The Change of Umbilical Cord Components in Intrauterine Growth Restriction Comparative with Normal Growth Fetuses by Using Sonographic Measurement

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Objective: *To determine the diameter changes of umbilical cord components in intrauterine growth restriction (IUGR) fetuses comparative with normal growth fetuses by using the ultrasonogram.*

Material and Method: *A cross sectional study was performed with 140 singleton pregnant women who was attended at Maternal- Fetal Medicine unit, Thammasat university hospital between June, 2007 to May, 2009. The fetuses were between the gestational ages of 24 to 37 weeks at the time of data collection. Seventy pregnant women with IUGR fetuses and 70 pregnant women with normal growth (Appropriate for Gestational Age, AGA) fetuses were included. The sonogram of the umbilical cord, umbilical artery and umbilical vein diameter and circumference were obtained at the free loop of cord. Fetal weights were estimated by calculation in all cases. IUGR was defined as a fetus having an estimated fetal weight below the 10th percentile for the gestational age at time of the sonographic measurements.*

Results*: The mean age of the patients were 27.03 and 31.86 years in IUGR group and AGA group, respectively. The mean birth weight of the fetuses was 2,153.60 $\pm$ 386.13 gm and 3,118.16 $\pm$ 353.28 gm in IUGR fetuses and AGA fetuses, respectively. The result demonstrated the expected progressive increase of the umbilical cord circumference and diameter as a function of gestational age in AGA fetuses. These changes were not observed in the umbilical cord of IUGR fetuses. It was a contradictory finding that the measurement values from umbilical artery and umbilical vein IUGR fetuses were neither consistent nor correlated with fetal age.*

Conclusion: *The ultrasonogram of the umbilical cord component demonstrated the increasing of umbilical cord circumference and diameter along with an increasing of gestational age in the AGA fetuses. These findings might be useful for further studies, such as early screening or prediction of adverse pregnancy outcome for high risk women.*

Keywords*: Umbilical cord components, Intrauterine growth restriction, Sonographic*

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Intrauterine growth restriction (IUGR) may be caused by fetal or maternal factors. The fetal origin of IUGR may be due to chromosomal abnormalities, infections, malformations or errors in metabolism. Maternal causes are related principally to low weight increase during pregnancy, low pre-gestational weight, smoking, hypertension and causes related to inadequate uteroplacental circulation. IUGR may lead to consequences in the fetus that are not restricted to the immediate effects, such as neonatal hypoxia, hypoglycemia and infections, but also include mid- and long-term consequences, such as impaired neurological development, cerebral palsy, diabetes type II and hypertension in adulthood. Early detection of fetal growth restriction may lead to a better prognosis[1]. Cnattingius et al found that when fetuses with IUGR were identified and monitored, the risk of intrauterine death diminished and the neonatal period was less complicated[2]. Changes in blood flow may be detected early by Doppler study of the umbilical artery blood flow velocity. The waveforms in fetuses with signs of IUGR are fetal responses to compensate a blood flow

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deficit in certain regions[3]. Other diagnostic parameters for the evaluation of fetal growth continue to be sought. Among them are the morphology of the umbilical cord which includes its diameter and the amount of Wharton's jelly (WJ). These metrics have been associated with IUGR[4]. The presence of thin or thick cords is also linked to adverse maternal-fetal outcomes and diabetes, respectively[5-7].

For several decades, the morphological and morphometry of the umbilical cord have been studied and retrospectively correlated with the perinatal outcome after delivery[8-11]. Nomograms for the diameter of the umbilical vessels obtained from healthy women have been reported by Weissman et al and Raio et al[5,12]. Many pathologic studies demonstrated that a lean umbilical cord is associated with adverse pregnancy outcomes[13-16]. Recently, it has become apparent that there is a need for prospective comparative studies which assess the clinical value of observing an ultrasonographically lean umbilical cord. These measurements are made during the second half of gestation in both healthy and intrauterine growth restricted fetuses.

Objective

The objective of this study is to evaluate the changes of umbilical cord components in intrauterine growth restricted fetuses in comparison with the corresponding changes in healthy fetuses. This included the changes in diameter and circumferences during gestation.

Research design

A cross sectional study combined with prospective data collection.

Material and Method

The prospective observational data collection method was used in this cross sectional study. The study was conducted at Maternal-Fetal Medicine Unit of Thammasat University Hospital, Thailand, during the June 2007-May 2009 period. The protocol was reviewed by the ethics committee of Thammasat University Hospital and the Faculty of Medicine, Thammasat University prior to the commencement of the study. The procedures, the objectives and the study process were fully communicated to all participants via a written informed consent form. Usually, the ultrasonogram is a part of investigation process for pregnant women who have an intrauterine growth restricted fetus.

The study involved 140 pregnant women who were submitted to ultrasonogram at the Maternal-Fetal Unit, Thammasat University Hospital between the 24th and 37th completed weeks of pregnancy. Inclusion criteria for healthy fetuses were single gestation, live fetus, gestational age was previously established as the date of the last menstrual period (LMP) if reliable or ultrasonography carried out in the first trimester, unruptured membranes, and normal amniotic fluid index.

Patients were excluded from the control group on the basis of diabetes mellitus, gestational diabetes, hypertension of any etiology, fetal malformations, oligohydramnios or polyhydramnios, fetuses with signs of intrauterine growth restriction (estimated fetal weight below the 10th percentile) or signs of fetal macrosomia (estimated fetal weight above the 90th percentile). They were also excluded if abnormalities in the morphology of the umbilical cord were detected in the ultrasound exam. In this study; intrauterine growth restricted fetus means fetuses with an estimated fetal weight which is below the tabulated value for the 10th percentile for the corresponding gestational age (GA) as per the table references by Chulalongkorn Hospital data.

The examinations were conducted using an Aloka Prosound (Tokyo, Japan) SSD- α5 SV with the transducer operated between 3.5 MHz convex transducer. For each evaluation, the following fetal parameters were calculated: biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), femur length (FL) and fetal weight estimation. The cross sectional diameter and circumferences of the umbilical cord and its vessels were measured on a plane of free loops cord by excluding the Wharton jelly. The measurement values were calculated automatically after the maximum magnification of the image using the included firmware/software function. The measurements were replicated twice in different parts of the umbilical cord.

The statistical analysis was performed using the SPSS version 11.5 program with significance level set at $p < 0.05$.

Results

A total of 70 intrauterine growth- restricted fetuses and 70 appropriate- for- gestational age fetuses were included in the study. Table 1 demonstrates the principal characteristics of the 140 pregnant women. The age of the patients ranged from 16 to 42 years with a mean age of 27.03 and 31.86 years in IUGR group and AGA group, respectively. Forty- seven percent of the

Table 1. Characteristics of study population

	IUGR group n (%)	AGA group n (%)
Age(years)		
14- 19	12 (17.2)	1 (1.4)
20- 24	18 (25.7)	10 (14.3)
25- 29	15 (21.4)	10 (14.3)
30- 34	10 (14.3)	22 (31.4)
≥ 35	15 (21.4)	27 (38.6)
Gestational age (weeks)		
24- 27	4 (5.7)	14 (20)
28- 31	23 (32.8)	24 (34.3)
32- 35	24 (34.3)	28 (40)
≥ 36	19 (27.2)	4 (5.7)
Total	70	70

Table 2. Outcome of the pregnancy

	IUGR group	AGA group
Birth weight (gram)	2,153.60 ± 386.13	3,118.16 ± 353.28
GA at birth	37.24 ± 2.03	38.51 ± 1.03
Route of delivery		
Normal delivery	41 (47.7%)	45 (52.3%)
Cesarean section	29 (53.7%)	25 (46.3%)

women in IUGR group were between 20- 29 years of age. Seventy percent in AGA group were age more than 30 years old.

Fig. 1, 2 are graphs for the umbilical cord circumference and diameter which shows the comparison between the IUGR fetuses and AGA fetuses. Graphs showed that the cord circumference and cord diameter in AGA group increased and correlated with the increasing of gestational age, GA. However, these findings were not true for the IUGR group. The circumferences and diameters of umbilical cord components (umbilical artery and umbilical vein) are shown graphically in Fig. 3-6. Comparison of the circumference and diameter of the umbilical vessels in AGA group and IUGR group shows that the relative increase of the circumference and diameter were not clearly demonstrated for the two groups.

The outcomes of the pregnancy in IUGR fetuses and AGA fetuses are shown in the Table 2. The mean birth weight of the fetuses was 2,153.60 ± 386.13 gm and 3,118.16 ± 353.28 gm in IUGR fetuses and AGA fetuses, respectively. The mean gestational age at

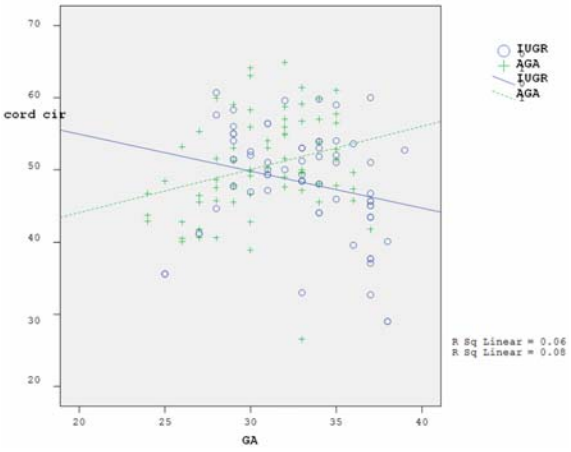

Fig. 1 Scatter diagram demonstrating the correlation between umbilical cord circumferences and gestational age (GA) in both IUGR fetuses and AGA fetuses

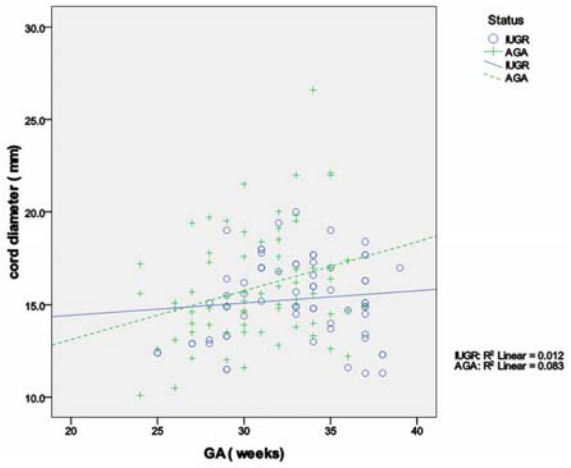

Fig. 2 Scatter diagram demonstrating the correlation between umbilical cord diameter and GA in IUGR fetuses and AGA fetuses

delivery and route of delivery were comparable for both IUGR fetuses and AGA fetuses.

Discussion

Traditionally, the prenatal assessment of the umbilical cord is limited to the sonogram evaluation of the vessel's number and the resistance of blood flow by Doppler analysis[17-20]. However, an increasing body of clinical evidence shows that the morphological and morphometric aspects of the umbilical cord have a correlation with the perinatal outcome after

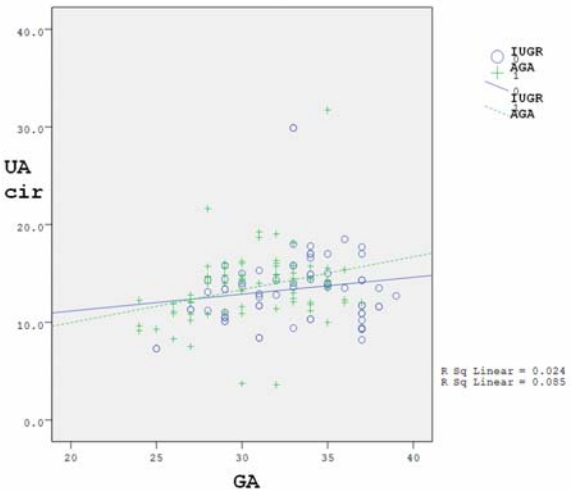

Fig. 3 Scatter diagrams demonstrating the correlation between umbilical artery circumferences and GA in IUGR fetuses and AGA fetuses

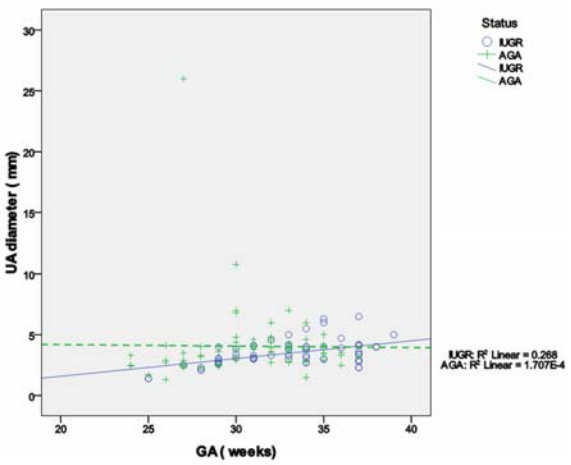

Fig. 4 Scatter diagram demonstrating the correlation between umbilical artery diameter and GA in IUGR fetuses and AGA fetuses

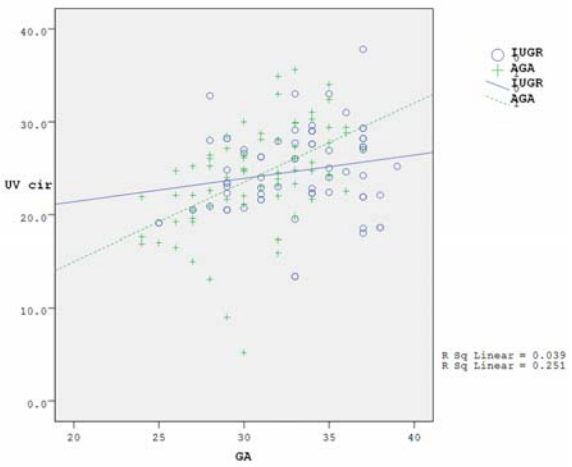

Fig. 5 Scatter diagram demonstrating the correlation between umbilical vein circumferences and GA in IUGR fetuses and AGA fetuses

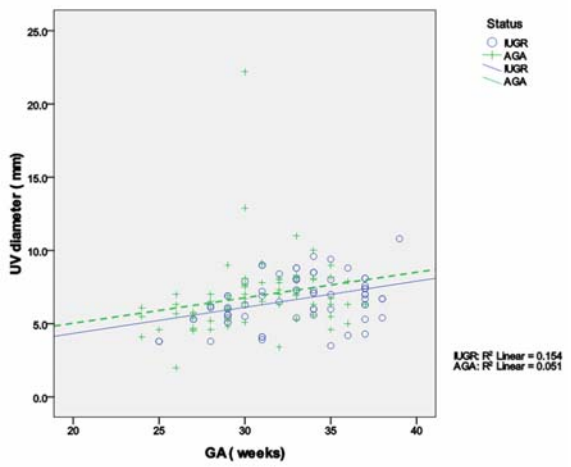

Fig. 6 Scatter diagram demonstrating the correlation between umbilical vein diameter and GA in IUGR fetuses and AGA fetuses

delivery[9-11].

This cross-sectional study of the umbilical cord size (circumference and cross sectional diameter) by using transabdominal ultrasonogram for prediction of fetal IUGR was initiated by assuming that it was possible to observe a correlation between umbilical cord size and fetal growth restriction status. The ultrasonogram is a non-invasive procedure and the machine is available in every province-hospital in Thailand. To the best of our knowledge, there was no previous study in Thailand that evaluated the relationship between the umbilical cord size and fetal growth restriction.

This study showed a progressive increase of umbilical cord circumference and diameter along with an increasing of gestational age in the AGA fetuses. Because the circumference is related to the diameter, therefore our data shows these correlations. The increase of cord size that correlates with GA is in an agreement with the report from Weissman et al[20] who reported the diameters of umbilical cord, artery and vein were measured in 368 healthy pregnant women

and the diameters increases along with GA from 16 weeks to term pregnancy. Raio et al have reported a significant relationship between umbilical cord diameter and cross sectional area and fetal size.

Our study shows that the umbilical cord circumference and diameter in the IUGR fetuses are smaller than in the AGA fetuses. However, these features of IUGR fetuses are not increasing proportionally with an increasing GA. This finding is in accordance with that of from Raio et al and Bruch et al who reported that the fetuses with lean umbilical cords have an association with smaller fetal size for the gestational age[21,22].

In the present study, the circumferences and diameters of umbilical artery were not clearly different between AGA group and IUGR group. However, the measured circumferences and diameters of the umbilical vein were larger in AGA fetuses compared to IUGR fetuses of comparable GA. These findings are in agreement with the work done by Rigano et al and Ghezzi et al[23,24]. Both groups reported that the umbilical veins of worst outcome IUGR fetuses were smaller than those of viable IUGR fetuses.

This study shows a relationship between ultrasonographically determined umbilical cord components (circumference and diameter) and fetal growth status. The result suggests that the measurement of umbilical cord circumference and diameter can be used as an early screening tool for the detection of fetal growth abnormalities. A prospective longitudinal study is recommended to assess the clinical value of small umbilical cord component information.

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การเปลี่ยนแปลงขนาดของสายสะดือในทารกที่มีภาวะเติบโตช้าในครรภ์เทียบกับทารกที่เติบโตปกติโดยใช้การตรวจคลื่นเสียงความถี่สูง

จรินทร์ทิพย์ สมประสิทธิ์, อธิตา จันทเสนานนท์, ต้องตา นันทโกมล

วัตถุประสงค์: *เพื่อศึกษาการเปลี่ยนแปลงของขนาดสายสะดือทารกเปรียบเทียบระหว่างทารกที่มีภาวะเติบโตช้าในครรภ์และทารกที่มีภาวะเติบโตปกติโดยใช้การตรวจด้วยคลื่นเสียงความถี่สูง*

วัสดุและวิธีการ: *ทำการศึกษาในสตรีตั้งครรภ์เดี่ยวจำนวน 140 ราย ที่มาฝากครรภ์และได้รับการตรวจคลื่นเสียงความถี่สูง ณ หน่วยเวชศาสตร์มารดาและทารกในครรภ์ โรงพยาบาลธรรมศาสตร์เฉลิมพระเกียรติ ในช่วงเวลา ตั้งแต่มิถุนายน พ.ศ. 2550 ถึง พฤษภาคม พ.ศ. 2552 โดยมีอายุครรภ์ตั้งแต่ 24 ถึง 37 สัปดาห์ กลุ่มละ 70 ราย ทารกในครรภ์ทุกรายได้รับการตรวจคลื่นเสียงความถี่สูงเพื่อวัดขนาดเส้นผ่าศูนย์กลางและเส้นรอบวงของสายสะดือ หลอดเลือดแดงและหลอดเลือดดำในสายสะดือ ที่ตำแหน่งของสายสะดือที่ลอยอิสระในน้ำคร่ำ ประมาณน้ำหนักทารกในครรภ์ด้วยการคำนวณจากการตรวจคลื่นเสียงความถี่สูง นิยามของภาวะทารกเติบโตช้าในครรภ์หมายถึงทารก ในครรภ์ที่มีน้ำหนักโดยการประมาณต่ำกว่าค่าเปอร์เซ็นไทล์ที่ 10 ของอายุครรภ์นั้น ๆ รวบรวมบันทึกข้อมูลและนำมาคำนวณทางสถิติ*

ผลการศึกษา: *อายุเฉลี่ยของสตรีตั้งครรภ์ในกลุ่มทารกที่มีภาวะเติบโตช้าในครรภ์และกลุ่มที่ทารกที่มี ภาวะเติบโตปกติเท่ากับ 27.03 และ 31.86 ปี ตามลำดับ น้ำหนักทารกแรกคลอดเฉลี่ย เท่ากับ 2,153.60 $\pm$ 386.13 กรัม และ 3,118.16 $\pm$ 353.28 กรัม ตามลำดับ การเปลี่ยนแปลงของขนาดเส้นรอบวงและเส้นผ่าศูนย์กลางของสายสะดือพบว่าในกลุ่มทารกที่มีภาวะเติบโตปกติ มีแนวโน้มเพิ่มสูงขึ้นตามอายุครรภ์ แต่ในกลุ่มทารกที่มีภาวะเติบโตช้าในครรภ์ไม่พบแนวโน้มการเพิ่มดังกล่าว อย่างไรก็ตามการเปลี่ยนแปลงของขนาดเส้นรอบวงและเส้นผ่าศูนย์กลางของหลอดเลือดแดง และหลอดเลือดดำในสายสะดือไม่สัมพันธ์กับอายุครรภ์ที่เพิ่มขึ้น*

สรุป: *ขนาดเส้นผ่าศูนย์กลางและเส้นรอบวงของสายสะดือทารกในครรภ์ที่มีภาวะเติบโตปกติแนวโน้มเพิ่มสูงขึ้น ตามอายุครรภ์ การเปลี่ยนแปลงดังกล่าวอาจมีประโยชน์ในการศึกษาต่อไป เช่น ช่วยตรวจคัดกรองหรือทำนายผลเบื้องต้นในมารดาที่มีความเสี่ยงต่อการมีภาวะทารกเติบโตช้าในครรภ์*