International Journal of Anatomy and Research,
Int J Anat Res 2019, Vol 7(2.1):6450-55. ISSN 2321-4287
DOI: https://dx.doi.org/10.16965/ijar.2019.141

Original Research Article

GROSS MORPHOMETRIC ASSESSMENT OF THE HUMAN PLACENTA WITH REFERENCE TO NEONATAL INDICES

Joshua Tetteh [1], Chrissie Stansie Abaidoo *[2], Nancy Darkoa Darko [3], Thomas Diby [4].

[1] Department of Anatomy School of Medical Sciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

*[2] Department of Anatomy School of Medical Sciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana,

[3] Department of Anatomy School of Medical Sciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

[4] Department of Anatomy School of Medical Sciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

ABSTRACT

The human placenta is considered as a mirror image of the neonate. The placenta provides an indirect link between the maternal circulation and that of the foetus and serves as the organ for exchange of materials through the process of diffusion. In evaluating the relationship between placental indices and neonatal outcome, a total of 236 placentae were obtained from the Kwame Nkrumah University of Science and Technology Hospital in Kumasi for this study. Placental indices measured were the placental weight, diameter and thickness whereas those of the neonates were Neonatal weight, head circumference and length. Mean placental indices for weight, diameter and thickness were 578.81 g, 17.40 cm and 2.04 cm respectively. The mean neonatal indices were 3.24 kg, 34.27 cm and 50.64 cm for weight, head circumference and length respectively. Neonatal weight correlated significantly with placental weight, neonatal length and neonatal head circumference. The strong correlation between neonatal weight and placental weight as well as placental volume suggests that the healthy development of the foetus depends on a healthy placenta. This study further affirms that the placenta should be critically examined in order to effectively monitor and manage adverse neonatal outcome.

KEY WORDS: Placenta, Neonate, weight, diameter, Indices.

Address for Correspondence: Dr. Chrissie Stansie Abaidoo (PhD), Department of Anatomy School of Medical Sciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, Tel: +233 208 126 817, **E-Mail:** knustsmsanat@gmail.com

Access this Article online	Journal Information
Quick Response code	**International Journal of Anatomy and Research**
	ICV for 2016 90.30 — ISSN (E) 2321-4287 | ISSN (P) 2321-8967
	https://www.ijmhr.org/ijar.htm
	DOI-Prefix: https://dx.doi.org/10.16965/ijar
DOI: 10.16965/ijar.2019.141	**Article Information**
	Received: 08 Feb 2019 — Accepted: 07 Mar 2019
	Peer Review: 08 Feb 2019 — Published (O): 05 Apr 2019
	Revised: None — Published (P): 05 Apr 2019

INTRODUCTION

The human placenta is a discoid organ which presents two surfaces; the chorionic plate facing the foetus and to which the umbilical cord is attached, and the basal plate which abuts the maternal endometrium [1,2].

The placenta is a dynamic organ which is unique in its development and functions. It is the only organ in thebody which is derived from two separate individuals, the mother and the foetus. The placenta functions as a selectivity filter, directing the influx of oxygen, inorganic salts, sugars, amino acids, peptides and other biologically active molecules to the foetal

circulation and the efflux of foetal waste materials to the maternal circulatory system[3,4].

The placenta cannot be measured directly until after birth, but the dimensions of the delivered placenta reveals the cumulative development of the placenta from conception to delivery [5,6]. Placental weight is one of several standard placental measurements by which placental growth can be characterized [1,7].

Placental weight is a summary of different dimensions of growth, including placental thickness, shape, number of blood vessels and cord insertion [5,7]. These standard placental measurements have been a routine part of gross placental pathologic examinations [3,4].

At term, the normal placenta weighs 350 – 600 g with a mean of about 590 g (15% of the normal neonatal weight) [8]. The term placenta is circular, semi-circular or oval and approximately 20 – 25 cm in diameter and 3 cm thick [9–11].

The factors that affect foetal and placental weight as well as placental microstructure include human pregnancies complicated by preeclampsia, Intra uterine growth restrictions (IUGR), maternal residence at high altitude, cigarette smoking, anaemia, diabetes mellitus or asthma [12].

Foetal head circumference provides information on intrauterine growth restrictions [13]. Birth weight on the other hand, is a straightforward measure of the outcome of birth and is affected by several factors (direct or indirect) necessary for perinatal survival [14]. Birth weight is probably the single most important factor that affects neonatal mortality, in addition to being a significant determinant of post-neonatal infant mortality and of infant and childhood morbidity.

In recent years more attention has been focused on the morphology of the placenta due to its vital role in foetal development and neonatal survival. While extensive studies have been documented in this area in the developed world, there is very little published information about the placental indices and neonatal outcomes in Ghana. Therefore this study sought to determine the relationship between gross placental morphometry and neonatal anthropometry.

MATERIALS AND METHODS

The study was conducted on delivered placentae and foetal anthropometry from the Kwame Nkrumah University of Science and Technology (KNUST) Hospital in the Kumasi Metropolis. A total of 236 placentae were collected for this study. Participant informed consent and ethical approval were sought from the Committee on Human Research and Publications Ethics at the Kwame Nkrumah University for Science and Technology, School of Medical Sciences and the Komfo Anokye Teaching Hospital in Kumasi, Ghana. The placentae delivered at the maternity unit were collected and washed under running tap water to wash off blood smear and clots. The umbilical cord was cut, leaving a stump of 5 cm from its foetal site of insertion. All the specimens were tagged with numbers that corresponded with the numbers indicated in the register for neonatal indices. The specimens were then placed in plastic containers filled with formalin (10%) with an airtight lid and kept at room temperature before transporting to the Department of Anatomy laboratory at the School of Medical Sciences – KNUST for detailed examination and measurements.

Placental Weight: Gross placentae (including umbilical cord and placental membranes) were weighed in grams in the laboratory using a highly sensitive mechanical kitchen scale (Zhongshan Camry Electronic Co. Model: KCH) graduated from 0 – 5000 g.

Placental Thickness: The toothpick method was used in the determination of placental thickness (15). This was done by piercing the placentae from the chorionic plate to the basal plate at nine different points selected along two planes that bisect at right angle including the point of umbilical cord insertion with a toothpick. The values were transferred onto a clear ruler 30 cm/ 12 inches (Helix China Inc.) calibrated in centimetres and their averages computed to determine the mean placental thickness

Placental Diameter: The diameter of the placenta was measured using a Dritz C150 fiberglass measuring tape (Prym consumer USA Inc.). Four different angles of each placenta were measured and the mean determined. This was done in view of the fact that, most of the

placentae upon gross examination were discoid or ovoid in shape making it impossible to take a single reading.

Neonatal Indices: Infant, indices including birth weight, body length, head circumference and sex were determined for all the babies. All measurements were done by the investigator with the help of the attendant within 24 hours after delivery.

Birth weight was measured with a Seca 725 mechanical baby weighing scale (Seca Co. Ltd. USA) calibrated in kilograms when the infant is naked. Body length, head circumference and abdominal circumference were measured with Dritz C150 fiberglass standard tape measure (Prym consumer USA Inc.) to the nearest centimetre. Ponderal index (PI) was computed as the ratio of birth weight in grams to the cube of body length in centimetres and multiplied by 100; PI = (BW/BL^3) x 100 (13), Where BW is the birth weight in grams and BL is body length in centimetres.

Inclusion criteria were placentae from normal singleton pregnancies with known gestational age. Meanwhile, those with conditions such as hypertension, diabetes, sickle cell disease, multiple pregnancy, unknown gestational age and Human Immune-deficiency Virus (HIV) were excluded from the study.

Statistical analyses were done using Microsoft Excel (2013 version) and the Statistical Package for the Social Sciences (SPSS) version 20.0 (SPSS Inc., Chicago, IL). Spearman correlation matrix and coefficients were used to determine correlations among various placental and neonatal anthropometric measurements. Multiple linear regressions were used to assess the effect of correlations observed between placental indices and the neonatal anthropometric parameters. The adopted level of statistical significance was $p < 0.05$.

RESULTS

The mean birth weight in this study was 3.24 kg (SD = 0.50; range = 1.25 – 4.50 kg). The body length of the neonates had a mean of 50.64 kg (SD = 3.43; range = 34.00 – 60.00 cm). The mean head circumference measurement was 34.27cm (SD = 1.95; range 0.90 – 8.10 cm). Ponderal index had a mean of 2.53 (SD = 0.63; range of 0.90 – 8.10) as shown in Table 1.

Table 1: Descriptive statistics of neonatal indices.

Variable	Mean ± SD	Range
Birth Weight (kg)	3.24 ± 0.51	1.25 – 4.50
Body Length (cm)	50.64 ± 3.43	34.00 – 60.00
Head Circumference (cm)	34.27 ± 1.95	26.00 – 49.00
Ponderal Index	2.53 ± 0.63	0.90 – 8.10

SD = Standard Deviation, kg = kilogram, cm = centimetres

The mean placental diameter was 17.40 cm (SD = 1.83; range = 11.75 – 23.00 cm). The mean placental weight was 578.81 g (SD = 121.60; range = 140.00 – 1050.00 g). Mean placental thickness was 2.04 cm (SD = 0.45; range = 1.50 – 3.49 cm). The mean placental area was 240.29 cm^2 (SD = 50.04; range = 202.06 – 995.81 cm^2). The mean placental volume was 486.91 cm^3 (SD = 135.15; range = 108.38 – 415.27 cm^3) (Tab. 2).

Table 2: Descriptive statistics of placental indices.

Variable	Mean ± SD	Range
Placental Diameter (cm)	17.40 ± 1.83	11.75 – 23.00
Placental Weight (g)	578.81 ± 121.60	140.00 – 1050.00
Placental Thickness (cm)	2.04 ± 0.45	1.50 – 3.49
Placental Area (cm^2)	240.29 ± 50.04	108.38 – 415.27
Placenta Volume (cm^3)	486.91 ± 135.15	202.06 – 995.81

SD = Standard Deviation, cm = centimetre, g = gram

Out of the 236 neonates, 86.86% (205) neonates had birth weight between 2.50 – 4.00 kg, whereas 91.10% (215) neonates had placental weight of 350.00 – 750.00 g. Neonatal birth weight was grouped into low birth weight (< 2.50 kg), normal birth weight (2.50 – 4.00 kg) and high birth weight (> 4.00 kg). For the male neonates, approximately 3.39% (8), 43.22 % (102) and 4.24 % (10) fell within the birth weight brackets < 2.50 kg, 2.50 – 4.00 kg and > 4.00 kg respectively. The trend was similar for the female neonates which showed 2.54 % (6), 43.64 % (103) and 2.97 % (7) for < 2.50 kg, 2.50 – 4.00 kg and > 4.00 kg weight brackets respectively. Placental weight of <350 g was more prevalent in male neonates 1.69% (4) than in the females 0.85% (2). Normal placental weight (350.00 – 750.00 g) prevalence was higher in the male neonatal population 47.46% (112) than females 43.64% (103). On the contrary, placental weight of >750.00 g prevalence was high in the female population 6.36% (15) than males 1.69% (4) (Table 3).

Table 3: Distribution of placental weight and neonatal birth weight amongst male and female neonates.

Neonatal weight (kg)	Sex of the neonate		Placental weight (g)	Sex of the neonate	
	Male	Female		Male	Female
< 2.50	8	6	<350.00	4	2
2.50 – 4.00	102	103	350.00 – 750.00	112	103
> 4.00	10	7	>750.00	4	15
Total	**120**	**116**		**120**	**116**

kg = kilogram, g = gram.

There was a linear relation between placental weight and birth weight (p = 0.0172, R^2 = 0.02402) and between placental volume and birth weight (p = 0.01488, R^2 = 0.0619) as shown in Figure 1. Head circumference and birth length exhibited significant correlation with birth weight. There was linear relation between both head circumference and birth length with birth weight having values of p = 0.001, R^2 = 0.09231 and p = 0.001, R^2 = 0.2473 respectively (Fig. 2).

Fig. 1: Linear regression graph showing placental weight (PW) and placental volume (PV) against birth weight (BW).

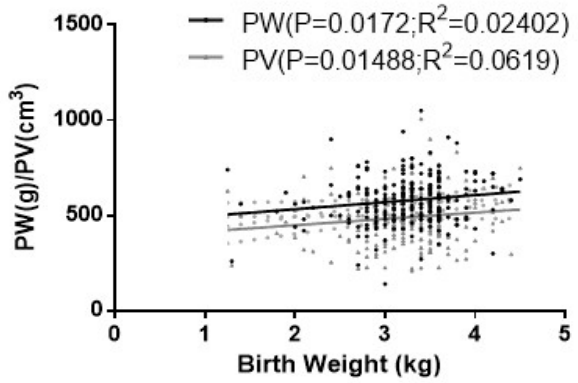
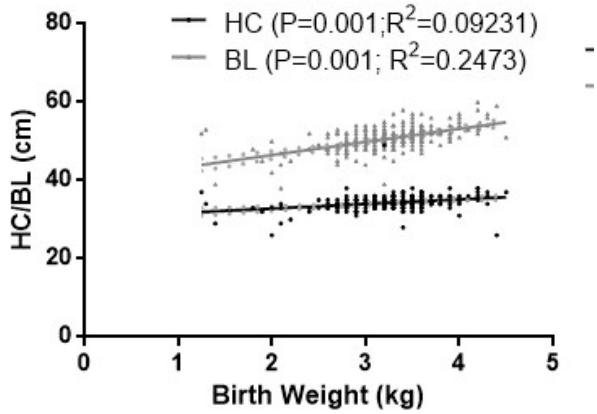


Fig. 2: Linear regression graph of head circumference (HC) and birth length (BL) against birth weight (BW).



DISCUSSION

The mean placental weight was 578.81 ± 121.60 g with a range of 140.00 – 1050.00 g. Other investigators have reported mean placental weights of 643.00 and 646.20 g in Western Europe [16] and China [17] respectively. While others have also reported means of 588.00 and 590.00 g in Asia and Sokoto in Nigeria respectively [18,19], nonetheless, Sanin and friends (2001) reported normal placental weight to be within 400.00 – 600.00 g [20]. The weight of the placenta was found to have a positive correlation with the weight of the neonate (p = 0.017, r = 0.155) but not with neonatal head circumference and length. The weight of the placenta is used in the determination of the foeto-placental ratio which is a useful marker of foetal nutrition and utero-placental function. Factors such as ethnicity, gestational diabetes, hypertension and hydrops foetalis have been reported to influence foetal and placental weight [21,22].

The mean placental diameter was 17.40 ± 1.83 cm with a range of 11.75 - 23.00 cm. This was found to be similar to previous studies by Ohagwu *et al*. (2009) who reported a term placental diameter range of 15.00 cm to 25.00 cm and Yetter (1998) who reported a mean placental diameter of about 22.00 cm. [23,24]. The diameter of the placenta did not correlate with any of the neonatal indices. However, the diameter of the placenta did correlate significantly with placental volume (p = 0.000, r = 0.920) and placental weight (p = 0.000, r = 0.283). The diameter of the placenta therefore may give an indication of the size of the placenta which in turn may give indirect information about the foeto-placental ratio. The diameter of the placenta affects the amount of nutrients, oxygen and carbon dioxide that will pass from the mother to the child and vice versa.

The mean placental thickness was 2.04 ± 0.45 cm with a range of 1.50 – 3.49 cm. Ohagwu *et al.* (2009) reported a similar placental average thickness of 3.00 cm while Yetter (1998) gave the term placental thickness range of 2.00 cm to 2.50 cm. [23,24]. Placentae less than 2.50 cm thick are associated with intrauterine growth restriction of the foetus whilst placentae more than 4.00 cm thick may be associated with maternal diabetes mellitus, foetal hydrops and intrauterine foetal infections [25].

The mean birth weight observed in this study was 3.24 ± 0.51 kg with a range of 1.25 – 4.50 kg. This mean birth weight is similar to the

3.10 ± 0.80 kg observed in Nigeria by Mutihir and Pam (2006) (26). The low birth weight (< 2.50 kg) rate in this study was 5.93 % while 86.86 % were normal for gestational age and 7.20% were large for gestational age (> 4.00 kg). Nkyekyer and friends (2006) reported that low birth weight rate in West Africa is about 15.4% and that of Ghana is said to be around 11.0%. The low birth weight observed in this study is lower than in these previous studies. Both low birth weight and high birth weight are foetal conditions associated with increased risks of peripartum morbidity and mortality. Neonates born with low birth weight may face an increased risk of dying during their early months or years. Those who survive may have impaired immune function and increased risk of diseases. They are likely to be at risk of remaining undernourished, with increased muscle weakness, throughout their lives and such babies suffer a higher incidence of heart diseases and diabetes. Birth weight greater than 4.00 kg is considered to be macrosomia. It affects 2 – 15% of all pregnancies, depending on maternal obesity, maternal pregnancy weight gain, maternal haemoglobin concentration, gestational diabetes mellitus, race, ethnic or socioeconomic composition of the population under study [27].

The mean head circumference in this study was 34.27 ± 1.95 cm with a range of 26.00 to 49.00 cm. This was similar to the 34.20 ± 2.60 cm observed by Eregie (1993) in Benin-City, Nigeria and 34.49 ± 1.59 cm in Jos [28]. These similarities can be attributed to race due to the fact that all these studies were conducted in West Africa. In a study conducted in India on the other hand, Salafia and Vintziloes (1990) found the mean head circumference to be 32.20 cm. [29].

The head circumference did not correlate with any of the placental indices but had a positive link with weight of the neonate ($p = 0.001$) and ponderal index ($p = 0.001$). The head circumference of the neonate gives an indirect assessment of the weight of the neonate in that the bigger the head circumference, the heavier the neonate. The uniqueness of all the changes that occur in foetal life has been the deceleration in growth rate of the head. Head circumference can be influenced by factors such as anorexia nervosa and bulimia nervosa. Women with a history of an eating disorder are at a risk of having babies with microcephaly.

The mean length of the neonates in this study was 50.64 ± 3.43 cm with a range of 34.00 – 60.00 cm. There was no positive correlation between the length of the neonate and any of the placental indices. The mean neonatal length obtained in this study is similar to the value (48.80 cm) reported by Lo *et al*. (2002). Contrary to the results of this study, Lo *et al*. (2002) had a positive correlation between the foetal length and the placental weight ($p < 0.01$, $r = 0.305$) [17].

Foetal growth and development are influenced by the genetic constitution of the parents as well as environmental factors. Maternal genes have an important specific influence over foetal growth. In particular, maternal height, which is a representation of uterine capacity and the potential for growth, is a major determinant of foetal size. The genetic make-up of the parents can significantly influence the length of the neonate. Valsamakis *et al*. (2006) in their study, reported that when both parents are tall, the neonate inherits tallness from both parents and if one is short and the other tall, based on their genetic make- up, the neonate may be tall or short [4].

CONCLUSION

The findings of this study have shown that majority of the placental and neonatal indices were within their respective normal brackets. The strong correlation between neonatal weight and placental weight as well as placental volume suggests that the healthy development of the foetus depends on how healthy the placenta is which verifies existing knowledge that the placenta is the single most appropriate sentinel for determining neonatal wellbeing hence the placenta being referred to as the mirror image of the foetus and an important component of the foeto-maternal exchange. This study further affirms that the placenta should be critically examined in order to effectively monitor and manage adverse neonatal outcome.

Conflicts of Interests: **None**

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How to cite this article: Joshua Tetteh, Chrissie Stansie Abaidoo, Nancy Darkoa Darko, Thomas Diby. GROSS MORPHOMETRIC ASSESSMENT OF THE HUMAN PLACENTA WITH REFERENCE TO NEONATAL INDICES. Int J Anat Res 2019;7(2.1):6450-6455. **DOI:** 10.16965/ijar.2019.141