Original Article

Serial plotting on customised fundal height charts results in doubling of the antenatal detection of small for gestational age fetuses in nulliparous women

Alphonse ROEX,[1]* Payam NIKPOOR,[1] Eva van EERD,[1] Nicolette HODYL[2] and Gus DEKKER[1]

[1]*Department of Obstetrics and Gynaecology, Lyell McEwin Hospital, The University of Adelaide, Adelaide, and* [2]*Robson Institute LMH, The University of Adelaide, Adelaide, South Australia, Australia*

Background: The antenatal detection of fetal growth restriction is a focus point of antenatal care. If detected fetal demise may be prevented and perinatal complications could be managed more appropriately.
Aims: To investigate whether introducing serial plotting on customised fundal height charts can increase the detection rate of small for gestational age (SGA) fetuses in low risk nulliparous women attending antenatal clinics in a public teaching hospital in Adelaide, South Australia.
Methods: An observational study was employed to compare SGA detection rates, utilising data from an historical Control group compared to data collected after the study intervention. In the Control group the fundal height (FH) was measured for every antenatal visit and documented in the notes, but not plotted on a chart. The study intervention used serial FH plotting on customised charts, with a dedicated clinical practice guideline and regular audits to increase clinician awareness of the intervention.
Results: The antenatal detection rate of SGA was 31/125 (24.8%) in the Control group and 44/87 (50.6%) in the Intervention group ($P < 0.001$; OR 3.10; 95% CI 1.73–5.57).
Conclusions: Serial plotting of the FH on customised charts supported by a clinical practice guideline resulted in a doubling of the antenatal detection of SGA in nulliparous pregnant women at low risk for SGA.

Key words: antenatal detection of SGA fetus, customised fundal height chart, serial plotting of fundal height.

Introduction

The detection of a small-for-gestational-age fetus (SGA) is an important objective of antenatal care. SGA is associated with an increased risk of stillbirth, neonatal death and other adverse outcomes.[1] SGA is linked to over 50% of stillbirths and 42% of early neonatal deaths.[2,3] Moreover, SGA is associated with perinatal morbidity, including fetal compromise during labour and increased risk of cerebral palsy in childhood.[4,5]. A confidential enquiry into stillbirths because of missed SGA in the UK showed that six of seven deaths were because of substandard care and therefore potentially avoidable.[6]

This study was triggered by a number of undetected SGA babies born in our unit. The adage fundal height (FH) in cm = gestational in weeks is currently the guideline used in most obstetric units in Australia (www.thewomens.org.au/StandardAntenatalCheck). Gardosi and Francis reported that the likelihood of detecting SGA increased twofold from 29.2% to 47.9% with serial plotting of the FH on customised charts.[7] The introduction of customised FH charts did not increase utilisation of ultrasound scans.[8] On the basis of this evidence, a RCOG guideline recommended this method.[9] However, other studies have questioned the usefulness of the FH measurements.[10–12] In 2007, the RCOG released a statement indicating that customised growth charts need to be piloted more widely to determine whether growth restriction can be identified and managed appropriately' (www.rcog.org.uk/what-we-do/campaigning-and-opinions/statement/rcog-statement-channel-4-dispatches-programme-undercov.)

The non-randomised, quasi-controlled Nottingham study was undertaken in a primary health care setting by midwives and general practitioners.[7] To date, these findings have not been confirmed elsewhere. Our aim was to investigate whether antenatal SGA detection in our practice would improve after the introduction of serial

**Correspondence*: Dr. Alphonse Roex, Haydown Road, Adelaide, SA 5112, Australia.
Email: alphonseroex@gmail.com

Received 12 January 2011; accepted 8 December 2011.

plotting of the FH on customised charts, if combined with a clinical practice guideline and regular audits. This package is referred to as the 'Intervention'.

Materials and Methods

Intervention cohort

In March 2009, customised FH charts were introduced as routine antenatal care in the Lyell McEwin Hospital (LMH), a public teaching hospital in South Australia. The LMH serves the northern suburbs of Adelaide, one of the most underprivileged urban areas in Australia. Antenatal care is provided by midwives, resident medical officers, registrars and consultants.

Given the use of the customised FH charts 'package' was introduced as part of standard antenatal care, the SGA detection rate was compared to a cohort of 1169 first-time mothers who delivered before this change in practice.

The 1564 subjects included were all low-risk, nulliparous women with a singleton pregnancy and a certain gestational age booked for antenatal care between March 2009 and June 2010. Exclusion criteria were as follows: chronic medical conditions associated with an increased risk for SGA, fibroid uterus, congenital uterine malformations or a BMI of > 40. Women were excluded if no more than one or two FH plots, of the expected eight to nine, were visible in the chart.

Individualised FH charts were generated and printed at booking using a software program downloaded with permission from www.gestation.net and incorporated in the women's record.[13] The data entered for customisation were the following: maternal age, ethnic group, parity, weight and height. For ethnicity, the four options available were the following: European (was used as default for any ethnic groups not otherwise available), African, Middle Eastern and Indian/Pakistani.

Education sessions were organised for all clinicians. Clinicians were instructed as follows: FH measurements should continue to be performed from the uterine fundus to the top rim of the symphysis pubis with the tape measure upside down. The FH measurement, rounded to the nearest half-centimetre, should be plotted using the primary *Y*-axis of the FH chart on the left-hand side. The new SGA guideline was explained.

Abnormal FH trends were defined as 'slow', where the slope of the actual graph was less than the expected one, 'flattening' where there was no increase in the FH between the last two measurements and 'decreased' where a downward slope was visible between the last two plots on the graph. All three abnormal FH patterns show a less than expected slope of the actual FH graph compared to the customised FH chart printout**.** In Figures 1, 2 and 3, examples of all three abnormal FH slopes are given. The guideline indicated as well that in the case of an abnormal FH trend, an ultrasound (US) for 'Fetal Growth' should be requested. This US includes fetal biometry – biparietal diameter, head circumference, abdominal circumference and femur length, calculation of the estimated fetal weight (EFW) – pulsatility index of the umbilical artery Doppler flow and amniotic fluid index. An important additional aspect of the customised FH charts is a second *Y*-axis on the right side, which enables plotting of the EFW (refer to Figs 1, 2 and 3). The actual plot of the US EFW in the same chart should be used to confirm or refute the suspected SGA. Six covert audits were performed, and feedback was given to clinicians to promote their adherence to the protocol.

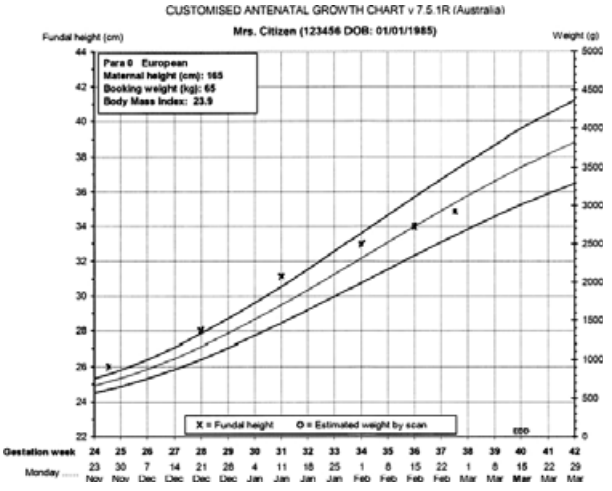

Figure 1 Customised fundal height chart showing a less than expected slope: slow increase.

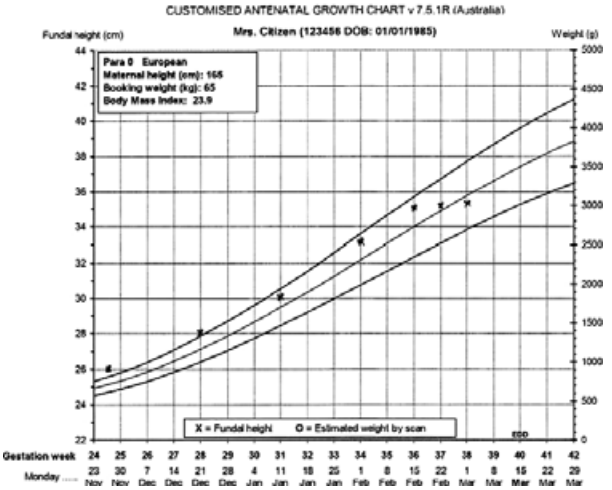

Figure 2 Customised fundal height chart showing a less than expected slope: no increase, 'flattening' or 'plateauing'.

SGA infants were the outcome of interest

The birthweight percentiles were calculated using the customised birthweight calculator (www.gestation.net

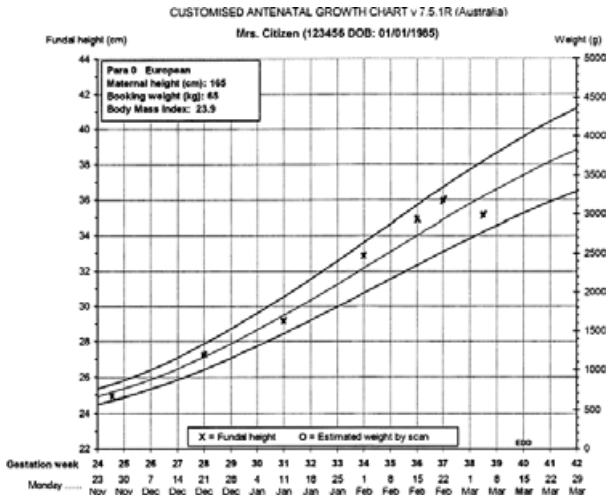

Figure 3 Customised fundal height chart showing a less than expected slope: decrease.

Australian version).[14] For all SGA neonates, a case note analysis was performed to determine whether the FH measurements were actually plotted in the chart. In case of an abnormal FH slope, two authors (PN and AR) independently verified whether SGA was suspected and whether the guideline had been applied. Suspected SGA was confirmed if written evidence was found in the case notes that an ultrasound for fetal growth was requested and/or CTG monitoring was performed and/or an induction of labour was arranged for a suspected SGA fetus.

Historic control cohort

This group of 1169 women was provided by an existing fully analysed database, namely the 'SCOPE' database, with detailed information of participating healthy nulliparous women. This prospectively collected database between August 2006 and February 2009 was used with permission from the Adelaide administrative authority. After the initial intake in the SCOPE (Screening for Obstetrical and Pregnancy Endpoints) study at a gestational age of 14–15 weeks by a research midwife, all participating pregnant women (98% of the whole nulliparous cohort at the LMH) received routine antenatal care by the same mix of antenatal care providers as the Intervention Group. Each antenatal clinic was run for both cohorts by one midwife, one RMO, one Registrar and one Consultant. Whilst the in and exclusion criteria, the method of measuring the FH was the same for both groups, the historic Control group was not accompanied by a SGA guideline, serial plotting of the FH or clinical practice audits. The SCOPE study was completed prior to the Intervention. The pregnancy records of all SCOPE SGA neonates were analysed in exactly the same way as described previously to find out whether SGA was suspected before delivery.

This study aimed to include a number of participants sufficient to detect a 20% increase in the SGA detection rate (80% power and $\alpha = 0.05$), based on the original Gardosi publication.[7] Statistical analysis was performed using SPSS (v17) software (Chicago, IL, USA). Maternal characteristics between the Intervention and the SCOPE group were compared using Mann–Whitney *U* tests, whilst frequency data were analysed using a chi-squared test. Odds ratios were performed to assess the likelihood of detecting SGA using the Intervention with the Control group as a reference.

Results

There were no significant differences in maternal and pregnancy characteristics between the women that delivered SGA neonates in the Intervention and Control groups (Table 1). In the Control group, 125 (10.7%) neonates were found to be SGA using customised birthweight centiles with 103 (6.5%) SGA cases in the total Intervention group of 1564 women.

In the Control group 31 and in the Intervention group 44 SGA cases were suspected before birth, resulting in a significantly higher sensitivity of 24.8% compared to 42.7% ($P = 0.0047$; 95% CI 0.62–0.92). The specificity was 99%. The positive predictive value (PPV) was 74.6% with a negative predictive value (NPV) of 96.1%. The false-positive rate (FPR) was 1% with a false-negative rate (FNR) of 57.3%.

Fundal height chart analysis revealed that in 16 of these cases there were less than three FH measurements recorded. These 'protocol violations' were excluded as the available information was inadequate for FH trend detection, leaving 87 cases of SGA for final analysis. The sensitivity of the customised FH protocol in the detection

Table 1 Maternal characteristics of the intervention and historical control group. Values are given as median [SD] or *n* (%) unless otherwise indicated

	SGA Intervention group ($n = 87$)	SGA Control group ($n = 125$)	*P* value
Maternal age	23 (5.71)	24 (5.47)	0.8
BMI (kg/m^2)	25.0 (5.6)	25.0 (5.8)	0.4
Gestational age at delivery (days)	275 (13)	278 (16)	0.2
Ethnicity			
Caucasian	77 (88.5)	119 (95.1)	0.09
Indian/Pakistani	2 (2.3)	0 (0)	
Aboriginal	2 (2.3)	0 (0)	
South East Asian	6 (6.9)	6 (6.9)	
Smoker	38 (43.7)	46 (37)	0.6
Number of previous miscarriages or terminations of pregnancy			
0	66 (75)	86 (68.8)	0.5
2	15 (17.2)	31 (24.8)	
3	4 (4.5)	6 (4.8)	
≥ 4	2 (2.3)	2 (1.6)	

SGA, small for gestational age.

Table 2 Comparison of intervention group (serial plotting of fundal height measurements SGA guideline and audits) and in the historic control group (non-plotting of fundal height measurements, no guideline, no audits).

	SGA detected *n* (%)	SGA missed *n* (%)	Unadjusted odds ratio (95 CI)	*P* value
Intervention	44 (50.6)	43 (49.4)	3.103 (1.730–5.5660)	<0.001
Control	31 (24.8)	94 (75.2)		

SGA, small for gestational age.

of SGA was 50.6% (95% CI 42.1–56.3), with a specificity of 99%. The PPV was 74.6%, the NPV 97.1%, with a FPR of 1% and a FNR of 49.4%. The odds of detecting an SGA infant in the antenatal period were greater than threefold higher with the use of the serial plotting compared to the traditional approach (OR = 3.10, 95% CI 1.73–5.57; $P < 0.001$) (Table 2).

Discussion

More than a decade after the Nottingham trial, this study in Adelaide has confirmed a significantly higher SGA detection rate of 50.6% ($P < 0.0001$) by using serial plotting of FH measurements compared to 24.8% in a similar historical Control group. The study in the UK was community-based, involved only midwives and general practitioners, included multiparous women and was conducted in an unselected population. However, this study in Adelaide was performed in a public hospital, involved multiple practitioners with different levels of experience and included only nulliparous women. Despite these more 'challenging' circumstances, clinically relevant and comparable findings were identified.

It is important to realise that a single third trimester ultrasound has a comparable SGA detection rate if used as a screening tool in a low-risk population, as previously shown in the Netherlands.[15] One US biometry examination early in the third trimester, involving primiparous and multiparous pregnant women, resulted in a sensitivity of 53% (95% CI 49–58%). Unlike a tape measure, the required US equipment and expertise are not readily available in most practices. Therefore, at this stage, US would appear not to be the preferred and most cost-effective SGA screening tool in a low-risk antenatal population.

Whilst Table 1 showed no statistically significant differences, it is acknowledged that comparing all low-risk nulliparous women of the Intervention group with self-selected SCOPE study participants could in theory result in bias. However, it needs to be noted that whilst the SCOPE study recruited almost all low-risk nulliparous women in the same maternity unit, non-English speaking, Indian/Pakistani and Aboriginal women were not represented.

Other potential more important sources of bias could be the observational nature of our cohort study and the 'Hawthorne effect'. The awareness of being 'observed' might in itself have led to improvements in practice. It is impossible to disentangle these effects from the direct impact of the serial plotting, the detection of an abnormal FH trend and the application of the guideline itself. In theory, a randomised controlled trial could clarify these points. Randomised controls are not necessarily unaffected by the Hawthorne effect, and more importantly ethics approval and recruitment to a Control group could be difficult, in the light of the findings of the Nottingham trial and the RCOG guideline, stating that serial plotting of FH is the recommended standard of practice.[7,8]

When analysing all 43 cases, where SGA was missed, we came across 34 clinicians errors (27 cases of incomplete plotting and seven cases of not requesting an US despite explicit recommendations in the guideline) and nine method errors. In retrospect, all 34 clinicians errors could have been avoided if the guideline had been adhered to, indicating a much higher potential detection rate of this new regime.

Our cohort study merely focussed on the antenatal detection of SGA infants. The numbers were too small to make valid comments about the possible effect on perinatal morbidity and mortality rates. It is important to note that the postnatal use of customised birthweight charts is still somewhat controversial. According to some studies, customisation enables to predict small babies with increased perinatal morbidity and mortality.[16,17] However, others have pointed at the fact that customisation is unable to differentiate between pathological and physiological influences of maternal characteristics on birthweight and suggested that customisation of birthweight could, in theory, cause an artefact.[18]

Change, even for the better, is hard to achieve, as is clinicians compliance. On the basis of our experience, we recommend that all clinicians attend a dedicated workshop educating them about the new customised FH chart guideline, including examples of incomplete plotting and non-detection of SGA. Offering case scenarios to practice abnormal FH trend detection is essential to avoid some of our clinicians errors. It must be stressed to the users, often with highly variable degrees of obstetrical experience, that it is the FH plotted in the chart, not the actual fetal weight. The importance of regular auditing with written and verbal feedback to all staff is not to be underestimated. After presenting our study, two other SA hospitals have introduced the customised FH package into their routine antenatal care.

The introduction of a customised growth chart 'package' resulted in a doubling of the antenatal detection rate of SGA fetus in nulliparous pregnant women at low risk for SGA. Taking into account the potential study bias on the one hand and 34 clinician errors on the other hand, this is a clinically relevant finding. The data presented suggest that more clinicians use serial FH plotting on a customised chart, as the primary screening tool for SGA detection, rather the traditional 'fundal height should be equal to gestational age'. It pleasing the note that the October 2011 update of the 'Grow' software program offers five additional ethniticies to choose from.

Acknowledgements

We would like to thank Professor Jason Gardosi and Ms Kate Morse for their guidance and A/Prof Vicki Clifton for her support. We are grateful to all triage midwives for generating the customised charts and to Dr Rose Vaughan and Ms Julie Sieben, RM for performing the audits.

References

1 Clausson B, Cnattingius S, Axelsson O. Outcomes of post-term births: the role of fetal growth restriction and malformations. *Obstet Gynecol* 1999; **94**: 758–762.
2 Gardosi J, Kady SM, McGeown P *et al.* Classification of stillbirth by relevant condition at death (ReCoDe): population based cohort study. *BMJ* 2005; **331**: 1113–1117.
3 Beamish N, Francis A, Gardosi J. Intrauterine growth restriction as a risk factor for infant mortality. *Arch Dis Child Fetal Neonatal Ed* 2008; **93** (Suppl I): Fa83.
4 Jarvis S, Gilianaia SV, Torrioli MG *et al.* Cerebral palsy and intrauterine growth in single births: European collaborative study. *Lancet* 2003; **362**: 1106–1111.
5 Jacobsson B, Ahkin K, Francis A *et al.* Cerebral palsy and restricted growth status at birth: population based case-control study. *BJOG* 2008; **115**: 1250–1255.
6 Confidential Enquiry into stillbirths with fetal growth restriction 2007. Perinatal Institute, 2007. Available from URL:www.pi.nhs.uk/rpnm/CE_SB_Final.pdf/.
7 Gardosi J, Francis A. Controlled trial of fundal height measurement plotted on customised antenatal growth charts. *BJOG* 1999; **106**: 309–317.
8 Gardosi J, Chang A, Kalyan B *et al.* Customised antenatal growth charts. *Lancet* 1992; **339**: 283–287.
9 The investigation and management of the small-for-gestational age. Royal College of Obstetricians & Gynaecologists. RCOG Green Top Guideline 2002 (No. 31). Available from URL: http//: www.rcog.org.uk/index.asp?PageID=531.
10 Lindhard A, Nielson PV, Mouritsen LA *et al.* The implications of introducing the symphyseal fundal height measurement. A prospective randomized control trial. *Br J Obstet Gynaecol* 1990; **97**: 675–680.
11 Persson B, Stangenberg M, Lunell NO *et al.* Prediction of size of infants at birth by measurement of symphysis-fundus height. *Br J Obstet Gynaecol* 1986; **93**: 206–211.
12 Neilson JP. Symphysis-fundal height measurement in pregnancy. *Cochrane Database Syst Rev* 1998 (2). Art. No.: CD000944. DOI: 10.1002/14651858.CD000944.
13 Gardosi J, Francis A. Customised Antenatal Growth Chart – GROW-Chart v7.6, 2009. Gestation Network. Available from URL: http://www.gestation.net.
14 Gardosi J, Francis A. Customised Weight Centile Calculator – GROW-Centile v5.15/6.4 2009. Gestation Network, www.gestation.net (v5.15: individual; v6.4: bulk centiles).
15 De Reu PA, Smits LJ, Oosterbaan HP, Nijhuis JG. Value of a single early third trimester fetal biometry for the prediction of birth weight deviations in a low risk population. *J Perinat Med* Jan 2008; **36**(4): 324–329.
16 McCowan LME, Harding JE, Stewart AW. Customised birthweight centiles predict SGA pregnancies with perinatal morbidity. *BJOG* 2005; **112**: 1026–1033.
17 Van Eerd EAM, Roex AJ, Nikpoor P, Dekker GA. Adverse perinatal outcomes and maternal risk factors in population versus customized defined babies. *J Matern Fetal Neonatal Med* 2011: 1–4, e publication ahead of print.
18 Hutcheon JA, Zhang X, Platt RW *et al.* The case against customized birthweight standards. *Paedatr Perinat Epidemiol* 2010; **25**: 11–16.