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ORIGINAL ARTICLE

Identification of Fetal Growth Patterns with Customized Growth Charts: A Prospective Study in South India

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ABSTRACT

Aim: To determine the diagnostic effectiveness of symphysis fundus height (SFH) measures plotted on customized growth charts for the identification of fetal growth patterns in a tertiary care perinatal center in south India.

Materials and methods: Serial SFH of pregnant women with singleton babies booked for antenatal care up to 22 weeks was measured from 24 weeks of gestation and plotted on customized growth charts that were developed using the gestation related optimal weight (GROW) software downloaded from www.gestation.net to identify fetal growth patterns. Fetal growth patterns were also ascertainedusing ultrasound in the antenatal period and confirmed at birth using a neonatal growth classification. The diagnostic effectiveness of SFH was compared with ultrasound and neonatal classifications using sensitivity, specificity, area under the ROC curve and likelihood ratio tests.

Results: The study included 666 pregnant women who presented at the antenatal clinics from January 2010 to October 2010. On ultrasound examination, 564 (84.6%) fetuses were AGA, 78 (11.7%) fetuses were LGA and 19 (2.9%) were SGA and 5 (0.8%) showed crossing centile from higher to lower pattern. On serial SFH measures, 426 (64.0%) of the fetuses were normal growth, 180 (27.0%) were excessive growth and 40 (6.0%) were slow growth. Serial SFH measures had a positive likelihood ratio of 4.7 (8.5 for USG) for the identification of SGA and a negative likelihood ratio of 0.06 for the detection of LGA.

Conclusion: The SFH measures plotted on a customized GROW curve have the potential to develop into a low cost screening tool to identify fetuses with altered growth. The diagnostic effectiveness of SFH plotted on customized growth charts has to be improved further through the development of appropriate customized growth charts for India before application on a larger scale.

Keywords: Fetal growth, Growth curves, SGA, LGA, Customization, Grow.

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INTRODUCTION

Altered growth of the fetus, in either direction, can lead to adverse perinatal outcomes.[1] Serial monitoring of the fetal growth *in utero*, especially when an altered growth is identified, can help to guide the obstetrician for the appropriate time and mode of delivery. Methods employed to screen for altered growth include obtaining previous history of small/large babies, abdominal palpation, conventional measurement of symphysis-fundal height (SFH) and estimating fetal weight by ultrasound. Physical examination of the abdomen by inspection and palpation detects as few as 30% of small for gestational age (SGA) fetuses.[2]

Conventional measurement of SFH has limited sensitivity (27%) and specificity (88%) that can increase with serial measurements.[3,4] Plotting of serial SFH measurements on individually adjusted customized antenatal charts is one of the better screening methods for detecting altered fetal growth especially fetal growth restriction. Use of customized SFH charts was found to result in improvement in sensitivity (29 and 48% using noncustomized and customized charts, respectively), resulting in increased antenatal detection of SGA babies with a reduction in unnecessary investigations for fetal growth.[5,6] Assessment of abdominal circumference and estimation of fetal weight by ultrasound are the most accurate diagnostic measurements to predict SGA.[7] Serial sonography, though accurate, is not practical as a screening method for growth assessment. The ultrasound machine is expensive and its operation requires special skill and is better used as a diagnostic rather than a screening tool. Customized gestation related optimal weight (GROW) charts that recognize the importance of main nonpathological factors affecting birth weight like gestational age, maternal height, and maternal weight at booking, parity and ethnic group were developed in the early 1990's.[8]

We conducted this study to determine the diagnostic effectiveness of these customized GROW charts to predict abnormal fetal growth pattern in an antenatal population attending an advanced tertiary care perinatal hospital in south India.

MATERIALS AND METHODS

The study protocol was approved by a registered Institutional Review Board and adhered to the tenets of the declaration of Helsinki. Pregnant women with an ultrasound dating of pregnancy and booked for antenatal care before 22 weeks of gestation, with a singleton fetus and longitudinal lie in an uncomplicated pregnancy were included for the study after obtaining written informed consent. The study excluded pregnant women with multiple pregnancies, fetal malformations, and diagnosed fetal growth restrictions, inaccurate dating of pregnancy and not booked for antenatal care, and those who did not provide written informed consent to participate.

Fetal growth was initially assessed by clinical history including past history of growth problems and risk factors in current pregnancy, maternal weight at booking, pregnancy weight gain, clinical assessment of uterine size by abdominal palpation and symphysis-fundal height measurement in centimeters. Ultrasound evaluation is done for confirmation of estimated fetal weight and amniotic fluid volume if there was a discrepancy in the measured symphysis-fundal height and gestational age in weeks.

The GROW software (downloaded from www.gestation.net) was used to generate customized antenatal growth charts. The chart is based on the calculation of an individual, optimal weight standard for the duration of the pregnancy to reflect the baby's growth potential. By adjusting for maternal variables (maternal height, weight in early pregnancy, parity and ethnic group), GROW is able to predict normal growth and hence identify abnormal, pathological growth better. The chart should be printed after confirmation of the expected date of delivery by ultrasound, and attached to the maternity notes. In our protocol, maternal variables (age, height, weight, parity and ethnic origin) and expected delivery date were entered into the above software to generate a customized GROW chart for each pregnant woman. These customized GROW charts were saved, printed and attached to the maternal antenatal record at the time of anomaly scan for plotting serial measurements of fundal height. In this study, we have plotted the symphysis-fundal height in centimeters on customized charts at each visit from 24 weeks of gestational age.

Symphysis-fundal height measurement was done in the routine antenatal clinic. The pregnant woman was placed in semirecumbent position after she emptied her urinary bladder. The measurement was performed if the abdomen was soft and the uterus was not contracting. After washing the hands thoroughly, the abdomen was adequately exposed and palpated with both the hands to determine the fundal height. A nonelastic tape with centimeter markings on the underside was used to measure the height of the uterus in the longitudinal axis to avoid any observational bias. The fundal height was measured only once without correcting the uterus to the abdominal midline, from the top of the fundus to the top of the pubic symphysis by an obstetrician. The correct technique of measurement was demonstrated to all doctors involved in antenatal care of mothers. Posters depicting correct technique of measurement were also displayed in the antenatal clinics. The fundal height measurement in centimeter was plotted on the customized growth charts and assessed against predicted or customized standard.

Fetal growth patterns were defined according to the serial plotting of SFH on the customized GROW charts. Normal SFH plots are those between 10th and 90th centiles and follow the same pattern as of the reference curves. Abnormal SFH plots include SGA where the initial SFH plot is below the 10th centile, large for gestational age (LGA) where the initial SFH plot is above 90th centile, slow growth where all SFH (at least 3 to 4 measurements) plots are within the 10th and 90th centile but the slope is less steep than the normal curves, static growth where the measurement is identical in two measurements separated by 2 weeks and excessive growth where the slope is steeper than the normal curves (Fig. 1).

Ultrasound assessment, Doppler studies and amniotic fluid assessments to confirm status were done routinely for those detected with an abnormal growth pattern in the GROW charts and formed the basis for further management of the fetus. The fetal growth was monitored using SFH measures and customized GROW charts if the ultrasound assessments did not detect any abnormality.

Postnatal growth patterns were defined as an SGA baby if the birth weight is below 10th percentile for gestational age, an LGA baby if the birth weight above the 90th percentile for the gestational age, an AGA baby if the birth weight is between 10th and 90th percentile for gestational age and macrosomia if the birth weight was in excess of 4000 gm.

The sample size for the study was estimated as 655 pregnant women based on the current proportion of fetal growth restriction in the study setting, 80% power and a 95% confidence limit around the point estimate of 10% and a two sided alpha of 0.05. Tests for diagnostic effectiveness focused on the sensitivity and specificity of the tests, area under the receiver operator characteristic (AUROC) curves, and the positive and negative likelihood ratios. The use of likelihood ratios to measure diagnostic effectiveness is better than predictive values in a clinical setting. The positive predictive value is influenced by the prevalence of the condition and can increase with an increase in the prevalence of the condition while the likelihood ratio is not affected by the prevalence of the

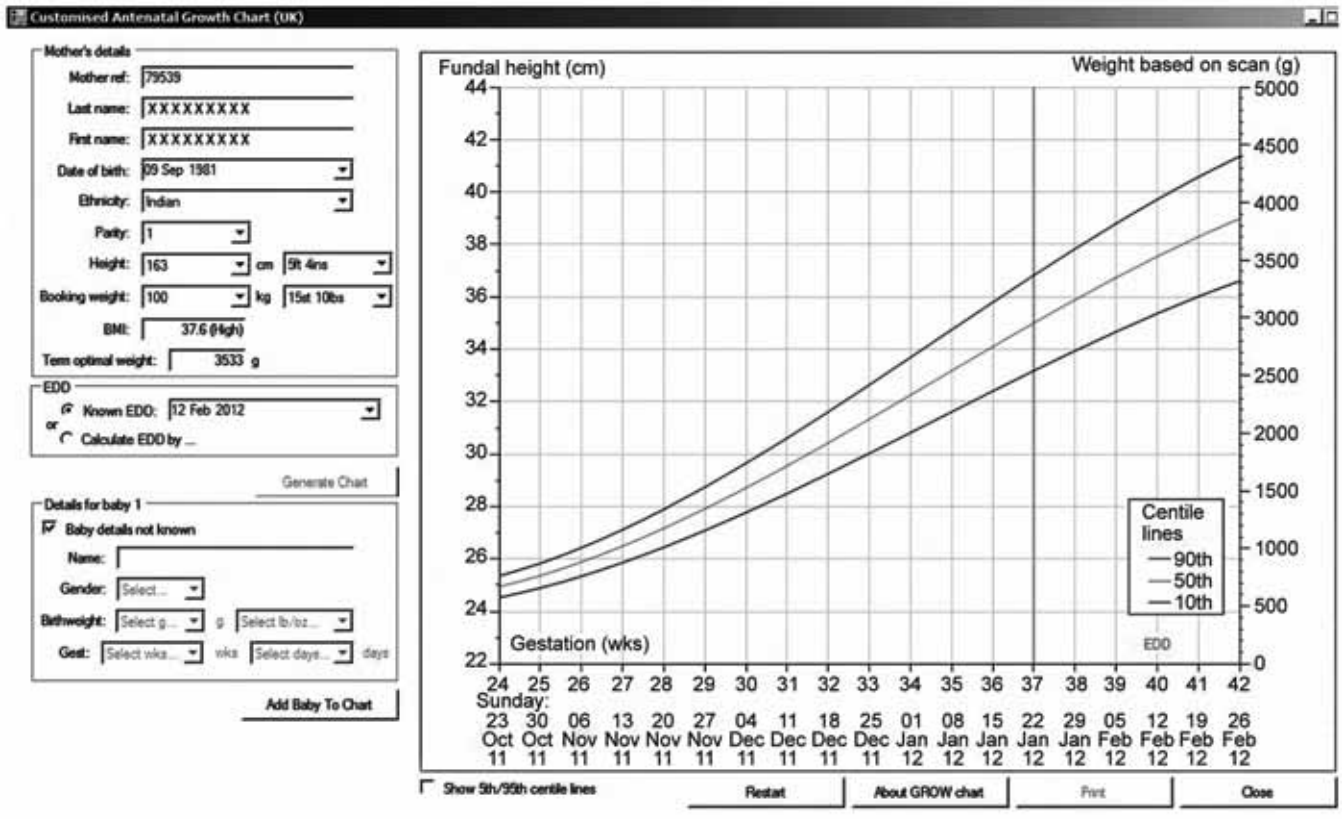

Fig. 1: Customized growth charts and fetal growth

condition under study. A positive likelihood ratio greater than 10 is considered clinically significant to adopt into clinical practice. We used STATA version 8.0 (college station, Tx, USA) for the statistical analysis.

RESULTS

The study included 666 pregnant women who presented at the antenatal clinics of the study institute from January 2010 to October 2010. The characteristics of these 666 pregnant women are presented in Table 1.

Growth as assessed by ultrasound scan was average for gestational age in 564 (84.6%) fetuses. Seventy-eight (11.7%) fetuses were determined as LGA, 19 (2.9%) were SGA and 5(0.8%) showed crossing centile from higher to lower pattern. Liquor volume was normal in 645 (96.9%) of pregnant women.

We found 426 (64.0%) of the fetuses to have normal growth pattern on serial measurements of the SFH. Excessive growth was determined in 180 (27.0%), and slow growth was determined in 40 (6.0%) of fetuses on serial measurements of the SFH.

SFH centile on customized GROW charts showed no disparity in only 137 (21.0%) patients. Disparity was considered to be present when the initial or subsequent SFH measurements plotted on the customized GROW charts were either below 10th or above 90th centiles. Of the remaining 529 patients in whom measurements showed disparity, 71.0% were above 90th centile and 8.0% were below 10th centile. The apparent frequency of disparity is at its maximum between 28 and 30 weeks.

The diagnostic effectiveness of SFH measurements are compared with USG (Table 2 using ultrasound as the gold standard) and with neonatal classification of growth (Table 3).

DISCUSSION

In our study, SFH measures plotted on a customized GROW curve detected SGA in 9.2% of fetuses while the ultrasound confirmed SGA/FGR in 3.6% and the incidence of SGA babies based on assessment at birth was 4.2%. SFH measures even on customized growth curves may, thus, tend to overestimate the incidence of SGA babies. We found, based on the negative likelihood ratio (0.06), that fetuses were less likely to be LGA if the SFH measurement on customized GROW chart did not identify them as LGA. SFH measurement was useful to identify SGA rather than LGA although the positive likelihood ratio did not reach clinical significance (4.7) and was lower than the positive likelihood ratio for ultrasound (8.4). Thus, ultrasound examination remained a better diagnostic test compared to SFH measurement on a customized GROW curve when we use the neonatal classification of growth as the gold standard.

There are several issues to consider as we attempt to extrapolate the results. The incidence of SGA babies (4.2%) in this series is much lower than the reported 10 to 30%

Table 1: Characteristics of the 666 pregnant women included in the study

Study population characteristic	
Age (mean, SD, median, range)	26.7, 4.2, 27, 18-40
Height (mean, SD, median, range)	158.4, 6.3, 158, 140-181
Weight (mean, SD, median, range)	61.1, 11.6, 60, 34-122
BMI (mean, SD, median, range)	24.4, 4.6, 24, 15-48
Primigravida (n, %)	326, 48.9%
Nulliparous (n, %)	406, 60.9%
Gestational age at booking (mean, SD, median, range)	12.1, 4.7, 11, 4-24
Spontaneous conception (n, %)	616, 92.5%
Diabetes mellitus (n, %)	171, 25.7%
Hypertension (n, %)	40, 6.0%
Hypothyroidism (n, %)	77, 11.6%
Anemia (n, %)	16, 2.4%
Induction of labor (n, %)	209, 31.4%
Cesarean section (n, %)	293 (44.0%)
Gestational age at delivery (mean, SD, median, range)	38, 1.4, 39, 30-41
Birth weight in Kgs (mean, SD, median, range)	2.9, 0.5, 2.9, 1.2-4.5
Neonatal SGA (n, %)	27, 4.1%
Neonatal LGA (n, %)	53, 7.9%

BMI: Body mass index; LGA: Large for gestational age; SD: Standard deviation; SGA: Small for gestational age

Table 2: Diagnostic effectiveness of symphysial fundal height measurements for fetal growth patterns compared with ultrasound growth classification

	SFH AGA
Sensitivity	23.4%
Specificity	96.1%
False positive	4.0%
False negative	77.0%
ROC area	0.6
Likelihood ratio (+)	6.0
	SFH LGA
Sensitivity	95.4%
Specificity	32.3%
False positive	68.0%
False negative	0.0%
ROC Area	0.7
Likelihood ratio (+)	1.5
	SFH SGA
Sensitivity	78.9%
Specificity	94.0%
False positive	6.0%
False negative	21.0%
ROC area	0.9
Likelihood ratio (+)	13.1

AGA: Appropriate for gestational age; LGA: Large for gestational age; ROC: Receiver operating characteristic; SFH: Symphysial fundal height

Table 3: Diagnostic effectiveness of symphysial fundal height measurements and utrasound for fetal growth patterns compared with neonatal growth classification

	SFH AGA	*USG AGA*
Sensitivity	21.2%	87.9%
Specificity	85.2%	38.3%
False positive	15.0%	62.0%
False negative	79.0%	12.0%
ROC area	0.5	0.6
Likelihood ratio (+)	1.4	1.4
Likelihood ratio (–)	0.9	0.3
	SFH LGA	*USG LGA*
Sensitivity	98.1%	49.1%
Specificity	30.8%	91.5%
False positive	69.0%	8.0%
False negative	2.0%	51.0%
ROC area	0.6	0.7
Likelihood ratio (+)	1.4	5.8
Likelihood ratio (–)	0.06	0.6
	SFH SGA	*USG SGA*
Sensitivity	33.3%	18.5%
Specificity	93.0%	97.8%
False positive	8.0%	2.0%
False negative	67.0%	81.0%
ROC area	0.6	0.5
Likelihood ratio (+)	4.7	8.5
Likelihood ratio (–)	0.7	0.8

SFH: Symphysial fundal height; USG: Ultrasound growth

incidence of SGA in India. While the possibility that this difference might reflect actual differences between the study population and the general population of India is a consideration. However, it is also possible that the low incidence of SGA in this study can be attributed to the exclusion of those who were not followed up through the entire antenatal period (all three trimesters) from the study. The lower incidence of SGA may thus, be attributable to regular antenatal care. The use of the likelihood ratios, however, allows us to reduce the influence of the incidence of the conditions on the diagnostic effectiveness.

The effectiveness of SFH measures can be influenced by inter-and-intra observer variations. Such variations are possible in a busy clinical setting although the obstetricians in the study institute were sensitized to the measures of SFH and plotting them on customized GROW charts. Calvert et al[9] have previously reported a co-efficient of variation of intraobserver and interobserver measurements of SFH were 4.6 and 6.4% respectively. The lack of estimation of inter-and-intra observer variation as part of this study can be considered as a limitation to extrapolate the results although the measurement of variation may not be pragmatically possible in a busy clinical setting.

The parameters input into the customized growth chart may have influenced the results of the diagnostic effectiveness of SFH measures. We had input parameters into an available grow chart in the absence of a customized grow chart for our population. Several reports have confirmed the utility of customized growth charts to identify fetal growth patterns, especially SGA.[6,10-12] Gardiosi, in 2006,[13] highlighted the need to adjust for

physiological variation in order to identify those babies who were pathologically small. He calculated the true growth potential by adjusting the variables and represented as individually customized fetal growth curves and birth weight percentiles. 'Customized SGA' as it was called defined neonates with intrauterine growth restriction, while 'small-normal' did not represent increased risk. Currently, coefficients are being developed for more ethnic groups, to broaden the international applicability of individualized standards. Work is also underway to incorporate the customized birth weight percentile as the starting point of infant growth curves.

Ebite LE et al in a prospective survey of SFH in 202 Nigerian pregnant women in Uromi, Nigeria, constructed a customized gravidogram and a growth velocity curve and compared with those derived in other regions of the world.[14] While the average SFH growth rate between 20 and 36 weeks was 0.9 cm/week, there was a marked deceleration to 0.3 cm/week from 36 to 40 weeks. The average deviation from the mean SFH was 1.96 cm. They concluded that, routine SFH assessments helped in early detection of fetal growth rate anomalies based on an understanding of the peculiarities of fetal growth patterns in each community. The outcomes of 17,855 New Zealand women of various ethnic groups comparing customized to population birth weight centiles showed that more preterm infants were identified as SGA using customized centiles whereas more were classified as SGA using population centiles at term.[15] It is possible that the diagnostic effectiveness of SFH measures may improve if we use a truly customized growth curve based on our population as has been done for other populations.[16-18]

Early identification and management of fetal growth restriction can help to prevent several perinatal complications besides improving long-term health for the fetus. We find that the SFH measures plotted on a customized GROW curve has the potential to develop into a low cost screening tool. Fetuses found positive for an altered growth with SFH have to undergo further confirmatory USG exams. The advantages of a customized GROW chart is that it gives an objective method of assessment of SFH when compared to a subjective estimation, which is used in majority of antenatal clinics. Additionally, since the SFH is plotted on customized curves, generated by maternal BMI, fetal growth assessment is done with relatively better accuracy compared to conventional SFH measures. However, the diagnostic effectiveness of SFH has to be improved further before it can be applied on a larger scale. Developing a customized growth chart for India that inputs various parameters allowing for a differentiation between the physiologically small and the truly growth restricted fetus might help improve the effectiveness of SFH as a screening test.

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