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Macroscopic morphological variation of human placenta in normotensive and pre-eclamptic pregnant mothers, Northwest Ethiopia

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SUMMARY

The normal growth and development of the fetus depends on the proper growth and functioning of the placenta. The macroscopic morphology of the placenta is highly affected by pre-eclampsia. This study was carried out to assess macroscopic morphological variation of the human placenta among normotensive and pre-eclamptic pregnant mothers in Northwest Ethiopia. A cross-sectional study was conducted on 200 term placentas. One hundred fifty placentas from normotensive mothers and 50 placentas from pre-eclamptic mothers were included in the study. Placental parameters such as shape, weight, diameter, thickness and number of cotyledons were examined. Fetal weight was also detected. The data were analyzed by using independent two-sample t-test and chi-square test. According to this study, the majority (68%) of placentas in normotensive participants were discoid-shaped and 18% oval. While 54% of placenta in pre-eclamptic mothers were oval-shaped and 24% were irregular. Mean placental weight, diameter and number of cotyledon in pregnant mothers with pre-eclampsia were significantly reduced as compared to normotensive mothers. The mean birth weight in pre-eclamptic pregnancies was significantly ($p = 0.0001$) lower than the mean birth weight in normotensive pregnancies. As a conclusion, mean fetal weight, placental weight, diameter, thickness and numbers of cotyledon in pre-eclamptic mothers were significantly lower than in normotensive mothers (p-value < 0.05). Placenta shape difference between normotensive and pre-eclamptic mothers was detected (p-value < 0.001).

Key words: Fetal weight – Macroscopic – Morphology – Placenta – Normotensive – Pre-eclampsia

INTRODUCTION

The placenta has maternal and fetal parts, which are derived from the villous chorion and the decidua basalis, respectively (Manae et al., 2014; Raghavendra and Veena, 2014). The placenta starts to satisfy the demand of the fetus as early as the third week of intrauterine life, even if the mother is not aware of her pregnancy (Sudha et al., 2012; Mandhana et al., 2014). It is a vital organ situated between the mother and the fetus that enables the transference of nutrients and gases, the removal of waste products, and the production of hormones until the end of pregnancy (Oliveira et al., 2002; Kulandaivelu et al., 2014). The normal growth and development of the fetus depends on the proper growth and functioning of the placenta (Patel et al., 2013; Agarwal et al., 2015). At term, the normal human placenta is discoid in shape, 500 g in weight, 18.5 cm in diameter, 2.5 cm in thickness and has 15 to 30 cotyledons (Gundalli et al., 2015). The architecture of the placenta is highly affected by different maternal diseases and envi-

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ronmental factors. Among maternal diseases, pre-eclampsia is the most important one that alters the macroscopic as well as the microscopic morphology of the placenta, which disturbs maternal and fetal well-being (Udainia and Jain, 2001).

Several studies describe that values in the morphology of the placenta like weight, diameter, thickness and number of cotyledons were lower in pre-eclamptic mothers than in normotensive mothers (Shevade et al., 2015). In developing countries like Ethiopia, the health care systems are overwhelmed by the preventive, therapeutic, and diagnostic challenges of pre-eclampsia. However, morphological variations of placenta in pre-eclamptic pregnancies are not well investigated in Ethiopia. Therefore, this study aims to assess macroscopic morphological variations of placenta among pre-eclamptic pregnancies in comparison with normotensive pregnancies in Northwest Ethiopia.

MATERIALS AND METHODS

The present study was cross-sectional, and was carried out in the department of anatomy from October 1/2015 to February 30/2016 at the University of Gondar Teaching Hospital, Northwest Ethiopia, after obtaining ethical approval from the ethical review board of the University of Gondar. Written permission to conduct the study was obtained from the Obstetrics and Gynecology Department. All mothers were properly informed of the purpose of the study and their written consent was obtained. Participation was on voluntary basis. Two hundred term placentas (150 from normotensive and 50 from pre-eclamptic pregnancies) were included in the study. Normotensive mothers were pregnant women without pre-eclampsia or other acute and chronic diseases. Pre-eclamptic mothers were pregnant mothers who were diagnosed with pre-eclampsia but were free of other acute and chronic diseases. The diagnosis of pre-eclampsia was based on one or more of pre-eclampsia diagnostic investigations (new onset of elevated blood pressure, presence of proteinuria in urine microscopy and/or clinical sign and symptoms).

The study was designed to have 80% statistical power with level of significance at 5% and normotensive to pre-eclamptic ratio of 3:1. The sample size was calculated by using mean difference formula. This study took under consideration the following assumptions to calculate sample size. Thus, the mean of placental weight was 478.8 g among normotensive mothers and 385.4 g among pre-eclamptic mothers. The variance of placental weight was 292.12 among normotensive mothers and 82.21 among pre-eclamptic mothers (Vijayalakshmi and Kittali, 2015). The samples were selected by using systematic random sampling with sampling interval of five to select normotensive mothers. All pre-eclamptic mothers who attended labour during the study period were included. In the placental processing, freshly delivered term placentas were collected immediately after delivery checked for completeness, washed with tap water to remove any blood clot, and prepared for measurement. Finally, the following placental parameters were noted.

Shape of placenta**:** The shape of each placenta was categorized as discoid, oval, irregular, bilobed or kidney shaped after observation.

Fetal and placental weight**:** Fetal and placental weight was measured by directly placing the placenta and the fetus over standardized weight scale.

Diameter of the placenta**:** After placing the placenta in the flat tray, the first maximum diameter was measured with a plastic measuring scale graduated in centimeter. Then the second maximum diameter was taken at the right angle to the first one. The mean of the two measurements was considered the diameter of the placenta (Fig. 1) (Kishwara et al., 2009).

Thickness of the placenta: By using a long needle, placental thickness was measured at five points. First, the placenta was divided into three equal parts by drawing two circles on the maternal surface of the placenta. These circle cut the radius of the placenta into three equal parts. One thickness was measured from the center of the central

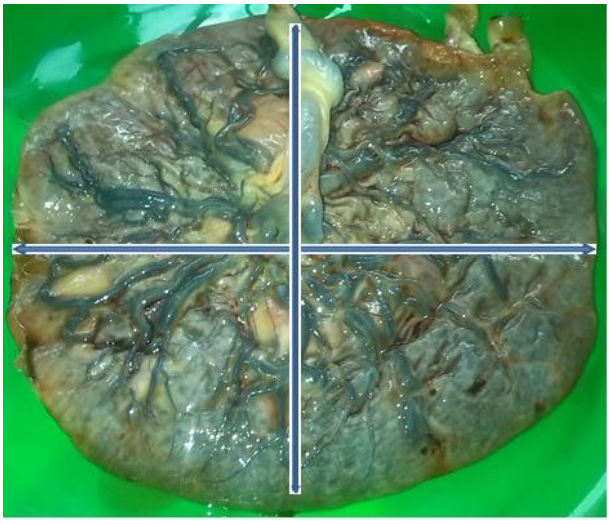

Fig 1.

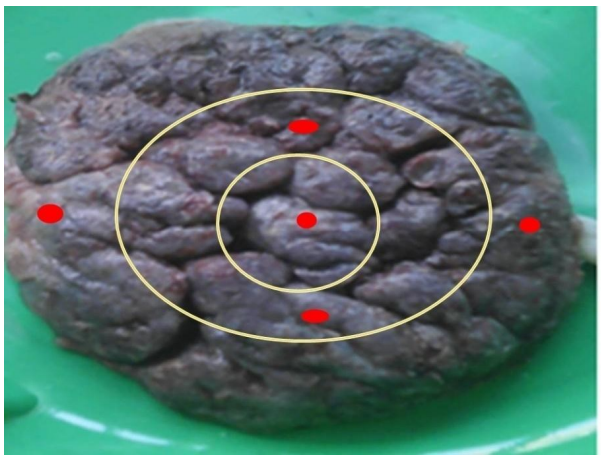

Fig 2.

Table 1. Demographic and obstetric characteristics of the study subjects.

		Number	%	Number	%
Maternal age in years	18 – 25	65	43.3	27	54
	26 – 32	65	43.3	19	38
	33+	20	13.3	4	8
Gravidity	Primigravida	74	49.3	27	54
	Multigravida	76	50.7	23	46
Mode of delivery	SVD	118	78.7	26	52
	Forceps	10	6.7	5	10
	C/S	22	14.6	19	38

***** SVD: Spontaneous vaginal delivery; *C/S: Caesarean section

Table 2. Analysis of shapes of placentae between normotensive and pre-eclamptic mothers

Shape of placenta	Normotensive (n=150)	Pre-eclampsia (n=50)	Chi-square	p-value
Discoid n (%)	103 (68.7%)	9 (18%)		
Oval n (%)	27 (18%)	27 (54%)		
Irregular n (%)	14 (9.3%)	12 (24%)	41.57	
Bilobed n (%)	2 (1.3%)	1 (2%)		0.0001*
Kidney shaped n (%)	4 (2.7%)	1 (2%)		

* Independently significant at α = 0.05

zone, two from the middle zone and two from the peripheral zone. The peripheral measurements were taken within the outer zone on a line perpendicular to the previous imaginary line in the middle zone. Finally, the mean of all five measurements was calculated as the thickness of the placenta (Fig. 2) (Vijayalakshmi and Kittali, 2015).

Number of cotyledons: The placenta was placed in 10% formalin solution for 24 hours in order to make the placental groove visible to count the cotyledons. Then, gentle pressure was applied on the center of the fetal surface of the placenta. As a result, the cotyledons on the maternal surface become prominent. The placenta was placed on a fetal surface with maternal surface facing upward. Counting was started from the left side of the one end of the placenta and then going to the right and again turning back to the left in a manner of loop. Finally, the total number of cotyledons was recorded (Fig. 3) (Vijayalakshmi and Kittali, 2015).

Data were filtered, checked and entered into Epi info version 7 then exported into SPSS version 20. Data was analyzed by using Independent two-sample t test and Chi Square test. $P < 0.05$ was considered as statistically significant.

RESULTS

Two hundred placentas (150 from normotensive women and 50 from pre-eclamptic women) obtained from the labour ward and the operation theatre were observed. In this study, 43.3% of study subjects belonged to an age group between 18-25 years among normotensive mothers. While 54% of study subjects belonged to an age group between 18-25 years among pre-eclamptic mothers.

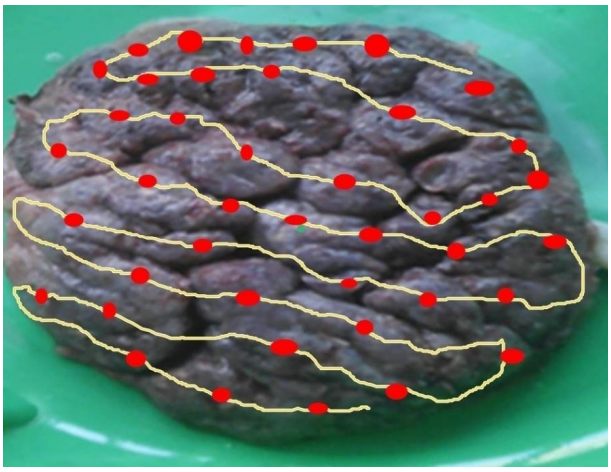

Fig 3.

Among pre-eclamptic mothers, 54% were primigravida and 46% were multigravida. Similarly, among normotensive study subjects, 49.3% were primigravida and 50.7% were multigravida. Among 150 normotensive placentas, the majority 78.7% were delivered by spontaneous vaginal delivery, 6.6% by assisted forceps delivery, and 14.7% by caesarean section. Likewise, of 50 pre-eclamptic placentas 52% were delivered by spontaneous vaginal delivery, 10% by assisted forceps delivery and 38% by caesarean section (Table 1).

In the present study, the shapes of placentas in normotensive pregnancies were discoid (68.7%), oval (18%), irregular (9.3%), bilobed (1.3%) and kidney (2.7%) shape (Table 2 and Fig. 4).

Similarly, the shapes of placentas among pre-

Table 3. Comparison of morphological parameters of the placenta between normotensive and pre-eclamptic groups by using independent two-sample t test.

Parameters	Normotensive (n=150) Mean ± SD	Pre-eclampsia (n = 50) Mean ± SD	T- value	P- value
Weight of placenta	497.95 ± 89.10	417.60 ± 102.41	5.32	0.0001
Diameter	19.20 ± 2.31	17.28 ± 2.15	5.16	0.0001
Thickness	2.43 ± 1.34	1.99 ± 0.39	2.25	0.026
Number of cotyledon	18.66 ± 3.09	14.86 ± 2.12	8.13	0.0001

* SD=Standard deviation

Table 4. Comparison of fetal weight in normotensive and pre-eclamptic groups by using independent two samples t test.

Variables	Group	Range	Mean	SD	T value	P value
	Normotensive	1.6-4.4	3.12	0.436		
Birth weight	Pre-eclampsia	1.3-3.9	2.62	0.587	6.20	0.0001

Table 5. Correlation between birth weight and placental weight, diameter, thickness and number of cotyledon by using Pearson correlation test.

Variables			Placental weight	Placentaldi-ameter	Placental Thickness	Number of cotyledon
Birth Weight	Over all	r	0.572	0.583	0.192	0.647
		p	0.0001	0.0001	0.007	0.0001
	Normotensive pregnancy	r	0.666	0.439	- 0.115	0.566
		p	0.0001	0.0001	0.165	0.0001
	Pre-eclamptic pregnancy	r	0.809	0.732	0.548	0.647
		p	0.0001	0.0001	0.0001	0.0001

Fig 4.

Fig 5.

eclamptic mothers were discoid (18%), oval (54%), irregular (24%), bilobed (2%) and kidney (2%) shaped (Table 2 and Fig. 5). According to chi-square test result, placental shape difference was statistically significant between the two groups (p-value = 0.001).

The mean weight of placentas among normotensive pregnant women was 497.95 g and for pre-eclamptic pregnant women was 417.80 g. The average diameter of placentas among normotensive women was 18.2 cm and for pre-eclamptic women was 17.2 cm. The mean thickness of placentas among normotensive pregnant women was 2.43 cm and for pre-eclamptic pregnant women was 1.99 cm. The mean number of cotyledons in normotensive pregnancies was 19 and 15 was for pre-eclamptic pregnancies (Table 3). Independent two-sample t test showed that morphological parameters (weight, diameter, thickness and number of cotyledons) were significantly lower in pre-eclamptic placentas if compared to normotensive placentas.

In this study, the mean fetal weight of pre-eclamptic pregnancies was less than that of normotensive's. The difference was highly significant (p = 0.0001) (Table 4).

Overall, there was a significant positive correlation between birth weight and placental weight, diameter, thickness and number of cotyledons respectively (Table 5). Comparatively, Pearson correlation test showed that birth weight was moderately correlated with placental weight and number

of cotyledons, and fairly correlated with placental diameter in normotensive group. While in pre-eclampsia, birth weight was strongly correlated with placental weight and moderately correlated with diameter, thickness and number of cotyledons. However, birth weight has no significant correlation with placental thickness in normotensive mothers (Table 5).

DISCUSSION

In this study, deviation of placental shape from the normal was higher in pre-eclamptic participants than in normotensive participants. Our finding was consistent with a research report that identified unusual shape of placenta in pre-eclamptic mothers more frequently than in normotensive mothers (Sudha et al., 2012).

The weight of the placenta gives insight about the amount of substances exchanged between the mother and the fetus (Appiah, 2009). In the present study, the mean placental weight in pre-eclamptic pregnancies was less than in normotensive placentas. This finding was similar to research conducted in India (Shevade et al., 2015). Another study done in Norway declared that a larger proportion of high placental weight was observed in pregnancies with term pre-eclampsia than pregnancies without pre-eclampsia (Dahlstrom et al., 2008). However, a larger number of cases of high placental weight was not observed in term pregnancies with pre-eclampsia in this study.

Placenta with larger diameter has higher surface area for the exchange of substances (Appiah, 2009). In our study, the mean diameter in the pre-eclamptic study group was less than in the normotensive study group. This was analogous with a study done in Dhaka (Kishwara et al., 2009). This small-sized placenta could link to underlying pathological processes of pre-eclampsia which hinder normal placental growth and function. On the other hand, a study finding in Pakistan showed that the mean placental diameter of the pre-eclamptic study group was lower than the mean placental diameter of pre-eclamptic mothers in our study (Rehman et al., 2013). This could be due to differences in maternal weight, genetics and/or nutrition between the two study populations.

The present study noted that mean placental thickness was 2.43 cm and 1.99 cm in normotensive and pre-eclampsia, respectively. This morphometric characteristics of the placenta demonstrated significant differences between the two groups at p = .026. The present study coincides with the data reported in Pakistan **(**Rehman et al., 2013) and India **(**Shevade et al., 2015**)** in normotensive and pre-eclampsia, respectively. However, a study conducted in India reported a higher value of mean placental thickness in normotensive and pre-eclampsia group (Sabita, 2014)**,** respectively. Additionally, higher placental thickness from pregnancies with pre-eclampsia than pregnancies without pre-eclampsia was reported in Finland (Kajantie et al., 2010). This was not seen in this study. The differences could be related to genetic variations.

Normal term placenta is 2 to 3 cm thick. Placenta less than 2 cm thick is associated with placental insufficiency, which causes intrauterine growth retardation of the fetus. In contrast, thickness of placenta more than 4 cm is associated with maternal diabetes mellitus, fetal hydrops and intrauterine fetal infection (Appiah, 2009). In the present study, out of 150 normotensive placentas 84% were ≥ 2 cm and 16% were less than 2 cm thick. While out of 50 pre-eclamptic placentas 54% were greater or equal to 2 cm thick and 46% were less than 2 cm thick. This research result indicates that 46% of pre-eclamptic and 16% of normotensive placentas lie below the normal range. Similar observations were noted in India (Shevade et al., 2015) and Pakistan (Rehman et al., 2013).

The number of cotyledons is directly associated with the distribution of chorionic blood vessels. As the number of cotyledons increases, the number and distribution of chorionic blood vessels increase. Higher number of cotyledons increase transfer of nutrients from the mother to the fetus (Appiah, 2009). Even though the number of placental cotyledons did not increase throughout gestational age, in this study the mean number of cotyledons was significantly reduced in the pre-eclamptic group. This is similar with a study conducted in India (Shevade et al., 2015). This could be due to the degeneration of individual cotyledons secondary to adverse effects of pre-eclampsia.

In the present study, the mean birth weight of pre-eclamptic cases was less than normotensive cases. The difference was significant (p = 0.0001). This study was agreed with the study carried out in India (Sabita, 2014) and Kamataka (Raghavendra et al., 2014). However lower values were reported in India (Shevade et al., 2015) in both normotensive and pre- eclamptic pregnancies, respectively. This may be due to genetic, maternal weight, height, nutritional variation among study participants.

In the present study, birth weight was positively correlated with placental weight, diameter, thickness, and number of cotyledons in both normotensive and pre-eclamptic groups as a whole. This finding of Pearson correlation indicates that when placental weight, diameter, thickness and number of cotyledons increase, birth weight also increases and vice versa.

Comparatively, Pearson correlation showed that birth weight was moderately correlated with placental weight and number of cotyledons and fairly correlated with placental diameter in the normotensive group. While in pre-eclampsia, it was strongly correlated with placental weight and moderately correlated with diameter, thickness and number of cotyledons. However, birth weight has not statistical significant correlation with placental thickness in the normotensive group. This result shows that pre-eclampsia causes low placental perfusion and restricts the expansion of the placenta. This insufficient placenta creates a compensatory mechanism

by cell proliferation to fulfill the demand. As a result, the thickness of the placenta is more affected in pre-eclampsia than in normotensive pregnancies.

In normotensive cases, placental weight is directly proportional to birth weight. When birth weight becomes large, placental weight and size also increase to accommodate a larger fetus. As placental size increases, the placental thickness becomes thin. This result was supported by a report noted in Pakistan (Rehman et al., 2013), Norwich (Pathak, 2010) and India (Londhe and Mane, 2011), which showed that birth weight was significantly associated with placental weight. This confers that the higher the birth weight, the higher placental weight is and vice versa. Another morphological comparative study of placenta in normotensive and pre-eclampsia done in Kamataka showed that the mean placental weight, diameter and number of cotyledosn were strongly correlated with fetal weight (Girish et al., 2015).

CONCLUSION

Mean fetal weight, placental weight, diameter, thickness and number of cotyledons in pre- eclamptic mothers were significantly lower than in normotensive mothers (p-value < 0.05). Placenta shape difference between normotensive and pre-eclamptic pregnant mothers was detected (p-value = 0.001). Morphology of placenta such as weight, diameter and number of cotyledons were correlated with birth weight in both groups. Placental thickness was only correlated with birth weight in the pre-eclamptic group but not in the normotensive group. Thus, careful examination of placental morphology at an early stage of the prenatal period by using ultrasound and even immediately after birth by inspection may be helpful in early detection of mother and child at risk and for better management of such and subsequent pregnancies.

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