

## EVALUATION OF FETAL WEIGHT SONOGRAPHICALLY USING AREA OF WHARTON'S JELLY AND MORPHOLOGY OF UMBILICAL CORD

SUSMITA SENAPATI<sup>1\*</sup>, SHASHI SHANKAR BEHERA<sup>2</sup>, PRAFULLA KUMAR CHINARA<sup>1</sup>

<sup>1</sup>Department of Anatomy, Institute of Medical Sciences and Sum Hospital, Bhubaneswar, Odisha, India. <sup>2</sup>Department of Obstetrics and Gynaecology, Kalinga Institute of Medical Sciences, KIIT University, Bhubaneswar, Odisha, India. Email:

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### ABSTRACT

**Objective:** To establish a sonographic relationship between Area of Wharton's Jelly (AWJ) and umbilical cord morphometry with the birth weight of the fetus in low-risk pregnancies from 13 to 40 weeks.

**Methods:** A total of 800 singleton pregnant females were subjected for routine sonographic evaluation. The umbilical cord length, diameter, and AWJ were determined. The gestational age and fetal weight were determined using usual fetal parameters. Umbilical cord morphometry along with Area of Wharton Jelly can be utilized as other parameters to increase the accuracy of fetal weight.

**Results:** In our study, the umbilical cord diameter at birth showed statistically significant positive correlation with birth weight ( $R=0.167$ ;  $p<0.001$ ). Umbilical cord length, diameter, and Area of Wharton Jelly showed statistically significant positive correlation with birth weight ( $p<0.001$ ).

**Conclusion:** Using statistical analysis, a positive correlation was established between estimated fetal weight and fetal age with umbilical cord morphometry and AWJ.

**Keywords:** Gestational age, Fetal weight, Wharton's Jelly.

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### INTRODUCTION

The well-being of the fetus is influenced by a number of factors all of which are clearly seen in terms of the birth weight. A low birth weight (LBW) baby is definitely a challenge to the obstetrician and neonatologist. Hence, accurate estimation of fetal weight in antenatal period is helpful in proper management of the pregnant mother and also decreases the associated morbidity [1].

Umbilical cord is connecting cord from developing fetus to placenta. It is derived from allantois and stalk of yolk sac. It is physiological and genetically part of the fetus which conveys the nutrients to fetus from placenta and carries waste products from fetus to placenta. It contains 2 arteries and 1 vein buried in Wharton's Jelly which gives flexibility, mobility, and strength to resist compression at the same time allows the fetus to move freely [1]. Umbilical cord plays an important role in fetal well-being. Several umbilical cord abnormalities are known to cause the adverse prenatal outcome. Abnormal cord length, thick or lean umbilical cords, hyper coiling or hypo coiling, marginal or velamentous insertion of cord may be associated with intrauterine growth restriction, and intrauterine death or fetal distress. Hence, umbilical cord parameters were studied and correlated with fetal parameters.

Studies on the morphological and morphometric characteristic of umbilical cord over the years have found a positive correlation with perinatal outcome and fetal weight [3]. While morphological characteristics such as tensile strength, diameter, umbilical cord circumference, Wharton's Jelly content, umbilical cord length and weight were determined genetically, the umbilical cord development, differentiation, growth and elongation would depend on the sex, nutrient supply, and health status of the fetus [4]. The Wharton's Jelly is one of the major components of the umbilical cord in the 2<sup>nd</sup> and 3<sup>rd</sup> trimesters of pregnancy.

In our study, we want to evaluate the accuracy of morphometry of umbilical cord and Area of Wharton's Jelly (AWJ) with relation to birth weight.

### MATERIALS AND METHODS

A prospective cohort clinical study was conducted after Institutional Ethics Committee approval, from January 2013 to December 2015. 800 clinically stable singleton antenatal mothers (aged 18-40 years) from (14<sup>th</sup>-39<sup>th</sup> weeks) attending the antenatal clinic of, Institute of Medical Sciences and Sum Hospital and Kalinga Institute of Medical Sciences Hospital, Bhubaneswar, Odisha, India, in the Department of Obstetrics and Gynaecology subjected for routine ultrasonography between 14 and 40 weeks of gestation were included in the study. Mothers with twin pregnancy, fetus with congenital malformation, fetus with growth retardation, intrauterine death and mothers with medical, and surgical, or obstetric complication associated with pregnancy were excluded from the study.

Normal, healthy, and singleton pregnant woman having accurate knowledge of her last menstrual period and bearing healthy single live fetus was considered as a subject for the above-mentioned study.

Ultrasonography was performed by a single sonologist using a single ultrasound machine to avoid intra observer bias. Area of the umbilical cord was measured along with diameters of all umbilical vessels. AWJ was computed by the formula used below:

$$AWJ = UCA - (UCV + UCA1 + UCA2)$$

AWJ=Area of Wharton's Jelly  
UCA=Area of umbilical cord  
UCV=Area of umbilical vein  
UCA1, UCA2=Area of both the umbilical arteries.

### Statistical analysis

Statistical analysis was performed using Microsoft Excel (2007 version) and the Statistical Package for the Social Sciences (SPSS) version 12. The various statistical tests such as Student t-test was done using

Microsoft Excel and Pearson's correlations were done using SPSS. All charts were drawn with Microsoft Excel. Statistical significance was defined as  $p < 0.05$ .

**OBSERVATIONS AND RESULTS**

Table 1 summarizes distribution of cases according to maternal age. In our study, majority of selected cases were in the age group of 21-25 years (50.50%) followed by age group 18-20 years (38.50%) and only 3% were in age group of >30 years. The mean age of cases was  $22.47 \pm 3.86$  years (range: 18-40 years).

Table 2 showed the distribution of patients according to trimester of pregnancy. It was observed that in our study majority of patients were from 2<sup>nd</sup> trimester (56.50%) followed by 3<sup>rd</sup> trimester (43.50%). The mean gestational age among patients during pregnancy was  $26.16 \pm 6.72$  weeks (range: 14-38 weeks).

Fig. 2 shows that in our study majority of patients were from 2<sup>nd</sup> trimester (56.50%) followed by 3<sup>rd</sup> trimester (43.50%).

Table 3 showed the distribution of patients according to umbilical cord diameter. The mean umbilical cord thickness at 14 weeks was  $3.73 \pm 0.66$  mm while  $21.27 \pm 0.21$  mm at 39 weeks. It shows the thickness of umbilical cord gradually increases as gestational increases.

Fig. 3 shows thickness of umbilical cord gradually increases as gestational increases.

The relation of gestational age and umbilical cord length during pregnancy showed a  $R^2 = 0.999$  and an adjusted  $R^2 = 0.990$ . ANOVA analysis showed  $F = 3651.701$  and a  $p < 0.0001$ . This shows a very strong correlation between umbilical cord length and gestational age which was also statistically significant.

The regression equation for umbilical cord length was  $Y = 0.721x - 6.242$ .

Table 4 showed the distribution of patients according to AWJ. The mean AWJ thickness at 14 weeks was  $22.50 \pm 0.20$  mm while  $141.32 \pm 1.28$  mm at 39 weeks.

The relation of gestational age and AWJ during pregnancy showed a  $R^2 = 0.886$  and an adjusted  $R^2 = 0.881$ . ANOVA analysis showed  $F = 2413.28$  and a  $p < 0.0001$ . This shows a very strong correlation between the AWJ and gestational age which was also statistically significant. The regression equation for Wharton's Jelly area was  $Y = 5.495x - 4.11$ .

Table 5 described umbilical cord characteristic just after delivery. The mean umbilical cord diameter was  $1.20 \pm 0.20$  cm; length  $54.94 \pm 6.89$  cm; and mean Wharton Jelly area was  $90.06 \pm 7.92$  mm.

The umbilical cord insertion among the majority of subjects was central (63.50%) followed by peripheral insertion (35%) and paracentral (1.50%).

**Table 1: Age distribution of patients under study**

Age group (years)	Number of patients	Percentage	Mean age (years)
18-20	308	38.50	22.47±3.86
21-25	404	50.50	
26-30	64	8.00	
≥30	24	3.00	
Total	800	100	

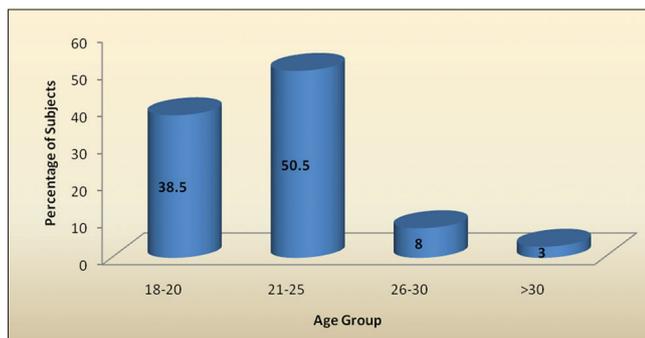
**Table 2: Distribution of patients as per gestational age**

Gestational age (weeks)	Number of patients	Percentage	Mean GA
>12-28	452	56.50	26.16±6.72
28-40	348	43.50	

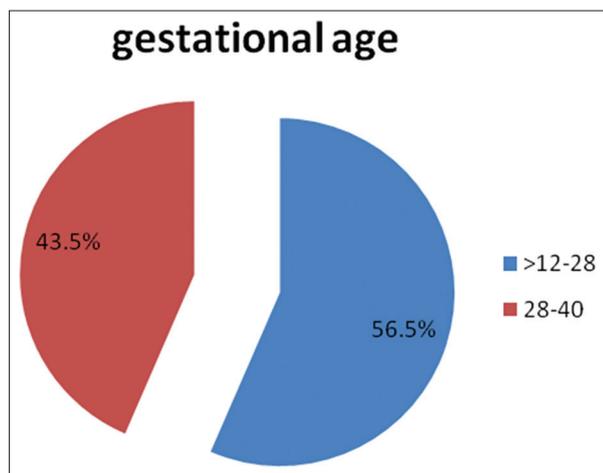
**Table 3: Distribution of umbilical cord diameter in as per gestational age in our study**

Gestational age	Number of patients	Umbilical cord diameter	SD
14	08	3.73	0.66
15	12	4.25	0.41
16	28	5.30	0.22
17	28	5.98	0.21
18	56	6.86	0.24
19	24	7.43	0.19
20	28	8.14	0.18
21	28	8.83	0.20
22	52	9.65	0.31
23	36	10.33	0.28
24	44	11.05	0.21
25	24	11.69	0.42
26	24	12.61	0.34
27	24	13.27	0.26
28	36	14.21	0.31
29	28	14.77	0.34
30	40	15.88	0.28
31	36	16.16	0.41
32	32	16.87	0.61
33	44	17.70	0.54
34	36	18.36	0.62
35	60	19.02	0.42
36	36	19.70	0.51
37	24	20.53	0.43
38	08	20.87	0.37
39	04	21.27	0.21

SD: Standard deviation



**Fig. 1: Age distribution of patients under study**



**Fig. 2: Distribution of patients as per gestational age**

The distribution of neonates according to birth weight showed that among 800 neonates, 404 (50.50%) neonates were having a weight between 2000 and 2500 g. 56 (7%) neonates had weight <2000 g while 340 (42.50%) neonates were having weight >2500 g (Table 6).

The distribution of neonates according to birth weight showed that neonates having a weight between 2000 and 2500 g were the majority in our study (Fig. 5).

Table 7 described the correlation between birth weight and umbilical cord characteristics. It was observed that umbilical cord length, diameter, and Area of Wharton Jelly showed statistically significant positive correlation with birth weight ( $p < 0.001$ ).

Fig. 6 summarizes correlation between birth weight and umbilical cord length. It was observed that umbilical cord length at birth showed statistically significant positive correlation with birth weight ( $R = 0.112$ ;  $p < 0.001$ ).

**Table 4: Distribution of AWJ as per gestational age in our study**

Gestational age	Number of patients	AWJ	SD
14	08	22.50	0.20
15	12	21.67	2.08
16	28	28.57	4.35
17	28	35.85	3.89
18	56	41.92	1.89
19	24	44.83	1.47
20	28	67.14	1.34
21	28	69.83	1.67
22	52	79.38	2.75
23	36	86.22	5.54
24	44	95.36	2.37
25	24	113.50	2.34
26	24	115.83	2.22
27	24	120.16	1.47
28	36	128.77	5.51
29	28	134.42	1.98
30	40	137.80	2.09
31	36	141.55	2.12
32	32	142.12	1.55
33	44	141.81	1.47
34	36	141.11	1.45
35	60	140.86	1.95
36	36	142.44	1.23
37	24	138.33	2.18
38	08	139.67	1.37
39	04	141.32	1.28

SD: Standard deviation, AWJ: Area of Wharton's Jelly

**Table 5: Characteristics of umbilical cord just after delivery**

Umbilical cord characteristic	Mean±2SD
Length (cm)	54.94±6.89
Diameter (cm)	01.20±00.20
Wharton jelly area (mm)	90.06±7.92
Cord Insertion (n=800) (%)	
Central	508 (63.50)
Peripheral	280 (35.00)
Paracentral	12 (01.50)

SD: Standard deviation

**Table 6: Distribution of neonates according to birth weight**

Birth weight (g)	Number of neonates (%)
<2000	56 (07.00)
2000-2500	404 (50.50)
>2500	340 (42.50)
Total	800 (100)

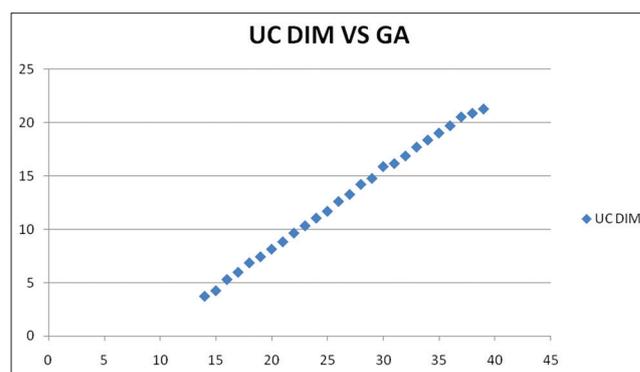
Fig. 7 summarizes correlation between birth weight and umbilical cord diameter. It was observed that umbilical cord diameter at birth showed statistically significant positive correlation with birth weight ( $R = 0.167$ ;  $p < 0.001$ ).

Fig. 8 summarizes correlation between birth weight and Wharton's Jelly area. It was observed that Wharton's Jelly area at birth showed statistically significant positive correlation with birth weight ( $R = 0.214$ ;  $p < 0.001$ ).

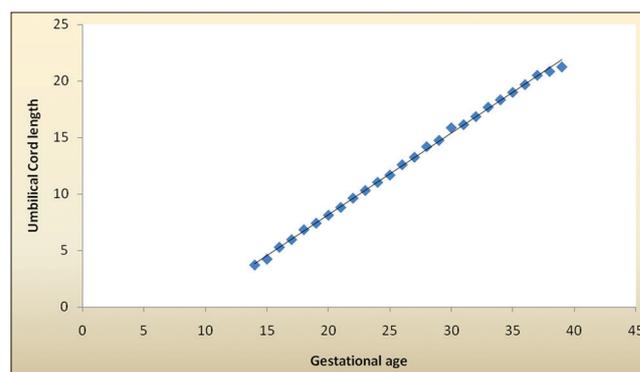
It was observed that umbilical cord length, diameter, and Wharton Jelly area were significantly lower in LBW as compared to normal weight neonates ( $p < 0.05$ ).

**DISCUSSION**

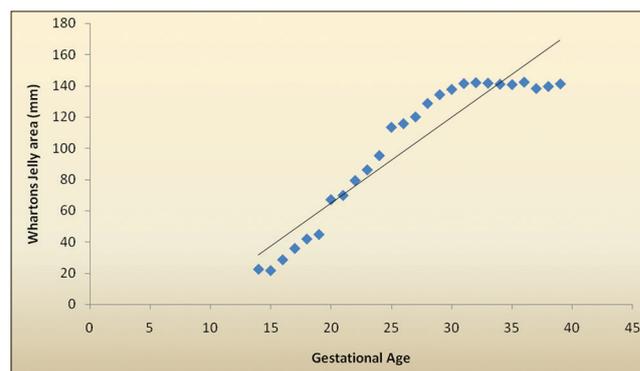
The present longitudinal study conducted to evaluate the accuracy of fetal weight from the measurement of umbilical cord morphometry



**Fig. 3: Distribution of umbilical cord diameter in as per gestational age in our study**



**Fig. 4: Relationship between gestational age and umbilical cord length**

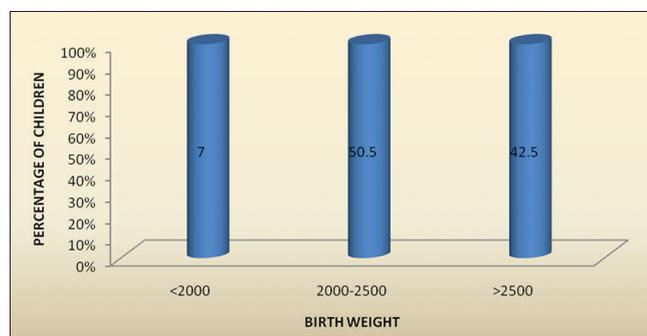


**Fig. 5: Correlation of gestational age and Wharton's Jelly area**

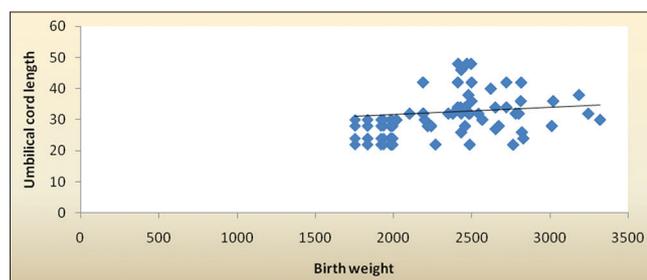
**Table 7: Correlation of birth weight and umbilical cord characteristics after birth**

Correlation of birth weight	R value	p value
Umbilical cord length	0.112	<0.001*
Umbilical cord diameter	0.167	<0.001*
AWJ	0.214	<0.001*

\*p<0.05 statistically significant, AWJ: Area of Wharton’s Jelly



**Fig. 6: Distribution of neonates according to birth weight**



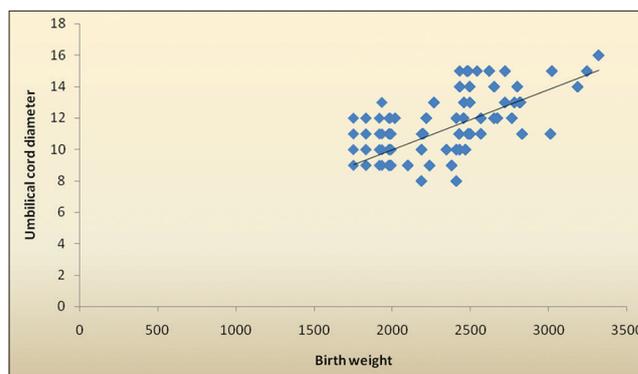
**Fig. 7: Correlation of birth weight and umbilical cord length**

and AWJ by ultrasound. The effect of umbilical cord length on fetal development has been analyzed by many researchers. It was reported that there was a positive correlation between umbilical cord length and fetal weight.

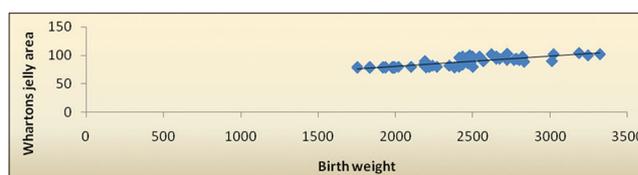
The study was conducted during the period of January 2013-December 2015. A total sample size of 800 subjects was enrolled in the study.

In this study, majority of selected cases were in the age group of 21-25 years (50.50%) followed by age group 18-20 years (38.50%) and least were in age group of >30 years (03%). The mean age of cases was 22.47±3.86 years (range: 18-40 years). Among 800 patients majority of patients were from gestational age 35 weeks (7.5%) followed by 18 weeks (7%).

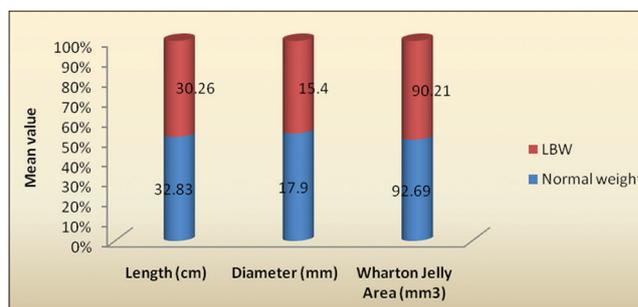
The length of the umbilical cord varies from no cord (achordia) to 300 cm, with diameters up to 3 cm (Valsamakis *et al.*, 2006). At term, the typical umbilical cord is 55-60 cm in length, with a diameter of 2.0-2.5 cm (Yetter, 1998). About 5% of cords are shorter than 35 cm, and another 5% are longer than 80 cm (Berg and Rayburn, 1995). Although it is not fully understood what controls cord length; various authors correlate cord length with fetal activity and movement. It is suggested that sufficient space in the amniotic cavity for movement and the tensile force applied to the umbilical cord during fetal movements are two main factors that determine cord length (Benirschke, 2004). In investigating the clinical significance of umbilical cord length in human pregnancies, Wu *et al.* (1996) found out that cord length was significantly related to birth weight. They, however, found out that the umbilical cord length does not significantly correlate with maternal age, gestational age, parity, fetal outcome, or intrauterine fetal well-being.



**Fig. 8: Correlation of birth weight and umbilical cord diameter**



**Fig. 9: Correlation of birth weight and Wharton's Jelly area**



**Fig. 10: Comparison of umbilical cord morphology in normal and low birth weight neonates**

In our study, Table 3 showed the mean umbilical cord thickness varies from at 14 weeks was 3.73±0.66 mm while 21.27±0.21 mm at 39 weeks.

The relation of gestational age and umbilical cord length during pregnancy in our study as showed in Fig. 5 was very strong. The correlation between umbilical cord length and gestational age was also statistically significant.

The mean AWJ thickness at 14 weeks was 22.50±0.20 mm while 141.32±1.28 mm at 39 weeks.

The relation of gestational age and AWJ during pregnancy showed a very strong correlation between the AWJ and gestational age which was also statistically significant. The regression equation for Wharton’s Jelly area was Y=5.495x-4.11.

Similar findings were seen in a study conducted by Barbieri *et al.* [11] where the AWJ increased according to gestational age (R<sup>2</sup>=0.64), stabilizing from the 32<sup>nd</sup> week onward. There was a significant linear correlation between AWJ and EFW up to 26 weeks (R=0.782), and after that, it remained practically constant (R=0.047). The AWJ increases according to gestational age, with a trend to stabilize at around 32 weeks of gestation. It is also linearly correlated with EFW only up to 26 weeks of gestation.

In this study; the mean umbilical cord diameter was 1.20±0.20 cm; length 54.94±6.89 cm; and mean Wharton Jelly area was 90.06±7.92 mm.

The findings of the present study were in accordance with a study conducted by Islam [10]; the mean umbilical cord diameter was  $1.22 \pm 0.24$  cm; length  $30.81 \pm 11.79$  cm; and mean Wharton Jelly area was  $95.18 \pm 9.12$  mm.

It was observed that umbilical cord length, diameter, and Area of Wharton Jelly showed statistically significant positive correlation with birth weight ( $p < 0.001$ ). It was observed that umbilical cord length at birth showed statistically significant positive correlation with birth weight ( $R = 0.112$ ;  $p < 0.001$ ).

Similar findings were seen in a study conducted by Petekkaya *et al.* [12] where there was a significant positive correlation between umbilical cord and birth weight.

In our study from Fig. 9, it was observed that umbilical cord length, diameter, and Wharton Jelly area were significantly lower in LBW as compared to normal weight neonates ( $p < 0.05$ ).

### CONCLUSION

The present longitudinal study was conducted to evaluate the accuracy of fetal weight from the measurement of umbilical cord morphometry and AWJ by ultrasonography. Correlation of cord parameters with perinatal outcomes suggests that antenatal detection of umbilical cord abnormalities may be useful in the detection of fetuses at risk of cord related complications.

There was a significant difference between the intrauterine ultrasonographic measurements and the gross anatomical measurements, therefore, intrauterine ultrasonography may be used as a preliminary guide for the determination of fetal well-being.

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