Predictive Values of Sonographic Parameters for Antenatal Diagnosis of Small for Gestational Age Fetus

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Abstract : *This prospective study examined the reliability of various sonographic parameters in detecting SGA fetus in utero. Sonographic BPD, AC, HC/AC ratio, FL/AC ratio, EFW and AFV were obtained within ten days of delivery of SGA (N=221) and non-SGA (N=276) newborns. The effectiveness of each ultrasound variable for antenatal diagnosis of the SGA fetus was assessed. Predictive values were computed using Bayes theorem and based upon a 10% prevalence rate of SGA. An HC/AC ratio was the best predictor, which could detect 87% of SGA with 76% of positive predictive value. Other variables (AC, FL/AC, EFW, AFV, BPD) were less accurate for predicting SGA. Negative predictive value was greater than 92% for all variables. However, with the exception for HC/AC and FL/AC ratios, the positive predictive values were disappointing. This report establishes the limitations of each ultrasound parameter in the antenatal diagnosis of the SGA fetus. (Thai J Obstet Gynaecol 1993;5:7-14.)*

Key words : abdominal circumference, head circumference, femur length, fetal weight, amniotic fluid volume

Accurate antenatal diagnosis of the small for gestational age (SGA) fetus could greatly decrease the high perinatal morbidity and mortality associated with this condition. The challenge remains primarily with the obstetrician to identify the fetus who is inappropriately growing in utero. This difficulty is understood by the fact that such identification is not always possible even after birth. Numeruous studies indicate that when selective clinical techniques are used to diagnose SGA, most cases continue to be missed. The diagnostic accuracy of SGA may be improved by sonographic parameter measurements[1,2]. Various sonographic techniques for diagnosis of SGA have been proposed. For a criterion to be clinically useful,

a positive finding must allow one to be confident that SGA is presented and a negative finding must allow one to exclude SGA confidently, therefore, positive and negative predictive values of each criterion should be evaluated. Mostly, only single sonographic variable was evaluated for its accuracy in each previous report, therefore, this study was carried out to compare various commonly used parameters in the same population. We conducted a large prospective study to evaluate the accuracy of each ultrasound parameter, i.e. biparietal diameter (BPD), abdominal circumference (AC), head to abdominal circumference ratio (HC/AC ratio), femur length to abdominal circumference ratio (FL/AC ratio), estimated fetal weight (EFW), and amniotic fluid volume (AFV) for diagnosing SGA.

Materials and Methods

The study population consisted of 497 patients with complete inclusion criteria referred for ultrasound examination during 32-40 gestational weeks due to clinically suspected SGA. Sonographic examinations were done several times in most patients but only the last one, within 10 days of the delivery, was evaluated. An SGA infant was typically defined as a birth weight below the 10th percentile for gestational age, and a non-SGA infant was defined as birth weight at or above the 10th percentile. Intrauterine growth curve for evaluation of newborns used in this study was the growth curve derived from our population[3]. All of the ultrasound measurements were performed by one experienced perinatal sonographer at the Maternal-Fetal Medicince Unit, Department of Obstetrics and Gynaecology, Faculty of Medicine, Chiang Mai University, Thailand, from June 1, 1988 to September 31,1992.

This study included only singleton pregnancies who were delivered between 32-40 complete weeks of gestation, patients with history of regular menstruation, exact dates of last menstrual period was also noted, attending antenatal clinic in the first trimester and clinical estimation of gestational age agreed with menstraul age calculated from dates, and Dubowitz scores, assessed by the pediatrician, had to confirm this age.

Sonographic measurements of BPD, HC, AC, and FL were performed on 497 liveborn fetuses within 10 days before delivery, using commercially available curvilinear real-time systems with 3.5 MHz tranducers (Aloka Model 650). FL was measured from the greater trochanter to the distal metaphysis and BPD from the outer margin of the proximal skull table to the inner margin of the distal skull table, using internal electronic calipers and a speed of sound of 1540 m/sec in tissue. HC was measured along the outer margin of the calvaria at the level of the BPD, and AC was measured along the outer bounderies of the abdomen at the level of the porto-umbilical vein complex. Circumferences were measured by mod-

ern electronic clipse caliper, that could be adjusted in all directions. The HC/AC ratio and FL/AC ratio were calculated from HC, AC, FL measurements; estimated fetal weight (EFW) in grams was derived using Hadlock's equations[4].

EFW, BPD, and AC below 10th percentile, HC/AC ratio and FL/AC of +2SD, or greater, and decreased amniotic fluid volume (AFV) were considered to be sonographic diagnosis of SGA. Decreased amniotic fluid volume or oligohydramnios has been defined using the vertical diameter method as no pocket of fluid of > 1 cm[5]. The standard values of BPD[6], AC[7] HC/AC ratio[8] for each gestational week and FL/AC ratio, which were constant throughout the second half of pregnancy (+2SD =0.234)[9],used in this study were derived from northern Thai pregnant women.

All of the data were prospectively collected and stored in a microcomputer and subsequently analyzed with statistic program SPSS/PC+.

The means of various ultrasound variables of SGA infants were compared with those of the non-SGA group. A *t-test* was used to analyze differences. Statistical significance was accepted at the 0.05 level. To avoid biasing the results, we corrected them for a population in which 10 % of infants would be SGA, which is the prevalence of SGA in our population corresponding to the commonly accepted definition of SGA : fetal weight at or below the 10th percentile for gestational age.

For each ultrasound variable, the percentages of true/false positive and true/false negative based on the actual percentage of positive tests in our SGA and non-SGA groups would be determined. The accuracy of each test in predicting an SGA fetus in a population with an expected 10% prevalence of SGA was assessed by calculating the sensitivity, specificity, positive predictive value, and negative predictive value. The positive and negative predictive values were determined using Bayes theorem[10].

Results

The study population consisted of 221 and 276 patients, each of whom delivered an SGA and non-SGA infants respectively within 10 days after ultrasound examination.

Table 1 shows the mean values and standard deviation for the various ultrasound growth variables in the SGA and non-SGA fetuses. The menstrual age of both groups at delivery ranged from 224-280 days. The interval between the time of ultrasound study to delivery averaged 4.4 days. All ultrasound variables among both groups were significantly different.

Table 2 shows the results of each test in detecting abnormal ultrasound variables as previously defined in the known SGA and non-SGA groups (true-positive/false-negative and false-positive/true-negative rates). The expected results for screening a popu-

Table 1 Comparative values for SGA and non-SGA population

Variables	SGA	Non-SGA (n=221)	p (n=276)
Menstrual age at delivery (days)	259±10	278±11	<0.05
Menstrual age at study (days)	254±9	274±10	<0.05
Birth weight (g)	2001.6±402	2781.5±422	<0.05
BPD	8.4±0.5	8.8±0.4	<0.05
AC	27.0±1.9	32.5±2.1	<0.05
HC/AC ratio	1.129±0.011	0.982±0.013	<0.05
FL/AC ratio	0.237±0.006	0.203±0.004	<0.05
EFW	2086±368	2890±452	<0.05

SGA = small-for-gestational age, BPD = biparietal diameter, FL/AC = femur length/abdominal circumference ratio, HC/AC = head/abdominal circumference ratio, EFW = estimated fetal weight.

Table 2 Accuracy of prediction for ultrasound variables (The results shown are actual numbers of incidence)

Population	BPD	AC	HC/AC	FL/AC	EFW	AFW
SGA (n=221)						
True-positive	151	203	192	68	156	60
False-negative	70	18	29	153	65	161
Non-SGA (n=276)						
False-positive	77	80	8	5	25	9
True-negative	199	196	268	271	251	267

SGA = small-for-gestational age, BPD = biparietal diameter, FL = femur length, AC = abdominal circumference, FL/AC femur length/abdominal circumference ratio, EFW = estimated fetal weight.

lation of 497 women (Table 3), based on a 10 % prevalence of SGA, were calculated from the percentage of abnormal measurements in the SGA and non-SGA groups (Table 2). As found in the true-positive rate, the highest sensitivity was obtained for abdominal circumference alone, followed by HC/AC ratio at 86% sensitivity. Estimated fetal weight had a sensitivity of 60%, compared with only 30% and 27.15% for FL/AC ratio and decreased AFV respectively. With exception for BPD and AC, the specificity was high for

Table 3 Sensitivity, specificity, and predictive values in detecting SGA for each ultrasound variable

Parameters	Ultrasound variables					
	BPD	AC	HC/AC	FL/AC	EFW	AFV
Sensitivity(%)	68.33	91.86	86.87	30.76	70.59	27.15
Specificity(%)	72.10	71.02	97.10	98.19	90.94	96.70
Predictive value						
Positive(%)	21.25	26.06	76.32	63.27	46.71	50.00
Negative(%)	95.29	98.76	98.53	92.74	96.58	92.28

Data are calculated from percentages for abnormal measurements shown in Table 2, based on 10% prevalence of SGA in the population.
SGA = small-for-gestational age, BPD = biparietal diameter, FL = femur length, AC = abdominal circumference, FL/AC femur length/abdominal circumference ratio, EFW = estimated fetal weight.

all tests. Positive predictive value of an abnormal variable was above 50 % for only HC/AC ratio and FL/AC ratio. The negative predictive value was greater than 92% for all ultrasound variables.

Discussion

Small for gestational age is strongly associated with perinatal mortality and morbidity, and long term handicap[11]. Accurate antenatal diagnosis offers the best opportunity to prevent the problems. As the SGA is, by definition, smaller in size than a normal fetus of the same gestational age, a variety of prenatal ultrasonographic dimensions have been proposed as predictors of SGA.

The sonographic BPD measurements for diagnosing SGA would be expected to be less accurate than measurement of the AC, because the fetal weight and growth appear to be better correlated with AC[12]. This observation corresponds with the fact that most cases of impaired fetal growth are asymmetric or brain-sparing, therefore, abnormal BPD measurements would not be expected when the ultrasound study is done. Our results indicate that BPD is a bad predictor for SGA due to low sensitivity, specificity and positive predictive value.

Of the ultrasonic variables we evaluated for the detection of the SGA fetus, an abnormal AC was the best sensitive parameter for antenatal detection of SGA (a sensitivity of 91.86%), as opposed to FL/AC ratio or AFV, which had 30.8% and 27.15% sensitivity respectively. However, AC measurement did not allow a confident antenatal diagnosis of SGA to be

made because the positive predictive value was very low.

Hadlock et al[13] suggested that the FL/AC ratio was the best parameter in detecting fetal growth impairment in the patient with inaccurate dates because this ratio may become abnormal before individual variables of BPD, abdominal circumference, femur length, or fetal weight. From our results, a FL/AC ratio of greater than +2SD (0.234)[9] correctly identified only 30.8% of our SGA, which is less than the findings in other study[13]. However, elevated FL/AC ratio has a 63% chance of being SGA, which is much higher than other studies[13,14], and may be useful in case of uncertain dates because it is date-independent predictor of SGA[9,13]. The low sensitivity of FL/AC ratio in this study may by due to the fact that the cut off level for diagnosis at +SD, suggested by Hadlock et al[13], is too high.

The most direct technique to predict fetal weight is to use EFW. The criterion of an EFW below the 10th percentile can be expected to help detect 70% of SGA fetuses. EFW, as determined by the formula using the BPD, femur length, and abdominal circumference, was moderately sensitive and predictive in confirming the SGA fetus in our series, however, it could not be used as a single reliable parameter.

The original report of the relationship of AFV and SGA suggested that the presence of normal AFV conveyed a low risk of SGA[5]. However, we found that the presence of normal AFV could not be used as a reliable method to exclude the diagnosis of SGA, the finding is consistent with some previous reports[15,16]. AFV may be well correlated with only abnormal growth but not all SGA fetuses. SGA infants are a heterogeneous mix and include a preponderance of normal small fetuses, such poor negative predictive value of normal AFV estimate is not surprising.

The best positive predictive value was obtained using the ratio of head to abdominal circumference. Use of the HC/AC ratio is based on the knowledge that chronic utero-placental insufficiency results in asymmetrical growth retardation. Since the liver is the most severely affected body organ, the AC measured at the level is significantly smaller than normal. On the other hand, the head circumference is less affected because the brain tend to be spared. As a result, the HC/AC ratio is unusually high in the asymmetrically growth-retarded fetus.

The only two techniques with a positive predictive value above 50% were estimation of HC/AC and FL/AC ratios. However, FL/AC ratio measurments have little practical use, since the technique has very low sensitivity. The 76% predictive value of the HC/AC ratio with a sensitivity of 98% appears to be the best clinical tool. Moreover, this ratio is particularly valuable in patients referred for initial scanning after 30 weeks gestation when it is difficult to distinguish accurately between true intrauterine

growth retardation and an error in dates on the basis of BPD measurements alone.

Each of the commonly used ultrasound variables had strong negative predictive value, whereas, predictive values of a positive finding were rather disappointing. This study also points out the weaknesses of each test as individual screening tools for SGA, as seen by the fairly high false-positive rate found for BPD, abdominal circumference in our non-SGA population.

Despite these low predictive values, it may be claimed that a negative predictive value of 92% to 98% proves the value of these tests because the obstetrician can safely conclude that the risk of SGA is small. However, the high negative predictive values may be less a reflection of the excellence of the tests than of the low prevalence of SGA. Ninety per cent of fetuses are not SGA, so the negative predictive value of any reasonable test will, of necessity, be at least that high. None of the proposed sonographic measurements allow a confident antenatal diagnosis of SGA to be made. Practically, however, we believe that the combinations of these sonographic parameters will be highly predictive for this condition.

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