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

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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 2nd and 3rd 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 (14-39+6 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:

\[ AWJ = \text{UCA} - (\text{UCV} + \text{UCA}_1 + \text{UCA}_2) \]

\[ AWJ = \text{Area of Wharton’s Jelly} \]
\[ \text{UCA} = \text{Area of umbilical cord} \]
\[ \text{UCV} = \text{Area of umbilical vein} \]
\[ \text{UCA}_1, \text{UCA}_2 = \text{Area of both the umbilical arteries} \]

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±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 2nd trimester (56.50%) followed by 3rd trimester (43.50%). The mean gestational age among patients during pregnancy was 26.16±6.72 weeks (range: 14-38 weeks).

Table 3 described umbilical cord characteristic just after delivery. 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 umbilical cord insertion among the majority of subjects was central (63.50%) followed by peripheral insertion (35%) and paracentral (1.50%).

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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±0.20 mm while 141.32±1.28 mm at 39 weeks.

The relation of gestational age and AWJ during pregnancy showed a R²=0.886 and an adjusted R²=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±0.20 cm; length 54.94±6.89 cm; and mean Wharton Jelly area was 90.06±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             | 380                | 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
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).

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

| 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±0.20 |
| Wharton jelly area (mm)       | 90.06±7.92 |
| Cord Insertion (n=800) (%)    | Central: 508 (63.50); Peripheral: 280 (35.00); Paracentral: 12 (1.50) |

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)              |
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). 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.

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 (R²=0.64), stabilizing from the 32nd 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.

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