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Original Article

Positive correlation between the quantity of Wharton's jelly in the umbilical cord and birth weight

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Abstract

Objective: To determine the possible protective effects of Wharton's jelly (WJ) in umbilical cord and fetal growth by investigating the relationship between the amount of WJ and fetal birth weight.

Materials and Methods: This study enrolled 299 women who delivered after an uneventful pregnancy. After separation of the placenta, a 5 cm long section of umbilical cord was removed by scalpel. The weight of the cord section; the weight, volume, and density of its WJ; and the weight of the newborn and placenta were measured.

Results: A significant positive correlation was found between WJ quantity, birth weight ($p = 0.002$), and placental weight ($p = 0.003$), whereas a significant negative correlation was observed for WJ density, fetal growth ($p = 0.035$), and placental growth ($p = 0.002$). WJ density was 1.63 ± 0.27 g/mL. No significant correlation was found between the amount of WJ and weight gained during pregnancy ($p = 0.274$) or maternal age ($p = 0.220$).

Conclusion: As the amount of WJ increases, fetal weight increases. Accordingly, the amount of WJ might be a factor that influences fetal growth.

Keywords: Birth weight; Umbilical cord; Wharton's jelly

Introduction

The umbilical cord is a helical structure that connects the fetus to the placenta and is vital for fetal growth. Its length averages 50−60 cm and the diameter is 1.5−2 cm. At term, the velocity of blood in the umbilical cord is 500−700 mL/min. In cross section, two arteries and a vein are seen in the cord, which are surrounded by Wharton's jelly (WJ), a soft sheath of specialized connective tissue.

Wharton's Jelly is homogenous, rich in proteoglycans, and surrounded by myofibroblasts, which are mesenchymal cells with the characteristics of both fibroblasts and smooth muscle cells. Myofibroblasts have both fibrogenesis and contractile functions and produce increasing amounts of Type I, II, and V collagen fibrils over the pregnancy, giving WJ elastic and contractile properties as well as microfibrils [1,2]. Hyaluronic acid is the most common glucosaminoglycan of WJ, and the hydrophilicity of WJ causes it to absorb water and electrolytes. Hence, its elasticity helps resist external pressure, and it acts as a physical buffer in the regulation of fetoplacental blood circulation and umbilical vessels [3].

Despite the documented importance of WJ in protecting fetoplacental circulation, little information is available on its quantitative variations and clinical correlations. Thus, knowledge on factors related to WJ quantity may have clinical utility. The aim of this study was to use postnatal and fetal birth weights to investigate the relationship between the amount of WJ and its protective role in umbilical cord vessels and, hence, on fetal growth.

Materials and methods

This study enrolled 299 women who delivered at 37−42 gestational weeks at the Delivery Unit of Zekai Tahir Burak

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Women's Education and Research Hospital, after an uneventful pregnancy. Excluded were patients with preeclampsia, intrauterine growth restriction (IUGR), intrauterine infection, gestational diabetes, or chronic systemic disorders, such as chronic hypertension, hearth disease, thyroid disorders and so on. The study was approved by the local ethics committee.

For each subject, age, gravidity, parity, weight gained during pregnancy, and gestational age confirmed by last menstruation period or first trimester ultrasonograph were recorded. Following vaginal or cesarean section delivery, and after proper separation of the placenta, the umbilical cord with three intact vessel structures was collected. A 5-cm long section of umbilical cord was cut by scalpel, approximately 30 cm from the insertion of the cord in the placenta. The sample was rinsed with saline solution at 37°C and cleaned, and after blood was drained, its weight in grams was measured using a scale with a sensitivity to 0.01 g. Cord sections were incubated in 10% formaldehyde in individual containers for 10 minutes. After removal and drying, the cord section was weighed again. Using a scalpel, the cord vessels and membranes were gently separated from the WJ and the weight of the WJ obtained. The volume of the WJ was calculated by measuring the amount of water displaced when the jelly was placed in a volume measurement container. Density of WJ was calculated [WJ (g)/ water (mL)]. All umbilical cord procedures were carried out by the same author (B. Rahime) to prevent interobserver variability during preparation. Newborns and placentas were weighed in grams using calibrated electronic baby scales.

Data analysis was performed using the SPSS 11.5 (SPSS Inc., Chicago, IL, USA) statistics program. Data distribution was assessed using the Kolmogorov-Smirnov test of normality. Mean values and standard deviations were calculated for continuous variables. Correlation between parameters was analyzed using Pearson's correlation coefficient and tested for significance (Pearson r value; p value). Significance was set at $p < 0.05$.

Results

Subject characteristics are shown in Table 1. By route of delivery, 210 (70.2%) cases were vaginal and 89 (29.8%) were cesarean section. Of the newborns, 151 were female (50.5%) and 148 (49.5%) were males.

Table 1
Characteristics of cases and cord sections (5 cm per umbilical cord)

Characteristics	Mean ± SD	Minimum−Maximum
Age (yr)	26.5 ± 5.5	17−41
Gravidity	2.4 ± 1.4	1−8
Parity	1.0 ± 1.1	0−5
Gestational age at birth (wk)	39.3 ± 1.4	37.0−42.0
Weight gain during pregnancy (kg)	12.4 ± 4.4	0−25
Birth weight (g)	3,315 ± 465	2,070−4,830
Placental weight (g)	588 ± 110	380−1,060
Umbilical cord weight (g)	5.28 ± 1.14	2.44−9.76
Wharton's Jelly weight (g)	3.34 ± 0.87	1.44−6.26
Wharton's Jelly volume (mL)	2.05 ± 0.68	1.5−5.5
Wharton's Jelly density (g/mL)	1.63 ± 0.27	0.96−2.14

SD = Standard deviation.

The mean weight of WJ was 3.34 ± 0.87 g, and the mean volume was 2.05 ± 0.68 mL. The mean WJ density was 1.63 ± 0.27 g/mL (Table 1). A significant positive correlation was observed between WJ weight and newborn birth weight ($r = 0.184$, $p = 0.002$), demonstrating that as birth weight increased, the amount of WJ increased (Fig. 1). A significant correlation was also found between the amount of WJ and the placental weight ($r = 0.173$, $p = 0.003$), with placental weight increasing as WJ amount increased (Fig. 2). In contrast, a significant negative correlation was observed between the WJ density and both birth weight ($r = -0.125$; $p = 0.035$) (Fig. 3), and placental weight ($r = -0.180$; $p = 0.002$) (Fig. 4).

No significant correlation was found between weight gained during pregnancy and the amount of WJ ($r = -0.081$, $p = 0.274$), and no significant correlation occurred between maternal age and WJ amount ($r = 0.133$, $p = 0.220$). Comparing the WJ weight and density according to fetal sex, mean WJ weight was higher for male fetuses (3.45 ± 0.86 g *vs.* 3.20 ± 0.85 g; $p = 0.013$), but the mean WJ density values were similar between male and female fetuses (1.74 ± 0.36 g/mL *vs.* 1.70 ± 0.31 g/mL; $p = 0.277$).

Discussion

The umbilical cord is involved in gas and substance exchange between the mother and the fetus and thereby directly influences fetal development and growth, and the prognosis of pregnancy and neonatal outcome [4,5]. The strong but flexible morphology of the cord makes it resistant to external compressive forces. Within the umbilical cord, WJ surrounds the umbilical vessels as a connective tissue, providing

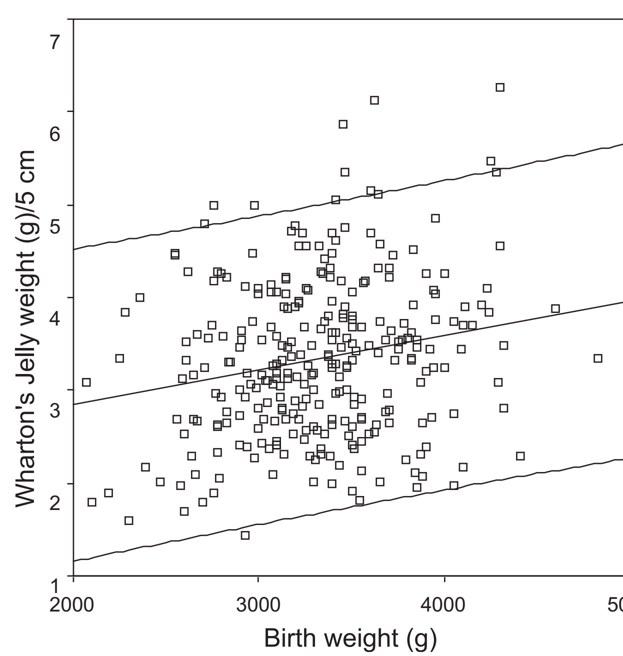

Fig. 1. Correlation between Wharton's Jelly weight and birth weight ($r = 0.184$; $p = 0.002$).

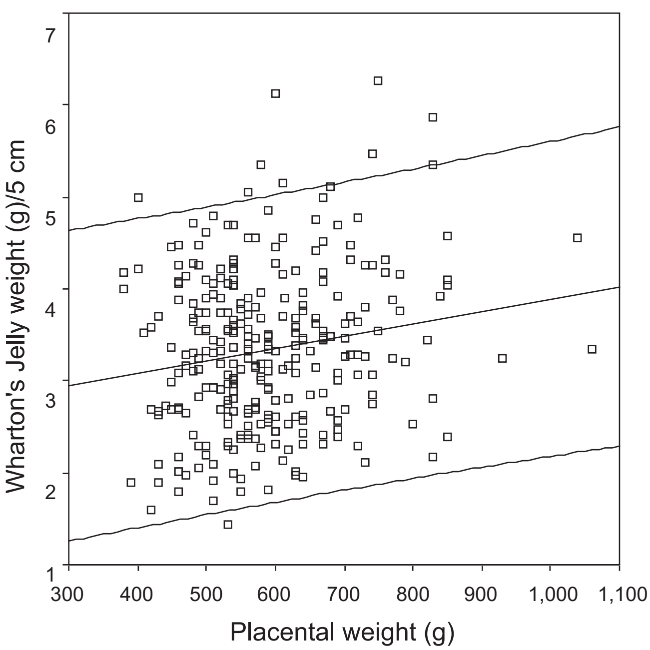

Fig. 2. Correlation between Wharton's jelly weight and placental weight ($r = 0.173$; $p = 0.003$).

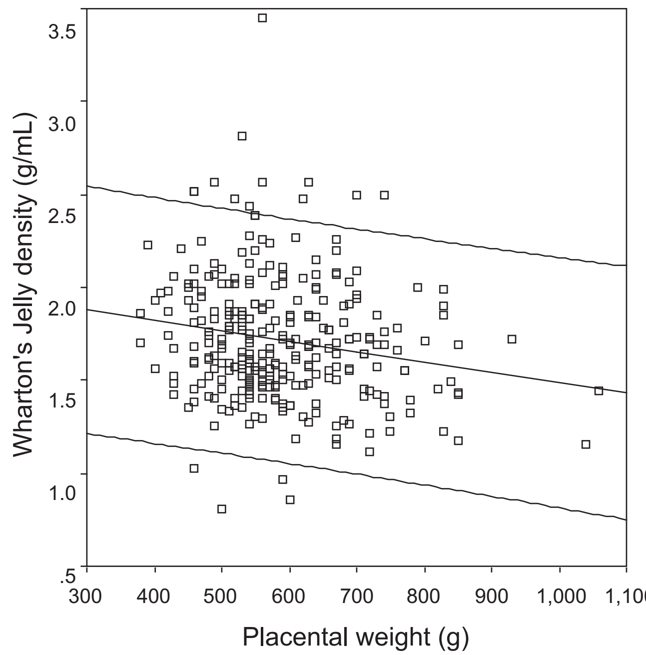

Fig. 4. Negative correlation between Wharton's Jelly density and placental weight ($r = -0.180$; $p = 0.002$).

a cushion-like protection and play a role like a vessel adventitia that has a critical importance in fetal growth. Theoretically, the protective effect of the jelly increases with its volume, and this should have a favorable effect on fetal nutrition by facilitating fetoplacental circulation. The absence of WJ around umbilical vessels is directly associated with fetal death [6], and a weak umbilical cord is associated with unfavorable pregnancy outcomes [7,8].

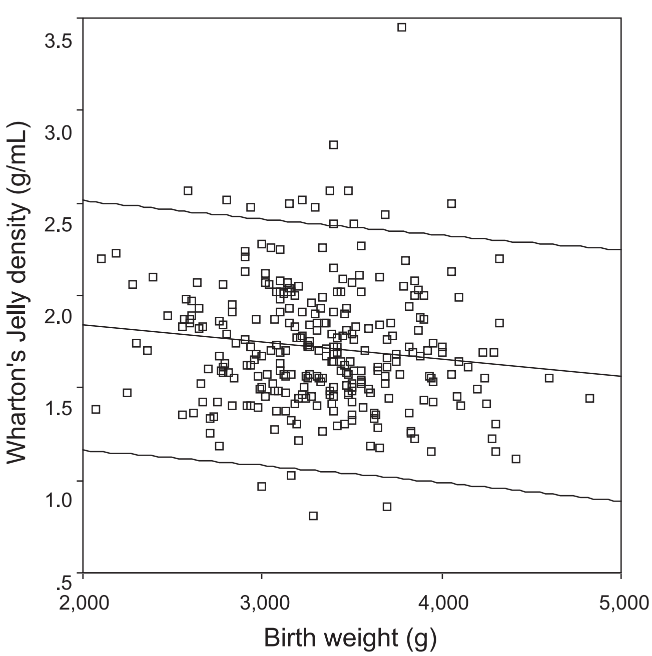

Fig. 3. Negative correlation between Wharton's Jelly density and birth weight ($r = -0.125$; $p = 0.035$).

To date, several studies have investigated the effects of WJ. However, all have used indirect measures, such as prenatal ultrasonographic measurements of the diameter and area of umbilical cord, and cross-sectional areas of umbilical vessel, to study the relationship between WJ and fetal anthropometric parameters [9–14].

Raio et al [10] found a significant correlation between the diameter and area of the umbilical cord, and fetal anthropometric parameters. In contrast, Silver et al [11] established that the diameter of the umbilical cord was smaller in postterm pregnancies with oligohydramnios, than in those with a normal amnion. The same study found that variable decelerations in the fetal hearth rate were higher in umbilical cords with small diameters than those with normal diameters. Several prospective studies carried out in the second trimester proposed that a weak umbilical cord measured by ultrasonographic evaluation might be used as an early determinant for infants with low birth weight and birth complications [4,7,11,12].

Bruch et al [4] found no difference in umbilical cord artery lumens in normal weight fetuses and fetuses with IUGR, suggesting that the cause of the weight difference is the amount of WJ in the cord or the reduction of the veins lumens. In contrast, Predanic and Perni [13] measured umbilical cord thickness in the second trimester by ultrasonography and found no correlation with neonatal birth weight.

Ghezzi et al [14] reported that whole umbilical cord area and umbilical vein cross-sectional area were markedly smaller in babies who required newborn intensive care; and in fetuses with IUGR, small umbilical vein area was associated with retardation in fetal growth and unfavorable neonatal outcome. The umbilical artery cross-sectional area and WJ area did not influence weight, however.

In this descriptive study, our aim was to determine relationships between WJ and birth weight using direct measurements. In addition, we calculated the density of WJ and analyzed its effect on birth and placental weight.

Gill and Jarjoura [15] analyzed quantitative variations of WJ and their correlation to clinical parameters, using the cross-sectional area of the umbilical cord to quantitate postnatal WJ. They did not, however, measure the amount of WJ directly. They determined a relationship between the cross-sectional area of the cord in square centimeter and birth weight and reported that WJ quantity is associated with male gender and maternal prepregnancy weight. Our results are similar to these, support the theoretical assumptions, and also find a positive correlation between WJ amount and fetal weight.

In addition, we found that the quality and characteristics of WJ were important. Results in which no correlation was seen between umbilical cord thickness and umbilical coiling pattern [13] and no effect of WJ area was observed on fetal outcome [14] may be caused by WJ structure and chemical content affecting the measured amount and area of WJ. In these cases, we believe that content analysis of the WJ might be beneficial. Abnormal situations, such as a decrease in hyaluronic acid content of WJ, WJ fibrosis, an increase in the artery collagen of the umbilical cord, or pressure on the cord vascular structures through torsion in the cord, may affect the mechanical characteristics of the cord, and anoxia resulting from impaired fetal circulation may lead to fetal death [7,8]. To test the hypothesis that the WJ density may indirectly reflect the WJ quality, we calculated the WJ density to be 1.63 g/mL. The amount of WJ was higher in male fetuses than in females, but its density did not show any gender differences. Interestingly, we found a significant negative correlation between WJ density and fetal growth. Specifically, when the WJ density increased, the birth and placental weights decreased. This may be the result of variation in the WJ structure, such as differences in the amount of water or other contents that might affect or impair its function. However, further studies are required to investigate this hypothesis.

In theory, WJ should decrease the likelihood of cord compression and negative fetal outcomes. WJ protects the vessels supplying the fetus from external influences by acting as a protective layer, and as this layer increases, blood flow to the fetus should encounter less resistance, positively affecting fetal nutrition and growth. Thus, as the amount of WJ increases, fetal weight should increase in parallel, and our finding supports this model. Therefore, the amount of WJ should be considered a factor that influences fetal growth.

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