. The birth weight increased from 2426 g to 2754 g ($p < 0.05$) of respective mothers with BMI <18.5 to 23 and above. The increases for placental weight were from 402 to 462 g ($p < 0.05$), volume 345 to 411 ml ($p < 0.01$), and thickness 2.0 to 2.2 cm ($p < 0.05$) [Table 2c]). The birth weight was lower although statistically not significant among babies from consanguineous marriage, but placental weight, volume, surface area, and thickness were higher as compared to non-consanguineous marriages [Table 2d]. The birth weight and placental morphometry of primipara mothers were lower as compared to those of multipara mothers [Table 2e].

The vertex and breech fetal presentation did not show any variation in birth weight and placental morphometry. In oblique lie fetal presentation, the birth weight and placental morphometry were lower as compared to other presentations, but the sampling variations cannot be ruled out as the number of subjects was small [Table 3a]. In the normal and elective caesarean groups, birth weight and placental morphometry did not show any marked difference. The emergency caesarean group had lower birth weight ($p < 0.05$) as compared to assisted delivery group. The birth weight and surface area showed statistically significant ($p < 0.05$) differences by mode of delivery [Table 3b].

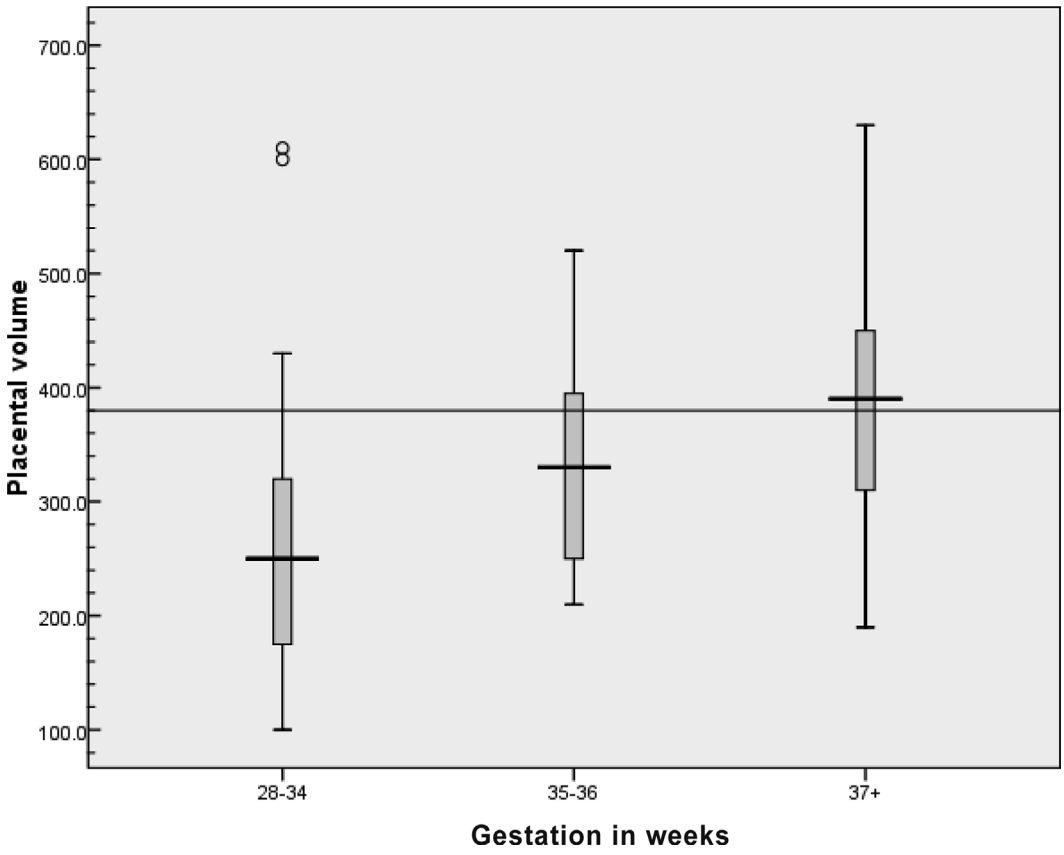

Figure 3: Box plot showing the locational measures of placental volume by gestational age.

Table 2: Birth weight and placental morphometry by age, education, BMI, consanguineous marriages, and parity

Variable	*n* (%)	Birth weight (g)	Placental morphometry			
			Weight (g)	Volume (ml)	Surface area (cm²)	Thickness (cm)
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Total	161 (100)	2570.1 ± 631.8	419.8 ± 104.9	367.7 ± 109.0	226.7 ± 51.1	2.1 ± 0.4
a. Age groups: **, $p < 0.01$; *, $p < 0.05$						
<20	4 (2)	2450.0 ± 1008.3**	386.5 ± 108.4	317.5 ± 160.9*	214.1 ± 38.2	1.9 ± 0.5
20–24	88 (55)	2486.5 ± 585.0**	406.0 ± 98.1	353.2 ± 95.5*	223.6 ± 48.4	2.1 ± 0.4
25–29	53 (33)	2561.2 ± 643.5**	426.3 ± 117.9	372.8 ± 126.9*	230.6 ± 59.2	2.1 ± 0.5
30+	16 (10)	3089.4 ± 549.7**	482.3 ± 73.0	443.5 ± 68.2*	233.7 ± 41.0	2.08 ± 0.5
b. Schooling in years: *, $p < 0.05$						
<6	18 (11)	2377.5 ± 585.1*	423.4 ± 104.4	359.4 ± 111.9	231.4 ± 51.9	2.1 ± 0.4
6–10	96 (60)	2522.2 ± 641.8	415.8 ± 107.9	365.7 ± 109.8	222.0 ± 47.5	2.1 ± 0.5
10+	47(29)	2741.8 ± 601.7*	426.5 ± 100.6	375.1 ± 108.1	234.4 ± 57.6	2.0 ± 0.4
c. BMI: *, $p < 0.05$						
<18.5	61 (38)	2426.7 ± 634.0*	402.2 ± 101.2*	345.4 ± 108.8*	219.2 ± 52.7	2.0 ± 0.4*
18.5–22.9	65 (40)	2605.6 ± 557.8*	413.7 ± 92.9*	365.2 ± 91.2*	226.5 ± 43.2	2.1 ± 0.4*
≥23	35 (22)	2754.1 ± 713.9*	461.7 ± 122.8*	411.4 ± 128.3*	239.9 ± 60.0	2.2 ± 0.4*
d. Consanguineous marriage: NS						
No	135 (84)	2597.5 ± 619.3	417.0 ± 104.0	366.6 ± 109.1	225.8 ± 50.2	2.1 ± 0.4
Yes	26 (16)	2427.9 ± 688.8	434.4 ± 110.6	373.8 ± 110.3	231.3 ± 56.7	2.1 ± 0.4
e. Parity: NS						
Primi	79 (49)	2496.4 ± 612.5	406.2 ± 97.8	352.8 ± 98.2	219.5 ± 47.9	2.1 ± 0.4
Multi	82 (51)	2641.1 ± 645.7	432.9 ± 110.4	382.1 ± 117.2	233.5 ± 53.4	2.1 ± 0.5

BMI, body mass index; NS, nonsignificant

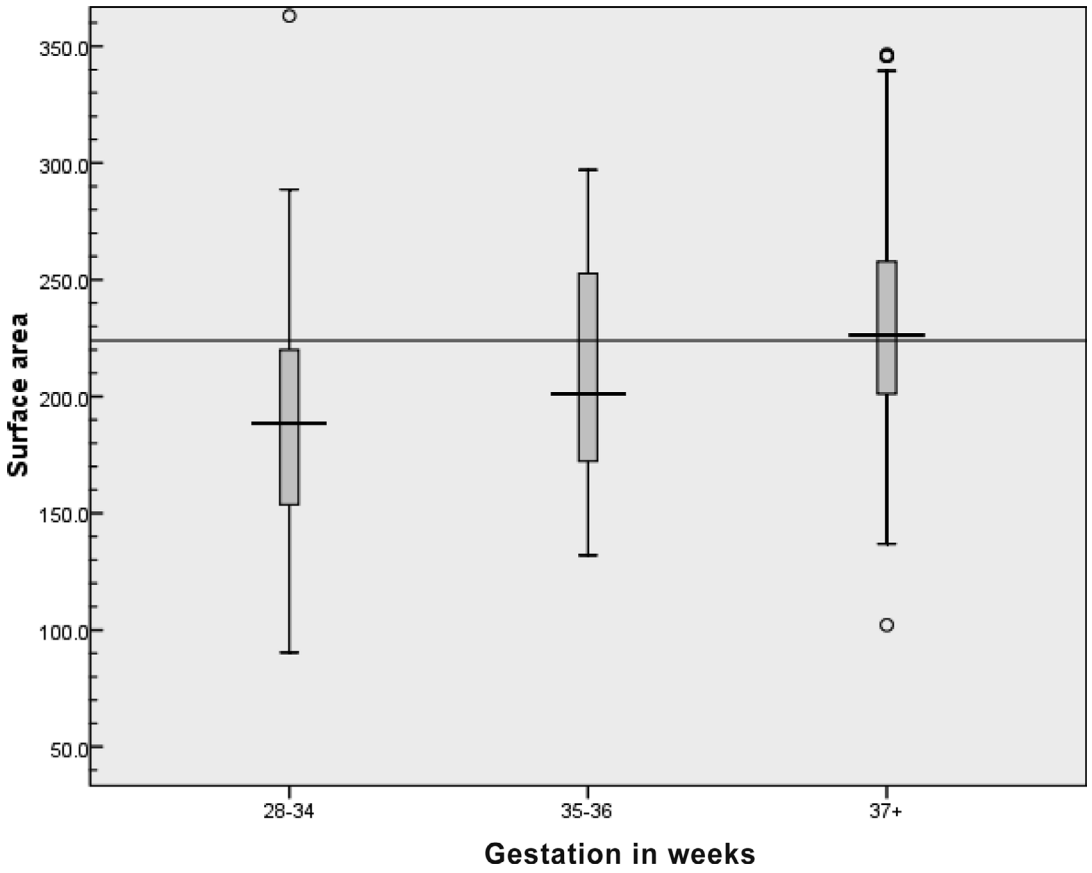

Figure 4: Box plot showing the locational measures of placental surface area by gestational.

Discussion

Studies have reported that abnormal placental growth is associated with adverse pregnancy outcome, as the placental morphology and physiology determine the growth trajectory of the fetus.[10,11] In the present study, it is observed that the gestation and placental morphometry were highly associated, affecting birth weight significantly. Further, birth weight increased significantly with an increase in the maternal age and BMI. The maternal education, consanguineous

Table 3: Birth weight and placental morphometry by fetal presentation and mode of delivery

Variables	*n* (%)	Birth weight Mean ± SD	Placental morphometry			
			Weight Mean ± SD	Volume Mean ± SD	Surface area Mean ± SD	Thickness Mean ± SD
Total	160 (100)	2568.7 ± 633.6	420.1 ± 105.2	368.0 ± 109.3	226.5 ± 51.2	2.1 ± 0.4
a. Fetal presentation (n = 160)						
Vertex	147 (91)	2582.8 ± 636.2	423.6 ± 104.6	371.9 ± 109.5	228.3 ± 50.4	2.1 ± 0.4
Breech	9 (6)	2490.5 ± 612.6	411.9 ± 109.5	336.7 ± 100.1	206.6 ± 54.1	2.1 ± 0.4
Oblique	3 (2)	2166.6 ± 750.5	304.0 ± 84.0	292.0 ± 128.3	188.3 ± 83.4	1.8 ± 0.3
Face	1(1)	2400.0 ± 0.0	333.0 ± 0.0	300.0 ± 0.0	253.7 ± 0.0	2.0 ± 0.0
b. Types of delivery (n = 160) ; *; $p < 0.05$						
Normal	78 (49)	2609.0 ± 524.4*	429.9 ± 93.0	378.6 ± 97.0	222.8 ± 45.0*	2.1 ± 0.4
Assisted	5 (3)	3012.00 ± 560.2*	459.0 ± 118.0	396.0 ± 111.9	265.9 ± 65.5*	1.8 ± 0.4
Elective	29 (18)	2693.45 ± 686.7*	437.6 ± 115.7	388.1 ± 124.7	244.4 ± 60.3*	2.1 ± 0.4
Emergency	48 (30)	2386.7 ± 730.6*	391.2 ± 111.4	337.3 ± 113.5	218.1 ± 50.8*	2.1 ± 0.5

marriages, parity, fetal presentation, and mode of delivery also influenced the birth weight and placental morphometry to a certain extent.

It is observed that increase in gestational age resulted in significant and consistent increase in the birth weight and placental weight, volume, surface area, and thickness. Further, birth weight and placental morphometry had consistent relation, indicating positive association among them. Many other reports have shown that birth weight and placental weight are directly related with gestational age.[4,12,13] Therefore, previously mentioned results are congruent with our results, indicating the growth of placenta throughout the gestational period. In the present study, placental weight, volume, and surface area increased consistently and significantly ($p < 0.001$) with the birth weight except placental thickness. Williams et al.,[4] have shown high correlation between placental weight and birth weight. Our study results regarding placental weight and birth weight coincides with those of this study.

In this study, birth weight increased significantly and consistently from maternal age group <20 years to 30 years and above. Maternal age had consistent relation with placental morphometry. Results of this study show that the mothers with age group <20 (teenagers) had low birth weight babies and had lesser placental weight, volume, surface area, and thickness. These results were consistent with those of another study, specifying adolescent mothers had greater risk of delivering premature and low birth weight babies.[14,15] One of the studies explained that adolescent risk is due to poor socioeconomic status, immature reproductive system, or the suboptimal maternal nutritional status and growth.[16] In the present study, birth weight increased consistently with years of schooling; from 2380 g in women with <6 years of schooling to 2740 g in 10 years or more ($p < 0.05$). However, education of mother did not show any consistent and significant relation with placental morphometry. Pregnant women with education less than sixth grade were more prone to deliver low birth weight babies with lesser placental weight, volume, surface area, and thickness. Similar results were reported in a study by Williams et al.[4] where they merged education with occupation and income under social class. They showed a significant and positive association between placental weight and lower socioeconomic status.[4] Education may not have direct relation with pregnancy outcome but indicates the economic status and life style of the pregnant women. In the current study, undernourished group of mothers had lower placental weight, volume, surface area, and thickness as compared to normal and obese groups; the increase was consistent and significant ($p < 0.05$) except in placental surface area. Birth weight increased consistently and significantly with BMI <18.5 to 23 and above, the similar results were observed for placental weight, volume, and thickness. These results were similar to those reported in the study of Salafia et al.[17] As per Barker et al.[6] poor nutritional status in prepregnancy and during pregnancy period determines the birth weight in relation to placental weight, which alters the fetal metabolism leading to predisposition of hypertension subsequently in the adult life.[6] In the present study, babies from consanguineous marriages were found to have low birth weight, and placentas of women had higher weight, volume, surface area, and thickness. This aspect showed opposing trend between birth weight and placental morphometry. Other studies have reported that in consanguineous marriages there is an increased risk of early preterm birth and low birth weight, due to involvement of recessive mode of inheritance.[18,19] There was scarcity of literature to compare the consanguineous marriage and placental morphometry. In this study, the placentas of multiparous women had higher values of placental weight, volume, surface area, and thickness than those of primiparous women. Therefore, parity had consistent relation with placental morphometry. This aspect is consistent with another study from Aberdeen.[20] It can be explained that the permanent changes in the anatomical structure of spiral arteries after pregnancy help in effective vascular remodeling by enhancing the trophoblast migration in the successive pregnancies.[21]

The emergency caesarean group had lower birth weight ($p < 0.05$) as compared to assisted delivery. The birth weight and surface area showed statistically significant ($p < 0.05$) differences by mode of delivery. Burkhard et al.,[22] reported that mean placental weight of vaginal delivery was 76 g lesser than caesarean deliveries; the prevalence of placental weight variations was more in caesarean deliveries as compared to normal vaginal deliveries. The present study results were in contrast; mean placental weight of vaginal delivery was 223 g more than emergency caesarean deliveries. Emergency caesarean deliveries were associated with low birth weight babies and lesser placental morphometry. This is consistent with that reported in the study of Asgharnia et al.[23] The author specified the reason for indirect correlation of caesarean deliveries and placental weight was fetal distress due to meconium defecation.[23]

Conclusion

Birth weight and placental morphometry increased with maternal age, parity and BMI. The maternal factors, education and consanguineous marriages, fetal presentation, and mode of deliveries showed consistent variation in birth weight and placental morphometry but the results were not statistically significant. The results mandate more vigilant monitoring during antenatal period and emphasize frequent growth scan.

Limitations

The results of the study can be used in maternal care during pregnancy. However, the results may need re-validation in other settings. The findings of maternal education and consanguineous marriages need further study with larger number of subjects.

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