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Fetal growth surveillance – Current guidelines, practices and challenges

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Abstract

Antenatal surveillance of fetal growth is an essential part of good maternity care, as lack of detection of fetal growth restriction is directly associated with stillbirth and perinatal morbidity. New algorithms and guidelines provide care pathways which rely on regular third trimester ultrasound biometry and plotting of estimated fetal weight in pregnancies considered to be at increased risk, and their implementation has increased pressures on ultrasound resources. Customised growth charts have improved the distinction between constitutional and pathological smallness and reduced unnecessary referrals. Their introduction, together with clinicians' training, e-learning and audit as the key elements of the growth assessment protocol, has resulted in increased antenatal detection of small for gestational age babies and a reduction in avoidable stillbirths. However, missed case audits highlight that further improvements are needed, and point to the need to address quality assurance and resource issues in ultrasound services.

Keywords

Estimated fetal weight, small for gestational age, fetal growth restriction, stillbirth

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Fetal growth restriction and stillbirth

There has been a recent focus on stillbirth prevention, stimulated by the fact that stillbirth rates in the UK were among the highest in Western Europe and had not changed substantially over the last 20 years.[1] The situation was not helped by the fact that the majority of stillbirths have until recently been classified as 'unexplained', which was taken to suggest that these deaths were unavoidable.[2,3]

However, independent case reviews into the care of pregnancies that ended with a stillbirth found that many were associated with substandard care and therefore potentially avoidable.[4] The largest category were babies with growth restriction which had not been recognised antenatally. Many of these mothers never had a growth scan, and never even came to any special attention of the maternity services, until presenting one day – often late in pregnancy – with absent fetal movements.

These observations were reinforced by a better classification system which included a category for 'fetal growth restriction' (FGR), defined as small for gestational age (SGA) according to customised centiles. FGR was found to be the largest category, accounting for over half of all normally formed stillbirths.[3] Subsequent population-based analysis confirmed that pregnancies with an SGA fetus had a seven-fold increased risk for stillbirth, and that most of them were not recognised antenatally.[5] The report also found that antenatal recognition of FGR can halve stillbirth risk through earlier delivery (Figure 1).

Risk factors and algorithms for surveillance

The Royal College of Obstetricians and Gynaecologists' guidelines[6] for surveillance and management of pregnancies with an SGA fetal outlined

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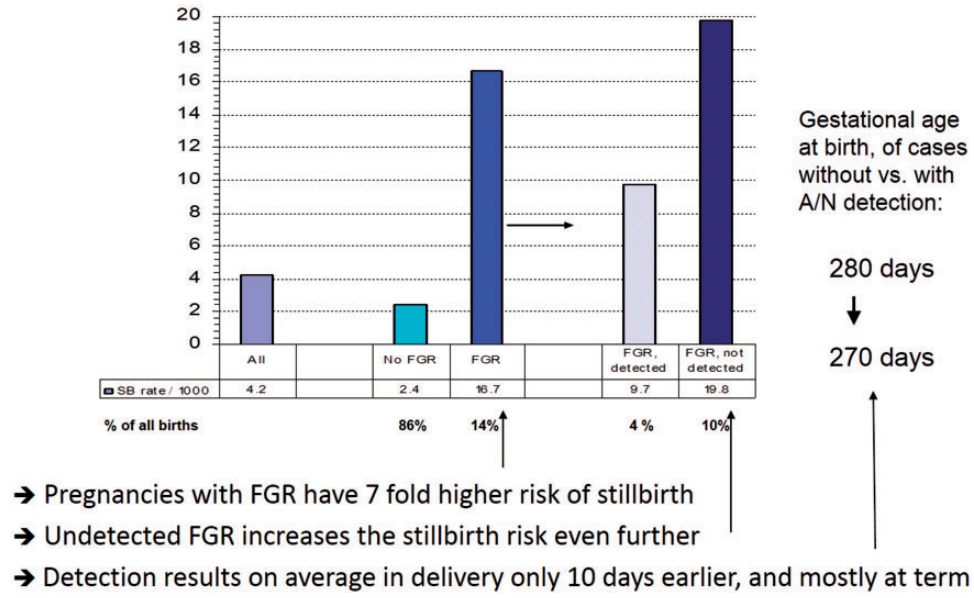

Figure 1. Stillbirth risk in pregnancies with and without antenatal (A/N) detection of fetal growth restriction (FGR), defined as < 10th customised centile. Illustration based on data in Gardosi et al.[5]

a standard of care that included serial measurement and plotting of fundal height and ultrasound biometry in low- and high-risk pregnancies, respectively. Customised charts (which adjust growth curves according to maternal height, weight, parity and ethnic origin) were recommended for plotting both fundal height and estimated fetal weight (EFW).[6]

The RCOG guidelines reviewed the risk factors associated with FGR and developed an algorithm which set out the recommended assessment of early pregnancy risk factors and care pathways contingent on low risk (→ serial measurement and plotting of fundal height) and increased risk (→ serial measurement and plotting of estimated fetal weight). Risk factors were divided into major and minor, with major risk factors requiring serial scans, and three minor prompting early pregnancy assessment by uterine Doppler to establish whether risk was major. Many units found this protocol too complicated for everyday use. Therefore, we assisted NHS England, as part of their Saving Babies' Lives Care Bundle initiative to develop a simplified algorithm which identified a list of risk factors, the presence of any of which would be an indication for serial ultrasound biometry.[7] The algorithm was adapted for the national GAP programme (see below) by including use of customised growth charts (Figure 2).

As most instances of FGR are 'late onset' in the third trimester (usually from 32 weeks),[5,8] the algorithm recommends surveillance *until delivery*. In high-risk pregnancy, a three-weekly regime would result in 4.5 third trimester scans – at 28, 31, 34, 37 and 40 weeks (the 40-week scan being needed for only half of all pregnancies still ongoing at that gestation).

Resource implications for guideline based surveillance

For many units, a schedule of 4.5 scans for all high-risk pregnancies is challenging and difficult to sustain within current resources. A West Midlands audit of 'current practice' in scan regimes afforded to pregnancies with a past history of SGA birth – a clinically undisputed indication for serial scans in subsequent pregnancies – found that the median number of scans performed was between 2 and 3 only, and 21% of these high-risk pregnancies had no third trimester scan at all.[9] The audit highlighted the importance of scan frequency: a one scan policy (usually at 32 weeks) or two scans (usually at 28 and 34 weeks) resulted in a detection rate of around 30%, which was little better than doing no scans at all.

We examined the proportion of the NHS population in the West Midlands that would be designated at increased risk requiring serial scans. According to the RCOG guidelines,[6] 25.5% of mothers would have either a major risk factor (20.6%) or 3 or more minor risk factors for SGA (4.9%).[10] The figure is higher – 36% – when applying the categories in the NHSE algorithm[11] (Table 1), mainly because all smokers, including those having <10 cigarettes per

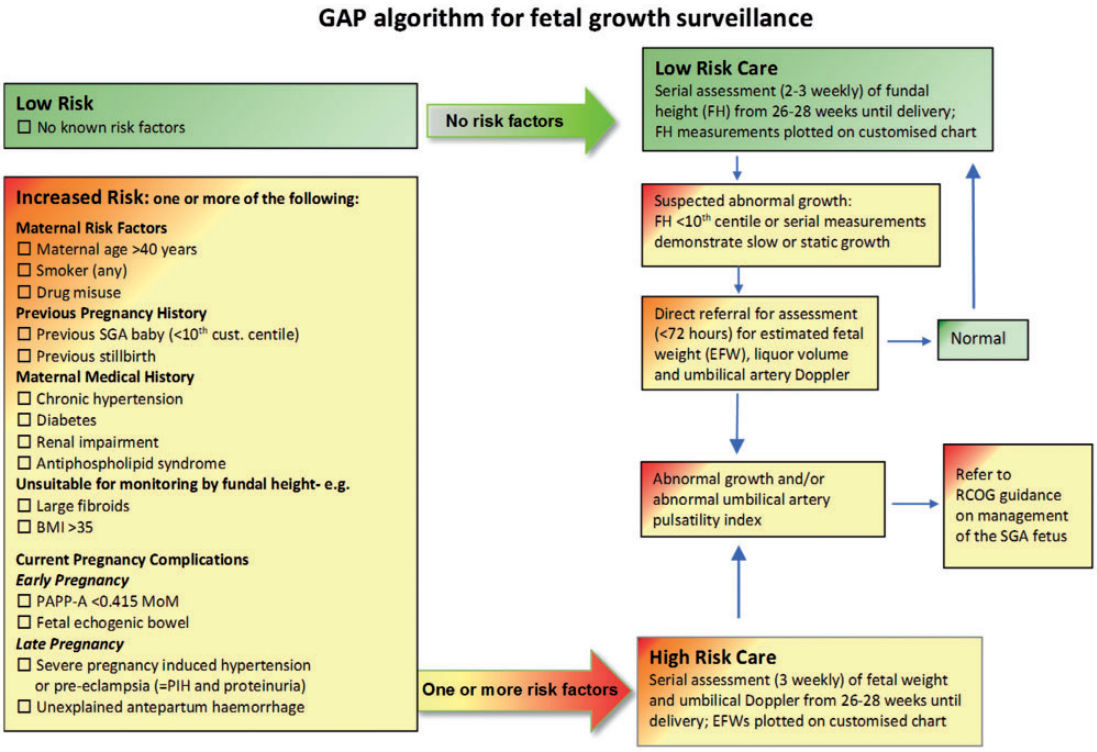

Figure 2. The growth assessment protocol (GAP) algorithm for fetal growth surveillance. Adapted from NHS England.[7]

Table 1. Prevalence of risk factors requiring serial ultrasound assessment of fetal growth according to new NHS England algorithm; West Midlands, N = 146,774

Risk factor	Prevalence (%)	Cumulative (%)
Previous stillbirth	0.3	0.3
Previous SGA baby	6.3	6.5
Pre-existing hypertension	6.2	12.4
Pre-existing diabetes	0.7	13.1
Maternal age 40+	3.2	15.6
Body mass index 35+	8.1	21.8
Drug misuse	1.1	22.6
Smoker 10 + cigarettes/day	9.6	29.5
Smoker 1–9 cigarettes/day	8.7	**36.2**

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SGA: small for gestational age.

day, are included as high risk. In practice, many units struggle to provide scans for all patients with these indications. Typically heavy smokers, or any smokers, and mothers with a raised BMI do not tend to receive serial scans.

Cost–benefit analysis

We assessed the cost benefit of a serial scan regime for increased risk pregnancies[10] according to RCOG defined risk factors.[6] An estimated 25% of the population at higher risk of SGA translated to 600–700 additional scans per 1000 births, depending on current scan provision.[10] A growth scan provided *additionally* to an already existing scanning service and infrastructure was estimated to cost £15 which, multiplied by the additional scan requirement, represented a cost of £10 per pregnancy, or £30,000 for a maternity unit with 3000 deliveries per annum. Against this, improved antenatal detection of IUGR has many benefits, including reduction in stillbirths (estimating 1 stillbirth saved per 1000 deliveries based on previous experience[12]), as well as reduced neonatal admissions, perinatal morbidity, cerebral palsy and litigation. We estimated that together,

Table 2. Effectiveness of ultrasound biometry at 34–36 weeks in the detection of SGA at birth

Weeks' gestation	34	35	36
N (pregnancies with a 'last scan')	12,612	10,285	17,301
% of all cases scanned at 34–36 weeks	31.4	25.6	43.1
SGA rate at birth (%)	14.1	18.4	19.3
Detection rate (DR)	**19.0**	**33.6**	**36.1**
False positive rate (FP)	1.3	3.7	3.5
Positive predictive value (PPV)	71.1	67.3	71.3
Negative predictive value (NPV)	88.1	86.5	86.4
Gestational age at delivery if EFW <10	262.4	268.5	270.0
Gestational age at delivery if EFW >10	277.3	276.5	277.3

Reproduced from Francis et al.[14] with permission.
SGA: small for gestational age; EFW: estimated fetal weight.

these will result in savings of at least £120 per pregnancy or £360,000 for a unit with 3000 births, representing a 12-fold return on investment.[10] However, the value of benefits was likely to be gross under-estimates in the absence of good data. In the case of stillbirths, they were confined to £5000 per death, mainly for costs of investigations; however, a more recent, detailed attempt in Australia[13] to estimate stillbirths' direct costs to the health service (in terms of investigations and counselling) as well as indirect costs including absenteeism and loss of productivity, resulted in an estimate of £36,000 per death.[13] Quite apart from the immeasurable loss of a human life, savings recognised in this way would vastly exceed any investment required to improve ultrasound services in step with national guidelines for fetal growth surveillance.

Accuracy of growth scans at term

The NHS England algorithm prescribes scans in increased risk pregnancies to be continued until delivery. The argument for this approach is strengthened by findings of a study where a prospective, routinely collected EFW at 'last scan' – performed for any indication – was assessed for its ability to predict SGA at birth[14] (Table 2). The data are analysed at the three most common gestational age points for a 'routine' third trimester scan – 34, 35 or 36 weeks. As shown in Table 2, pregnancies that had scans for any reason were at increased risk of SGA at delivery, with rates ranging from 14 to 19%. However, detection rates by EFW were overall poor, ranging from 19.0% at 34 weeks up to only 36.1% at 36 weeks. This may indicate poor scan technique or limitations of fetal weight estimation by ultrasound, but is more likely to be associated with slowing of growth towards an SGA birthweight late in third trimester, which is missed if the last scan is done too early.

When protocols for scanning up to delivery were first introduced, many ultrasound departments were reluctant because of concerns that scans at term are less inaccurate, although there seemed little evidence to support such a belief. We therefore investigated the accuracy of preterm and term scans, based on routine measurements collected from all 19 West Midlands regional maternity units.[15] The cohort consisted of 2296 pregnancies where an ultrasound scan was performed within three days of delivery, and this included 606 preterm (<37 weeks) and 1690 term deliveries. EFW was calculated by the Hadlock formula programmed into most units' ultrasound equipment. The assumed weight gain during the 1, 2 or 3 day delay between scan measurement and birth was adjusted using the previously described 'proportionality formula'.[16] The results showed that EFWs at term were at least as good, and in fact marginally better than scans done in the preterm period, with 73% of EFWs falling within a ±10% margin of error (Table 3).

Practitioners' concern about obtaining accurate fetal head measurement when it was fully engaged at term could be addressed by EFW formulae such as that by Hadlock,[17] which relies on abdominal circumference (AC) and femur length (FL) only.

Table 3. Accuracy of ultrasound scan at preterm vs. term gestational age, with scan performed within three days before delivery preterm ($n = 606$) or term ($n = 1690$).[15]

Proportion of error within	±10%	±15%	±20%
Gestational age at scan:			
<37 weeks	69.6	85.6	91.9
≥37 weeks	72.8	89.6	95.9

The growth assessment protocol: A comprehensive programme for surveillance

The case reviews of adverse outcomes and epidemiological analysis provided the rationale and urgent need to focus on antenatal detection of FGR, and the national guidelines provided the pathway to achieve this within routine antenatal care. We integrated these elements into the growth assessment protocol (GAP), a comprehensive programme including accreditation training for midwives, obstetricians and ultrasonographers, use of customised growth charts, birthweight centiles and audit. It included a recommended surveillance pathway which was broadly based on the NHS England algorithm,[7] but included use of customised charts according to RCOG guidelines[6] (Figure 2).

The emphasis is on longitudinal assessment, preferably by the same practitioner. In low-risk pregnancy, the main method of surveillance is serial fundal height measurement, with protocols prompting immediate referral when the first measurement is below the 10th customised centile, or the slope of sequential measurement does not follow the growth curves on the individually customised chart. Trained midwives can make autonomous referrals for scans if they have concerns about growth, without having their fundal height measurements 'checked' by other care provider(s).

Identification of increased risk pregnancy is contingent on primary care surveillance and referral, as well as risk assessment at the beginning of pregnancy to identify mothers who need serial scans. In either case, the required measure is the EFW plotted on a customised growth chart.

Customised growth charts

Underpinning the low and increased risk pathways (Figure 2) is the plotting of fundal height (FH) and EFW measurements on customised charts, as recommended by RCOG Green Top guidelines.[6] A controlled study has shown that a standardised approach significantly increases detection rates while reducing unnecessary referrals for ultrasound scans.[18] Customised charts also improve EFW assessment and reduce false positive diagnosis of SGA.[19]

The advantages of customised GROW ('gestation related optimal weight') charts become most apparent when looking at subgroups within the population, e.g. according to maternal size. There is better correlation between SGA defined by customised centiles and perinatal death than any population based, one-size-fits-all standard.[20]

GROW charts also improve the definition of SGA in multi-ethnic populations[21]: in a cohort of 10,405 South Asian mothers from India, Pakistan and Bangladesh, who had a third trimester scan, 1554 (14.9%) were SGA according to the Hadlock fetal weight curve; however, 864 of these (55.6%) were not SGA if the growth curves were customised according to the mother's characteristics (height, weight, parity and ethnic origin). This effect is illustrated in Figure 3(a) and (b). Significantly, these cases re-classified as not SGA had the same perinatal mortality risk as the general, non-SGA population.[21]

Recently, INTERGROWTH 21st has been promoted as an internationally applicable, one-size-fits all standard for birthweight[22] and fetal weight.[23] It was derived from low risk, well-nourished mothers in eight countries and was therefore meant to provide a prescriptive optimal standard for all pregnancies. However, this concept has been challenged on theoretical grounds,[24] and when applied to detailed multi-ethnic maternity datasets, it performed poorly compared to a customised standard.[25] In a recent study using a 10-country cohort of 1.25 million births, INTERGROWTH 21st showed unrepresentative rates of SGA (4.4%) and LGA (20.6%), and poor correlation with outcome.[26]

Plotting estimated fetal weight versus abdominal circumference measurement

Many ultrasonographers and clinicians are accustomed to plotting individual parameters like HC, AC and FL rather than EFW. While these need of course to be recorded, there are a number of reasons why calculation and plotting of EFW is preferred for the assessment of fetal growth:[27]

1. Although AC is the main component in the estimation of fetal weight, EFW is able to detect additional at-risk cases compared to AC alone.[28] Serial EFW measurement is furthermore as good or better than serial AC in predicting adverse outcome.[29]
2. Fetal weight curves can be customised using a predicted 280 day endpoint together with fetal weight

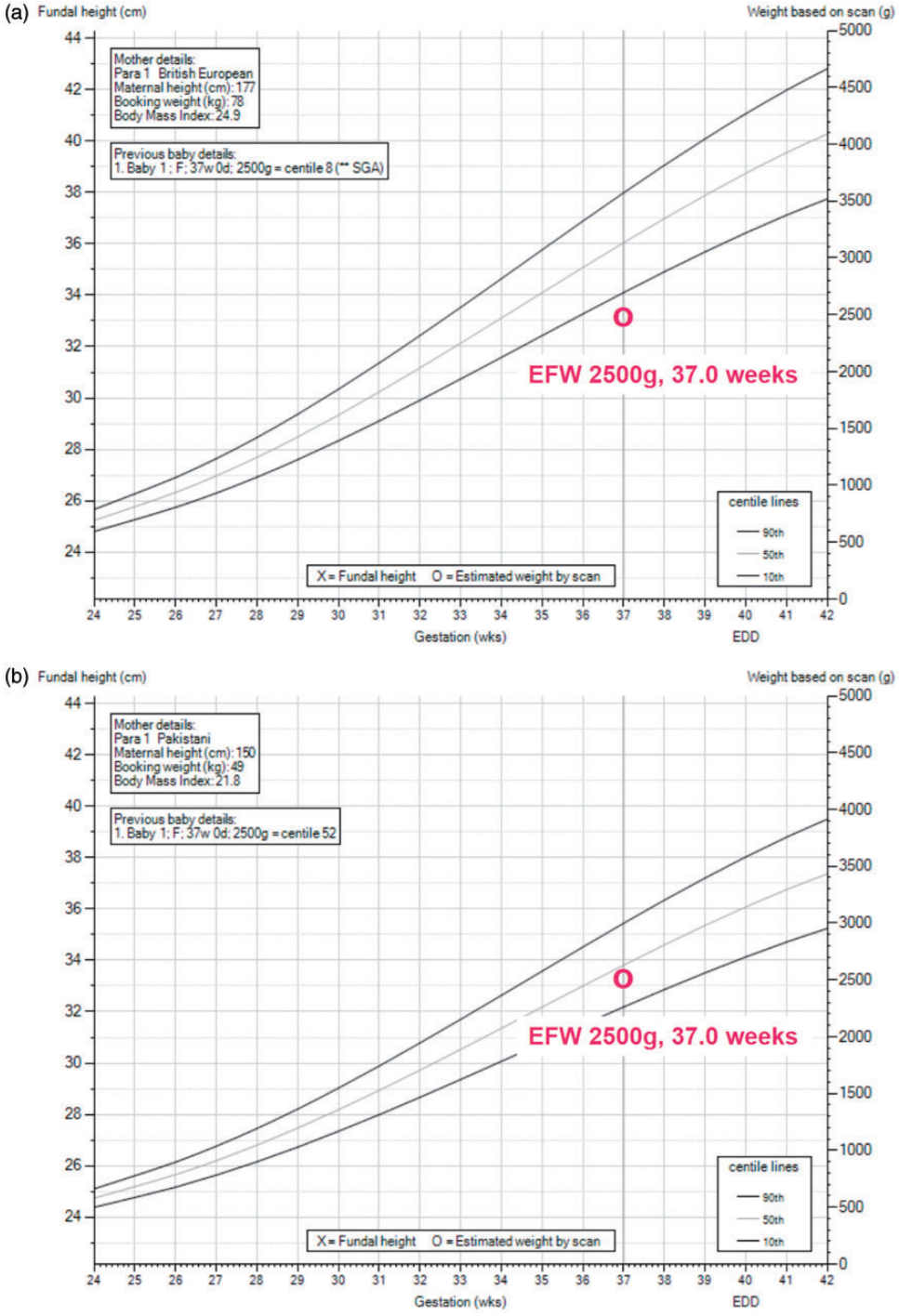
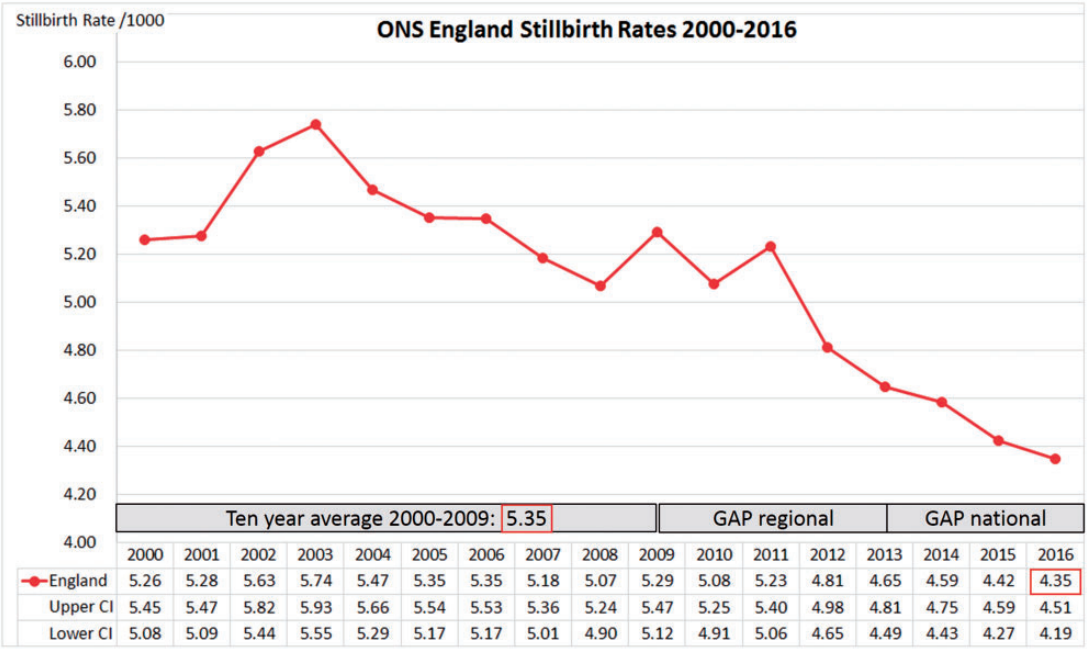


Figure 3. (a) and (b) Examples of customised charts for British-European (a) and South Asian (b) mothers. A sample estimated fetal weight (EFW) of 2500 g at 37.0 weeks is plotted on each chart to illustrate different results and clinical implications; 56% of SGA EFWs in pregnancies of South Asian mothers are not SGA if plotted on their own customised charts, and are not associated with increased perinatal mortality risk.[21]

based 'proportionality curve',[16,30] whereas individual biometry parameters cannot.

3. Scan error for EFW can be quantified and audited against birthweight (after adjusting for time delay between scan and delivery), while there is no such neonatal gold standard for AC or any other ultrasound biometry parameter.
4. The GROW chart is carried by the mother, and EFW means something to her in terms of the current size of her baby and the projected



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
England	5.26	5.28	5.63	5.74	5.47	5.35	5.35	5.18	5.07	5.29	5.08	5.23	4.81	4.65	4.59	4.42	4.35
Upper CI	5.45	5.47	5.82	5.93	5.66	5.54	5.53	5.36	5.24	5.47	5.25	5.40	4.98	4.81	4.75	4.59	4.51
Lower CI	5.08	5.09	5.44	5.55	5.29	5.17	5.17	5.01	4.90	5.12	4.91	5.06	4.65	4.49	4.43	4.27	4.19

Figure 4. Trend in stillbirth rates in England. Stillbirth rates (per 1000) in England, according to ONS. The rate remained similar over a 10-year period (2000, 5.26; 2009, 5.29) and averaged 5.35; the fall to 4.35 by 2016 following the implementation of the GAP program represented a 19% drop ($P<.01$).
CI: confidence interval; GAP: growth assessment protocol; ONS: office of national statistics.
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birthweight, while this is not the case for AC and other parameters.

Standardising fetal growth surveillance:

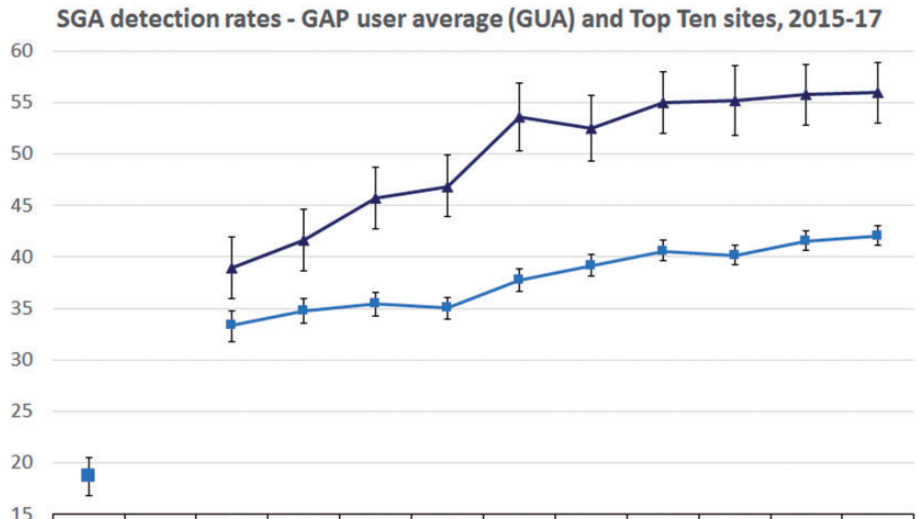
The Growth Assessment Protocol (GAP)[31] combines customised growth charts with accreditation training, e-learning support and audit tools, and has the principal objective of improving antenatal awareness of intrauterine growth restriction, thereby initiating further investigation and management, ultimately reducing the risk of intrauterine death or other adverse outcomes.

A regional version of GAP was first introduced in the West Midlands in 2009, where implementation resulted in the drop in stillbirth rates to below the national level for the first time ever, with evidence that this reduction was due to fewer deaths associated with growth restriction.[12] The programme was subsequently adopted in two additional NHS regions and resulted in further significant reductions in stillbirth rates which was confirmed to be causally associated with the intervention as no similar drop occurred in the other NHS regions.[32] Since then GAP has been implemented in nearly 80% of all Trust and Health Boards in the UK.[33] As illustrated in Figure 4, the national roll-out was associated with a year-on-year drop in ONS reported stillbirth rates in England to their lowest ever level of 4.35/1000 in 2016, a 19% reduction compared to the previous 10 year average (2000–2009: 5.35/1000).[34] GAP has adapted the RCOG guidelines[6] and the NHS England algorithm[7] into a workable and successful quality improvement and stillbirth prevention programme.

Auditing performance

Audit is an essential component of GAP and is facilitated by software integral to the customised chart (GROW App). Following delivery, information is entered about birthweight, sex and gestational age at delivery, as well as whether there was antenatal suspicion (referral) or diagnosis of fetal growth problems. This is then compared with outcome, i.e. whether the birthweight was small, normal or large for gestational age. Before a unit implements GAP, an audit is undertaken to establish baseline detection rates, which is followed in the majority of GAP units with ongoing recording of outcome, with high (>90%) ascertainment rates.

Figure 5 shows the baseline and national trend over the last 2 years, with an overall 'GAP user average' as well as the average for the 10 best performing units. The baseline detection rate of SGA birthweight averaged 18.7% which is consistent with published audits from



	Baseline		Q1 2015/16	Q2 2015/16	Q3 2015/16	Q4 2015/16	Q1 2016/17	Q2 2016/17	Q3 2016/17	Q4 2016/17	Q1 2017/18	Q2 2017/18
GUA Detection Rate	18.7		33.3	34.8	35.5	35.0	37.8	39.2	40.6	40.2	41.6	42.0
Top Ten Detection Rate			38.9	41.6	45.7	46.9	53.6	52.5	55.0	55.2	55.8	56.0
Cases - GAP User Average	13,844		27,414	43,406	53,233	56,393	65,455	73,360	74,774	77,507	83,388	92,112
Cases - Top Ten Average			7,535	7,876	8,806	8,927	8,174	11,200	11,424	10,844	12,884	8,388

Figure 5. Antenatal detection of SGA. Trend of detection of newborn infants with SGA birthweight (<10th customised centile). Baseline rates, GAP user average (GUA) and average for top ten performing units is shown.
GAP: growth assessment protocol; GUA: GAP user average; SGA: small for gestational age.
Reproduced from Gardosi et al.,[34] with permission.

other environments.[35,36] There has been a steady increase in antenatal detection rates to 42% (a 2.5 fold increase from baseline), with the top 10 units averaging 56%.

A limitation of this audit is that there is no routinely collected neonatal 'gold standard' for fetuses that had intrauterine growth restriction *without* being SGA. Thus, auditing SGA birthweight as the denominator accounts for only a proportion of cases with growth problems that may have been detected. Similarly, it is difficult to assess false positive rates, as in many instances, scans may have identified clinically relevant slow growth, without the fetus or neonate being SGA.

Audit of missed cases

Alongside routine audit of referral and detection rates, GAP-enrolled Trusts and Health Boards also audit randomly selected cases where babies with SGA birthweight had not been recognised to be small antenatally. This is undertaken using bespoke software – GAP SCORE (standardised clinical outcome review and evaluation). The application systematically examines the care of each case by looking at:

- Assessment of risk factors at booking and subsequent management plan.
- Routine fetal growth surveillance of both high risk and low risk pregnancies including the number of third trimester scans.
- Accuracy of EFW in relation to the neonatal birthweight.

The software then derives a taxonomy of the substandard care factors responsible for the SGA status not having been recognised.

Analysis of 2 years of data ($n = 2977$) from local audits undertaken in 64 UK Trusts and Health Boards participating in the GAP programme, showed that these missed cases fall into 4 main categories (Figure 6).

As the pie chart shows, low-risk cases managed by fundal height measurement which failed to be suspected of SGA and referred for a scan were one of the smaller categories, with 18.8% of the missed cases. It is important to acknowledge here that, in units with trained midwives and other health professionals, low-risk pregnancies screened with fundal height measurement contributed less than a fifth to the overall 'burden' of unrecognised SGA cases. This is relevant as some clinicians consider routine scanning of all pregnancies as a shortcut solution to replace fundal height measurement and referral pathways. While a routine 36-week scan was reported to reach an antenatal detection rate of 56% of SGA (<10th birthweight centile) within

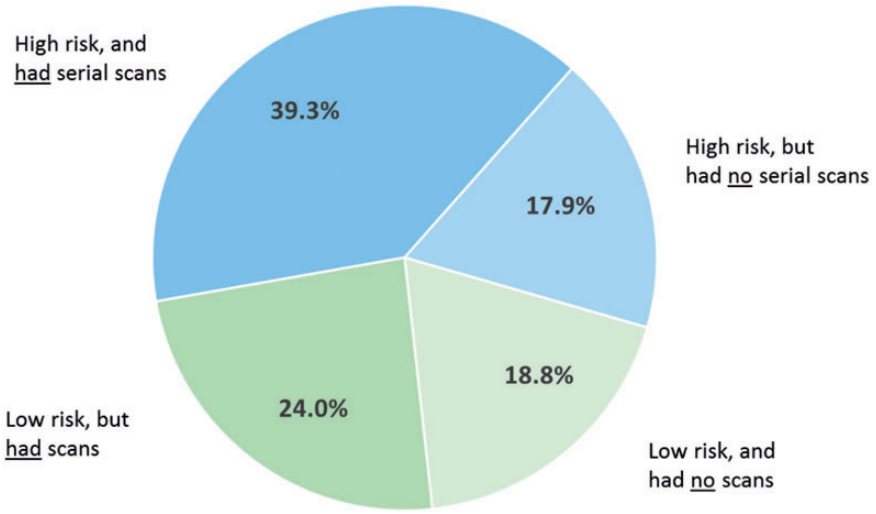


Figure 6. Missed case audit of 2977 pregnancies with SGA newborn from 64 Trusts and Health Boards in the UK GAP programme. Data source: Perinatal Institute.

a research setting,[37] this has not been demonstrated in routine practice[14] (Table 2). Routine growth scans have also not shown to have benefits according to Cochrane reviews[38] and may provide false reassurance. In general terms, longitudinal assessment of growth is better than a spot-check of fetal size.

The remaining three categories (Figure 6) all related to ultrasound scans, when they were done but still failed to detect that the baby was SGA, or not done despite being indicated according to the risk assessment. This points towards quality issues which need further investigation, but is also likely to be the result of insufficient scan provision reflecting resource issues. The largest category of missed cases, 39.3%, comprised pregnancies which had been recognised as high risk and had 'serial' (2 or more) third trimester growth scans, yet were still missed. The average number of ultrasound scans in these high risk pregnancies was only 2.4, and the average delay between the last scan and delivery was 3 weeks, which suggests that, contrary to protocol, serial scanning was usually not continued up to delivery and, not surprisingly, failed to recognise late onset fetal growth restriction.

Challenges and next steps

The widespread shortages in ultrasound resources have led to a Department of Health sponsored initiative coordinated by Health Education England, to train an additional 200 health care professionals (from a range of relevant professions) in obstetric ultrasound by the middle of 2018. This is an interim measure which needs to be followed by a more sustained effort to ensure that the service catches up with requirements, as currently clinical non-adherence to evidence based guidelines are putting babies at risk.

Further work is also needed to enhance quality assurance of growth scans. Fetal weight estimation is more sensitive and specific than other measures for detecting smallness for gestational age, but can have large random errors.[39] Estimated fetal weight can be assessed against birthweight using the freely available EFW Audit Tool[40] which adjusts for the time interval between scan and delivery using the proportionality growth formula[16] and calculates the percentage error of the scan. There have been also useful efforts in local Trusts (e.g. Taunton & Somerset – D Downs, personal communication) to audit performance, feed-back to individual operators, and identify outliers requiring further training. Finally, research is also underway to develop automated fetal measurement systems which provide real-time feedback to sonographers on measurement technique, consistency and image selection.

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Ethical approval

None required – article is a review.

Guarantor

JG.

Contributors

JG conceived the review and wrote the first draft, and worked with MW on subsequent versions. All authors reviewed and approved the final version of the manuscript.

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