

12 Fetal growth and wellbeing

Clinical question

What is the diagnostic value and effectiveness of the following methods for determining fetal growth?

- symphysis–fundal height measurement (SFH)
- ultrasound scanning (US)
- use of customised growth charts with SFH measurement
- use of customised growth charts with US scanning
- clinical judgement/abdominal palpation
- frequency

Previous NICE guidance (for the updated recommendations see below)

The use of umbilical artery Doppler ultrasound for the prediction of fetal growth restriction should not be offered routinely. [A]

The use of uterine artery Doppler ultrasound for the prediction of pre-eclampsia should not be offered routinely. [B]

The evidence does not support the routine use of ultrasound scanning after 24 weeks of gestation and therefore it should not be offered. [A]

The evidence does not support the routine use of antenatal electronic fetal heart rate monitoring (cardiotocography) for fetal assessment in women with an uncomplicated pregnancy and therefore it should not be offered. [A]

Auscultation of the fetal heart may confirm that the fetus is alive but is unlikely to have any predictive value and routine listening is therefore not recommended. However, when requested by the mother, auscultation of the fetal heart may provide reassurance. [D]

Routine formal fetal-movement counting should not be offered. [A]

Pregnant women should be offered estimation of fetal size at each antenatal appointment to detect small- or large-for-gestational-age infants. [A]

Symphysis–fundal height should be measured and plotted at each antenatal appointment. [Good practice point]

Future research:

Further research on more effective ways to detect and manage small- and large-for-gestational age fetuses is needed.

Fetal presentation should be assessed by abdominal palpation at 36 weeks or later, when presentation is likely to influence the plans for the birth. Routine assessment of presentation by abdominal palpation should not be offered before 36 weeks because it is not always accurate and may be uncomfortable. [C]

Suspected fetal malpresentation should be confirmed by an ultrasound assessment. [Good practice point]

12.1 Introduction and background

The average duration of a full term pregnancy is 282 days from the first day of the last menstrual period and during this time the fetus passes through various stages of growth and development. Monitoring the growth of the fetus is of vital importance in identifying small- and large-for-

Table 12.1 Characteristics of included studies on diagnostic value of clinical examination

Study and EL	Study characteristics	Population characteristics	Sample size (% of study population)	Timing of screening test with threshold(s) (prevalence of test positive)	Outcome in weeks (incidence of SPTB)	Diagnostic value with 95% CI
Bais (2004) ⁹¹⁶ (Netherlands) EL II	Retrospective analysis of database of a geographical cohort, blinding not specified.	All low-risk singleton pregnancies with confirmed GA by US at 20 weeks Exclusions: women who delivered between 16–20 weeks, gave birth to infant < 500 g, multiple pregnancies	6318 (93.9)	Abdominal palpation by midwives after 20 weeks till referral or delivery (frequency not specified) Threshold: clinical judgement	BW < 10th centile for SGA and < 2.3rd centile for severe SGA (8.5% SGA, 1.5% severe SGA)	For SGA: ST 0.21 (0.18–0.24), SP 0.96 (0.95–0.96), LR+ 5.19 (4.23–6.37), LR– 0.82 (0.79–0.86)
Secher (1990) ⁹¹⁷ (Denmark) EL III	Retrospective cohort, single centre, blinding not specified.	Randomly selected singleton pregnancies with confirmed GA by US at 16–18 weeks. Exclusions: pregnancies complicated by diabetes or severe blood group incompatibilities.	199 (Not specified)	Once a week from 33–36 weeks, study sample with more than 3 measurements. EFW calculated and EFW curve generated using modelling. Threshold: Last EFW value < 10th centile, and EFW curve < 10th centile.	BW < 85% of expected for GA (or < 9.4th centile for GA).	For EFW value < 10th centile: ST 0.45 (0.32–0.58), SP 0.91 (0.87–0.95), LR+ 4.82 (2.69–8.78), LR– 0.61 (0.48–0.77) For EFW curve < 10th centile: ST 0.38 (0.26–0.50), SP 0.92 (0.88–0.96)

gestational age babies, both of whom are at an increased risk of associated morbidity and mortality. The methods currently used to screen fetal growth are abdominal palpation, symphysis–fundal height (SFH) measurements, ultrasound scanning and fetal biometry, and customised growth charts. But the challenge is to identify these high-risk pregnancies using the most effective screening methods. There is currently no agreed UK population standard to define normal ranges for estimated fetal weight, fetal growth or birthweight.

12.2 Diagnostic value for predicting SGA babies

Twenty one studies have been reviewed under this section. Most of them are prospective cohort studies. Blinding has not been specified in most studies and these have been assigned [EL = II] except for Doppler US of Umbilical Artery where all the included studies are of EL Ib.

The population in these studies was either a low-risk group of women with singleton pregnancies or an unselected group. Exclusions and number of women in the study population have been specified where information was available. Details of screening tests including timing, frequency and thresholds have been described if recorded. Many studies have evaluated screening performance of various tests at different thresholds and used different criteria for defining SGA. For the sake of comparison efforts have been made to calculate diagnostic value for commonly used thresholds (< 2SD or < 10th centile of reference curve/value) and outcome as birthweight < 10th centile for gestational age.

12.2.1 Clinical examination/abdominal palpation

Description of included studies

Two retrospective studies were identified – one using a database of a large geographical cohort,⁹¹⁶ [EL = II] and the other random selection of hospital records.⁹¹⁷ [EL = III] Low-risk singleton pregnancies with confirmed gestational age were included in both the studies, but blinding was not specified. Women were examined regularly after the 20th week in the first study and the diagnostic value of abdominal palpation calculated for SGA defined as birthweight < 10th centile. In the other study with a much smaller sample size, examination was done once a week from 33 to 36 weeks, and the last value of estimated fetal weight (EFW) taken. Based on three or more measurements, an EFW curve was also generated. Predictive accuracy was calculated for threshold < 10th centile in both parameters with birthweight < 9.4th centile as the outcome (Table 12.1).

Findings

In the larger study (Bais *et al.*⁹¹⁶) abdominal palpation had a sensitivity of 0.21 and specificity of 0.96 for predicting SGA babies. It had an LR+ value of 5.19 (4.23–6.37) and an LR– value of 0.82 (0.79–0.86).

In the second study,⁹¹⁷ the diagnostic value of both the EFW value (single) and EFW curve was similar. EFW had sensitivity of 0.45 and specificity of 0.91, while EFW curve had sensitivity of 0.38 and specificity of 0.92. Wide variation was observed in confidence intervals owing to the small sample size. The LR for a positive test was 4.82 (2.69–8.78), while that for a negative test was 0.61 (0.48–0.77).

Evidence summary

There is a lack of good-quality evidence on the diagnostic value of clinical examination/abdominal palpation. The available evidence indicates that clinical examination/abdominal palpation does not have good diagnostic value for predicting SGA babies.

12.2.2 Symphysis–fundal height measurement

Description of included studies

All the five studies included under this heading had EL = II. Blinding was not specified in most of the studies. One was a retrospective cohort⁹¹⁸ and the other four were prospective cohort studies.^{919–922} In one study the population was made up of a cohort of singleton pregnancies

Table 12.2 Characteristics of included studies on diagnostic value of SFH measurement

Study and EL	Study characteristics	Population characteristics	Sample size (% of study population)	Timing of screening test with threshold(s) (prevalence of test positive)	Outcome(s) and its threshold (incidence in %)	Diagnostic value with 95% CI
Persson (1986) ⁹¹⁹ (Sweden) EL II	Prospective cohort, multicentre, blinding not specified.	Singleton pregnancies with regular menstrual cycles and known LMP. <i>Inclusions:</i> multiple gestation, mothers with more than 1 infant during study period or lack of registration in Medical Register.	2919 (91.3%)	15 times approx. during the entire pregnancy. <i>Threshold:</i> SFH value < 2 SD of Reference Curve generated from 1350 healthy pregnant women.	BW < 10th centile for GA and sex (9.0% in sample population)	ST 0.27 (0.22–0.32), SP 0.88 (0.87–0.89)
Harding (1995) ⁹²⁰ (Australia) EL II	Prospective cohort, single centre, single blinded. (cohort was a group of women in one arm of RCT)	Randomly selected pregnant women who had approx. 5 scans between 18–38 weeks. <i>Exclusions:</i> multiple pregnancies, pre-existing HT, diabetes, maternal renal disease, fetal anomalies	747 at 28 weeks, 913 at 34 weeks. (65.8% at 28 weeks and 80.4% at 34 weeks)	5 times at 18–20, 24, 28, 34, and 38 weeks. <i>Threshold:</i> Single SFH value < 10th centile for sample population and best cut-off from ROC curve.	BW < 10th centile for GA. (12.3% at 28 weeks, 11.8% at 34 weeks)	Threshold < 10th centile (28 weeks): ST 0.32 (0.23–0.40), SP 0.88 (0.86–0.90) Threshold < 10th centile (34 weeks): ST 0.31 (0.22–0.40), SP 0.87 (0.85–0.89)
Rosenberg (1982) ⁹¹⁸ (UK) EL II	Retrospective cohort, single centre, blinding not specified.	Singleton pregnancies with known GA at < 26 weeks gestational age. <i>Exclusions:</i> multiple pregnancies, uncertain GA	753 (98.9%)	From 20 weeks till delivery. <i>Threshold:</i> Two consecutive for GA or three isolated SFH values < 10th centile of Reference Curve generated from 478 healthy pregnant women.	BW < 10th centile for GA (6.6% in sample population)	ST 0.56 (0.42–0.70), SP 0.85 (0.82–0.87)
Grover (1991) ⁹²¹ (India) EL II	Prospective cohort, single centre, blinding not specified	Singleton pregnancies with known GA attending ANC. <i>Exclusions:</i> Not defined	350 (87.5%)	SFH recording fortnightly till 30 weeks then weekly till term. <i>Threshold:</i> SFH value < 1 SD of Reference Curve generated from 200 healthy pregnant women	BW < 10th centile for GA (29.7% in sample population)	ST 0.81 (0.73–0.88), SP 0.94 (0.91–0.97)
Rogers (1985) ⁹²² (UK) EL II	Prospective cohort, single centre, blinding not specified.	Randomly selected pregnant women attending ANC of a hospital. <i>Exclusions:</i> not well defined	250 (study population not specified)	SFH measurements in the third trimester. <i>Threshold:</i> Single SFH value < 3 cm below mean of sample or 3 consecutive static or declining values.	BW < 10th centile for GA (10.4% in sample population)	ST 0.73 (0.56–0.90), SP 0.92 (0.88–0.96)

included in one arm of an RCT.⁹²⁰ Two studies did not have well-defined exclusion criteria. SFH was measured in all studies from 20 weeks onward till term, but the exact timing, frequency and threshold of a positive test were different. All studies evaluated birthweight < 10th centile as the outcome. Meta-analysis was not performed owing to existing heterogeneity (Table 12.2).

Findings

There was wide variation in the results. Results from the two studies with smaller sample size showed better values of LR+ and LR- compared with the other studies. The best results were seen in the Grover study,⁹²¹ with an LR+ of 12.42 (95% CI 7.66 to 20.13) and an LR- of 0.21 (95% CI 0.14 to 0.31). However, the study with largest sample size (Persson *et al.*⁹¹⁹) showed poor values for LR+ at 2.22 (95% CI 1.77 to 2.78) and LR- at 0.83 (95% CI 0.77 to 0.90) (Figure 12.1).

Evidence summary

A wide variation in the results was observed for predictive accuracy of SFH measurement during pregnancy. The results from a multicentre study show that it does not have good diagnostic value for predicting and ruling out SGA babies.

12.2.3 Fetal biometry

Description of included studies

Four of the included studies were prospective cohort studies⁹²³⁻⁹²⁶ and one was a retrospective⁹²⁷ – all with EL II and well-defined exclusion criteria. Ultrasound was conducted in the third trimester and the diagnostic value calculated for a single measurement. All studies had used abdominal circumference (AC) as a parameter, two had also used EFW based on Shepard’s formula (using AC, BPD), and one used head circumference (HC). The threshold for a positive test was similar in all (< 10th centile) and the outcome assessed was birthweight < 10th centile for gestational age. Meta-analysis was performed for diagnostic accuracy of a single AC measurement in the third trimester (Table 12.3).

Findings

With AC as the only parameter used and threshold < 10th centile, sensitivity ranged from 48% to 87% while specificity ranged from 69% to 96%. Threshold values were not properly defined in the study by Hedriana *et al.*⁹²⁶ On combining results of all the five studies, strong evidence of statistical heterogeneity was observed ($P < 0.00001$). The summary LR+ was 6.25 (95% CI 5.60

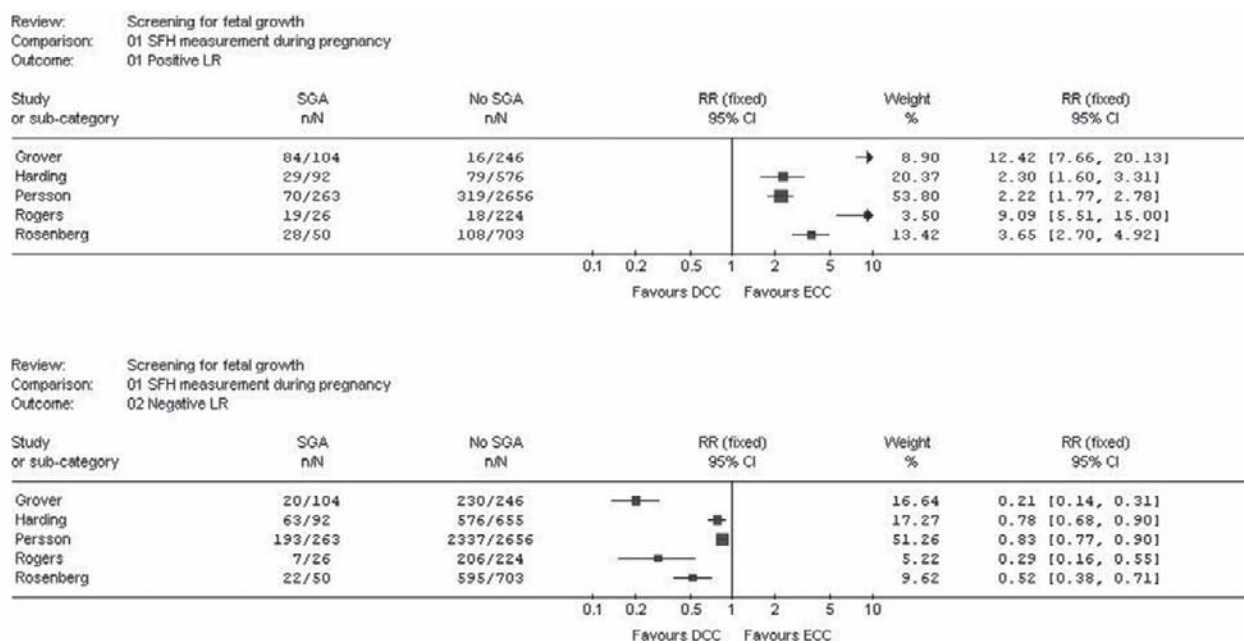


Figure 12.1 SFH measurement

Table 12.3 Characteristics of included studies on diagnostic value of fetal biometry

Study and EL	Study characteristics	Population characteristics	Sample size (% of study population)	Timing of screening test with threshold(s) (prevalence of test positive)	Outcome(s) and its threshold (incidence in %)	Diagnostic value with 95% CI
Warsof (1986) ⁹²³ (UK) EL II	Prospective cohort, single centre, blinding not specified.	Ultrasonically confirmed singleton pregnancies before 24 weeks. <i>Exclusions:</i> lack of dating scan before 24 weeks.	3616 (79.9%)	Once in third trimester at 28, 30, 32, 34 or 36 weeks. <i>Threshold:</i> BPD, HC and AC values < 25th centile or < 10th centile for GA.	BW < 10th centile for GA. (12.4% in sample population)	Threshold < 25th centile: For AC: ST 0.79 (0.76–0.82), SP 0.80 (0.79–0.81); For HC: ST 0.54 (0.50–0.58), SP 0.78 (0.77–0.80) Threshold < 10th centile: For AC: ST 0.48 (0.45–0.51), SP 0.93 (0.93–0.94); For HC: ST 0.35 (0.32–0.39) SP 0.91 (0.90–0.92)
Skovron (1991) ⁹²⁴ (USA) EL II	Prospective cohort, single centre, blinding not specified.	Singleton pregnancies <i>Exclusions:</i> gestational diabetes, placenta praevia, preterm labour, Rh sensitisation, fetal anomalies.	768 (77.1%)	Once between 26 and 34 weeks. <i>Threshold:</i> AC and EFW (Shepard's formula) at < 10th and < 25th centile for GA.	BW < 10th centile for GA and sex (9.9% in sample population)	Threshold < 25th centile: For AC: ST 0.83 (0.74–0.92), SP 0.56 (0.52–0.60); For EFW: ST 0.51 (0.40–0.62), SP 0.80 (0.77–0.83) Threshold < 10th centile: For AC: ST 0.72 (0.62–0.83), SP 0.69 (0.66–0.72); For EFW: ST 0.25 (0.15–0.35), SP 0.97 (0.96–0.98)
Newnham (1990) ⁹²⁵ (Australia) EL II	Prospective cohort, single centre, not blinded for AC.	Singleton pregnancies with known GA at < 18 weeks gestational age. <i>Exclusions:</i> multiple pregnancies, gestational age > 20 weeks, language difficulties, not pregnant, major fetal anomaly.	535 (87.0%)	At 28 and 34 weeks. <i>Threshold:</i> AC < 5th centile for GA in the study population.	BW < 10th centile for GA (9.5% in sample population)	At 28 weeks: ST 0.27 (0.14–0.40), SP 0.96 (0.94–0.98) At 34 weeks: ST 0.49 (0.33–0.65), SP 0.94 (0.92–0.96)
Lin (1990) ⁹²⁷ (USA) EL II	Retrospective cohort, single centre, blinding not specified	Singleton pregnancies undergoing obstetric US at a tertiary hospital. <i>Exclusions:</i> multiple gestation, ruptured membranes, uncertain dates, fetal anomalies.	463 (study population not specified)	Twice in third trimester at interval of 2–4 weeks. <i>Threshold:</i> AC < 10th centile for GA in the study population.	BW < 10th centile for GA (13.8% in sample population)	ST 0.87 (0.78–0.96), SP 0.77 (0.73–0.81)
Hedriana (1994) ⁹²⁶ (USA) EL II	Prospective cohort, single centre, blinding not specified.	Ultrasonically confirmed singleton pregnancies. <i>Exclusions:</i> multiple gestation, maternal complications associated with severe intrauterine growth retardation, fetuses with anatomic defects.	249 (94.3%)	Single and serial third-trimester scans between 28 and 42 weeks. <i>Threshold:</i> Slope \pm SD calculated for AC and EFW (Shepard's formula) centile using regression analysis. Exact values not specified.	BW < 10th centile for GA (7.6% in sample population)	For single scan: For AC: ST 0.68 (0.47–0.89), SP 0.88 (0.84–0.92); For EFW: ST 1.00 (1.00–1.00), SP 0.76 (0.71–0.82)

to 6.97) and summary LR- was 0.55 (95% CI 0.52 to 0.58). Values for LR+ ranged from 3.84 to 8.20 and those for LR- from 0.16 to 0.78 (Figure 12.2).

Evidence summary

There is some evidence to indicate that a single measurement of fetal AC in the third trimester has some diagnostic value in predicting the birth of SGA babies but the studies show statistical heterogeneity.

12.2.4 Reduced amniotic fluid volume by ultrasound

Description of included studies

Three studies have been included – two cohort studies^{920,927} with EL II (one prospective and the other retrospective) and one case-control study⁹²⁸ with EL III. Blinding was not specified in any but exclusions were well defined. Timing, frequency and threshold of a positive test were all different in the three studies. In one study (Lin *et al.*⁹²⁷) the diagnostic performance of AC and reduced amniotic fluid volume was calculated as a single test (Table 12.4).

Findings

Values for LR+ and LR- in the prospective cohort study (Harding *et al.*⁹²⁰) were poor at 1.02 (95% CI 0.58 to 1.79) and 1.00 (95% CI 0.93 to 1.07), respectively. The Lin *et al.* study⁹²⁷ showed a high LR+ of 12.47 and LR- of 0.77, but results from the third study were not consistent (Figure 12.3).

Evidence summary

Evidence from three studies shows that reduced amniotic fluid volume diagnosed by ultrasound during pregnancy has poor diagnostic value in predicting and ruling out SGA babies.

12.2.5 Umbilical artery Doppler examination

Description of included studies

All of the five included studies were prospective cohort studies [EL = Ib] with blinding^{925,929-932} and one was conducted in more than one centre. The exclusion criteria were well defined in

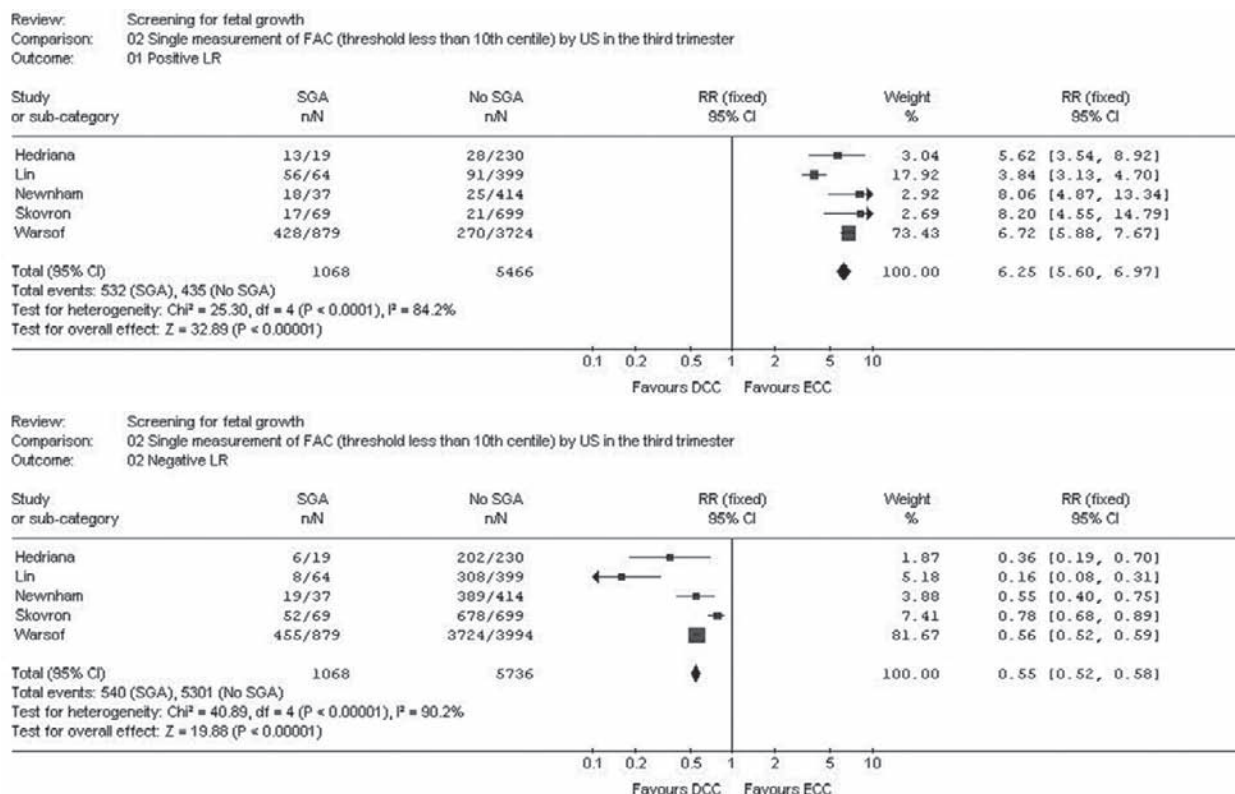


Figure 12.2 Fetal abdominal circumference by ultrasound

Table 12.4 Characteristics of included studies on diagnostic value of reduced amniotic fluid volume (AFI) by ultrasound

Study and EL	Study characteristics	Population characteristics	Sample size (% of study population)	Timing of screening test with threshold(s) (prevalence of test positive)	Outcome(s) and its threshold (incidence in %)	Diagnostic value with 95% CI
Harding (1995) ⁹²⁰ (Australia) EL II	Prospective cohort, single centre, not blinded for US measurements. (cohort was a group of women in one arm of RCT)	Randomly selected pregnant women who had approx. 5 scans between 18–38 weeks. <i>Exclusions:</i> multiple pregnancies, pre-existing HT, diabetes, maternal renal disease, fetal anomalies.	760 at 28 weeks, 914 at 34 weeks. (67.0% at 28 weeks and 80.5% at 34 weeks)	5 times at 18–20, 24, 28, 34, and 38 weeks. <i>Threshold:</i> Single AFI value < 10th centile for sample population.	BW < 10th centile for GA. (12.6% at 28 weeks, 11.7% at 34 weeks)	Threshold < 10th centile (28 weeks): ST 0.21 (0.13–0.29), SP 0.93 (0.91–0.95) Threshold < 10th centile (34 weeks): ST 0.11 (0.05–0.17), SP 0.89 (0.87–0.91)
Lin (1990) ⁹²⁷ (USA) EL II	Retrospective cohort, single centre, blinding not specified	Singleton pregnancies undergoing obstetric US at a tertiary hospital. <i>Exclusions:</i> multiple gestation, ruptured membranes, uncertain dates, fetal anomalies.	463 (study population not specified)	Twice in third trimester at interval of 2–4 weeks. <i>Threshold:</i> AC < 10th centile for GA in the study population and vertical diameter < 2 cm in largest pocket of amniotic fluid for oligohydramnios.	BW < 10th centile for GA (13.8% in sample population)	For AC < 10TH centile and oligohydramnios: ST 0.25 (0.15–0.36), SP 0.98 (0.97–0.99)
Chauhan (1999) ⁹²⁸ (USA) EL III	Retrospective case-control, single centre, blinding not specified.	Cases: Singleton pregnancies, AFI ≤ 5 cm, reliable GA and no known anomalies. Controls: Next pregnancy with same GA and AFI between 5.1 to 23.9 cm.	324 (Cases – 162 Controls – 162)	Third-trimester US for AFI within 72 hours of delivery. Threshold: AFI ≤ 5 cm	BW < 10th centile for GA (13.6% in sample population)	ST 0.66 (0.52–0.80), SP 0.53 (0.47–0.58)

AFI = amniotic fluid index.

four studies. Doppler ultrasound was conducted in either the late second or the third trimester. Three studies evaluated the systolic/diastolic (S/D) ratio as a screening parameter, one study used pulsatility index (PI) and the fifth study evaluated both of them. Meta-analysis was performed for two different timings – 26–31 weeks (four studies) and 32–36 weeks (three studies) without taking into account the parameter used. One study was not included for meta-analysis as it did not provide data for calculation of their confidence intervals (Table 12.5).

Findings

Sensitivity at both 26–31 weeks and 32–36 weeks ranged between 17% and 43% while specificity at both times was as high as 96%. There was not much variation in the values of positive and negative LR for individual studies.

At 26–31 weeks, LR+ ranged from 2.20 to 4.18 while LR– ranged from 0.71 to 0.87. No evidence of statistical heterogeneity was observed for either positive or negative LRs. The summary values for LR+ and LR– were 2.67 (95% CI 2.02 to 3.53) and 0.84 (95% CI 0.78 to 0.90), respectively (Figure 12.4).

At 32–36 weeks there was also no evidence of heterogeneity for either LR. The summary LR+ was 3.34 (95% CI 2.27 to 4.93) and LR+ ranged from 2.74 to 3.92 in individual studies. The LR– ranged from 0.83 to 0.88 and its summary value was 0.85 (95% CI 0.79 to 0.92) (Figure 12.5).

Evidence summary

High-quality evidence indicates that umbilical artery Doppler ultrasound examination in the third trimester (at 26–31 weeks and 32–36 weeks) has poor diagnostic value in predicting SGA births in a low-risk population.

12.2.6 Customised fetal growth charts

No study was identified that provided sufficient data to calculate the predictive accuracy of SFH measurements using customised fetal growth charts (CFGC).

Evidence summary

There is no good-quality evidence on the predictive performance of SFH measurements using customised fetal growth charts.

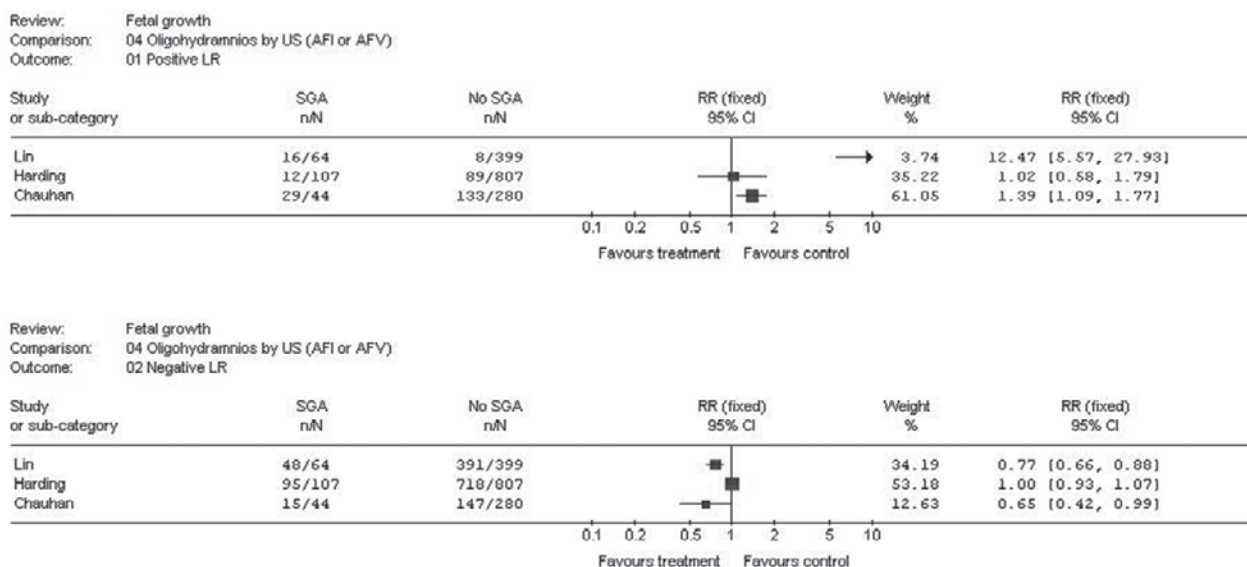


Figure 12.3 Reduced amniotic fluid volume by ultrasound

Table 12.5 Characteristics of included studies on diagnostic value of Doppler ultrasound (umbilical artery)

Study and EL characteristics	Population characteristics	Sample size (% of study population)	Timing of screening test with threshold(s) (prevalence of test positive)	Outcome(s) and its threshold (incidence in %)	Diagnostic value with 95% CI
Beattie (1989) ⁹²⁹ (UK) EL Ib	Ultrasonically dated singleton pregnancies attending within 7 days of their 28th gest. week. <i>Exclusions:</i> private patients, late bookings, with altered dates who attended after 29 weeks, late referrals.	2097 (62.0%)	At 28, 34 and 38 weeks. Thresholds: Pulsatility index (PI), Systolic/diastolic (S/D) ratio and Resistance parameter – all > 90th centile for GA in the study population.	BW < 5th centile for GA. (values not given)	At 28 weeks: For PI: ST 28%, SP 89%; For S/D ratio: ST 31%, SP 90% At 34 weeks: For PI: ST 32%, SP 89%; For S/D ratio: ST 40, SP 84%
Todros (1995) ⁹³⁰ (Italy) EL Ib	Singleton pregnancies with no obstetrical risk, pre-pregnancy pathologic condition or anomaly. <i>Exclusions:</i> women delivered at other hospitals	916 (95.2%)	At 19–24 and 26–31 weeks Threshold: S/D ratio of 4.5 (at 19–24 weeks) and 3.5 (at 26–31 weeks) derived from ROC curve.	BW < 10th centile for GA (4.6% in sample population)	At 19–24 weeks: ST 0.45 (0.30–0.60), SP 0.74 (0.71–0.77) At 26–31 weeks: ST 0.43 (0.28–0.58), SP 0.80 (0.78–0.83)
Newnham (1990) ⁹²⁵ (Australia) EL Ib	Singleton pregnancies with known GA at < 18 weeks gestational age. <i>Exclusions:</i> multiple pregnancies, gestational age > 20 weeks, language difficulties, not pregnant, major fetal anomaly.	535 (87.0%)	At 18, 24, 28 and 34 weeks. Threshold: S/D ratio > 95th centile for GA in study population.	BW < 10th centile for GA (9.5% in sample population)	At 28 weeks: ST 0.19 (0.07–0.30), SP 0.96 (0.94–0.97) At 34 weeks: ST 0.17 (0.04–0.29), SP 0.95 (0.93–0.97)
Sijmons (1989) ⁹³¹ (Netherlands) EL Ib	Randomly selected singleton pregnancies from a tertiary referral centre.	339 to 394 (84.5% to 98.5%) for different timing and outcomes	At 28 and 34 weeks Threshold: PI > 95th centile for GA in the study population.	1) BW < 10th centile for GA (22% in study population) 2) Ponderal index < 10th centile for GA	At 28 weeks: 1) ST 0.17 (0.09–0.25), SP 0.95 (0.93–0.97); 2) ST 0.19 (0.06–0.32), SP 0.95 (0.93–0.97) At 34 weeks: 1) ST 0.22 (0.13–0.31), SP 0.94 (0.92–0.97); 2) ST 0.24 (0.09–0.39), SP 0.93 (0.90–0.96)
Atkinson (1994) ⁹³² (USA) EL Ib	Low-risk nulliparaous women with singleton pregnancies. <i>Exclusions:</i> multiple gestation, history of renal disease, collagen vascular disease, diabetes, hypertension.	475 (84.0%) at 27–31 weeks, 439 (77.7%) at 32–36 weeks	At 20–26, 27–31, 32–36 and 37–42 weeks Threshold: S/D ratio > 90th centile for GA in study population.	BW < 10th centile for GA (7.8% in study population)	At 27–31 weeks: ST 0.20, SP 0.91 At 32–36 weeks: ST 0.24, SP 0.91

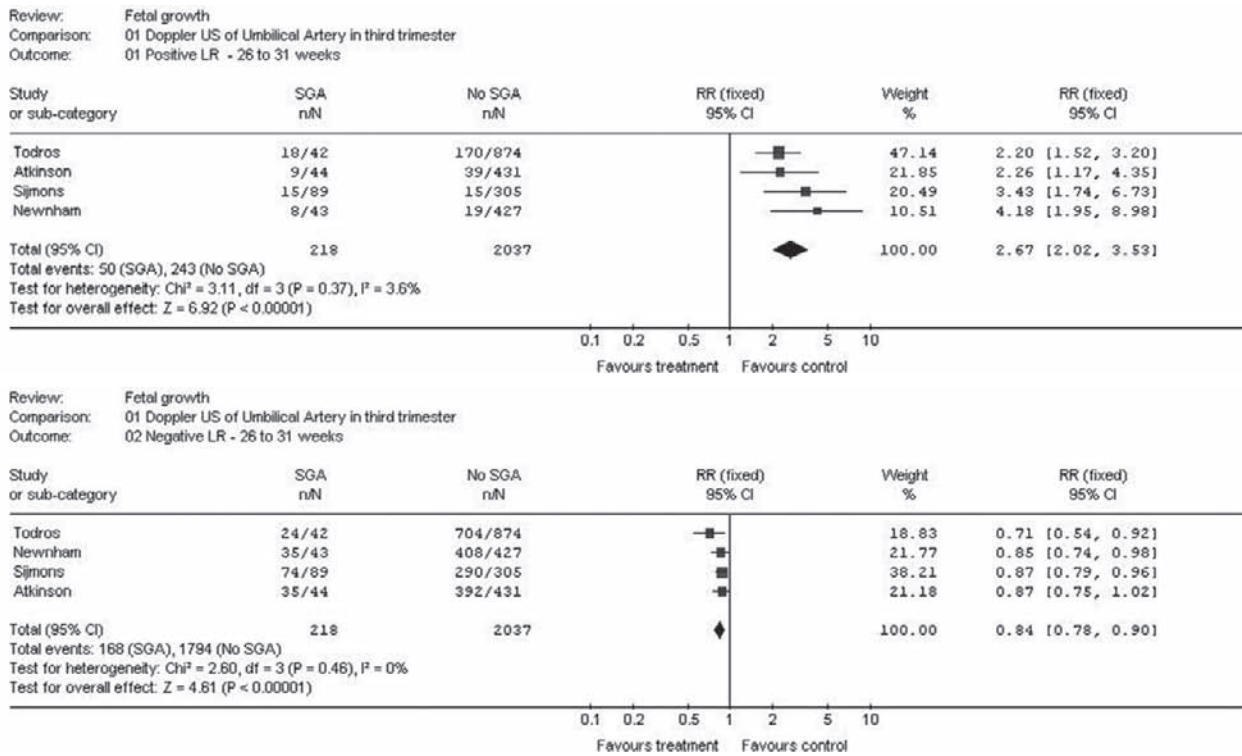


Figure 12.4 Doppler ultrasound of umbilical artery at 26–31 weeks

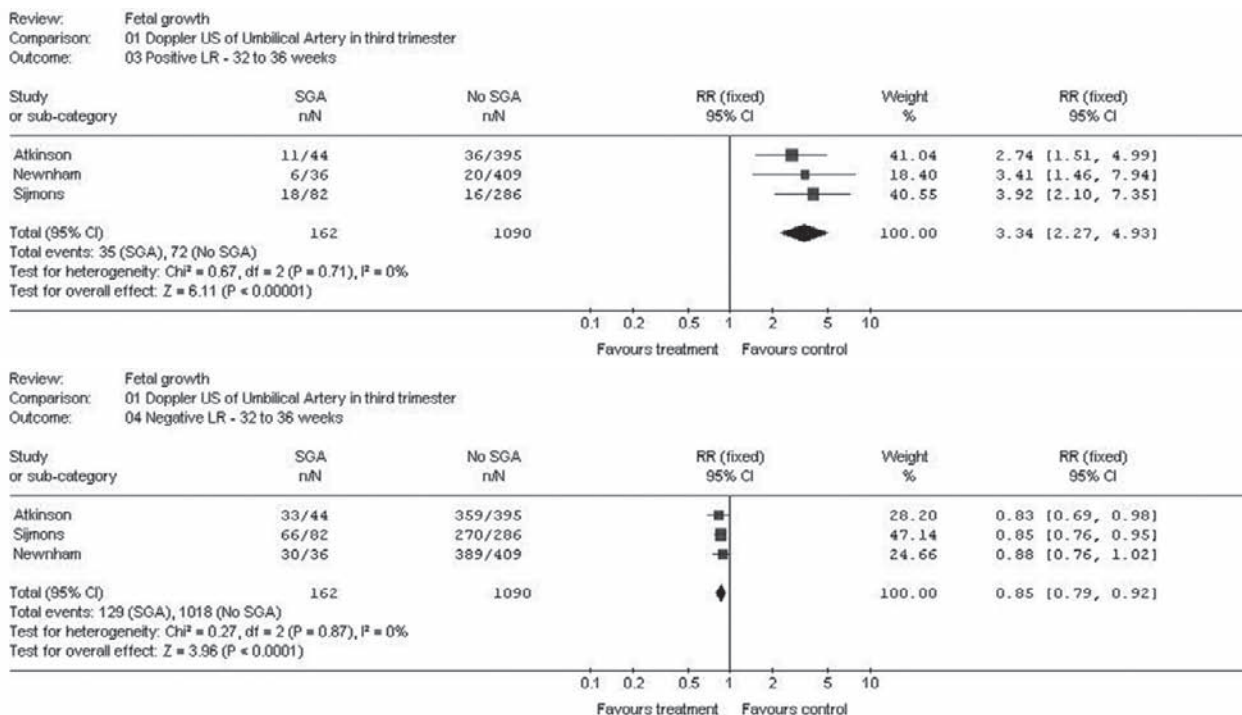


Figure 12.5 Doppler ultrasound of umbilical artery at 32–36 weeks

Table 12.6 Characteristics of included studies on diagnostic value of SFH measurement for LGA babies

Study and EL	Study characteristics	Population characteristics	Sample size (% of study population)	Timing of screening test with threshold(s) (prevalence of test positive)	Outcome(s) and its threshold (incidence in %)	Diagnostic value with 95% CI
Persson (1986) ⁹¹⁹ EL II	Prospective cohort, multicentre, blinding not specified.	Singleton pregnancies with regular menstrual cycles and known LMP. <i>Inclusions:</i> multiple gestation, mothers with more than 1 infant during study period or lack of registration in Medical Register.	2919 (91.3%)	15 times approx. during the entire pregnancy. <i>Threshold:</i> SFH value > 2 SD of Reference Curve generated from 1350 healthy pregnant women.	BW > 90th centile for GA and sex (9.5% in sample population).	ST 0.38 (0.33–0.43), SP 0.88 (0.87–0.89), LR+ 3.09 (2.57–3.71), LR– 0.71 (0.65–0.78)
Grover (1991) ⁹²¹ (India) EL II	Prospective cohort, single centre, blinding not specified	Singleton pregnancies with known GA attending ANC. <i>Exclusions:</i> Not defined	350 (87.5%)	SFH recording fortnightly till 30 weeks and then weekly till term. <i>Threshold:</i> SFH value > 1 SD of Reference Curve generated from 200 healthy pregnant women	BW > 1SD according to national BW chart (13.7% in sample population)	ST 0.79 (0.68–0.90), SP 0.95 (0.93–0.98), LR+ 16.63 (9.39–29.42), LR– 0.22 (0.13–0.38)
Okonofua (1986) ^{93,4} (UK) EL III	Prospective cohort, single centre, blinding not specified.	Singleton uncomplicated pregnancies attending a hospital ANC clinic and who were sure of their LMP. <i>Exclusions:</i> Not defined	100 (study population not specified)	SFH measurements and US biometry after 20 weeks in the third trimester. <i>Threshold:</i> Two consecutive SFH values > 90th centile of Reference curve generated from a sample of 30 healthy uncomplicated singleton pregnancies.	BW > 90th centile for GA (6.0% in sample population)	ST 0.33, SP 0.85

12.3 Diagnostic value for predicting LGA babies

No study was identified for diagnostic accuracy of four screening tests – clinical examination, amniotic fluid volume or polyhydramnios by ultrasound, Doppler ultrasound of umbilical artery and customised fetal growth charts. For the two remaining screening tests – SFH measurement and ultrasound biometry – all the six studies included are cohort studies with EL II (blinding not specified). Details of these studies have been tabulated. Meta-analysis could not be performed for either screening test owing to heterogeneity in timing, thresholds and outcome assessed.

12.3.1 Symphysis–fundal height measurement for LGA babies

Description of included studies

All the three studies included were prospective cohort studies.^{919,921,934} Two of them also assessed the diagnostic value of SFH in SGA babies. [EL = II] None of the studies specified blinding, and two did not specify the exclusion criteria. In all studies, SFH measurements were made in the third trimester and plotted on a reference curve generated from a normal population of healthy pregnant women. One study did not specify exact values for diagnostic accuracy results,⁹³⁴ [EL = III] and thus its diagnostic value is given as published without the corresponding confidence intervals (Table 12.6).

Findings

The prospective cohort study with the largest sample size⁹¹⁹ did not show good values for sensitivity (38%), specificity (88%), LR+ (3.09, 95% CI 2.57 to 3.71) or LR– (0.71, 95% CI 0.65 to 0.78). The other prospective cohort study⁹²¹ showed a very high LR+ of 16.63 (95% CI 9.39 to 29.42) and a low LR– or 0.22 (95% CI 0.13 to 0.38). However, this was a single centre unblinded study with a small sample size.

Evidence summary

There is wide variation in the results for the diagnostic accuracy of SFH measurements in the prediction of LGA babies. Results from the largest study show that this measurement has poor diagnostic value in predicting and ruling out LGA babies.

12.3.2 Fetal biometry for LGA babies

Description of included studies

Three studies were included – two prospective cohorts^{926,934} [EL = II and EL = III, respectively] and one retrospective cohort.⁹³⁵ [EL = III] Exclusions were not defined in one study. Wide variation was seen in the timing, frequency, parameters employed and the threshold used for a positive test, but all studies used birthweight > 90th centile as the outcome for defining LGA (Table 12.7).

Findings

Two studies employing EFW by Shepard's formula showed sensitivity of 48% and 74%, and similar specificity values of 94%. LR+ in one was 12.87 (95% CI 8.22 to 20.15) while it was 8.09 (95% CI 4.32 to 15.14) in the other. Values for LR– were 0.28 (95% CI 0.18 to 0.45) and 0.55 (95% CI 0.42 to 0.73), respectively. Positive and negative LR values for AC measured in one study were 5.01 (95% CI 3.12 to 8.07) and 0.51 (95% CI 0.37 to 0.70), respectively.

Evidence summary

There is a lack of good-quality studies for the diagnostic value of fetal biometry for detecting LGA babies. Results from one small study show that it might have some value in predicting and ruling out birth of LGA babies.

Table 12.7 Characteristics of included studies on diagnostic value of fetal biometry for LGA babies

Study and EL	Study characteristics	Population characteristics	Sample size (% of study population)	Timing of screening test with threshold(s) (prevalence of test positive)	Outcome(s) and its threshold (incidence in %)	Diagnostic value with 95% CI
Hedriana (1994) ^{92,6} (USA) EL II	Prospective cohort, single centre, blinding not specified.	Ultrasound confirmed singleton pregnancies. <i>Exclusions:</i> multiple gestations, maternal complications associated with severe intrauterine growth retardation, fetuses with anatomic defects.	249 (94.3%)	Single and serial third-trimester scans between 28 and 42 weeks. <i>Threshold:</i> Slope \pm SD calculated for AC and EFW (Shepard's formula) centile using regression analysis. Exact values not specified.	BW > 90th centile for GA. (18.5% in sample population)	For single scan: For AC: ST 0.54 (0.40–0.68), SP 0.89 (0.85–0.93), LR+ 5.01 (3.12–8.07), LR– 0.51 (0.37–0.70) For EFW: ST 0.48 (0.34–0.62), SP 0.94 (0.91–0.97), LR+ 8.09 (4.32–15.14), LR– 0.55 (0.42–0.73)
Okonofua (1986) ^{93,4} (UK) EL III	Prospective cohort, single centre, blinding not specified.	Singleton uncomplicated pregnancies attending a hospital ANC clinic and who were sure of their LMP. <i>Exclusions:</i> Not defined	100 (study population not specified)	SFH measurements and US biometry after 20 weeks in the third trimester. <i>Threshold:</i> Two consecutive values > 90th centile of BPD and AC reference curve generated from a sample of 30 healthy uncomplicated singleton pregnancies.	BW > 90th centile for GA (6.0% in sample population)	ST 0.66, SP 0.95
Ott (1984) ^{93,5} (USA) EL III	Retrospective cohort, single centre, blinding not specified.	Pregnant women undergoing US examination within 72 hours of delivery. <i>Exclusions:</i> not defined.	595 (study population not specified)	BPD and AC measured within 72 hours of delivery and EFW (Shepard's formula) calculated. <i>Threshold:</i> EFW > 1.5 SD for the reference curve.	BW > 90th centile for GA (8.2% in sample population)	ST 0.74 (0.62–0.86), SP 0.94 (0.92–0.96), LR+ 12.87 (8.22–20.15), LR– 0.28 (0.18–0.45)

12.4 Effectiveness studies

Nine studies were included – two Cochrane reviews, one controlled trial, four retrospective and one prospective cohort study, and one nested case–control study. Apart from three studies (two Cochrane reviews and one controlled trial) which compared the effectiveness of screening tests, the rest of the studies compared the risk of adverse perinatal outcomes between pregnant women with positive test results and those with negative tests results.

The two Cochrane reviews were on effectiveness of SFH measurement and Doppler ultrasound, respectively. Two cohort studies were selected for ultrasound biometry, and two studies (one cohort and one nested case–control) for amniotic fluid volume. No effectiveness study was identified for clinical examination of fetal growth. Three studies (one controlled trial and two retrospective cohorts) were identified for customised fetal growth charts, and the two retrospective cohort studies had analysed the same Swedish birth cohort database but in a different manner.

12.4.1 Symphysis–fundal height measurement

Description of included studies

A Cochrane review⁵⁶⁶ was conducted to assess whether routine use of SFH measurement during antenatal care improves pregnancy outcome compared with abdominal examination. [EL = 1+] It included all controlled trials of tape measurement of SFH during pregnancy compared with an abdominal palpation method alone. Studies were identified using the Pregnancy and Childbirth search strategy of the Cochrane group. One reviewer assessed the quality of included studies and extracted data. Analysis was done using Review Manager software. The primary outcomes were:

- complications associated with FGR – intrauterine death, intrapartum asphyxia and neonatal hypoglycaemia
- complications associated with fetal macrosomia – cephalopelvic disproportion, caesarean section for failure to progress, shoulder dystocia
- complications associated with multiple pregnancy – preterm delivery, perinatal mortality.

The secondary outcomes were other indices of maternal and perinatal mortality and morbidity, and indices of obstetric care including admission to hospital.

Findings

A single trial enrolling 1639 participants was included. Pregnant women at around 14 weeks of gestation were randomly allocated to the experimental or control group using sealed, opaque and unnumbered envelopes. Twenty-one women with twin pregnancies, 13 with uncertain dates and 60 with antenatal care somewhere else were excluded from the study. SFH was routinely measured after 28 weeks and the results plotted on a locally derived centile chart. Women in the control group had observations made with a fabric strip.

The Peto OR for the main outcomes was:

- perinatal mortality – 1.25 (95% CI 0.38 to 4.08)
- labour induction for FGR – 0.84 (95% CI 0.44 to 1.59)
- caesarean section for FGR – 0.72 (95% CI 0.31 to 1.67)
- birthweight < 10th centile – 1.34 (95% CI 0.91 to 1.98)
- admission to neonatal unit – 1.07 (95% CI 0.69 to 1.65).

No statistically significant difference was found for other outcomes (Apgar score < 4 at 1 minute and 5 minutes, umbilical artery pH < 7.15 or antepartum hospitalisation for suspected FGR).

Evidence summary

The results from the single trial in the Cochrane review show no evidence of improved outcome from SFH measurements.

12.4.2 Ultrasound biometry

Description of included studies

A retrospective cohort study⁹³⁶ was carried out in a tertiary care hospital in the USA to determine whether fetal growth measured at serial ultrasound examinations can predict neonatal morbidity

independently of whether gestational age is known. [EL = 2+] The study population ($n = 321$) was selected from a cohort of 1836 singleton pregnancies and included all those women who underwent two or more ultrasound examinations 2–17 weeks apart during the study period (July 1994 to March 1997). Excluded were women with five or more ultrasound examinations, twin pregnancies reduced to singleton, those who had undergone fetal surgery, those transferred for delivery, and fetuses with major congenital and chromosomal anomalies. Results of ultrasound including fetal biometry measurements were obtained from the computerised database and EFW calculated using HC, AC and FL. Data from 236 women were used to construct a reference growth chart for EFW, and fetal growth < 10th centile was defined as FGR while that between the 20th and 80th centile was defined as normal fetal growth (NFG). Information from the obstetric and neonatal database was collected for the following outcomes: low birthweight (birthweight < 2500 g, < 2000 g, < 1500 g, < 5th centile and < 3rd centile for gestational age) and poor neonatal outcomes: preterm birth (< 37 weeks), long hospital stay (> 4 days), admission to NICU, and assisted ventilation required at birth. The risk of each outcome for the FGR and NFG groups was calculated in women with known gestational age only ($n = 236$), and relative risk (RR) with 95% CI computed. Multivariate analysis was then performed after adjusting for potential confounders (maternal age, height, weight, race, BMI, parity, fetal sex, history of substance abuse and EFW). In the end, gestational age was simulated for those with unknown gestational age and RR calculated for the whole sample. Blinding of investigators was not specified.

A prospective cohort study in Ireland⁹³⁷ aimed to identify fetuses with ultrasound evidence of inadequate growth but born with birthweight > 10th centile for gestational age, and to determine whether these infants have high risk of obstetric interventions, intrapartum complications and neonatal morbidity compared with a group with normal ultrasound for fetal growth. [EL = 2–] The study population was 285 unselected mothers with singleton pregnancies and confirmed gestational age by a second-trimester scan referred for third-trimester ultrasound examination. Cases with multiple pregnancies and fetal anomalies incompatible with life were excluded. Two scans were performed – in the early third trimester and later at an average interval of 6 weeks. The Hadlock formula using HC, AC and FL was used to calculate EFW and its reference chart was drawn using data from 40 004 singleton healthy pregnancies. Inadequate fetal growth (IFG) was defined as a fall in EFW centile > 20 between the two scans, and this group was compared with the group not showing evidence of inadequate fetal growth (adequate fetal growth (AFG)) for the following complications: abnormal Doppler, induction of labour, meconium staining, need for intrapartum fetal blood sampling, operative vaginal delivery, caesarean section, Apgar score < 7 at 5 minutes and need for admission to NICU.

Findings

In the first study⁹³⁶ there was no statistically significant difference in age, racial distribution, parity or substance abuse between the study population ($n = 321$) and the total cohort ($n = 1836$). 71.9% of the study population underwent two second- or third-trimester ultrasound examinations while others had more than two.

The relative risk in women with fetuses of known gestational age is shown in Table 12.8.

Table 12.8 Summary of findings from a retrospective cohort study⁹³⁶ to determine the predictive value of fetal growth restriction detected by serial ultrasound

Outcome	FGR ($n = 24$)	NFG ($n = 212$)	RR
<i>Low birthweight</i>			
BW < 2500 g	63%	16%	3.9 (95% CI 2.5 to 6.0)
BW < 1500 g	25%	3%	8.8 (95% CI 3.1 to 25.2)
BW < 5th centile	25%	1%	17.7 (95% CI 4.7 to 66.1)
<i>Poor neonatal outcome</i>			
Preterm birth	50%	22%	2.3 (95% CI 1.4 to 3.7)
Long neonatal hospital stay	50%	19%	2.6 (95% CI 1.6 to 4.2)
NICU admission	46%	13%	3.6 (95% CI 2.1 to 6.3)
Assisted ventilation required	21%	5%	4.0 (95% CI 1.5 to 10.6)

Fetuses with FGR had significantly increased risk of being low birthweight or having poor neonatal outcome compared with the NFG group. In multivariate analysis after adjusting for potential confounding variables, fetal growth remained an independent predictor of low birthweight and poor neonatal outcomes, with adjusted odd ratios ranging from 4.1 to 36.1. The risks of poor neonatal outcomes were very similar when analysis was done for the whole group using simulated gestational age.

In the second study⁹³⁷ 89 women were excluded from the study population because their birthweight was either < 10th centile ($n = 60$) or > 90th centile ($n = 29$). Infants with birthweight < 10th centile had significantly increased incidence of intrapartum fetal blood sampling and admission to NICU ($P < 0.05$ for both with χ^2 analysis) compared with infants with birthweight between the 10th and 90th centile. Infants having birthweight > 90th centile had increased incidence of caesarean section ($P < 0.05$).

Of the remaining 196 fetuses, 75 showed evidence of inadequate growth (IFG group) while the remaining 121 formed the comparator group (AFG group). Babies in the IFG group had a significantly higher incidence of admission to the NICU (OR 3.1, 95% CI 1.19 to 8.52; $P < 0.05$), and higher incidence of meconium staining but this was not statistically significant (OR 1.40, 95% CI 0.64 to 3.03; $P = 0.36$). No difference was observed between the two groups regarding all other outcomes.

Evidence summary

Inadequate fetal growth detected by ultrasound is associated with an increased risk of low birthweight and poor neonatal outcome.

There is no difference in the risk of obstetric and neonatal complications between fetuses with evidence of inadequate growth on ultrasound but with birthweight appropriate for gestational age, and fetuses with adequate growth.

12.4.3 Ultrasound for amniotic fluid volume

Description of included studies

The first cohort study conducted in the USA⁹³⁸ examined fetal growth and perinatal outcomes in pregnancies with isolated oligohydramnios (OH) by using data from the multicentre clinical trial of Routine Antenatal Diagnostic Imaging with Ultrasound (RADIUS trial). [EL = 2+] The study population for this cohort ($n = 7549$) included English-speaking women at least than 18 years of age with singleton pregnancy, known LMP and gestational age below 18 weeks in the screening arm of trial only, that is, those who underwent ultrasound screening twice at 15–22 and 31–35 weeks. Oligohydramnios was defined as AFI ≤ 5 cm and clinicians were blinded to the results. This cohort was used to describe the incidence and conditions associated with OH. To examine perinatal outcomes further, women with OH were compared with those having normal AFI (Normal/N group, $n = 7215$). This comparison was made in both groups: Group 1 with associated maternal/fetal conditions (PROM, congenital malformations, hypertension (HT), diabetes, FGR, post-term) and Group 2 without any such condition. Isolated OH was defined as OH in women without any associated maternal/fetal condition. The χ^2 test was used for comparison and RR with 95% CI calculated wherever appropriate.

The other study was a nested case–control study from the USA⁹³⁹ carried out to determine whether hydramnios is associated with increased risk of adverse perinatal outcomes. [EL = 2+] Computerised records of all ultrasound examinations carried out from 1986 to 1996 were reviewed to identify singleton pregnancies in which AF volume was assessed. Cases were defined as pregnancies complicated by hydramnios after 20 weeks of gestation and controls included all singleton pregnancies having normal AF volume on ultrasound after 20 weeks. Hydramnios was taken as AFI ≥ 25 cm or depth more than 8 cm measured in a single vertical pocket or sonographer's subjective impression. Multiple gestations and OH cases were excluded. Blinding was not specified. Comparison was made for adverse perinatal outcomes using χ^2 test/Fischer exact test for dichotomous variables and Student's t test for continuous variables. Confounding variables known to influence perinatal outcomes were analysed in a multiple logistic regression model.

Findings

In the cohort study OH was diagnosed in 113/7549 of the study cohort and among these 47% had certain associated maternal/fetal conditions, leaving 60 cases with isolated OH. To compare perinatal outcomes, all cases of OH including those from the other arm of the trial ($n = 164$) were used. OH in pregnancies associated with unfavourable maternal/fetal conditions (Group 1) had higher risk of adverse perinatal outcomes, but isolated OH (in Group 2) had perinatal outcomes similar to those with normal AFI (Table 12.9).

Table 12.9 Summary of findings comparing labour and neonatal outcomes for women with oligohydramnios plus coexisting pregnancy complications and those with isolated oligohydramnios⁹³⁸

Outcome	Group 1			Group 2		
	OH (n = 78)	N (n = 644)	RR (95% CI)	OH (n = 86)	N (n = 6571)	RR (95% CI)
Preterm delivery	24.4%	13.2%	1.9 (1.2–3.1)	3.5%	4.1%	0.9 (0.3–2.7)
Caesarean section	24%	29%	0.9 (0.6–1.3)	19%	14%	1.4 (0.8–2.4)
Apgar < 7 (5 minutes)	7.7%	3.1%	2.2 (1.1–4.7)	1.2%	1.2%	1.0 (0.1–7.0)
Perinatal mortality	5.1%	1.2%	4.1 (1.3–13.4)	0%	0.5%	0
Severe morbidity	7.7%	5.3%	1.5 (0.5–3.8)	1.2%	0.8%	1.4 (0.2–10.3)
Moderate morbidity	6.4%	5.9%	1.1 (0.3–2.9)	1.2%	2.2%	0.5 (0.1–3.8)

Severe morbidity included grade IV retinopathy of prematurity (ROP), bronchopulmonary dysplasia (BPD), ventilation more than 48 hours, intestinal perforation due to necrotising enterocolitis, grade III or IV intraventricular haemorrhage, subdural/cerebral haemorrhage, neonatal seizures, chest tube insertion, documented neonatal sepsis, and special care nursery stay ≥ 30 days.

Moderate morbidity included presumed neonatal sepsis, oxygen requirement > 48 hours, NEC without perforation, intraventricular haemorrhage grade I or II, fracture of clavicle or other bone, facial nerve or brachial plexus injury, and special care nursery stay ≥ 5 days.

In the nested case–control study,⁹³⁹ ultrasound examinations were done in 40 065 women during the study period. After exclusion, 370 cases with hydramnios and 36 426 controls with normal AF volume were identified. The perinatal mortality rate was more than 3 times higher, fetal anomalies 25 times higher, rate of caesarean section 3 times higher and diabetes 6 times higher in cases compared with women with normal AF volume (Table 12.10).

After controlling for confounding variables in a regression model, women with hydramnios still had increased risk of perinatal mortality (RR 3.8, 95% CI 1.9 to 7.3) and fetal anomalies (RR 18.2, 95% CI 8.7 to 38.2).

Table 12.10 Summary of findings comparing labour and neonatal outcomes for women with hydramnios and those with normal volume of amniotic fluid⁹³⁹

Outcome	Cases	Controls	RR (95% CI)
Perinatal mortality rate (per 1000 births)	49	14	3.4 (2.2–5.4)
Fetal anomalies	8.4%	0.3%	25.4 (17.4–37.2)
FGR	3.8%	6.7%	0.6 (0.3–0.9)
Caesarean section	47%	16.4%	2.9 (2.6–3.2)
Diabetes	19.5%	3.2%	6.0 (4.9–7.5)

Evidence summary

Pregnancies with reduced amniotic fluid volume and no associated maternal or fetal conditions do not show an increased incidence of obstetric interventions or adverse perinatal outcomes. However, oligohydramnios in the presence of pregnancy complications is associated with an increased risk of preterm delivery and perinatal death.

Increased amniotic fluid volume in pregnancies is associated with increased risk of maternal diabetes, fetal anomalies and perinatal mortality.

12.4.4 Doppler ultrasound*Description of included studies*

A Cochrane review⁵⁷⁵ was carried out to assess the effectiveness of routine Doppler ultrasound in obstetric practice and pregnancy outcomes in unselected and low-risk pregnancies. [EL = 1++] It included all randomised and quasi-randomised controlled trials where routine Doppler ultrasound of umbilical artery and/or uterine artery was done in both unselected and low-risk pregnant women. Primary outcome measures were induction of labour, caesarean section, preterm delivery < 28 and < 34 weeks, all deaths (perinatal, neonatal and infant), neurodevelopment at 2 years of age, and maternal psychological effects. The Cochrane Pregnancy and Childbirth Group Specialized Register and Cochrane Controlled Trial Register were searched. Two independent reviewers evaluated the trials for methodological quality and inclusion criteria. Additional information was sought from the authors of two trials by personal communication. Data were extracted by both reviewers independently and double-checked for discrepancies. Statistical analysis was performed using RevMan software and stratified analysis was planned for single, multiple and Doppler in all versus no Doppler/selective Doppler.

Findings

Five trials were included – two studied unselected population and three only low-risk populations. A total of 14 338 pregnant women were recruited. Three trials evaluated umbilical artery Doppler only and used sealed envelopes for randomisation. The other two evaluated both umbilical and uterine artery waveforms and in addition used serial ultrasound or serial Doppler for the population. The methodological quality of all included studies was generally good. No data were available for prespecified outcomes of acute neonatal problems, long-term neurodevelopment or maternal psychological effects. Owing to the small number of included trials, no stratified analysis was performed.

Routine Doppler ultrasound (umbilical and/or uterine) versus no/concealed/selective Doppler ultrasound:

Meta-analysis of four trials showed no differences between the two groups in antenatal admissions or other tests of fetal wellbeing, induction of labour, instrumental deliveries, caesarean section, neonatal interventions or overall perinatal mortality. Three trials reported perinatal mortality for fetuses/neonates without congenital anomalies, but there was heterogeneity of results (χ^2 10.44; $P < 0.025$) with one trial finding increased perinatal mortality in the screened group (OR 3.31, 95% CI 1.37 to 2.53).

Serial ultrasound and Doppler ultrasound versus selective ultrasound:

A single trial compared the two groups and no difference was found between them for all the primary outcomes. More babies in the screened group were of birthweight < 10th and < 3rd centile.

Evidence summary

Existing evidence shows that routine use of Doppler ultrasound (umbilical and/or uterine) in low-risk or unselected populations does not seem to be beneficial for either mother or baby.

12.4.5 Customised fetal growth charts

The customised fetal growth chart (CFG) is the term used for an individually adjusted standard for fundal height, EFW and birthweight which takes into consideration maternal characteristics such as height, country of family origin, cigarette smoking and diabetes.

Description of included studies

A prospective non-RCT in the UK⁵⁶⁷ was carried out to evaluate the effect of a policy of using serial SFH measurements plotted on CFGC compared with a routine antenatal care policy of recording SFH against women's gestational age. Two similar catchment areas (in terms of distance from hospital, ethnicity and socio-economic background of population, and number of referrals per year) of a tertiary level hospital served by separate and non-overlapping groups of community midwives and GPs were selected as the study and control group. The study commenced in May 1994 and ended in March 1995. The study group comprised all singleton pregnancies ($n = 734$) booked before 22 weeks gestational age and issued CFGC, but 67 were excluded owing to miscarriage or migration to other areas before delivery. The control group included 605 consecutive singleton pregnancies booked before 22 weeks and delivered in the hospital. Primary outcomes measured were the number of SGA (< 10th centile) and LGA (> 90th centile) babies detected antenatally in each group. Secondary outcomes were the total number of investigations performed in each group, including referrals to ultrasound department/pregnancy assessment unit, and admissions to the ward. Sample size was calculated to detect an increase of 25% detection of SGA at a significance level of 5% and power of 80%. Blinding of outcome investigator and concealment of allocation was not possible owing to the study design. [EL = 1-]

The second study was a population-based cohort study⁹⁴⁰ using the Swedish Birth Register. Two standards for estimating birthweight were constructed from the database – a fixed population one based on gender and gestational length, and an individually customised one with further adjustment for maternal height, weight, parity and ethnic group. SGA determined by the population standard was termed SGA (pop.), by the customised standard as SGA (cust.), and by both standards as SGA (both). In both the groups, SGA was defined as the lowest 10%, 5% or 2.5% of birthweights in the population. Risks of stillbirth, neonatal death and Apgar score < 4 at 5 minutes were then compared in infants classified as SGA by the two standards with that of non-SGA infants (classified using both standards). The cohort included all recorded births from 1992 to 1995 and the study sample excluded multiple births and those with congenital malformations, unknown gestation and missing values for the required parameters. All the outcomes were adequately defined, but confounding factors were not controlled for. [EL = 2 +]

In the third study⁹⁴¹ the same Swedish database as the one used in the second study was analysed retrospectively to examine the potential biases underlying the use of customised standards of birthweight for gestational age. It included all recorded births with complete data for a period of 10 years (1992–2001). Apart from using the same exclusion criteria as the other study, this study also excluded births with gestational age < 28 weeks in order to ensure comparability between the two groups. After classifying the births as non-SGA (both standards), SGA (cust.), SGA (pop.), and SGA (both), the same outcomes as used in the earlier study were compared. In addition, logistic regression models were used to examine the association between the two standards and different outcomes taking into account the effect of potential confounding variables. [EL = 2+]

Another multicentre study from France (Ref ID 38842) used the same methodology as that followed by the Swedish study above to determine the association between customised standards and adverse pregnancy outcomes. Data sets from five maternity hospitals were analysed retrospectively to identify SGA babies using both the population-based standard and the customised standard, and the risk of adverse perinatal outcomes was compared between these two group of babies using non-SGA babies (classified by both standards) as the reference group. About 25% of the data could not be analysed because of missing values, and the study did not make any adjustment for confounding variables. [EL = 2+]

In the last study from Spain (Ref ID 38840), a database of a tertiary hospital was analysed retrospectively and SGA babies identified with the two standards using the same methodology as in the above-mentioned three studies. The risk of perinatal mortality and neonatal morbidity (neurological and non-neurological) was then compared between the two groups of SGA babies after adjusting for gestational age at delivery by means of logistic regression. [EL = 2+]

Findings

The baseline characteristics including those related to pregnancy were similar in the two groups in the controlled trial.⁵⁶⁷ 96.3% of the issued CFGC were retrieved after birth and most of them had from three to seven measurements plotted.

A significantly higher proportion of SGA infants in the study group were suspected antenatally compared with the control group (47.9% versus 29.2%; OR 2.23, 95% CI 1.12 to 4.45). Furthermore, higher numbers of LGA babies were detected before birth in the study group (45.7% versus 24.2%; OR 2.63, 95% CI 1.27 to 5.45). However, no data were collected to allow determination of specificity.

No difference was observed between the two groups for obstetric interventions (induction of labour, caesarean section, and instrumental delivery), preterm delivery, admission to special care baby unit, fetal abnormality or resuscitation at birth.

There were significantly fewer referrals from the study group to a pregnancy assessment centre, both in numbers of women referred and total number of visits. The number of women admitted to antenatal ward was also significantly lower in the study group.

The study sample in the second study⁹⁴⁰ was 326 377, and the rates of adverse outcomes were similar between the study group and the excluded group.

Based on the population standard, maternal age < 19 years, primiparity, BMI < 19.9 kg/m² and maternal height < 154 cm were found to be the risk factors for SGA babies while BMI > 30 kg/m² and maternal age more than 35 years were the risk factors found with a customised standard.

Table 12.11 presents the risks (odds ratio) between the two groups using births that are non-SGA by both standards as the reference category.

Table 12.11 Comparison of risks for poor neonatal outcomes for babies that are non-SGA defined by population standard and customised standard as the reference category

	Stillbirth OR	Neonatal death OR	Apgar < 4 OR
SGA (pop.) vs non-SGA (cust.)	1.2 (95% CI 0.8 to 1.9)	0.9 (95% CI 0.3 to 2.3)	1.2 (95% CI 0.9 to 1.5)
SGA (cust.) vs non-SGA (pop.)	6.1 (95% CI 5.0 to 7.5)	4.1 (95% CI 2.5 to 6.6)	2.2 (95% CI 1.9 to 2.7)
SGA (cust.) vs SGA (pop.)	5.1 (95% CI 4.3 to 5.9)	3.4 (95% CI 2.4 to 4.8)	2.0 (95% CI 1.7 to 2.3)

cust. = customised; pop. = population.

Compared with births that were non-SGA by both standards, births classified as SGA (cust.) had 5–6 times higher risk of stillbirth regardless of whether they were also small by the population standard. In contrast, SGA classified by population standard only did not show an elevated risk. For the other two adverse outcomes a similar pattern of increased risk was seen among babies classified as SGA by the customised standard. They had an increased risk of neonatal death (OR 3.4, 95% CI 2.4 to 4.8) and low Apgar score < 4 (OR 2.0, 95% CI 1.7 to 2.3) compared with SGA babies classified by the population standard.

In the third study,⁹⁴¹ a total of 782 303 singleton pregnancies at ≥ 28 weeks were included. There was substantial agreement in the classification by the two standards, with 95% of births classified as SGA or non-SGA by both standards. Analysis of the database showed increased risks of stillbirths (crude OR 7.8) and neonatal death (crude OR 6.7) among the SGA (cust.) babies, compared with marginally increased risks for SGA (pop.) births (crude OR 1.4 and 1.3, respectively). The risk among SGA (cust.) babies was even higher than that of SGA classified by both standards (crude OR 5.7 for both outcomes). These results were similar to those of the previous study.

However, after controlling for gestational age as the potential confounder, the risk of adverse outcomes in SGA (cust.) babies (adjusted OR 2.4 and 2.1) became less than that of SGA by both standards (adjusted OR 4.8 and 4.9), and slightly higher than that of SGA (pop.) babies (adjusted OR 1.6 and 1.5). A substantial number of babies classified as SGA (cust.) were born at < 37 weeks compared with the other groups (16.6% versus 7.0% for SGA both standards, 3.4% for SGA (pop.), and 4.2% for non-SGA). Among the stillbirths and neonatal deaths, the mean

gestational age among SGA (cust.) births was 234 days and 239 days, respectively. This is much lower than that of SGA (both) at 257 and 258 days, and SGA (pop.) births at 273 days for both groups. Similar results were seen after controlling for another confounding variable – maternal pre-pregnancy BMI.

There were 75 306 recorded singleton births in the French multicentre study between 1997 and 2002, but for 18 700 births the information was insufficient to calculate the customised birthweight and hence these were excluded from the final analysis. This group of excluded births had a much higher rate of stillbirths and neonatal deaths compared with the population included for the study ($n = 56\ 606$). In 95.5% of cases, there was complete agreement between the two standards for classification of either SGA or non-SGA babies, while 1.8% of all infants were reclassified as non-SGA and 2.7% as newly identified SGA by using the customised standard. Compared with non-SGA babies with both standards as the reference group, risk of stillbirth (OR 4.5, 95% CI 2.5 to 8.1) and perinatal mortality (OR 2.6, 95% CI 1.6 to 4.1) was higher in the SGA (cust.) babies compared with the SGA (pop.) babies where the odds ratio contained the null value for both these outcomes. No statistically significant difference was found between the two groups for the other adverse outcomes – caesarean section before onset of labour, Apgar score < 7, admission to NICU or neonatal death.

In the last study from Spain, the final sample of 13 661 cases excluded the 1803 cases with one or more missing data, and the rates of stillbirth and neonatal death were significantly higher among the excluded cases than the included cases (stillbirth 1.3% versus 0.6%, $P = 0.001$; neonatal death 0.5% versus 0.1%, $P < 0.001$). The unadjusted odds ratios for perinatal mortality and neurological and non-neurological morbidity was higher for SGA babies identified by a customised standard compared with SGA babies identified using the population-based standard (perinatal mortality OR 3.2 versus 1.8; neurological morbidity OR 3.2 versus 1.6; non-neurological morbidity OR 8.0 versus 1.1). After adjusting for gestational age at the time of delivery, the odds ratios for neurological and non-neurological morbidity were 1.6 (95% CI 1.0 to 2.6) and 2.1 (95% CI 1.2 to 3.6), respectively, for SGA (cust.) cases and 1.4 (95% CI 0.8 to 2.3) and 1.5 (95% CI 0.7 to 2.9), respectively, for SGA (pop.) cases.

Evidence summary

One prospective study has been conducted to evaluate the effectiveness of CFGC, plus four retrospective studies. Findings from the single prospective study suggest that customised fetal growth charts lead to antenatal detection of a higher proportion of SGA and LGA babies compared with routine SFH charts and a decrease in referrals to obstetricians and referrals to the antenatal ward, but do not decrease obstetric interventions such as caesarean section or adverse perinatal outcomes such as admission to neonatal intensive care. However, there is variable evidence on the effectiveness of CFGC in identifying SGA babies at increased risk of perinatal mortality. Data from the prospective study were insufficient to allow calculation of predictive accuracy. Results from four studies with retrospective analysis of the data set have indicated that babies with a higher risk of stillbirths and perinatal mortality are more likely to be categorised as SGA on a CFGC compared with a population-based standard. Two of these studies did not control for confounding variables. In the remaining two studies, the increased risk of adverse perinatal outcomes in SGA babies identified using the customised standard was lowered after adjusting for confounding variables (substantial reduction in the study with a larger sample size). No study was identified where the CFGC was prospectively used to evaluate its effectiveness in improving the outcome in identified SGA babies.

12.5 Health economics evidence

A systematic review of the evidence found no studies concerned with the cost-effectiveness of fetal growth monitoring and so it was decided that a decision-analysis model would be developed. For full details of the review and the model, please refer to Appendix G. The GDG felt that through the identification of babies that are SGA, approximately 185–225 perinatal deaths could be prevented. Cost-effectiveness analysis showed that if this were the case then SFH measurement followed by ultrasound monitoring of fetal growth would be a cost-effective intervention.

GDG interpretation of evidence for Sections 12.1 to 12.13

SGA babies:

Abdominal palpation is not useful in identifying fetuses at risk.

SFH measurement may have limited use in identifying SGA babies but good-quality evidence is lacking and the GDG felt it was not appropriate to recommend a change in current practice. There is no evidence to suggest that there is any benefit in measuring SFH prior to 24 weeks.

Measurement of fetal abdominal circumference has some diagnostic value in identifying SGA babies but the studies show statistical heterogeneity.

AFI is a poor predictor of SGA babies.

Doppler examination has limited diagnostic value in the low-risk population.

There is a lack of good-quality prospective evidence for plotting SFH on customised growth charts to identify SGA babies, but the GDG is aware they are in use in some maternity units.

There is no good-quality prospective evidence that the use of customised fetal growth charts improves perinatal outcomes.

LGA babies:

Evidence suggests SFH measurements are not good at predicting LGA babies.

There is lack of good-quality evidence for the diagnostic value of fetal biometry for LGA. One small study suggested that fetal biometry may be of some value in identifying LGA babies.

Recommendations on determining fetal growth

Symphysis–fundal height should be measured and recorded at each antenatal appointment from 24 weeks.

Ultrasound estimation of fetal size for suspected large-for-gestational-age unborn babies should not be undertaken in a low-risk population.

Routine Doppler ultrasound in low-risk pregnancies should not be used.

Research recommendations on determining fetal growth

Further prospective research is required to evaluate the diagnostic value and effectiveness (both clinical and cost-effectiveness) of predicting small-for-gestational-age babies using:

- customised fetal growth charts to plot symphysis–fundal height measurements
- routine ultrasound in the third trimester.

Why this is important

Poor fetal growth is undoubtedly a cause of serious perinatal mortality and morbidity. Unfortunately, the methods by which the condition can be identified antenatally are poorly developed or not tested by rigorous methodology. However, existing evidence suggests that there may be ways in which babies at risk can be identified and appropriately managed to improve outcome, and this should form the basis of the study.

12.6 Fetal wellbeing

12.6.1 Abdominal palpation for fetal presentation

A study of clinicians using Leopold manoeuvres to assess presentation and engagement if the presenting part found that 53% of all malpresentations were detected and that there was a definite correlation with years of clinical experience and better results.⁵⁶² [EL = 3] This finding was supported by another study which looked specifically detection of breech presentation.⁵⁶³

[EL = 3] The sensitivity and specificity of Leopold manoeuvres is reported to be about 28% and 94%, respectively.⁵⁶⁴ [EL = 3]

One descriptive study reported that women do not enjoy being palpated, finding it uncomfortable and not reassuring or informative.⁵⁶⁵ [EL = 3]

Recommendations

Fetal presentation should be assessed by abdominal palpation at 36 weeks or later, when presentation is likely to influence the plans for the birth. Routine assessment of presentation by abdominal palpation should not be offered before 36 weeks because it is not always accurate and may be uncomfortable. [C]

Suspected fetal malpresentation should be confirmed by an ultrasound assessment. [Good practice point]

12.6.2 Routine monitoring of fetal movements

There is often no obvious cause of late fetal death of normally formed singleton births. Many of these deaths are unpredictable and occur in women who are healthy and who have had otherwise uncomplicated pregnancies.

Maternal recognition of decreased fetal movement has long been used during antenatal care in an attempt to identify the jeopardised fetus and intervene to prevent death. Given the low prevalence of fetal compromise and an estimated specificity of 90% to 95%, the positive predictive value of the maternal perception of reduced fetal movements for fetal compromise is low, 2% to 7%.⁵⁶⁸

One RCT was found that assessed the ability of the 'count to ten' method to reduce the prevalence of antenatal fetal death.⁵⁶⁹ [EL = 1b] The method records on a chart the time interval each day required to feel ten fetal movements. This cluster RCT randomised 68 000 women to either routine formal fetal-movement counting or to standard care. It found that there was no decrease in perinatal mortality in the test group and this policy would have to be used by about 1250 women to prevent one unexplained death.

Following a reduction in fetal movements women should be advised to contact their midwife or hospital for further assessment.

The evidence does not support the routine use of formal fetal movement counting to prevent late fetal death.

Recommendation

Routine formal fetal-movement counting should not be offered. [A]

12.6.3 Auscultation of fetal heart

Auscultation of the fetal heart is a component of the abdominal examination and forms an integral part of a standard antenatal examination. Although hearing the fetal heart confirms that the fetus is alive there appears to be no other clinical or predictive value.^{570,571} [EL = 3] This is because it is unlikely that detailed information on the fetal heart such as decelerations or variability can be heard on auscultation.

There is a perception among doctors and midwives that fetal heart rate auscultation is enjoyable and reassuring for pregnant women and therefore worthwhile. This is not based on published evidence and may not be a correct assumption. Research done on attitudes of women towards auscultation compared with electronic fetal monitoring in labour revealed that many women found the abdominal pressure from auscultation uncomfortable,⁵⁷² [EL = 3] so perhaps their attitudes to antenatal auscultation cannot be presumed.

Recommendation

Auscultation of the fetal heart may confirm that the fetus is alive but is unlikely to have any predictive value and routine listening is therefore not recommended. However, when requested by the mother, auscultation of the fetal heart may provide reassurance. [D]

12.6.4 Cardiotocography

There is no evidence to evaluate the use of antenatal cardiotocography (CTG) for routine fetal assessment in normal pregnancies. RCTs which included women who were healthy and who had uncomplicated pregnancies were not found.

A systematic review of RCTs assessed the effects of antenatal CTG monitoring on perinatal morbidity and mortality and maternal morbidity.⁵⁷³ [EL = 1a] Four trials were included randomising 1588 women who satisfied the inclusion criteria. In these trials, carried out on high- or intermediate-risk women, antenatal CTG appeared to have no significant effect on perinatal morbidity or mortality. There was no increase in the incidence of interventions such as elective caesarean section or induction of labour.

Recommendation

The evidence does not support the routine use of antenatal electronic fetal heart rate monitoring (cardiotocography) for fetal assessment in women with an uncomplicated pregnancy and therefore it should not be offered. [A]

12.6.5 Ultrasound assessment in the third trimester

One systematic review of seven RCTs examined the use of routine ultrasound after 24 weeks in an unselected and designated low-risk population. There was a wide variation in the provision of ultrasound within the studies. The main comparison group of six studies compared routine ultrasound after 24 weeks with no, selective or concealed ultrasound after 24 weeks.⁵⁷⁴ [EL = 1a]

There were no differences between preterm delivery, birthweight or perinatal mortality. The screened group was less likely to deliver post-term (over 42 weeks), although this may be a result of more accurate dating prior to 24 weeks, as outlined above. Similarly, there were no differences in other outcomes of antenatal, obstetric or neonatal interventions.⁵⁷⁴

Recommendation

The evidence does not support the routine use of ultrasound scanning after 24 weeks of gestation and therefore it should not be offered. [A]