Validity of Antenatal Diagnosis of Intrauterine Growth Restriction by Umbilical Doppler Waveform Index

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Objective : *To evaluate the validity of systolic/diastolic (S/D) ratio of the umbilical artery in predicting intrauterine growth restriction (IUGR).*
Study Design : *Diagnostic test study.*
Setting : *Maharaj Nakorn Chiang Mai Hospital, Chiang Mai University.*
Subjects : *Two hundred and twelve singleton pregnancies between 30 and 42 weeks' gestation with clinical suspicion of IUGR were recruited and followed-up between December 1st 1995 and June 30th 1998. They were sonographically examined for routine fetal biometry and S/D ratio of umbilical artery Doppler waveform measurement within 14 days of delivery. All of them had an accurate date of last menstrual period and were between 30-42 weeks' gestation.*
Material and Method : *The umbilical artery S/D ratio was obtained by the same experienced sonographer, using the same ultrasound machine, Aloka 680EX, (Tokyo, Japan). The S/D ratio of 3 or greater was considered abnormal, predicting IUGR prenatally for every gestational week. IUGR was defined as low birth weight of less than the 10th percentile of the standard birth weight curve of Maharaj Nakorn Chiang Mai Hospital.*
Main Outcome Measures : *sensitivity, specificity, positive predictive value and negative predictive value.*
Results : *The prevalence of IUGR among the study group was 50.9%. The S/D ratio of 3 or greater for predicting of IUGR gave the sensitivity, specificity, positive predictive value, and negative predictive value of 52.96%, 78.85%, 74.42% and 65.08%, respectively.*
Conclusion : *The umbilical artery S/D ratio has relatively low sensitivity and is not a suitable test for IUGR screening. However, the specificity is rather high and it may be helpful in combination with other parameters.*

Keywords : *Doppler waveform index, Umbilical artery, S/D ratio, Intrauterine growth restriction, Detection*

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Intrauterine growth restriction (IUGR) is generally defined by a fetus that has not reached its growth potential or birth weight below the 10th percentile for each gestational age[1] because of genetic or environmental factors. In addition, IUGR is associated with high perinatal morbidity and mortality[2] and the newborn appear to develop medical problems including hypertension, hyperlipidemia, coronary heart disease, and diabetes mellitus in adult life[3,4]. Early IUGR detection and appropriate fetal intervention, therefore, play important role in antenatal care to achieve a good pregnancy outcome. Fundal height measurement is simple, inexpensive, and widely used to detect poor fetal growth. However, the accuracy of this procedure is still controversial from 28 to 85 percent[5-8]. A variety of sonographic parameters have been used to screen for and diagnose IUGR including fetal biometry[9], fetal body proportions[10-13], amniotic fluid volume[14], subcutaneous tissue thickness and estimated fetal weight (EFW). However, EFW estimated from fetal multiparameters seems to be the most reliable value for identifying fetuses whose birth weight is likely to be below the 10th percentile for GA[15, 16].

Doppler ultrasound is a noninvasive technique that is commonly used to evaluate maternal and

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fetal hemodynamics[17]. In general, the fetoplacental blood flow impedance decreases with advancing gestation and is reflected by a progressive decline in the systolic/diastolic (S/D) ratio and resistance index. Many investigators have reported an association between abnormal umbilical artery S/D ratio and IUGR[18, 19]. As the S/D ratio increases, the birth weight for each GA decreases; an S/D of greater than 3.0 is considered abnormal after 30 week's gestation. Using the above criteria, Fleisher et al reported the sensitivity, specificity of S/D ratio greater than 3.0 for identifying IUGR of 78-87, 85-87, respectively[18, 19].

Assessment of Doppler flow index with appropriate intervention, therefore, could be a promising practice to prevent fetuses from chronic hypoxia and reduce perinatal mortality in pregnancies complicated by IUGR. However, before clinical application, the accuracy of S/D ratio needs to be evaluated due to the differences among the population groups. Consequently, the present study aimed to determine the validity of S/D ratio of the umbilical artery Doppler waveform in predicting intrauterine growth restriction (IUGR) among a Thai population.

Material and Method

The pregnant women attending the antenatal care clinic at Maharaj Nakorn Chiang Mai Hospital between December 1st, 1995 and June 30th, 1998 were recruited into the study. All women meeting the inclusion criteria of 1) singleton pregnancy, 2) accurate date of last menstrual period, 3) attending the antenatal clinic within the first trimester of pregnancy and menstrual age consistent with clinical estimation at first visit, 4) gestational age of 30-42 weeks, and 5) clinical suspicion for IUGR were recruited into the study with written informed consent. Clinical suspicion for IUGR is defined as the fundal height is less than 3 cm of the expected height for two consecutive measurements. On ultrasound examination fetal biometry was determined. Umbilical arterial Doppler flow was obtained by the color Doppler duplex ultrasound system, using transabdominal curvilinear transducers of 3.5 MHz, Wall Filter 50 Hz, (Aloka SSD 680 EX; Tokyo, Japan). Doppler indices were sampled from the free-floating cord. Three best quality waveform signals were measured during the fetal apnea period by the same sonographer. Serial Doppler flow evaluation every 2 weeks was performed until delivery. Only those pregnancies that delivered within 14 days after the last ultrasound measurement were analyzed. Based on the sensitivity from the previous study[12], this study needed a sample size of growth-restricted cases to gain power of test 80% at 95% confident interval.

All demographic data and Doppler waveform indices measurements were recorded and collected for further analysis. The S/D ratio at 3.0 or greater was considered abnormal compared with the standard method of low birth weight of less than 10th percentile of the standard birth weight curve of the authors' hospital. Data analysis was performed by using SSPC/PC+ program. The accuracy of the Doppler test was determined in terms of sensitivity, specificity, positive predictive value, and negative predictive value.

Results

Two hundred and twelve singleton pregnancies between 30 and 42 weeks' gestation with a clinical suspicion of IUGR were recruited and followed-up during the study period. The prevalence of IUGR among the study group was 50.9% (108 in 212) using the low birth weight of less than 10th percentile for final diagnosis or gold standard.

The mean maternal age ($\pm$ SD) was 28.24 $\pm$ 6.36 years, ranged from 16 to 45 years. The number of nulliparous and multiparous women was almost the same (48.1% and 51.9%). The majority of the patients in both groups delivered at term (81.5% - 84.6%) with an overall mean gestational age of 37.66 $\pm$ 1.81 weeks as shown in Table 1. Most (72.6%) had vaginal delivery and 12.3% had cesarean section. The fetal weight ranged from 1,070 to 3,380 gm with the lower mean birth weight in IUGR than in the non-IUGR groups (2,029.28 $\pm$ 387.23 gm and 2,530.48 $\pm$ 306.39 gm, respectively). The mean umbilical artery S/D ratio was significantly higher in IUGR fetuses compared to non-IUGR fetuses. Mean S/D ratios were 3.29 $\pm$ 0.821 and 2.765 $\pm$ 0.703, respectively. No absent end diastolic volume (AEDV) or reversed end diastolic volume (REDV) were observed in this population. The

Table 1. The gestational age at delivery of the studied population

Gestational age (wk)	IUGR		Non-IUGR		Total
	No.	(%)	No.	(%)	
30-36	20	18.5	16	15.4	36
37-42	88	81.5	88	84.6	176
Total	108	100	104	100	212

Table 2. The efficacy of the umbilical S/D ratio compared with the standard low birth weight (< 10th percentile) criteria for predicting IUGR

S/D ratio	Standard Low Birth Weight Criteria		Total
	IUGR	Non-IUGR	
> 3	64	22	86
< 3	44	82	126
Total	108	104	212

S/D ratio of 3 or greater for predicting of IUGR gave the sensitivity, specificity, positive predictive value, and negative predictive value of 52.96%, 78.85%, 74.42% and 65.08%, respectively, as shown in Table 2.

Discussion

The present result revealed a low sensitivity of S/D ratio (59.26 %) for IUGR detection similar to the studies of Berkowitz[20] and Anyaegbunam[21], but, different from the studies of Fleisher[18] and Divon[19], which revealed a sensitivity as high as 78-87%. The discrepancy of research methodology and the characteristics of the studied population may be the important factors leading to the different result. Furthermore, the intra-observer variation and the different location of the Doppler measurement might contribute to the error variance[22]. In addition, the standard criteria of birth weight less than 10th percentile is controversial because it does not make a distinction among fetuses who are constitutionally small, growth restricted and small, and growth restricted but not small. The constitutionally small fetuses are not at high risk and have no rising of feto-placental vascular impedance[23]. Thus, the misclassification of a normally nourished, healthy, but constitutionally small, neonate as growth restricted may reduce the sensitivity of the test. However, the relatively high specificity of 78.85% and positive predictive value of 74.42% in the present study also provide suggestive evidence that the umbilical artery S/D ratio may be appropriate for confirmation rather than early detection of IUGR. Nevertheless, the present study has clearly shown the usefulness of the umbilical artery S/D ratio as a non-invasive back up technique that ensures fetal well being. To achieve a better result, more selective cases using the sonographic EFW, strict criteria of IUGR definition as well as strict Doppler waveform indices measurement technique should be considered in future studies. The value of Doppler velocimetry assessment has been extensively studied for a high-risk pregnancy. It has been proven to significantly reduce perinatal death and lower unnecessary induction of labor in preterm IUGR fetuses as described in a meta-analysis of these trials[24]. Suspicious small fetuses with abnormal Doppler velocimetry require intensive monitoring and possible intervention. However, the perinatal outcome and proper management of IUGR fetuses with normal Doppler remain obscure. Further study in this aspect would be very encouraging and useful.

Conclusion

The sensitivity of umbilical artery S/D ratio is relatively low and not appropriate for screening IUGR. Nonetheless, the specificity is rather high and may be helpful in combination with other parameters to confirm the diagnosis.

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ความถูกต้องในการวินิจฉัยทารกโตช้าในครรภ์ด้วยคลื่นเสียงดอพเลอร์ของเส้นเลือดแดงสายสะดือของทารก

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วัตถุประสงค์ : เพื่อประเมินความถูกต้องในการวินิจฉัยภาวะทารกโตช้าในครรภ์ (IUGR) ด้วยอัตราส่วน systolic/diastolic (S/D) ของหลอดเลือดแดงสายสะดือ จากการตรวจด้วยคลื่นเสียงดอพเลอร์

ชนิดของการวิจัย : การวิจัยเชิงตรวจยืนยันการวินิจฉัย

สถานที่ทำการวิจัย : โรงพยาบาลมหาราชนครเชียงใหม่ คณะแพทยศาสตร์มหาวิทยาลัยเชียงใหม่

กลุ่มตัวอย่าง : สตรีตั้งครรภ์ 212 คนที่มารับการฝากครรภ์และคลอดในระหว่างวันที่ 1 ธันวาคม 2538 ถึงวันที่ 30 มิถุนายน 2541 ซึ่งมีลักษณะทางคลินิกสงสัยว่ามีภาวะทารกโตช้าในครรภ์ เนื่องจากมีขนาดมดลูกเล็กกว่าที่ควรจะเป็นเมื่อเทียบกับอายุครรภ์ เป็นครรภ์เดี่ยวที่ทราบอายุครรภ์แน่นอน และอายุครรภ์อยู่ในช่วง 30 ถึง 42 สัปดาห์ ได้รับการตรวจวัดค่าอัตราส่วน S/D ของหลอดเลือดสายสะดือโดยแพทย์ผู้เชี่ยวชาญท่านเดียวในระยะ 14 วันก่อนคลอด

วิธีการ : ตรวจคลื่นเสียงดอพเลอร์ทางหน้าท้องเพื่อวัดอัตราส่วน S/D ของหลอดเลือดแดงสายสะดือ และใช้อัตราส่วนนี้ทำนาย IUGR โดยถือเอาค่าอัตราส่วนที่เท่ากับ 3 หรือ มากกว่าเป็นเกณฑ์ในการวินิจฉัยก่อนคลอดว่าเป็น IUGR และเทียบผลกับการวินิจฉัย IUGR โดยวิธีมาตรฐาน ซึ่งได้จากน้ำหนักทารกแรกคลอดที่ต่ำกว่า 10 เปอร์เซนต์ไทล์ของน้ำหนักทารกแรกคลอดมาตรฐานของโรงพยาบาลมหาราชนครเชียงใหม่

ตัววัดที่สำคัญ : ความไว ความจำเพาะ ค่าทำนายผลบวกและค่าทำนายผลลบ

ผลการวิจัย : ความชุกของภาวะทารกโตช้าในครรภ์ในประชากรที่ศึกษาซึ่งวินิจฉัยโดยวิธีมาตรฐานเท่ากับร้อยละ 50.9 ค่าอัตราส่วน S/D ของหลอดเลือดแดงสายสะดือเท่ากับ 3 หรือมากกว่าสามารถทำนายภาวะทารกโตช้าในครรภ์ได้ โดยให้ผลการทดสอบที่มีความไวร้อยละ 59.26 และความจำเพาะร้อยละ 78.85 ค่าทำนายผลบวกร้อยละ 74.42 และค่าทำนายผลลบร้อยละ 65.08

สรุป : อัตราส่วน S/D ของหลอดเลือดแดงสายสะดือมีความไวต่ำในการทำนายภาวะทารกโตช้าในครรภ์ จึงไม่เหมาะต่อการใช้เป็นวิธีตรวจคัดกรอง แต่มีความจำเพาะค่อนข้างสูง จึงอาจมีประโยชน์ในการใช้ร่วมกับ parameter อื่น ๆ ในการช่วยยืนยันภาวะนี้