Original scientific papers UDK 004.9:618.46
DOI 10.7251/COMEN1901100LJ

DIGITAL IMAGING ANALYSIS OF THE PLACENTA

Vesna Ljubojević[*]
University of Banja Luka, Faculty of Medicine, Department of Histology and Embryology,
Save Mrkalja 14, 78 000 Banja Luka, Republic of Srpska

Abstract: Introduction: Recent studies indicate that placental and umbilical cord morphometry are the factors that may be associated with pregnancy complications, such as fetal growth restriction. Recently, placental and umbilical cord morphometry have been performed using digital image analysis. The aim of this study was to determine the morphometric parameters of placentas using digital image analysis.

Material and methods: The digital imaging analysis of twenty placentas and umbilical cord were performed using Image Analysis LAS V4.3 software.

Results: The length of the placentas was 191,77 mm ± 35,86 mm (mean ± standard deviation). The width of the placentas was 166,01 mm ± 19,01 mm. The placental surface area was 24495,13 mm^2 ± 7038,86 mm^2. The insertion of the umbilical cord to the placenta was central in 50 %, peripheral in 37,50 % and marginal in 12,5 % of analyzed placentas. The average distance of the umbilical cord insertion from the nearest placental margin was 38,89 mm ± 28,39 mm. The umbilical cord diameter at the insertion site was 21,16 mm± 5.69 mm. The diameter of the umbilical cord two centimeters from the insertion site was 12,36 mm ± 3,45 mm.

Conclusion: Digital image analysis enables obtaining the objective morphometric parameters of the placenta and umbilical cord. The obtained morphometric parameters of the placenta and umbilical cord for our population are comparable to results of previous studies and open further placental research directions for the development of the screening method.

Keywords: digital imaging, morphometric parameters, placenta, umbilical cord.

1. INTRODUCTION

The placenta is a temporary organ for the growth and development of the fetus and provides the transfer of nutrients from the mother's organism. This organ, with discoid shape, is the only fetal source of oxygen and nutrients. The shape of the fetal surface of the human placenta is usually described as round with the central insertion of the umbilical cord. In practice, the shape of the fetal surface varies from oval, round, to irregular and it is rarely circular [1,2]. Umbilical insertion site can also be peripheral and marginal.

Morphological characteristics of the placenta, or placental growth measures, are the result of the placental growth and are directly related to its functional efficiency [3,4]. Placental measures are: the placental surface area, the largest diameter or maximal linear dimension (length), the smallest diameter or the greatest dimension of the axis perpendicular to this linear measurement (width), the placental disk shape, the disk thickness or the mural minimal and maximal thickness, the placental weight trimmed of extraplacental membranes and umbilical cord, location of the umbilical cord insertion in relation to the center/margin of the placenta, the diameter of the cord and the cord length[5]. Placental growth measures were designed to determine different aspects of the placenta that are associated with placental function [5]. Recent studies indicate that placental and umbilical cord morphometry are factors that may be associated with pregnancy complications, such as fetal growth restriction and reduced fetal movements Also, they can be associated with an individual's long-term health [6-10]. The diagnosis of the fetal growth restriction is based on the neonates weight at delivery. Independently of neonates weight, in the identification of the fetuses and neonates with growth restriction, a gross examination of the placenta and placental morphometry can be used [11–14].

After birth, placental growth measures are easy to acquire. There should be data for each population regarding these placental measures in order to be able to determine morphometric parameters of the placenta after birth. Contemporary placental measure standards derived from the respective local or similar population should be used [15]. In recent studies,

[*] Corresponding author: ljubojevic.v@gmail.com

placental and umbilical cord morphometry have been performed using digital image analysis [16]. For our population, limiting data about morphometric parameters of the placenta are available.

2. AIM

The aim of this study was to determinate morphometric parameters of the placentas and umbilical cords using digital image analysis of delivered placentas.

3. MATERIAL AND METHODS

Twenty placentas after delivery were analyzed in this research. The placentas of pregnant women that have given term birth and have lived in the western part of Bosnia and Herzegovina have been analyzed. The placentas were analyzed after delivery of a healthy newborn that did not have fetal growth restriction (figure 1). Analyzed placentas were obtained in cooperation with the Clinic for Gynecology and Obstetrics of UKC RS Banja Luka. The study was conducted in accordance with the ethical rules of the Declaration of Helsinki.

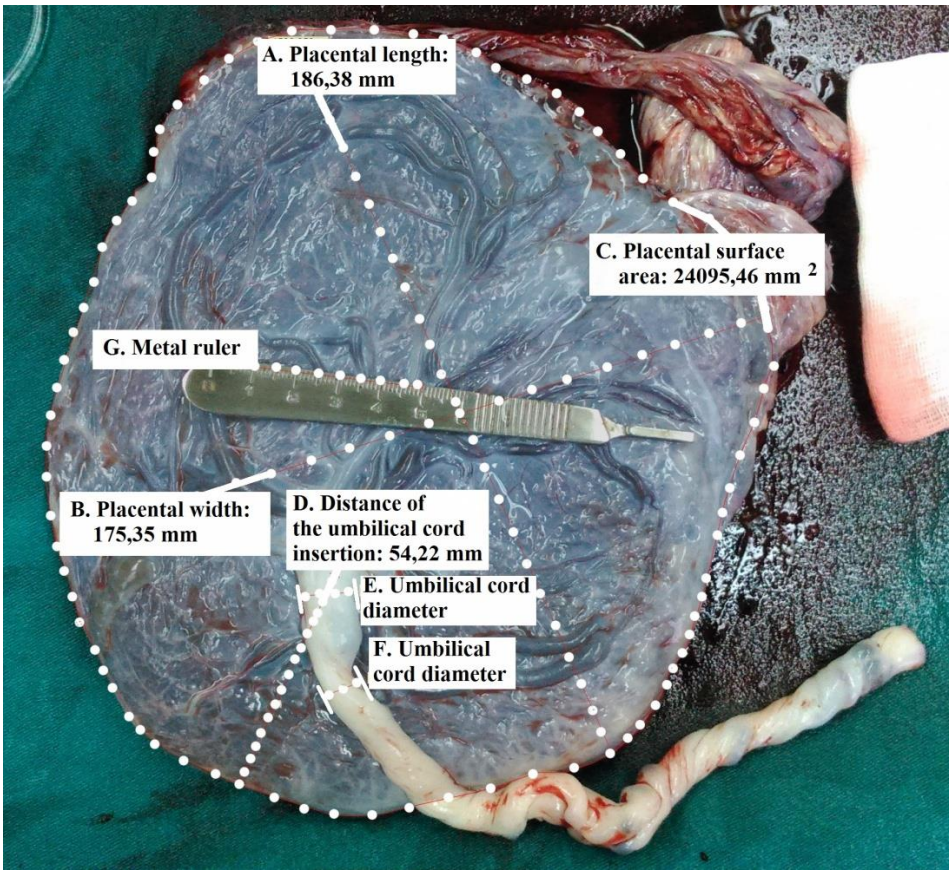

Figure 1. The placental measures: A. placental length, B. placental width, C. placental surface area, D. distance of the umbilical cord insertion, E. umbilical cord diameter at the insertion site, F. diameter of the umbilical cord two centimeters from the insertion site, G. metal ruler

The placentas were placed with fetal surface up on a clean sterile compress. The blood was wiped from the fetal surface and the metal ruler was put on the fetal surface of the placenta. Using a standard high-resolution digital 13-megapixel camera, the fetal surface of the placenta, with the metal ruler in the field of view, was photographed.

The digital imaging analysis of the placenta and umbilical cord were performed using Image Analysis LAS V4.3 software.

Placental measures measured digitally were: the placental surface area, the largest diameter or maximal linear dimension (length), the smallest diameter or the greatest dimension of the axis perpendicular to the length (width), umbilical cord insertion site, the diameter of umbilical cord at the insertion site and the diameter of the umbilical cord two centimeters from the insertion site (figure 1).

The location of umbilical cord insertion was determined in relation to the margin of the placenta.

It was determined by measuring the distance between the insertion site and the nearest placental margin.

The insertion site of umbilical cord smaller than one centimeter from the nearest placental margin was classified as the marginal insertion site. The insertion site that was three centimeters away from the nearest margin was taken as a peripheral insertion site [5,17].

The results were analyzed by methods of descriptive statistics.

4. RESULTS

In this research morphometric parameters of placentas have been determined (table 1).

Table 1. Morphometric parameters of the placenta and the umbilical cord

Morphometric parameter	Average and standard deviation	Range
The length of the placenta (A)	191,77 mm ± 35,86 mm	146,82mm -291,07 mm
The width of the placenta (B)	166,01 mm ± 19.01 mm	142,22 mm -197,69 mm
The placental surface area (C)	24495,13 mm^2 ± 7038,86 mm^2	14303,52 mm^2 - 43184,78 mm^2
The average distance of the umbilical cord insertion (D)	38,89 mm ± 28,39 mm	0 - 76,78 mm
The umbilical cord diameter at the insertion (E)	21,16 mm± 5.69 mm	11,39 mm - 30,63 mm
The diameter of the umbilical cord two centimeters from the insertion (F)	12,36 ± 3,45	10,08 mm -21,85 mm

The analyzed placenta had a disk format with the fetal side of the circular shape. The average length of the placentas, estimated using digital imaging analysis, was 191,77 mm ± 35,86 mm (mean ± standard deviation). The minimal placental length was 146,82mm and maximal was 291,07mm.

The width of the placenta (the smallest diameter of the placenta, the greatest dimension of the axis perpendicular to the length) was 166,01mm ± 19.01 mm. The minimal placental width was 142,22 mm and maximal placental width was 197,69 mm (table 1).

The placental surface area was 24495,13 mm^2±7038,86 mm^2. The minimal placental surface area was 14303,52 mm^2 and the maximal placental surface area was 43184,78 mm^2.

The location of umbilical cord insertion to the placenta was central, peripheral and marginal (figure 2).

The insertion of the umbilical cord to the placenta was central in 50 % of analyzed placentas, peripheral in 37,50 % and marginal in 12,5 % of analyzed placentas (figure 3).

The average distance of the umbilical cord insertion from the nearest placental margin was 38,89 mm ± 28,39 mm (table 1).

The distance of the umbilical cord inserted exactly on the placental margin has been zero. The distance of this insertion has been the smallest distance. The maximal distance of the umbilical cord insertion was 76,78 mm. The umbilical cord diameter at the insertion site was 21,16 mm± 5,69 mm (table 1). The minimal umbilical cord diameter at the insertion site was 11,39 mm and maximal was 30,63 mm. The diameter of the umbilical cord two centimeters from the insertion site was 12,36 ± 3,45 (table 1). The minimal umbilical cord diameter two centimeters from the insertion site was 10,08 mm and maximal was 21,85 mm.

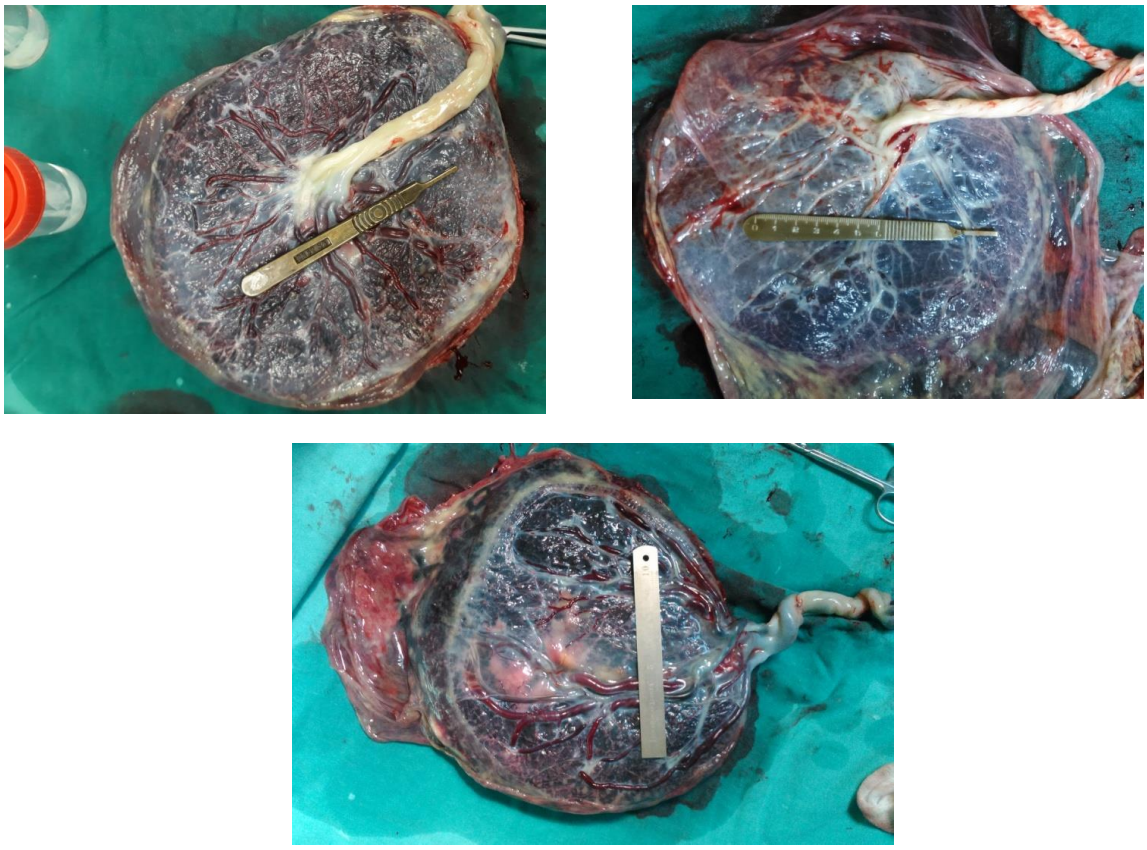

Figure 2. The location of the insertion of umbilical cord to the placenta: A. central insertion, B. peripheral insertion, C. marginal insertion.

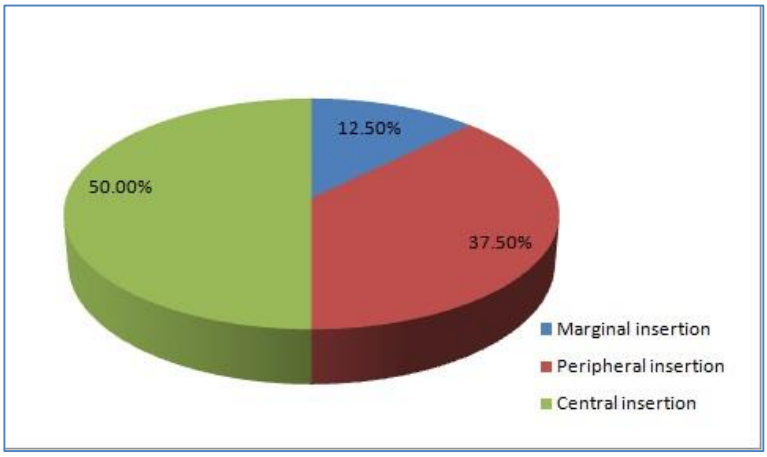

Figure 3. The insertion of the umbilical cord to the placenta

5. DISSCUSION

Normal placental morphometry and normal structure, which include size and shape, determine normal placental function. One of the morphometric parameters is the placental surface area determined by the largest and the smallest diameters. It was determined by the lateral expanding during the growth of the chorionic plate. Reduced placental size and altered placental nutrient transport capability are impairments of the placental development that are contributing to the placental dysfunction and consequently to the fetal growth restriction [18].

The diagnosis of fetal growth restriction (FGR) was for a long time mainly based on the birth weight below a reference cut-off [19]. In recent time, more focus has been made on examining the role of the gross examination of the placenta, its size, weight, shape and

cord insertion, in the detection of babies that are in risk. The examination of the placenta is cheap and easy to perform and the postnatal placenta can retrospectively aid the diagnosis of FGR. Postnatal measurement of the placenta gives the opportunity to help in differentiation of the neonates who have suffered undetected growth restriction and should be monitored more closely during the postnatal period. The small placenta may indicate a prompt examination of the baby. The placental morphometry should be used for generating the methods helpful in the antenatal and postnatal screening of the fetuses with FGR. Contemporary placental measure standards derived from the appropriate local or similar population should be used.

In this research, placentas after delivery of term neonates were analyzed. The placental average length was 191,77 mm ± 35,86 mm. The minimal placental length was 146,82 mm and the maximal was 291,07 mm. Grandi and coauthors in their study found the largest diameter of placenta of 16,6 ± 2,5 cm. The minimal length was 5.0 cm and the maximal length was 29.0[15]. In the study of Grandi and coauthors, the placentas of preterm neonates delivered after 22 weeks of gestation were included in the examination. Compared to their study, in this study only the placentas of term neonates were analyzed.

The placental average width was 166,01 ± 19.01 mm. The minimal placental width was 142,22 mm and maximal placental width was 197,69 mm. In the study of Grandi and coworkers, the smallest diameter of placentas was 12,4 ± 2,9 cm. Minimal width was 3,0 cm and maximal width was 23,0 [15].

The placental surface area was 24495,13 mm² ± 7038,86 mm². The minimal placental surface area was 14303,52 mm² and maximal was 43184,78 mm². Grandi and coworkers found the surface area of placenta of 164.8 ± 55.8cm². The minimal placental surface area was 15,70cm² and maximal was 397cm² [15]. Ismail and coauthors estimated the surface area of 303.78 ± 54.52 cm². Their study analyzed placentas of term neonates and preterm neonates delivered after 24 weeks of gestation [16].

The placental cord insertion site can be central, peripheral and marginal. The estimated umbilical cord insertion to the placenta was central in 50%, peripheral in 37,50 % and marginal in 12,5 % of analyzed placentas. In a recent study, the rates of velamentous (insertion into the membrane) and marginal cord insertions were 3.6% and 6.4% respectively [11]. In literature, some studies suggest that noncentral placental cord insertions had an association with reduced transport efficiency and fetal growth restriction [15].

The estimated distance of the umbilical cord insertion from the nearest placental margin was 38,89 ± 28,39 mm. The umbilical cord diameter at the insertion site was 21,16± 5,69 mm. The diameter of the umbilical cord two centimeters from the insertion site was 12,36 ± 3,45 mm. In the study of Ismail and coauthors, the distance of placental cord insertion to the placental margin was 5.21 ± 2.16 cm and the average diameter of the umbilical cord at the placental end was 10.72 ± 2.11 mm.

6. CONCLUSION

This research presented that digital image analysis enables obtaining the objective morphometric parameters of the placenta and umbilical cord. The obtained morphometric parameters of the placenta and umbilical cord for our population are comparable to results of previous studies and open further placental research directions for the development of the screening method.

7. REFERENCES

[1] K. Benirschke, P. Kaufmann, R..Baergen, *Pathology of the Human Placenta. The architecture of Normal Villous Trees*, New York: Springer Verlag, 2006.

[2] I. R. Nikolić, G. Rančić, G. Radenković, V. Lačković, V. Todorović, D. Mitić, D. Mihailović, *Embriologija čoveka tekst i atlas*, Data Status, 20015.

[3] G. J. Burton, E. Jauniaux, *What is the placenta?*, Am J Obstet Gynecol., Vol. 213–4 (2015) 6–S.

[4] L. K. Warrander, G. Batra, G. Bernatavicius, et al., *Maternal perception of reduced fetal movements is associated with altered placental structure and function*, PLoS One., Vol. 7–4 (2012) 34851.

[5] T. Y. Khong; E. E. Mooney, I. Ariel, N. Balmus, T. Boyd, *Sampling and Definitions of Placental Lesions*, Arch Pathol Lab Med, Vol. 140 (2016) 698–713.

[6] D. J. Barker, C. Osmond, K. L. Thornburg, E. Kajantie, J. G. Eriksson, *The lifespan of men and the shape of their placental surface at birth*,Placenta, Vol. 32-10 (2011) 783–787.

[7] D. J. Barker, C. Osmond, K. L. Thornburg, E. Kajantie, J. G. Eriksson, *The shape of the placental surface at birth and colorectal cancer in later life*, Am J Hum Biol., Vol. 25-4 (2013) 566–568.

[8] J. G. Eriksson, E. Kajantie, K. L. Thornburg, C. Osmond, D. J. Barker, *Mother's body*

size and placental size predict coronary heart disease in men, Eur Heart J., Vol. 32–18 (2011) 2297–2303.

[9] D. P. Misra, C. M. Salafia, A. K. Charles, R. K. Miller, *Placental measurements associated with intelligence quotient at age 7 years*, J DevOrig Health Dis., Vol. 3–3 (2012) 190–197.

[10] M. S. Longtine, D. M. Nelson, *Placental dysfunction and fetal programming: the importance of placental size, shape, histopathology, and molecular composition*, SeminReprod Med., Vol. 29–3 (2011) 187–196.

[11] K. I. Ismail, A. Hannigan, P. Kelehan, K. O'Donoghue, A. Cotter, *Abnormal Placental Cord Insertion and Adverse Pregnancy Outcomes: Results from a Prospective Cohort Study*, Am J Perinatol., Vol. 34–11 (2017) 1152–1159.

[12] M. R. Marques, C. Grandi, L. M. P. Nascente, R. C. Cavalli, V. C. Cardoso, *Placental morphometry in hypertensive disorders of pregnancy and its relationship with birth weight in a Latin American population*, Pregnancy Hypertens, Vol. 13 (2018) 13:235–241.

[13] N. R. Winder, G. V. Krishnaveni, S. R. Veena, et al., *Mother's lifetime nutrition and the size, shape, and efficiency of the placenta*, Placenta, Vol. 32-11 (2011) 806–810.

[14] N. Salavati, M., Smies, W. Ganzevoort, A. K. Charles, J. J. Erwich, T. Plösch, S. J. Gordijn, *The Possible Role of Placental Morphometry in the Detection of Fetal Growth Restriction*, Frontiers in physiology, Vol. 9 (2018) 1–12.

[15] C. Grandi, A. Veiga, N. Mazzitelli, C. CavalliRde, V. Cardoso, *Placental Growth Measures in Relation to Birth Weight in a Latin American Population*, Rev Bras GinecolObstet, Vol. 38–8 (2016) 373–380.

[16] K. I. Ismail, A. Hannigan, P. Kelehan, B. Fitzgerald, K. O'Donoghue, A. Cotter, *Small for gestational age infants and the association with placental and umbilical cord morphometry: a digital imaging study*, J Matern Fetal Neonatal Med, Vol. 32 (2019) 1–8.

[17] G. Luo, R. W. Redline, *Peripheral insertion of the umbilical cord*, PediatrDevPathol., Vol. 16-6 (2013) 399–404.

[18] S. Zhang, T. Regnault, P. Barker, K. Botting, I. McMillen, C. McMillan, *Placental adaptations in growth restriction*, Nutrients, Vol. 7 (2015) 360–389.

[19] I. Beune, A. Pels, S. J. Gordijn, W. Ganzevoort, *Definitionsof fetal growth restriction in existing literature over time*, Ultrasound ObstetGynecol, Vol. 53–5 (2019) 569–570.

ДИГИТАЛНА АНАЛИЗА СЛИКЕ ПОСТЕЉИЦЕ

Сажетак: Увод: Новије студије указују на то да су морфолошке карактеристике постељице и пупчаника фактори који су повезани са компликацијама трудноће, као што је фетални застој у развоју. Морфометрија плаценте и пупчаника се у новијим студијама обавља дигиталном анализом слике постељице. Циљ истраживања је био да се уз помоћ дигиталне анализе слике утврде морфолошке карактеристике постељице.

Материјали и методе: Дигитална анализа слике од двадесет постељица урађена је софтвером Image Analysis LAS V4.3.

Резултати: Утврђена је дужина постељице од 191,77 мм ± 35,86 мм (средња вриједност ± стандардна девијација). Ширина постељице је износила 166,01 мм ± 19.01 мм. Површина постељице је износила 24495,13 мм^2 ± 7038,86 мм^2. Припој пупчаника за постељицу је био централан у 50%, периферан у 37,50% и маргиналан у 12,5% анализираних постељица. Просјечна удаљеност припоја пупчаника од најближе маргине постељице је била 38,89 мм ± 28,39 мм. Пречник пупчаника на припоју износио је 21,16 мм ± 5.69 мм. Пречник пупчаника на удаљености два центиметра од припоја износио је 12,36 мм ± 3,45 мм.

Закључак: Ово истраживање је показало да дигитална анализа слике омогућава утврђивање објективних морфометријских параметара постељице и пупчаника. Утврђени морфометријски параметри постељице и пупчаника за нашу популацију могу се упоређивати са резултатима презентованим у претходним студијама и отварају даље правце истраживања постељице за развој методе скрининга.

Кључне ријечи: дигиталне слике, морфометријски параметри, плацента, пупчана врпца.

Paper received: 6 june 2019
Paper accepted: 18 june 2019