



## CLINICAL ARTICLE

# The cross-sectional area of umbilical cord components in normal pregnancy

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Received 17 June 2006; received in revised form 3 October 2006; accepted 4 October 2006

### KEYWORDS

Umbilical vein;  
Umbilical artery;  
Wharton jelly;  
Prenatal ultrasonography

### Abstract

**Objective:** To determine the normal cross-sectional areas of the umbilical vein, umbilical artery, and Wharton jelly in healthy pregnancies, and correlate the obtained values with fetal anthropometric parameters. **Methods:** A cross-sectional study was performed with 312 women between the 24th and 39th weeks of a normal pregnancy. The cross-sectional areas of umbilical cord vessels were measured at the junction of the cord and fetal abdomen, and the values were subtracted from the total cord cross-sectional area to assess the cross-sectional area of the Wharton jelly. The anthropometric parameters analyzed were biparietal diameter, head circumference, femur length, and estimated fetal weight, and the Spearman correlation was used to assess the correlation between the cross-sectional areas of umbilical cord components and fetal anthropometric parameters. A polynomial regression analysis was performed to identify the curves that best adjusted to mean and standard deviation according to gestational age. **Results:** A statistically significant correlation was observed between the cross-sectional areas of cord components and fetal anthropometric parameters ( $P < 0.001$ ) as well as gestational age ( $P < 0.001$ ). **Conclusions:** Reference measurements of the cross-sectional areas of umbilical cord components are important tools in the assessment of fetal growth.

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## 1. Introduction

The umbilical cord begins to appear in the 4th week of embryonic development [1], or between the 5th and the

12th week of gestation [2]. The primitive umbilical ring, precursor of the primitive umbilical cord, comes from the ventral flexion line of the amnio-ectodermal junction.

In the last few years, progress in prenatal ultrasonography has allowed to assess morphometric alterations of the umbilical cord associated with adverse perinatal outcomes. In pregnancies complicated by early pre-eclampsia, the cross-sectional areas of the Wharton jelly and umbilical vein are reduced in comparison to these areas in normal

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pregnancies [3]. Lean umbilical cords are more common in fetuses with intrauterine growth restriction (IUGR) than in fetuses of an appropriate size for their gestational age (GA), and when the umbilical vein caliber decreases significantly, the Doppler parameters of the umbilical arteries worsen [4]. An increase in the umbilical cord's diameter in pregnancies complicated by gestational diabetes was also observed [5].

A study comparing fetuses with IUGR and fetuses appropriate for gestational age has shown that the cross-sectional area of all components of the umbilical cord is reduced in fetuses with IUGR [6]. Other studies have concluded that the umbilical cords of aneuploid fetuses are thicker than the cord of chromosomally normal fetuses of the same gestational age during the first [7] and the second [8] trimesters.

The first study toward the construction of nomograms for the umbilical cord components was conducted by Weissman and colleagues [9]. The authors established reference measures for the diameters of the umbilical cord, vein, and arteries. This pioneering study was followed by those of Raio and colleagues [10] and Ghezzi and colleagues [11], who sought to establish nomograms for the cross-sectional areas of the cord vessels and Wharton jelly, respectively. Recently, reference measures for the umbilical arteries and vein were established [12].

The aim of the present study was to establish reference measurements, via ultrasonography, for the cross-sectional areas of umbilical cord vessels and Wharton jelly during gestation, and correlate the obtained values with fetal anthropometric parameters.

## 2. Patients and methods

The cross-sectional study performed at the prenatal ambulatory care facility of São Paulo's Federal University (Unifesp/EPM) hospital involved 312 healthy women between the 24th and 39th completed weeks of a normal pregnancy. The women who consented to participate signed an agreement form, and the study was approved by the Ethics in Survey Committee of Unifesp/EPM (Approval No. 0251/04).

Inclusion criteria were the following: singleton pregnancy with GA based on the last menstruation date in women with regular periods, and/or an ultrasonographic evaluation performed up to the 15th week; a Doppler fluxometry result below the 95th percentile according to the table by Arduini and Rizzo for the umbilical arteries [13]; and an amniotic fluid index [14] between the 10th and 90th percentiles according to the table by Moore and Cayle [15]. Exclusion criteria were maternal disorders that might interfere with fetal growth, and estimated fetal weight less than the 10th or more than the 90th percentile for the corresponding GA according to the table by Hadlock [16].

For each evaluation, the following anthropometric parameters were calculated: biparietal diameter, head circumference, abdominal circumference, femur length, and fetal weight estimation.

The examinations were performed using either of 2 ultrasonographs, a Toshiba Power Vision, model 6000 SSA-370 (Toshiba, Tokyo, Japan) or a MultiSync Synergy, model M500 (Synergy Diasonic, Haifa, Israel), both equipped with a 3.5-MHz convex transducer. The cross-sectional areas of the umbilical cord vessels were measured on a plane adjacent to



**Figure 1** Measurements of the cross-sectional area of umbilical vein and arteries.

the junction of the umbilical cord and the fetal abdomen, in cross-section, with maximum magnification of the image. The cord vessels were manually circled, and their cross-sectional areas were automatically calculated by the ultrasonograph. The cross-sectional area of the Wharton jelly was obtained by subtracting the values obtained for the vessels from the total cross-sectional area of the umbilical cord (Fig. 1).

To calculate reference measures for the umbilical cord components, means, medians, and standard deviations were established for the cross-sectional areas of the umbilical vein, arteries, and Wharton jelly for each GA studied.

Statistical analysis was performed using the software package SPSS for Windows, version 12.0 (SPSS Inc., Chicago, IL, USA). The Spearman correlation was used to assess the correlation between the measurements for the components of the cord and fetal anthropometric parameters, with 95% confidence intervals (CIs). Polynomial regression analysis was performed to identify the regression curves that best adjusted to the means and standard deviations according to GA. Model adjustment was assessed through residual analysis. The 5th and 95th percentiles for the vein, arteries, and Wharton jelly measurements during gestation were calculated according to the following formula:  $\text{mean} \pm 1.645 \text{ mm}^2$ .

$P < 0.05$  was considered significant in all analyses.

## 3. Results

The mean  $\pm$  S.D. age of the participants was  $28 \pm 6$  years (range, 16–34 years); 41% were nulliparas, 30% were primigravidas, 28% were secundigravidas, and 20% were multigravidas; and 63% were white.

Table 1 shows Spearman correlation values between the anthropometric parameters and the cross-sectional areas of the components of the umbilical cord, with statistically significant correlations ( $P < 0.001$ ).

A statistically significant correlation was observed between cross-sectional area of the umbilical vein and GA ( $r = 0.45$ ;  $P < 0.001$ ; 95% CI: 0.36–0.53). Table 2 shows the means  $\pm$  S.D. of the measurements for the cross-sectional area of the umbilical vein for each GA studied, with their respective polynomial regression equations. Table 3 shows

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