Ultrasound measurements of umbilical cord transverse area in normal pregnancies and pregnancies complicated by diabetes mellitus

Badanie ultrasonograficzne pola przekroju sznura pępowinowego w ciąży prawidłowej oraz powikłanej cukrzycą

Marek Pietryga[1], Jacek Brązert[1], Ewa Wender-Ożegowska[1], Agnieszka Zawiejska[1], Maciej Brązert[1], Mariusz Dubiel[2], Saemundur Gudmundsson[3]

[1] Department of Obstetrics and Women's Diseases, Poznan University of Medical Sciences, Poznan, Poland
[2] School of Medicine, Torun University, Torun, Poland
[3] University of Lund, Dept of Obstet. and Gynecol, Skanes University Hospital, Malmö, Sweden

Abstract

Objective: *A voluminous umbilical cord has been described in diabetic pregnancies. The aim of this study was to see if measurements of cord diameters might be of value in the evaluation of diabetic pregnancies and especially those suspected of a large for gestational age (LGA) fetus.*

Methods: *In an observational, prospective study, umbilical cord areas and vessel diameters were measured between gestational age of 22 and 40 weeks in transverse ultrasound images of the central part of the cord in 141 normal and 135 diabetic pregnancies of which 30 were suspected of being LGA. Wharton's jelly area was calculated by subtracting the vessel area from the total transverse cord area. Normal reference curves were constructed for gestational age.*

Results: *Umbilical cord and Wharton's jelly areas increased with gestation. The vessel area leveled out at 32-33 weeks of gestation and the umbilical vein area decreased after 36 weeks of gestation. The umbilical cord parameters in diabetic pregnancies did not differ from controls. Cord areas were enlarged in 1/3 of the LGA fetuses.*

Conclusion: *Umbilical cord area measurements are of limited value for the evaluation of diabetic pregnancies suspected having a LGA-fetus.*

Key words: **umbilical artery** / **umbilical vein** / **gestational diabetes** / / **pregestational diabetes** / **fetal growth** / **LGA** /

Address for correspondence:
Marek Pietryga
Department of Obstetrics and Women's Diseases
Poznan University of Medical Sciences, Poznan
ul. Polna 33, 60-535, Poland
tel: +48618419334, fax: +48618419334
e-mail: marekp2003@gmail.com

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Streszczenie

Cel badania: *W piśmiennictwie opisuje się zwiększony wymiar sznura pępowinowego w ciąży powikłanej cukrzycą. Celem niniejszego badania była analiza przydatności wymiarów sznura pępowinowego w ocenie rozwoju płodu w ciąży powikłanej cukrzycą, w szczególności w przypadku podejrzenia nadmiernego wzrastania płodu (LGA).*

Materiał i metoda: *Prospektywne badanie obserwacyjne z grupą kontrolną. Między 22 a 40 tygodniem ciąży mierzono przekroje poprzeczne sznura pępowinowego i poszczególnych naczyń pępowinowych w 141 ciążach prawidłowych oraz 135 ciążach powikłanych cukrzycą, w tym 30 ciążach powikłanych cukrzycą z podejrzeniem LGA. Pole powierzchni galarety Whartona obliczano przez odjęcie pól powierzchni naczyń pępowinowych od całkowitego pola powierzchni sznura pępowinowego. Skonstruowano krzywe wartości referencyjnych dla ciąży prawidłowej.*

Wyniki: *Pole powierzchni sznura pępowinowego i galarety Whartona wzrastało wraz z wiekiem ciążowym. Pole powierzchni tętnicy pępowinowej osiągało plateau w 32-33 tygodniu ciąży, a pole powierzchni żyły pępowinowej zmniejszało się po 36 tygodniu ciąży. Nie zaobserwowano różnicy parametrów sznura pępowinowego porównując ciężarne chorujące na cukrzyce z grupą kontrolną. U 1/3 płodów z LGA zaobserwowano zwiększenie przekroju sznura pępowinowego.*

Wnioski: *Pole powierzchni pępowiny ma ograniczoną przydatność w ocenie rozwoju płodu w ciąży powikłanej cukrzycą z podejrzeniem LGA.*

Słowa kluczowe: **tętnica pępowinowa** / **żyła pępowinowa** / **cukrzyca ciążowa** / / **cukrzyca przedciążową** / **wzrastanie płodu** / **LGA** /

Introduction

Wharton's jelly protects the umbilical vessels and prevents them from twisting and compression during pregnancy and delivery [1]. The jelly is composed of collagen fibers, forming a network of interconnected cavities, cavernous and perivascular spaces in which the ground substance of the jelly is stored [1-6].

Changes in the cord ultrastructure have been described in different disorders. Sonographic measurements of transverse section of the umbilical cord area in normal pregnancies were first reported by Weissman et al. [7].

Raio et al., found a correlation between small umbilical cord and small for gestational age (SGA) newborn at delivery [8]. Increased sonographic umbilical parameters (the so-called "swollen cord") have been reported in gestational diabetes [9].

Several authors also report associations between changes in the components of the umbilical cord and perinatal complications such as hypertensive disorders, fetal distress and abnormalities of fetal growth, both large-for-gestational age (LGA) and SGA [8-12]. Thus, diagnosis of abnormalities in the size of the cord might give valuable information for fetal surveillance in high-risk pregnancies, especially in case of diabetes, where a LGA newborn may be expected.

The aim

The aim of the study was to obtain umbilical cord ultrasound parameter reference values in normal pregnancy and to compare them with values in diabetic pregnancies.

We hypothesized that maternal diabetes is associated with alterations in cross-sectional diameters of the umbilical cord as a whole, and/ or particular umbilical vessels.

Material and methods

We performed a multicenter, observational, prospective study of the umbilical cord ultrasound measurements in 141 normal and 135 diabetic pregnancies between 22 and 40 weeks of gestation.

Pregestational diabetes mellitus (PGDM) was reported in 82 subjects, including 8 cases with microvascular diabetic complications. There were 35 women with gestational diabetes mellitus, treated by diet (30-35 Kcal/kg/24h; class G1), and 18 cases treated with insulin (class G2), according to P. White's classification [13]. A total of 150 participants were enrolled at the University of Medical Sciences, Poznan, Poland and 126 at the Skanes University Hospital in Malmö, Sweden, between 2007 and 2011. The diagnosis of gestational diabetes mellitus was made following abnormal 75g glucose tolerance test between 24-28 weeks of gestation, according to the WHO criteria. Gestational age in all pregnancies was determined by a sonographic examination performed before 20 weeks of gestation.

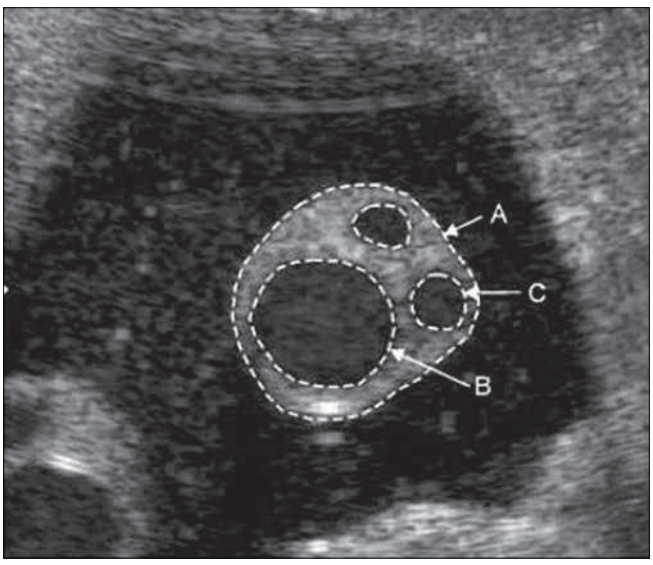

Figure 1. The sonographic cross-sectional area of the umbilical cord (A), umbilical arteries (C) and umbilical vein (B) were measured in a transverse section of a free-loop central part of the cord.

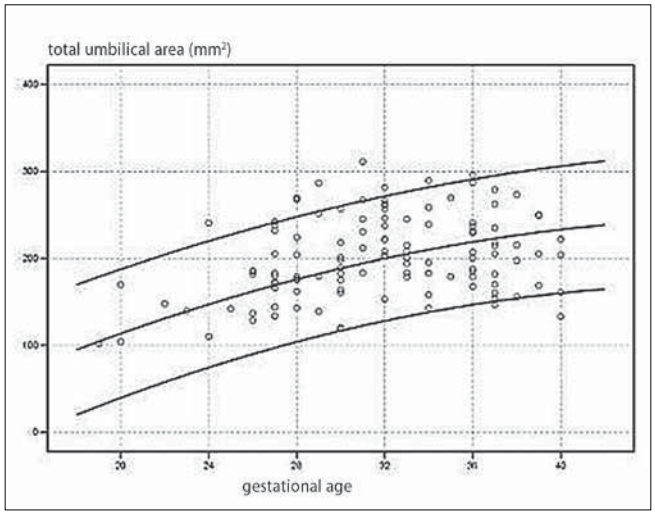

Figure 2a. Sonographic measurement of total umbilical area in controls (references curves) and diabetic pregnacies (plots).
Graph formula for LGA fetuses: $y=-829.75=62.5943x-0.9304x^2$.

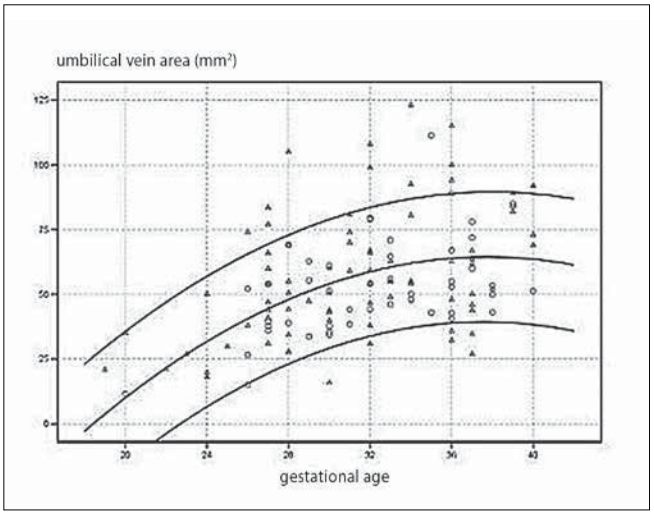

Figure 2b. Sonographic measurement of umbilical vein area in controls (references curves) and diabetic (PGDM – △, GDM – o) pregnacies (plots).
Graph formula for GDM pregnancies: $y=-161.03+11.3009x-0.1417x^2$.
Graph formula for PGDM pregnancies: $y=-101.93+8.4782x-0.1056x^2$.

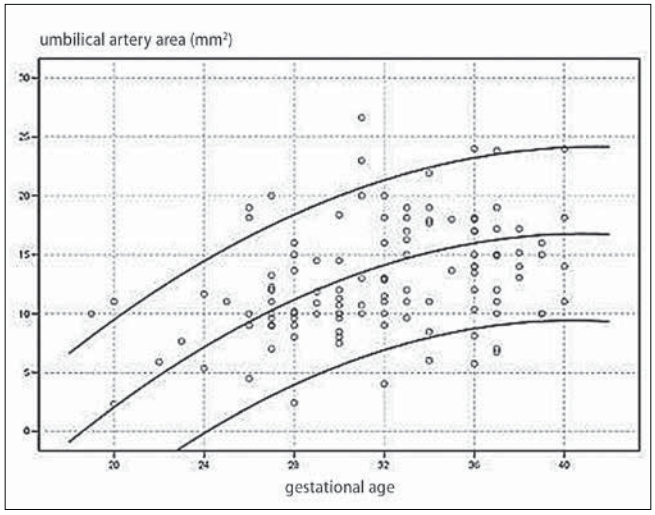

Figure 2c. Sonographic measurement of umbilical artery area in controls (references curves) and diabetic pregnancies (plots).
Graph formula for diabetic pregnancies: $y=-20.370+1.7740x-0.224x^2$.

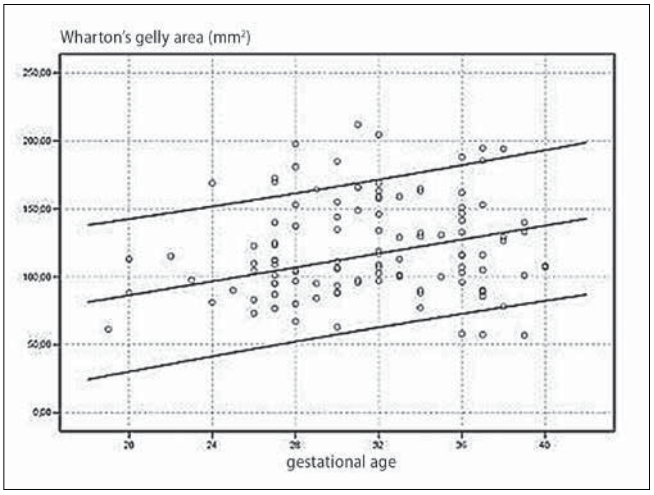

Figure 2d. Sonographic measurement of Wharton's gelly area in controls (references curves) and diabetic pregnancies (plots).
Graph formula for diabetic pregnancies: $y=-243.48+23.5489x-0.3748x^2$.

All ultrasound examinations were performed using Voluson 730 Expert. We measured the cross-sectional area of the umbilical cord, umbilical arteries and umbilical vein in a transverse section of a free-loop in the central part of the cord using the software of the ultrasound machine (Figure 1.). The calipers were set from the outer to outer border for total transverse area of the umbilical cord and for each vessel separately. The Wharton's jelly area was calculated by subtracting the arteries and vein areas from the total umbilical cord area, following protocols developed by other authors [10, 11]. Each examination was performed only once during pregnancy. All women gave an informed consent for participation in the study.

In the diabetic cohort, maternal metabolic control was monitored using serum glycated hemoglobin (HbA_{1c}). Measurements were performed with Bio Rad affinity chromatography using the following analyzers: Bio-Rad Hitachi Analyser 912, Japan, with a reference value <6.4% (Polish group) and the Abbott Imx - Abbott Laboratories, Diagnostic Division, IL, USA, with reference value <6.0% (Swedish group). The HbA_{1c} determinations were a part of a routine work-up for diabetic patients. As every diabetic participant had her HbA_{1c} measured several times during pregnancy, we used the mean for the analysis.

Statistical analysis was performed using SPSS 12.0 software for Windows. The curves were constructed in the Statistica 7.0 software. Distribution of variables was checked using the Kolmogorov-Smirnov test. As the variables violated assumption of normality, we used Mann-Whitney rank test to test for differences in continuous variables and Spearman's correlation (Rho-coefficient) to check for associations between variables. Formulas were calculated from linear regression. P value of <0.05 was considered as statistically significant.

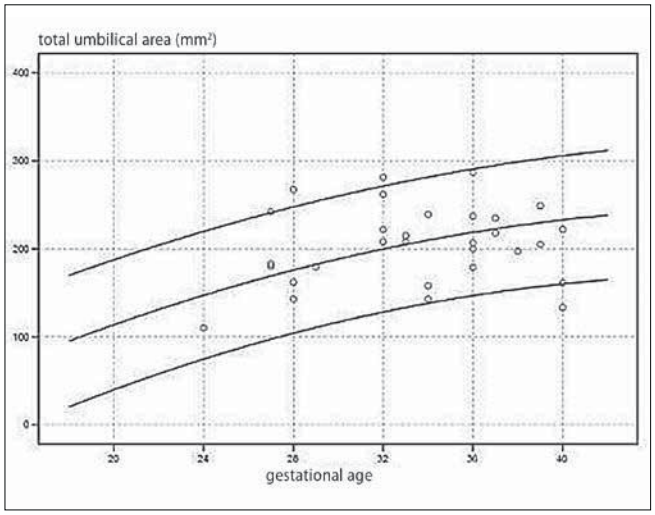

Figure 3a. Sonographic measurement of total umbilical area in controls (references curves) and LGA-fetuses (plots).
Graph formula for LGA fetuses: $y=-829.75+62.5943x-0.9304x^2$.

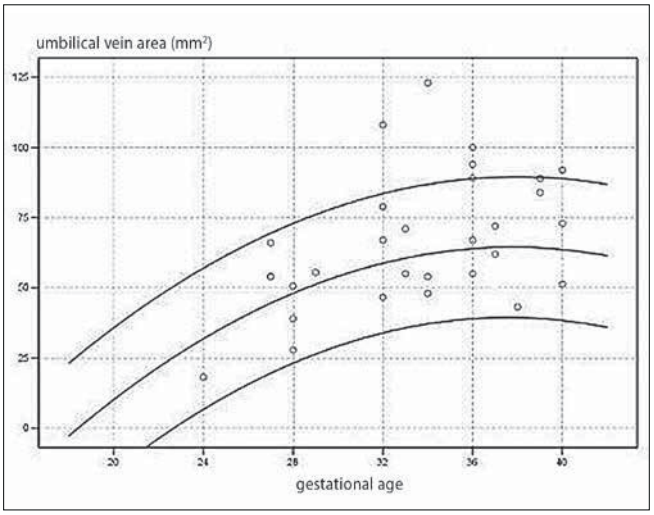

Figure 3b. Sonographic measurement of umbilical vein area in controls (references curves) and LGA-fetuses (plots).
Graph formula for LGA fetuses: $y=-371.15+24.4947x-0.3354x^2$.

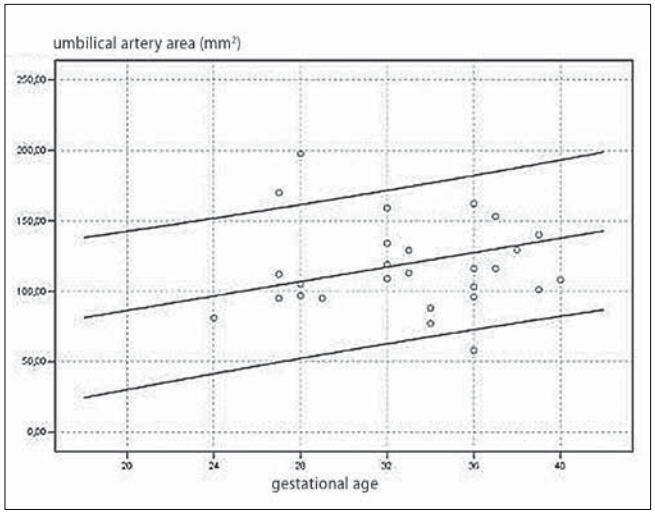

Figure 3c. Sonographic measurement of umbilical artery area in controls (references curves) and LGA-fetuses (plots).
Graph formula for LGA fetuses: $y=-34.710+2.3960x-0.0288x^2$.

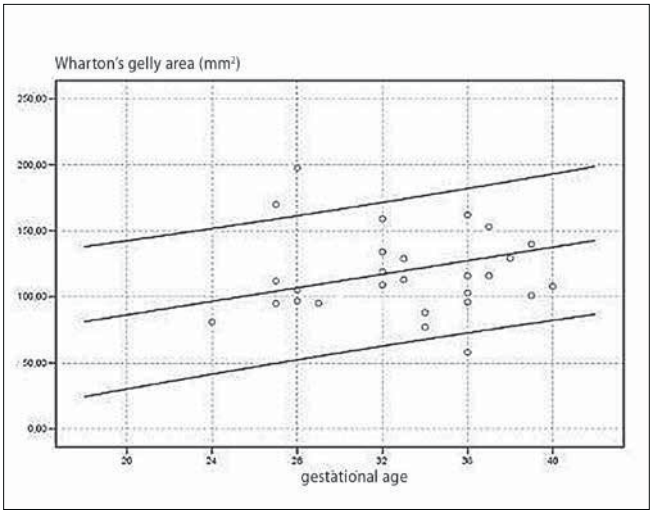

Figure 3d. Sonographic measurement of Wharton's gelly area in controls (references curves) and LGA-fetuses (plots).
Graph formula for LGA fetuses: $y=-357.62+31.1358x-0.5020x^2$.

Results

Sonographic measurements of the umbilical cord parameters (total umbilical area, umbilical vein, artery and Wharton's jelly area) were collected in normal pregnancies and plotted against gestational age to obtain reference curves (Figure 2a-2d).

Total umbilical area and Wharton's jelly area increased during pregnancy (Fig. 2a and 2d). Umbilical artery transverse area reached a plateau at 32-33 weeks of gestation (Fig. 2c). The vein area decreased slightly after 36 weeks of gestation (Fig. 2b).

No difference was found between sonographic measurements of the umbilical cord in normal and diabetic pregnancies. The same applied to LGA fetuses (Figure 3a-3d). Only 1/3 of the LGA cases had the umbilical cord area above the 90th percentile. Five out of six cases with reduced umbilical vein and artery area (below 10th percentile) were SGA at birth. No differences were found in umbilical cord area size between pre-gestational and gestational diabetes.

No correlation was seen between maternal HbA1c and umbilical cord area size. Levels of glycated hemoglobin in the two centers were different, with an average of 7.1 ± 0.5% and 5.8 ± 09 in the Poznan and the Malmö groups, respectively. However, in PGDM patients, mean values of HbA1c were similar, with 6.5 ± 1.1% and 6.4 ± 1.2%, respectively.

Discussion

Doppler examination has become an integral part of fetal surveillance in high-risk pregnancies [14]. The aim of the study was to estimate sonographic umbilical cord measurements in normal and diabetic pregnancies and assess their usefulness in management of pregnancies complicated by diabetes mellitus. We hypothesized that the measurements of the umbilical vessels and Wharton's jelly could be helpful for early diagnosis of accelerated fetal growth that might result in a LGA newborn. The results suggest that measurements of the umbilical cord diameters

are of limited value in the evaluation of diabetic pregnancies. Increased umbilical vessels and Wharton's jelly area were noted only in 30% of the gestations resulting in a LGA newborn.

A decrease in the umbilical parameters (below 10th percentile) was noted in SGA fetuses in our study. They might constitute additional parameters for prediction of intra-uterine growth restriction. However, the number of SGA fetuses was small. The results should therefore be considered with caution.

In our study, the umbilical artery area ceased to enlarge toward the end of pregnancy. The umbilical vein area showed a tendency to decrease at the end of gestation, whereas umbilical cord total area and Wharton's jelly area increased throughout pregnancy. Our finding may provide a possible explanation for a reduction in umbilical venous blood flow that has been reported at the end of gestation [20]. Moreover, placental perfusion per kilogram of the fetal size is known to decrease with gestation that may also correspond to a reduced venous lumen that we described in our cohort in term pregnancy [22,23]. The same was also reported after 33 weeks of gestation as digital analysis of pixel density of placental power Doppler signals showed a reduced signal [24]. Histological changes in the placenta have been poorly correlated to disease severity in diabetes [15,17]. However, good correlation has been reported between abnormal placental spectral Doppler and histology [25,26].

The results of our study are not consistent with the findings of Weissman et al., who reported an increase in sonographic umbilical parameters in pregnancies complicated by gestational diabetes [9]. This difference might be due to well-controlled maternal glycemia in our diabetic patients, that possibly ameliorated the difference in fetal growth between normal and diabetic pregnancies, finally resulting in similar umbilical cord parameters between the groups. However, our results on intra-uterine growth restricted fetuses remain in line with those of Raio and Ghezzi, who also reported an increased risk of SGA in fetuses with a small umbilical cord [10-12].

Conlusion

No significant difference was found between sonographic estimation of the umbilical cord diameters and area in normal and diabetic pregnancies.

Authors' statement :

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Authors' Contribution:

1. Marek Pietryga – study design, data collection, prepared a draft of the manuscript.
2. Jacek Brązert – study design, reviewed and contributed to the final manuscript.
3. Ewa Wender-Ożegowska – reviewed and contributed to the final manuscript.
4. Agnieszka Zawiejska – statistical analysis, reviewed and contributed to the final manuscript.
5. Maciej Brązert – data collection.
6. Mariusz Dubiel – study design, data collection, reviewed and contributed to the final manuscript
7. Saemundur Gudmundsson – study design, data collection, reviewed and contributed to the final manuscript

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