First Trimester Umbilical Cord and Vessel Diameters of Thai Fetuses

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Objective : *To establish the reference ranges for first trimester umbilical cord and vessel diameters of Thai fetuses.*

Material and Method : *A prospective study was performed on normal pregnant women between 10^{+0} and 13^{+6} weeks of gestation who underwent ultrasound examination. The diameter measurements were obtained by a 7.5 MHz vaginal - or a 3.75 MHz abdominal transducer. Statistics were analyzed using SPSS computer program.*

Results : *Records of 184 pregnancies were analyzed and the outcome demonstrated a strong correlation between umbilical cord diameter and gestational age ($r = 0.90$; $p < 0.001$). Umbilical vessel diameters were also correlated with gestational age.*

Conclusion : *First trimester umbilical cord and vessel diameters of Thai fetuses are related to gestational age. The presented reference ranges might be useful for further studies, such as prediction of adverse pregnancy outcome or combination with biochemical or other ultrasound markers for fetal aneuploidy screening.*

Keywords : *Diameter, Umbilical cord, Umbilical vessels, First trimester, Thai fetuses*

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Umbilical cord is a structure invariably visible by ultrasound examination in the late first trimester of pregnancy. The progress of more sophisticated imaging techniques nowadays allows the enlarging detail in its morphological evaluation. Recent studies suggested that the umbilical cord itself plays a role in both normal and abnormal fetal growth[1-4]. In addition, there are several reports about the association between an altered morphology of the umbilical cord (i.e. umbilical cord size, umbilical vein and artery diameters and Wharton's jelly area [WJA]) and adverse pregnancy outcome[5-7]. However, all studies were performed in Western populations and it is not known whether or not ethnicity influences umbilical cord size.

The purpose of this study was to establish the reference ranges for first trimester umbilical cord and vessel diameters of Thai fetuses.

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Material and Method

Subjects

The study was conducted as a prospective descriptive study including 202 pregnancies between 10^{+0} and 13^{+6} weeks of gestation according to their last menstrual period (LMP) who underwent one ultrasound examination at the Division of Maternal-Fetal Medicine, Department of Obstetrics and Gynaecology, King Chulalongkorn Memorial Hospital, Bangkok, Thailand. Informed consent was obtained from each participant and the ethical committee of the institution approved this study. Inclusion criteria were (1) singleton gestation, (2) accurate dating based on LMP and calculated gestational age (GA) by crown-rump length (CRL) measurement, and (3) term delivery with a normal birth weight fetus. Exclusion criteria were (1) vaginal bleeding at the time of ultrasound examination, (2) pregnancy complications (e.g. diabetes or hypertensive disorders), (3) miscarriage or fetal demise, (4) fetuses with structural or chromosomal abnormalities, (5) fetuses with growth restriction or macrosomia, and (6) lost to follow-up.

Fig. 1 Ultrasonographic measurements of diameters of umbilical cord (A) and umbilical vessels (B) in first trimester

Study procedures

All measurements were performed with an Aloka model Prosound 5000 (Aloka Co., Ltd., Tokyo, Japan) ultrasound machine with a 7.5 MHz vaginal - or a 3.75 MHz abdominal transducer. CRL was measured from the cranial to the caudal end of the body with the fetus in neutral position. The diameter measurements of umbilical cord and vessels were made in a free loop from the long axis view. Maximal magnification was used and average of the values obtained from two measurements was utilized for statistical analysis. The diameter of the umbilical cord was measured from outer-to-outer border, while the vessels were measured from inner-to-inner border[8] (Fig. 1A, 1B). Each woman was included only once and measurements were made by two of the authors. Intraobserver variability for each examiner was obtained from 20 patients who underwent ultrasound examination prior to this study. Umbilical cord and vessel diameters were measured by the first examiner and then were rescanned by the second examiner. Interobserver variability was calculated using the measurements obtained on the first scan. Intra and interobserver variabilities for diameter measurements were 3.7% and 4.3%, respectively.

Statistical analysis

Statistical analysis was performed with the SPSS software package version 11.0 (SPSS Inc., Chicago, IL, USA). Mean and standard deviation (SD) of mean for the diameters were calculated at weekly intervals for GA. Regression analysis was performed and the curves that best fitted the data points were calculated and plotted. Relationship between the diameter and GA was calculated by using Spearman's rank correlation. P-value < 0.05 was considered statistically significant.

Results

During the study period, 202 pregnancies were recruited. The records from 18 patients were

Table 1. Patient characteristics (N = 184)

	Mean	SD
Maternal age (years)	29.3	5.7
Gestational age at measurement (weeks)	12.1	1.2
Gestational age at delivery (weeks)	38.9	1.0
Birth weight (g)	3141.5	314.7

SD = standard deviation

Table 2. Umbilical cord, vein and artery diameters according to gestational age

Week of gestation (weeks $^{+days}$)	N(184)	Umbilical cord diameter		Umbilical vein diameter		Umbilical artery diameter	
		Mean(mm)	SD(mm)	Mean(mm)	SD(mm)	Mean(mm)	SD(mm)
10^{+0}-10^{+6}	43	3.30	0.09	0.80	0.10	0.53	0.08
11^{+0}-11^{+6}	40	3.63	0.15	0.88	0.07	0.58	0.06
12^{+0}-12^{+6}	45	4.06	0.13	1.04	0.16	0.67	0.10
13^{+0}-13^{+6}	56	4.47	0.14	1.33	0.10	0.82	0.08

SD = standard deviation.

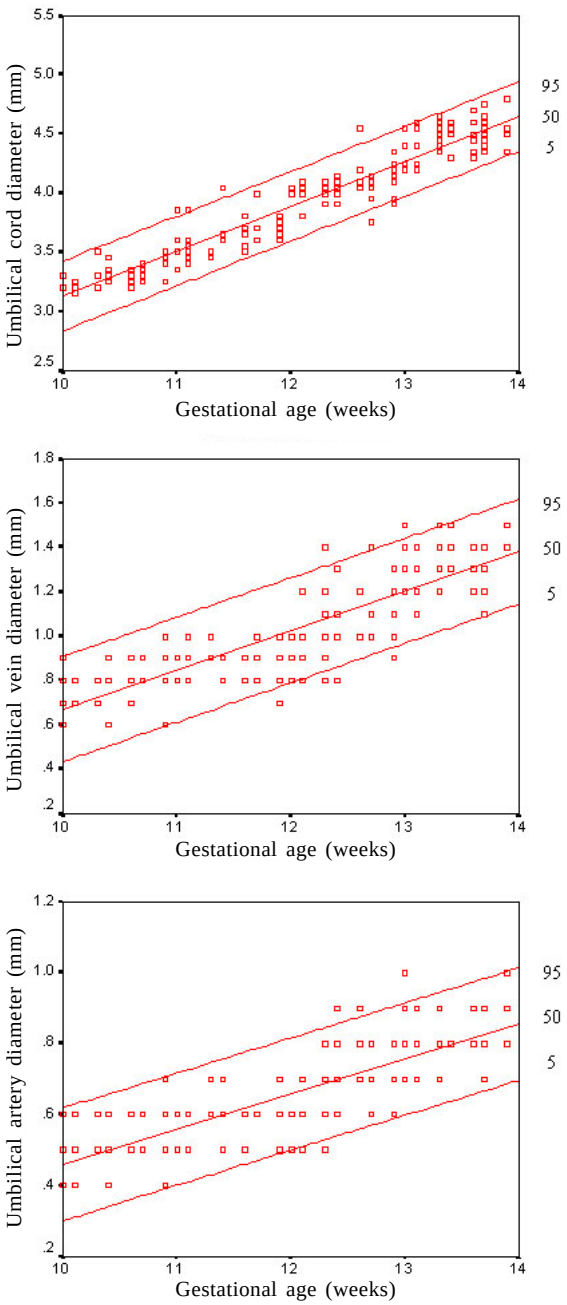
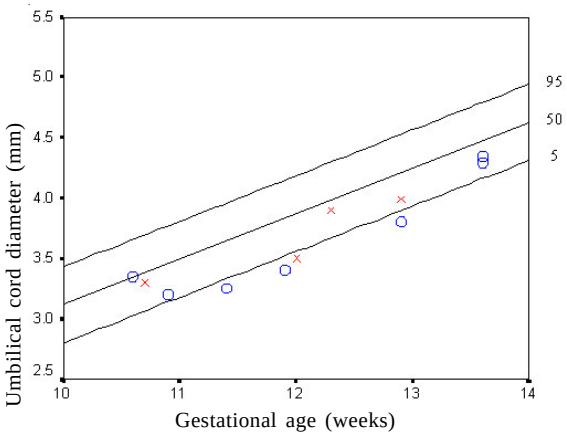


Fig. 2 Umbilical cord, vein and artery diameters according to gestational age. Lines represent the 5th, 50th and 95th percentiles



O = preeclampsia
X = fetal growth restriction

Fig. 3 Plotted umbilical cord diameter according to gestational age of cases with adverse pregnancy outcomes (O = preeclampsia, X = fetal growth restriction) compared with the reference range. Lines represent the 5th, 50th and 95th percentiles

excluded. Patient characteristics are shown in Table 1. Umbilical cord, vein and artery diameters according to GA are presented in Table 2.

The regression curves that best fitted the data points of umbilical cord, vein and artery diameters for GA are shown in Fig. 2. The normal ranges were expressed as the 5th, 50th and 95th percentiles. There was a strong correlation between umbilical cord diameter and GA. Umbilical vein and artery diameters were also correlated with GA. The regression equation for umbilical cord diameter (UC) according to GA was: UC (mm) = -0.66 + 0.38GA (week), $r = 0.90$; $p < 0.001$, for umbilical vein (UV) was: UV (mm) = -1.10 + 0.18GA (week), $r = 0.76$; $p < 0.001$, and for umbilical artery (UA) was: UA (mm) = -0.53 + 0.10GA (week), $r = 0.68$; $p < 0.001$. There was no correlation between umbilical cord diameter and birth weight as well as between umbilical vessel diameters and birth weight.

Fig. 3 shows the plotted umbilical cord diameter of cases with adverse pregnancy outcomes compared with the reference range. Of seven patients who developed preeclampsia (all women had mild preeclampsia) in the later half of pregnancy, the umbilical cord diameter was below the 5th percentile in three cases (43%). Same as one of four fetuses with growth restriction (25%) had the umbilical cord diameter below the 5th percentile.

Discussion

This study demonstrates that the diameters of umbilical cord and vessels in the first trimester increase as a function of gestation. The present results are similar to the reports in Western populations[1,4,6] therefore it might be possible that the umbilical cord size in the first trimester is not affected by ethnicity.

The present results showed a strong correlation between umbilical cord diameter and GA (r =

0.90; $p < 0.001$). Umbilical vessel diameters were also correlated with GA ($r = 0.76$; $p < 0.001$ and $r = 0.68$; $p < 0.001$ for umbilical vein and artery diameters, respectively). However, the latter correlations were not as strong as the former one. The most likely explanation is that the major part of the umbilical cord constitutes with Wharton's jelly while umbilical vessels occupy a minor portion. As gestation advances, it gives rise to a significant increase in WJA[6,8,9], thus, resulting in increased umbilical cord size rather than causing enlarged vessels.

Recently, the umbilical cord morphology was studied in great detail and the relationships between abnormal cord size and adverse pregnancy outcome (e.g. intrauterine growth restriction, preeclampsia and fetal distress during labor) were reported[5-7]. The postulation was that the mutual association between umbilical vessels and composition of Wharton's jelly may influence pregnancy outcome[6,7]. In a study of the first trimester umbilical cord measurement, Ghezzi et al[4] reported that 42.9% of patients who had a miscarriage within 15 weeks of gestation, the umbilical cord diameter was below 2 SD from the mean. Among these, 37.5% of patients who developed preeclampsia, the umbilical cord diameter was below 2 SD from the mean. In the present study there were no miscarriages, however, the authors found that 43% of fetuses whose mothers subsequently developed preeclampsia had an umbilical cord diameter below the 5th percentile and 25% of cases with fetal growth restriction had an umbilical cord diameter below the 5th percentile. Nevertheless, the number of cases with adverse pregnancy outcomes in the present study was too small to draw a conclusion that an abnormal umbilical cord size is correlated with adverse pregnancy outcome.

Of interest for the potential role of umbilical cord diameter measurement is that the result of recent study demonstrated a high proportion of fetuses with first trimester umbilical cord diameter above the 95th percentile in the group of chromosomal abnormalities[10]. The hypothesis for underlying pathophysiologic mechanisms leading to an increase in umbilical cord diameter might be those that also explain the increased nuchal translucency in fetuses with abnormal karyotype, such as alterations of extracellular matrix components or fetal venous congestion[11-13]. However, there was only one study with reference to this finding and in the present study there were no fetuses with chromosomal aneuploidy, so the authors could not confirm that report. Larger prospective studies need to be performed to explore the potential role of the first trimester umbilical cord evaluation for fetal aneuploidy screening.

In conclusion, the presented reference ranges for umbilical cord and vessel diameters serve as a normative data of Thai fetuses. It might be useful to do further prospective studies in the prediction of adverse pregnancy outcome and screening for fetal aneuploidy.

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ขนาดเส้นผ่าศูนย์กลางของสายสะดือ และของเส้นเลือดสายสะดือในไตรมาสแรกของทารกไทย

ชาดากานต์ ผโลประการ, วรพงศ์ ภู่พงศ์, เยื้อน ตันนิรันดร, บุญชัย เอื้อไพโรจน์กิจ, ธีระพงศ์ เจริญวิทย์, ธีระ วัชรปรีชานนท์

วัตถุประสงค์ *: เพื่อสร้างช่วงอ้างอิงของขนาดเส้นผ่าศูนย์กลางของสายสะดือ และของเส้นเลือดสายสะดือในไตรมาสแรกของทารกไทย*

วิธีการศึกษา *: ทำการศึกษา prospective study ในสตรีตั้งครรภ์ปกติระหว่างอายุครรภ์ 10^{+0} ถึง 13^{+6} สัปดาห์ โดยวัดขนาดเส้นผ่าศูนย์กลางของสายสะดือ และของเส้นเลือดสายสะดือทารกด้วยเครื่องตรวจคลื่นเสียงความถี่สูง ขนาด 7.5 MHz ทางช่องคลอด หรือ ขนาด 3.75 MHz ทางหน้าท้อง ข้อมูลที่ได้นำมาวิเคราะห์ด้วยโปรแกรม SPSS*

ผลการศึกษา *: ข้อมูลจากสตรีตั้งครรภ์ 184 ราย ถูกนำมาวิเคราะห์ ผลลัพธ์แสดงถึงความสัมพันธ์อย่างแน่นแฟ้นระหว่างขนาดเส้นผ่าศูนย์กลางของสายสะดือกับอายุครรภ์ ($r = 0.90$; $p < 0.001$) เช่นเดียวกับขนาดเส้นผ่าศูนย์กลางของเส้นเลือดสายสะดือที่มีความสัมพันธ์กับอายุครรภ์*

สรุป *: ขนาดเส้นผ่าศูนย์กลางของสายสะดือ และของเส้นเลือดสายสะดือในไตรมาสแรกของทารกไทยสัมพันธ์กับอายุครรภ์ ช่วงอ้างอิงที่ได้จากการศึกษานี้อาจมีประโยชน์สำหรับการศึกษาต่อไป เช่น การทำนายผล การตั้งครรภ์ที่ไม่ดี หรือ นำไปใช้ร่วมกับการตรวจทางชีวเคมี หรือ การตรวจคลื่นเสียงความถี่สูงอื่น ๆ เพื่อตรวจกรองภาวะโครโมโซมผิดปกติของทารก*