Original Article

DOI: 10.7860/JCDR/2024/66258.19080

Radiology Section

Correlation of Cross-sectional Area of the Umbilical Cord on Antenatal Ultrasound with Neonatal Birth Weight in Pregnant Women with and without Gestational Diabetes Mellitus: A Prospective Cohort Study

ARJUN PRAKASH[1], DIVYASHREE P KATTI[2], NAVEEN KG REDDY[3], KISHORE S KUDLANNAVAR[4], L SMRITHIKA[5], SHALINI B SURESH[6]

ABSTRACT

Introduction: Many foetal and maternal complications, such as polyhydramnios, macrosomia, birth injuries, and operative interference, are linked with Gestational Diabetes Mellitus (GDM). Among these, macrosomia is particularly significant, as it increases the risk of shoulder dystocia, brachial plexus injury, birth asphyxia, and maternal complications, including emergency Lower Segment Caesarean Section (LSCS), Postpartum Haemorrhage (PPH), and perineal trauma. Therefore, one of the most essential perinatal goals in GDM is to predict macrosomia by estimating birth weight, thereby preventing adverse maternal and foetal outcomes.

Aim: To evaluate whether there is a correlation between the cross-sectional area of the Umbilical Cord (UCA) and the Neonatal Birth Weight (NBW) in pregnant women with GDM.

Materials and Methods: A prospective cohort study was conducted in the Departments of Radiology and Obstetrics Bangalore Medical College, Bengaluru, Karnataka, India. A total of 100 pregnant women (50 with GDM and 50 without GDM) were recruited from July 2021 to July 2022. Ultrasound examination (USG) was performed on pregnant women after 36 weeks of gestation. The UCA was measured in a free-floating loop, and the NBW was measured using a digital scale. The correlation coefficient was calculated to determine the degree of correlation between UCA and NBW.

Results: The mean age of the subjects was 26.5±3.9 years. The frequency of macrosomia was higher in the GDM group (8%) compared to the control group (4%). A strong positive correlation was observed between UCA and NBW in both diabetics (r=0.819) and control groups (r=0.736).

Conclusion: A strong positive correlation exists between UCA and NBW in women with GDM. Therefore, it should be estimated during routine antenatal USG for the prediction of birth weight in such women.

Keywords: Birth injuries, Haemorrhage, Macrosomia, Polyhydramnios, Ultrasonography

INTRODUCTION

One of the most common medical complications during pregnancy is Diabetes Mellitus (DM). Pregnant women can be categorised into those who had the onset of diabetes before pregnancy - pregestational DM; and those diagnosed during pregnancy - GDM [1,2]. The increasing incidence of type 2 DM has led to a growing number of pregnancies with GDM.

The prevalence of GDM in India varies from 3.8 to 21% [3-5], and the pooled global standardised prevalence is 14% [6]. It is associated with many foetal and maternal complications such as macrosomia, premature rupture of membranes, preeclampsia, polyhydramnios, placental abruption, birth injuries, and operative interference. Among these, macrosomia is particularly important [7].

Macrosomia is defined as NBW ≥ 4000 grams or as gestational age-adjusted birth weight >90th percentile of the reference population [8]. Approximately, 12% of newborns of women without GDM and 15-45% of newborns of women with GDM can be affected by macrosomia [8]. Macrosomia results in an increased risk of shoulder dystocia, brachial plexus injury, meconium aspiration, thus causing neonatal morbidity and the need for assisted ventilation [9]. Maternal complications result from operative delivery, which includes PPH, intra-abdominal infection, perineal lacerations [9]. Therefore, one of the most essential perinatal goals in GDM is to predict macrosomia by estimating birth weight, thereby preventing adverse maternal and foetal outcomes. Foetal weight plays a significant role in obstetrical decision-making.

The purpose of the present study was to determine the correlation between UCA and NBW in the south Indian population and whether macrosomia can be predicted based on it, and also to assess whether the inclusion of UCA measurement in conventional biometry will improve prenatal detection of macrosomia.

MATERIALS AND METHODS

A prospective cohort study was conducted in the departments of Radiology and Obstetrics, Bangalore Medical College, Bengaluru, Karnataka, India, from July 2021 to June 2022. After obtaining approval and clearance from the Institutional Ethics Committee (IEC number: BMCRI/PG/352/2019-20), a total of 100 pregnant women after 36 weeks of gestation were recruited.

Sample size calculation: Based on a previous study by Henan Dh et al., the umbilical cord area in pregnant women was 220.4±61.6 mm^2, assuming equal standard deviation in the GDM group and expecting a minimum difference between the two groups to be 35 mm^2 [10]. The minimum sample size required was 50 in each group.

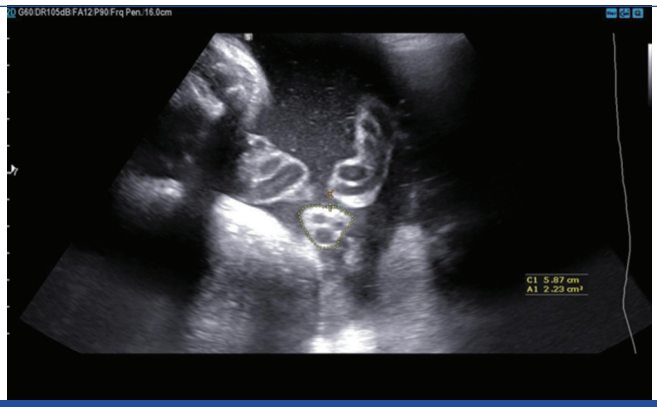
Inclusion and Exclusion criteria: Pregnant women with and without GDM and singleton pregnancies were included in the study. Pregnant women with pregestational diabetes, preeclampsia, multiple gestation

pregnancies, foetal congenital anomalies, and maternal chronic diseases such as hypertension, cardiac diseases, renal diseases, pulmonary diseases, and epilepsy were excluded from the study.

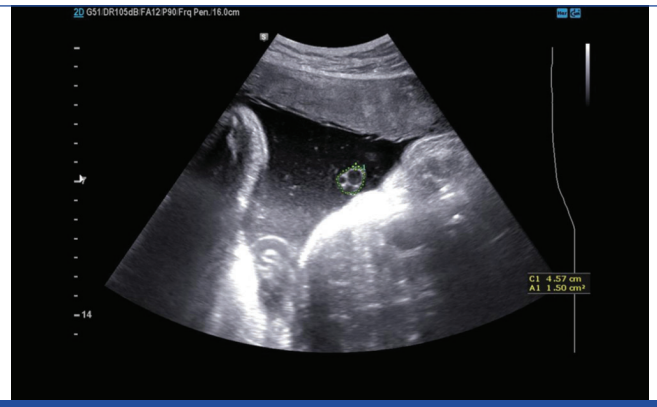
Study Procedure

Detailed clinical history with clinical examination was conducted, and the findings were recorded in the case record form. The pregnant women were divided into two groups. Group-I included 50 pregnant women with GDM diagnosed based on the Diabetes in Pregnancy Study Group India (DIPSI) criteria, and Group-II included 50 pregnant women without GDM as controls. DIPSI is a one-step screening and diagnostic procedure with 75 gm of oral glucose advocated during the first Antenatal Care (ANC) visit, irrespective of the last meal, and a venous sample was drawn at two hours [11].

Ultrasound technique: USG was performed using the Samsung Accuvix A35 Ultrasound machine with a 2-5 Mega Hertz curvilinear transducer in all women after 36 weeks. All the ultrasound examinations were performed by a single radiologist with 11 years of experience in the field of obstetric radiology. UCA was measured in a free-floating loop, away from the foetal and maternal insertion site, according to the method used by Binbir B et al., [12]. It was measured around the outer edges of the umbilical cord by using the trace function [Table/Fig-1,2]. Three measurements were taken, and the average value was recorded.



[Table/Fig-1]: Ultrasound image showing measurement of Umbilical Cord (UCA) cross-sectional area in a pregnant woman with GDM at 38 weeks.



[Table/Fig-2]: Ultrasound image showing measurement of Umbilical Cord (UCA) cross sectional area in a pregnant woman with GDM at 37 weeks.

Head Circumference (HC), Bi-parietal Diameter (BPD), Abdominal Circumference (AC), and Femur Length (FL) were measured, and Estimated Foetal Weight (EFW) was calculated using Hadlock's formula.

Maternal and neonatal outcomes were observed by following-up with the women until delivery. The NBW was measured by a digital scale. Macrosomia was defined as a birth weight ≥4000 grams.

STATISTICAL ANALYSIS

The correlation coefficient was calculated to determine the degree of correlation between UCA and NBW using the Pearson's correlation test [Table/Fig-3]. The correlation coefficient was compared between the GDM and non GDM groups. Data were entered into a Microsoft excel data sheet and analysed using Statistical Package for Social Sciences (SPSS) 22.0 software. Categorical data were represented in the form of frequencies and proportions. Continuous data were represented as mean and Standard Deviation (SD).

Correlation coefficient (r)	Interpretation
0-0.3	Positive weak correlation
0.3-0.6	Positive moderate correlation
0.6-1.0	Positive strong correlation
0 to (-0.3)	Negative weak correlation
(-0.3) to (-0.6)	Negative moderate correlation
(-0.6) to-(1)	Negative strong correlation

[Table/Fig-3]: Correlation coefficient to indicate the degree of correlation.

RESULTS

Total 78% of the patients belonged to the age group of 21-30 years. The mean age of participants was 26.5±3.9 years, ranging from 19 to 36 years [Table/Fig-4]. The mean gestational age at delivery was 39.3±0.96 weeks [Table/Fig-5]. The average calculated Body Mass Index (BMI) was 25.1±2.16 kg/m^2, 55% of the women were in the normal range (<25 kg/m^2), 41% were overweight, and 4% were obese.

Age distribution	Count	%
18 to 20 years	9	9.0%
21 to 25 years	31	31.0%
26 to 30 years	47	47.0%
>30 years	13	13.0%
Total	100	100.0%

[Table/Fig-4]: Maternal age distribution.

Profile distribution	Mean	SD	Median	Minimum	Maximum
Age (years)	26.55	3.91	27.00	19.00	36.00
Weight (kg)	64.29	5.08	64.00	52.00	79.00
Height (m)	1.60	0.05	1.60	1.49	1.70
BMI (kg/m^2)	25.11	2.16	24.78	19.49	31.65
Gestational age at delivery (in weeks)	39.33	0.96	39.00	37.00	42.00

[Table/Fig-5]: Maternal profile distribution.

A total of 48 newborns were delivered by LSCS, and 52 were delivered by normal vaginal delivery. The average birth weight of the newborns was 3200±480 grams and ranged from 2000 to 5000 grams. The majority (88%) of the newborns were in the range between 2500 and 4000 grams [Table/Fig-6]. A higher incidence of macrosomia was found in GDM Group (8%) compared to control Group (4%).

	Group			
	DM		Non DM	
Neonatal birth weight (grams)	Count	%	Count	%
< 2500 g	2	4.0 %	4	8.0 %
2500 to 4000 g	44	88.0 %	44	88.0 %
4000 to 4500 g	3	6.0 %	2	4.0 %
>4500 g	1	2.0 %	0	0 %

[Table/Fig-6]: Distribution of Neonatal Birth Weight (NBW).

According to Hadlock's formula, the average EFW was 3160 (±440) grams. The mean UCA was 228.5 (±54.99) mm^2 and ranged from 130 to 330 mm^2 [Table/Fig-7].

The authors found a strong positive correlation between UCA and NBW (r=0.79) [Table/Fig-8,9]. A strong positive correlation was also

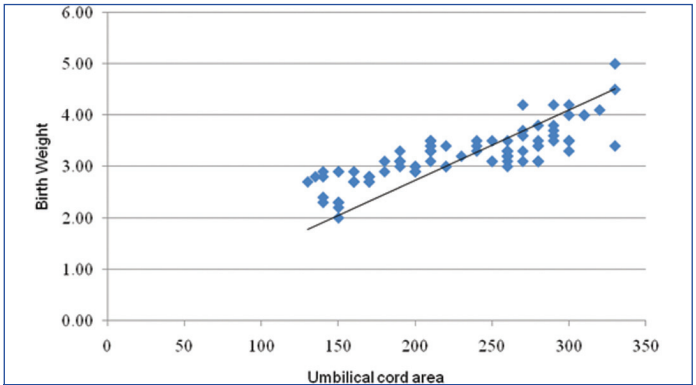
Parameters	Mean	SD	Median	Minimum	Maximum
EFW (kg)	3.16	0.44	3.20	1.80	4.50
Umbilical cord area (MM)	228.55	54.99	220.00	130.00	330.00
Umbilical cord area in GDM (MM)	241.4	58.75	260	130	330
Umbilical cord area in non GDM (MM)	215.7	46.94	210	100	290
Neonatal birth weight (kg)	3.22	0.48	3.20	2.00	5.00

[Table/Fig-7]: Main foetal parameters and sonographic indicators of foetal birth-weight.

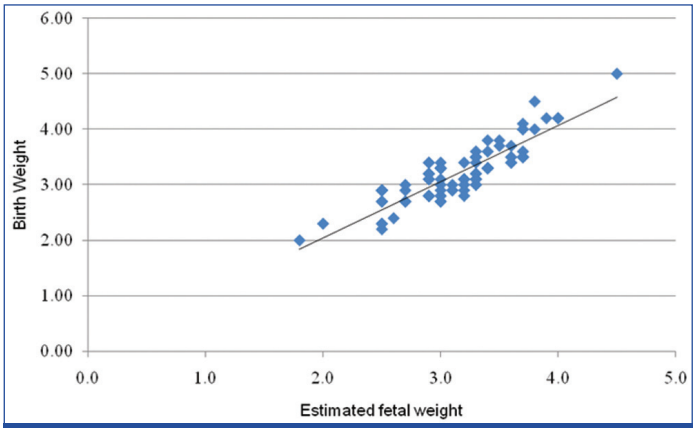
seen in both diabetic groups (r=0.819) and control groups (r=0.736). However, the correlation was stronger in GDM. A strong positive correlation was also found between NBW and EFW (r=0.860) [Table/Fig-10].

Parameters	Umbilical cord area (MM)	Birth weight (kg)
Pearson correlation	1	0.796**
p-value		<0.001**
N	100	100

[Table/Fig-8]: Correlation between Umbilical Cord (UCA) area and Neonatal Birth Weight (NBW).
**Correlation is significant at the 0.01 level (2-tailed)



[Table/Fig-9]: Scatterplot showing correlation between Umbilical Cord (UCA) area and Neonatal Birth Weight (NBW).



[Table/Fig-10]: Scatterplot showing correlation between Estimated Foetal Weight (EFW) and Neonatal Birth Weight (NBW).
Ethical Committee Clearance Certificate

There was a stronger positive correlation (r=0.860) between EFW and NBW compared to UCA and NBW (r=0.79).

DISCUSSION

In the present study, a higher incidence of macrosomia was found in the GDM group. Among diabetics, 8% had NBW >4000 gm. However, in subjects without diabetes, only 4% had NBW >4000 gm. This correlates with the study conducted by Binbir B et al., in which 6 of 41 (14.6%) pregnant women with GDM or pre-GDM delivered macrosomic foetuses, while 5 of 50 (10%) fetuses delivered by non diabetic pregnant women were macrosomic [12]. The relative risk of macrosomia for the diabetic group was found to be 1.5 times higher.

Naylor CD et al., reported the incidence of macrosomia as 16-29% in pregnant women with GDM and 10% in women without GDM [13]. This finding is in accordance with the present study.

Henan Dh et al., studied the correlation between UCA and NBW and concluded that the NBW prediction by UCA is more accurate than that by Hadlock's formula [10]. A statistically significant correlation was found between the Wharton's jelly and NBW (p-value <0.001).

Cromi A et al., found a large UCA in 11.1% (114/1026) fetuses, and the number of fetuses with a large UCA was significantly higher in the group of macrosomic fetuses than in that of non macrosomic fetuses, i.e., 29/53 (54.7%) vs. 85/973 (8.7%) (p<0.0001) [14]. Rakesh KG and Amit M studied the UCA with pregnancy outcome and found a significant correlation between the NBW and UCA (p-value <0.001) [15]. Barbeiri C et al., concluded that UCA is a weak prognosticator of the body weight [16]. This difference might be due to a difference in gestational age (20-40 weeks) and inclusion of low-risk pregnancy in the study.

In a retrospective study by Predanic M and Perni S done in 470 women, in which umbilical cord diameter was measured at a gestational age of 18-23 weeks, no significant correlation was found between umbilical cord diameter and NBW (p=0.332) [17].

Jain N and Singh A found that in women without GDM, UCA was comparable at 30-32 weeks (224.0 mm^2) and 36-38 weeks (228.8 mm^2) without a significant increase in UCA with advancing gestational age [18]. However, in the group with GDM, a significant increase was seen from 30-32 weeks (239.7 mm^2) to 36-38 weeks (250.1 mm^2), showing that in women with GDM, UCA increases significantly with advancing gestational age.

The most widely used formula for the assessment of foetal weight is the one proposed by Hadlock based on foetal biometric measurements. The positive predictive value of EFW is between 60 and 79% [19]. Cromi A et al., concluded that there is a significant improvement in the positive predictive value for macrosomic fetuses when EFW and UCA are combined [14]. The assessment of UCA is not likely to be affected by amniotic fluid volume or gestational age.

In the present study, there was a stronger positive correlation (r=0.860) between EFW and NBW compared to UCA and NBW (r=0.79). This differs from the study conducted by Henan Dh et al., who compared the EFW obtained by UCA with that of Hadlock's formula [10]. Upon comparing these two methods, they found that the prediction of NBW by UCA is more accurate than that by Hadlock's formula (R2 0.38 vs. 0.194).

In late pregnancy, UCA is an easily obtained sonographic value, unlike sonographic measurement of conventional biometric parameters (FL, BPD, HC, AC), which are technically difficult due to the relatively low position of the foetal head, distortion of AC, and posterior position of the femora. An additional advantage is that it took significantly less time for satisfactory measurement.

Limitation(s)

The basis for the larger umbilical cord in women with GDM is an increased amount of Wharton's jelly. The authors did not calculate the cross-sectional area of Wharton's jelly and umbilical cord vessels separately. The authors included women after 36 gestational weeks; thus, further studies are required to find the correlation between UCA and NBW in earlier gestational ages. Since all the examinations were performed by a single radiologist, the interobserver variations could not be accounted for.

CONCLUSION(S)

A strong positive correlation was seen between UCA and NBW. Therefore, a large UCA can be used to predict foetal macrosomia in a simple and reliable manner. UCA measurement can also be combined with the other foetal biometric parameters to increase the accuracy of foetal macrosomia prediction.

REFERENCES

[1] Akinci B, Celtik A, Yener S. Prediction of developing metabolic syndrome after gestational diabetes mellitus. Fertil Steril. 2010;93(4):1248-54.
[2] American Diabetes Association. Standards of medical care in diabetes-2010. Diabetes Care. 2010;33(Suppl 1):S11-61.
[3] Seshiah V, Balaji V, Balaji MS, Panneer Selvam A, Arthi T, Thamizharasi M, et al. Prevalence of GDM in South India (Tamil Nadu)-A Community based study. J Assoc Physicians India. 2008;56:329-33.
[4] Zargar AH, Sheikh MI, Bashir MI, Masoodi SR, Laway BA, Wani AI, et al. Prevalence of gestational diabetes mellitus in Kashmiri women from the Indian subcontinent. Diabetes Res Clin Pract. 2004;66(2):139-45.
[5] Grewal E, Kansra S, Khadgawat R, Kachhawa G, Ammini AC, Kriplani A, et al. Prevalence of GDM among women attending a Tertiary Care Hospital AIIMS Presented at DIPSI 2009 and 5th DIP Symposium, Sorrento, Italy. 2009.
[6] Wang H, Li N, Chivese T, Werfalli M, Sun H, Yuen L, et al. IDF Diabetes Atlas Committee Hyperglycaemia in Pregnancy Special Interest Group. IDF Diabetes Atlas: Estimation of Global and Regional Gestational Diabetes Mellitus Prevalence for 2021 by International Association of Diabetes in Pregnancy Study Group's Criteria. Diabetes Res Clin Pract. 2022;183:109050.
[7] Capobianco G, Gulotta A, Tupponi G, Dessole F, Pola M, Virdis G, et al. Materno-fetal and neonatal complications of diabetes in pregnancy: A retrospective study. J Clin Med. 2020;9(9):2707.
[8] Kamana Kc, Shakya S, Zhang H. Gestational diabetes and macrosomia: A systematic review. Ann Nutr Metab. 2015;66(Suppl 2):14-20.
[9] Beta J, Khan N, Fiolna M, Khalil A, Ramadan G, Akolekar R. Maternal and neonatal complications of fetal macrosomia: Cohort study. Ultrasound Obstet Gynecol. 2019;54(3):319-25.
[10] Henan Dh, Al-Jebory S, Cabog U, Asaad B, Mbchb, Skheel H. Cross sectional area of umbilical cord as a predictor for neonatal birth weight. Mustansiriya Med J. 2016;15(2):46-51.
[11] Seshiah V, Sahay BK, Das A, Balaji V, Shah S. Diagnosis and management of gestational diabetes mellitus: Indian guidelines. Diabetology. 2013;44(5):201-04.
[12] Binbir B, Yeniel A, Ergenoglu A, Kazandi M, Akercan F, Sagol S. The role of umbilical cord thickness and HbA1c levels for the prediction of fetal macrosomia in pregnant women with gestational diabetes mellitus. Arch Gynecol Obstet. 2012;285(3):635-39.
[13] Naylor CD, Sermer M, Chen E, Sykora K. Cesarean delivery in relation to birth weight and gestational glucose tolerance. Pathophysiology or practice style? JAMA. 1996;275(15):1165-70.
[14] Cromi A, Ghezzi F, Di Naro E, Siesto G, Bergamini V, Raio L. Large cross-sectional area of the umbilical cord as a predictor of fetal macrosomia. Ultrasound Obstet Gynecol. 2007;30(6):861-66.
[15] Rakesh KG, Amit M. Prognostic indices for pregnancy outcome on ultrasound: A prospective study. Pak J Radiol. 2012;22(3):78-83.
[16] Barbieri C, Guilherme Cecatti J, Krupa F, Francisco Marussi E, Vilton Costa J. Validation study of the capacity of the reference curves of ultrasonographic measurements of the umbilical cord to identify deviations in estimated fetal weight. Acta Obstet Gynecol Scand. 2008;87(3):286-91.
[17] Predanic M, Perni S. Absence of a relationship between umbilical cord thickness and coiling patterns. J Ultrasound Med. 2005;24(11):1491-96.
[18] Jain N, Singh A. Estimation of sonographic umbilical cord area and its correlation with birth weight in gestational diabetes mellitus. Annals of Applied Bio-Sciences. 2016;3(2):A123-27.
[19] Bolanca I, Kuna K, Herman R, Kosec V, Herman M. Ultrasonographic estimation of fetal weight-residents accuracy. Coll Antropol. 2005;29(2):465-68.

PARTICULARS OF CONTRIBUTORS:
1. Associate Professor, Department of Radiology, Bangalore Medical College, Bengaluru, Karnataka, India.
2. Senior Resident, Department of Radiology, Bangalore Medical College, Bengaluru, Karnataka, India.
3. Associate Professor, Department of Radiology, Bangalore Medical College, Bengaluru, Karnataka, India.
4. Senior Resident, Department of Radiology, Bangalore Medical College, Bengaluru, Karnataka, India.
5. Senior Resident, Department of Obstetrics and Gynaecology, Bangalore Medical College, Bengaluru, Karnataka, India.
6. Senior Resident, Department of Radiology, Bangalore Medical College, Bengaluru, Karnataka, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Divyashree P Katti,
Senior Resident, Department of Radiology, Bangalore Medical College,
Bengaluru-560002, Karnataka, India.
E-mail: divyaabdf4@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Jul 11, 2023
- Manual Googling: Sep 15, 2023
- iThenticate Software: Dec 11, 2023 (11%)

ETYMOLOGY: Author Origin

EMENDATIONS: 7

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

Date of Submission: **Jul 05, 2023**
Date of Peer Review: **Sep 05, 2023**
Date of Acceptance: **Dec 14, 2023**
Date of Publishing: **Feb 01, 2024**