Published in final edited form as:

Cochrane Database Syst Rev. ; (4): CD001451. doi:10.1002/14651858.CD001451.pub3.

Routine ultrasound in late pregnancy (after 24 weeks' gestation)

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Abstract

Background—Diagnostic ultrasound is used selectively in late pregnancy where there are specific clinical indications. However, the value of routine late pregnancy ultrasound screening in unselected populations is controversial. The rationale for such screening would be the detection of clinical conditions which place the fetus or mother at high risk, which would not necessarily have been detected by other means such as clinical examination, and for which subsequent management would improve perinatal outcome.

Objectives—To assess the effects on obstetric practice and pregnancy outcome of routine late pregnancy ultrasound, defined as greater than 24 weeks' gestation, in women with either unselected or low-risk pregnancies.

Search methods—We searched the Cochrane Pregnancy and Childbirth Group's Trials Register (February 2008).

Selection criteria—All acceptably controlled trials of routine ultrasound in late pregnancy (defined as after 24 weeks).

Data collection and analysis—All three review authors were involved in assessing trial quality and data extraction.

Main results—Eight trials recruiting 27,024 women were included. The quality of trials overall was satisfactory. There was no difference in antenatal, obstetric and neonatal intervention or morbidity in screened versus control groups. There was a slightly higher caesarean section rate in the screened group, but this difference did not reach statistical significance. Routine late pregnancy ultrasound was not associated with improvements in overall perinatal mortality.

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Editorial group: Cochrane Pregnancy and Childbirth Group.

Publication status and date: Edited (no change to conclusions), published in Issue 3, 2009.

Review content assessed as up-to-date: 27 May 2008.

CONTRIBUTIONS OF AUTHORS: L Bricker and JP Neilson drafted the review. T Dowswell assisted with updating the review.

DECLARATIONS OF INTEREST: JP Neilson was principal investigator in a trial that was considered for inclusion.

Placental grading as an adjunct to third trimester examination scan was associated with a significant reduction in the stillbirth rate in the one trial that assessed it. There is little information on long-term substantive outcomes such as neurodevelopment. There is a lack of data on maternal psychological effects.

Authors' conclusions—Based on existing evidence, routine late pregnancy ultrasound in low-risk or unselected populations does not confer benefit on mother or baby. It may be associated with a small increase in caesarean section rates. There is a lack of data about the potential psychological effects of routine ultrasound in late pregnancy, and limited data about its effects on both short- and long-term neonatal and childhood outcome. Placental grading in the third trimester may be valuable, but whether reported results are reproducible remains to be seen, and future research of late pregnancy ultrasound should include evaluation of placental textural assessment.

Medical Subject Headings (MeSH)

*Ultrasonography, Prenatal; Pregnancy Outcome; Pregnancy Trimester, Second; Pregnancy Trimester, Third; Randomized Controlled Trials as Topic

MeSH check words

Female; Humans; Pregnancy

BACKGROUND

Diagnostic ultrasound is a sophisticated electronic technology, which utilises pulses of high frequency sound. The transducer, which is moved across the area to be examined, emits the pulses of ultrasound which propagate through the tissues, and some are reflected back to the transducer which converts these returning echoes into electronic signals. Tissue interface characteristics determine the strength of the returning echo. Signals are processed by a computer which displays each echo in both strength and position as an image on a screen.

Diagnostic ultrasound is used selectively in late pregnancy where there are specific clinical indications, such as antepartum haemorrhage or clinical concern that the fetus may be poorly grown. However, the value of routine late pregnancy ultrasound screening in unselected populations is controversial. The rationale for such screening would be the detection of clinical conditions which place the fetus or mother at high risk, which would not necessarily have been detected by other means such as clinical examination, and for which subsequent management would improve perinatal outcome.

Fetal growth/size

Small for gestational age (SGA) fetuses are at greater risk of stillbirth, birth hypoxia, neonatal complications in the perinatal period, impaired neurodevelopment and cerebral palsy in childhood, and non-insulin dependent diabetes and hypertension in adult life (Barker 1993). The majority of these small infants are not diagnosed until delivery (Leeson 1997), and detecting these fetuses prenatally remains a priority of antenatal care (Lindqvist 2005). Methods of detecting SGA fetuses include antenatal clinical examination, measurement of symphysis-fundal height, fetal anthropometry and ultrasound estimated

fetal weight. Harding 1995 demonstrated that symphysis-fundal height measurements perform relatively poorly compared with ultrasound abdominal circumference measurements, while Hendrix 2000 suggested that, for term pregnancies, clinical examinations provide more accurate estimates of birthweight than ultrasound. A combined approach of screening with symphysis-fundal height measurement, complemented with ultrasound derived fetal abdominal circumference if failing growth is suspected has been advocated. Holmes 1996 cautions that small size should be viewed as a clinical sign, and not a diagnosis, as a number of small fetuses are not at risk of adverse outcome. Furthermore, the use of ultrasound to detect the SGA fetus is dogged by a number of complicating factors, including the lack of defined thresholds for normality versus abnormality, its dependence on accurate gestational dating, the fact that the assessment of growth velocity (serial measurements) may be more valuable clinically than a single estimate of size, and differences due to other factors, namely, maternal ethnicity and parity, fetal gender and environmental factors (Altman 1989). A previous systematic review of routine late pregnancy anthropometry concluded that despite increased intervention (admission to hospital and induction of labour), there was no identifiable benefit in fetal outcome (Neilson 1995).

Another clinical concern is with the large-for-gestational-age (LGA) fetus. These babies are at increased risk of perinatal morbidity and mortality, which arises mainly from birth injury and asphyxia; their mothers are at increased risk of cephalo-pelvic disproportion and its sequelae, and operative delivery and the associated morbidity. Our ability to detect fetal macrosomia antenatally by clinical examination remains limited (Lurie 1995), and the antenatal prediction of fetal macrosomia is associated with a marked increase in caesarean births without a significant reduction in the incidence of shoulder dystocia or fetal injury (Weeks 1995). This is because most cases of shoulder dystocia and birth trauma occur in non-macrosomic infants (Gonen 1996). Hence, the value of detecting LGA fetuses by routine ultrasound in late pregnancy is questionable.

Amniotic fluid

Fetal urine is the major source of amniotic fluid in the latter half of pregnancy (Brace 1989). Decreased amniotic fluid volume (oligohydramnios) in the absence of ruptured membranes or fetal anomalies is thought to be associated with chronic fetal compromise and redistribution of regional blood flow leading to reduction in fetal renal blood flow, fetal oliguria and thus less amniotic fluid. Increased amniotic fluid volume (polyhydramnios) occurs as a result of overproduction (polyuria in fetuses of diabetic mothers, rare placental tumours), decreased turnover (congenital anomalies affecting fetal swallowing), or unknown aetiology. Both oligohydramnios and polyhydramnios can be diagnosed by ultrasound measurement of maximum pool depth, two-diameter amniotic fluid pocket or amniotic fluid index (the sum of the vertical maximum pool depths in four quadrants), and applying the result to normal reference ranges. While in high-risk pregnancies, such as postdates pregnancy, the measurement of amniotic fluid volume may have bearing on management decisions, there is some debate about the best measurement method, and the clinical significance of the available reference ranges, which compounds the uncertainty about the effect on perinatal outcome of detecting amniotic fluid abnormalities.

The placenta

Placenta praevia occurs in 0.5% of pregnancies and is associated with considerable risk to both mother and fetus. Ultrasound is the best available method for locating the placental position (Neilson 1989). Only 10% of low placentas at second trimester scan remain low at term (Rizos 1979). However, in most pregnancies with placenta praevia, a clinical indication for diagnostic ultrasound will arise such as antepartum haemorrhage and fetal malpresentation, and therefore the role of screening for placenta praevia is debatable. Grannum 1979 described a classification system to grade the placental texture appearances on ultrasound imaging, and suggested a correlation between maturational changes of the placenta as seen on ultrasound and fetal pulmonic maturity. This was not confirmed in further study, but an association between 'mature' appearances at earlier gestations with maternal smoking and placental dysfunction was postulated. Therefore, the knowledge of placental appearances in late pregnancy could, in theory, result in care leading to improved perinatal outcome (Abramowicz 2007).

Structural fetal abnormalities

A number of structural fetal abnormalities may manifest later in pregnancy. These include craniospinal abnormalities (microcephaly and hydrocephaly), gastrointestinal abnormalities (intestinal obstruction and atresia), urinary tract abnormalities, and some skeletal abnormalities (Chitty 1995). It has been suggested that the value of detecting fetal structural abnormalities before birth allows for the optimal timing and mode of delivery leading to improved management and outcome. However, a report of a Working Party of the Royal College of Obstetricians and Gynaecologists on Ultrasound Screening for Fetal Abnormalities (RCOG 1997) stated that further research is required to evaluate whether prior identification of an abnormality before birth, particularly those amenable to intrauterine procedures and neonatal surgery, is advantageous in both the short and long term.

Fetal presentation

Some fetal malpresentations (e.g. breech) go undetected during routine antenatal care but would be identified by routine ultrasound in late pregnancy. In a retrospective case review, Nwosu 1993 showed that babies undiagnosed as a breech were not subject to increased morbidity and mortality compared with a breech diagnosed prior to labour. This highlights the uncertainty about the clinical value of routine ultrasound screening for fetal malpresentations.

Safety

The use of routine pregnancy ultrasound needs to be considered in the context of potential hazards. Theoretically, some ultrasonic energy propagated through tissue is converted to heat, and biological effects of ultrasound have been observed in laboratory experiments. However, these effects have been produced using continuous wave ultrasound with long 'dwell' time (time insonating one area) and high power output. Diagnostic ultrasound is pulsed wave (short pulses of sound propagation), and most modern machines have inbuilt safety features, so that safe power output limits cannot be exceeded. Operators are advised

to apply the ALARA principle (as low as reasonably attainable) to the ultrasound power output used (EFSUMB 1995), and to ensure time taken for an examination, including the 'dwell' time over a specific target, is kept to a minimum. However, there is some evidence that operators' knowledge about safety may not be accurate (Sheiner 2007). At present, there is no clear epidemiological evidence that ultrasound examination during pregnancy is harmful, but no firm conclusion has been reached from available data (*see* Cochrane review: Ultrasound for fetal assessment in early pregnancy (Neilson 1998)), and therefore, continual vigilance is necessary. This is particularly important in a context where scans are increasingly being carried out for non-medical reasons, and where there is a paucity of information on the number of scans women actually receive as a part of their antenatal care (ACOG 2004).

Cost and maternal psychological effects

There have been few studies evaluating the cost effectiveness of ultrasound scans (Henderson 2002). While there is some information on the direct costs of ultrasound examinations, there is much less on indirect cost (e.g. the costs of associated counselling, follow-up tests and related interventions, and indirect costs to women). Further, there is relatively little information on the psychological impact of ultrasound on women and their families (partners are frequently present for scans). Scans are popular with women, but women may not fully understand the purpose of their scan, and may be either falsely reassured or unprepared for adverse findings (Garcia 2002).

OBJECTIVES

To assess the effects on obstetric practice and pregnancy outcome of routine late pregnancy ultrasound, defined as greater than 24 weeks' gestation, in women with either unselected or low-risk pregnancies.

METHODS

Criteria for considering studies for this review

Types of studies—All acceptably controlled trials of routine ultrasound in late pregnancy (after 24 weeks). Due to an anticipated paucity of randomised controlled trials, we considered quasi-randomised trials for inclusion. Routine ultrasound in early pregnancy (Neilson 1998) has been considered in a previous Cochrane review. Routine doppler ultrasound in pregnancy will be considered in a separate review (Bricker 2007b).

Types of participants—Women in late pregnancy (after 24 weeks' gestation) in both unselected populations and designated low-risk populations.

Types of interventions—Routine ultrasound examination in late pregnancy (after 24 weeks' gestation) to assess one, some or all of the following: fetal size; amniotic fluid volume; placental site; placental grading; fetal structural anatomy; fetal presentation.

Types of outcome measures

Primary outcomes

1. Induction of labour.
2. Caesarean section.
3. All deaths (perinatal, neonatal and infant).
4. Preterm delivery less than 34 weeks.
5. Neurodevelopment at age two.
6. Maternal psychological effects.

Secondary outcomes

Interventions: Antenatal admission to hospital.

Antenatal fetal monitoring:

- kick count chart;
- cardiotocography;
- biophysical profile;
- Doppler ultrasound;
- further ultrasound.

Intention to deliver.

Operative delivery:

- elective caesarean section (CS);
- emergency CS;
- instrumental vaginal delivery;
- CS for distress;
- CS for distress antepartum;
- CS for distress intrapartum.

Perinatal outcome: Gestational age at birth.

Birthweight (mean and standard deviation).

Birthweight less than tenth percentile.

Birthweight less than third percentile.

Preterm delivery less than 37 weeks.

Low birthweight (less than 2.5 kg).

Very low birthweight (less than 1.5 kg).

Need for resuscitation.

Need for ventilation.

Admission to special care baby unit and average stay.

Low Apgar score (less than seven at five minutes).

Neonatal outcome: Acute neonatal problems:

- hypoxic ischaemic encephalopathy;
- necrotising enterocolitis;
- intraventricular haemorrhage (IVH);
- IVH with cystic periventricular leukomalacia;
- pulmonary haemorrhage.

Early neonatal death (in first week of life).

Late neonatal death (from one to four weeks).

Infant death (one month to one year).

Maternal outcome: Psychological effects (including stress, anxiety, depression, quality of life, satisfaction).

Detection of:

- major anomaly before birth;
- malpresentation before labour.

Furthermore, the following non-prespecified outcome measures were used:

Post-term delivery greater than 42 weeks.

Birthweight less than 5th percentile.

Moderate neonatal morbidity (includes any of the following: presumed neonatal sepsis, oxygen required greater than 48 hours, necrotising enterocolitis without perforation, grade I or II intraventricular haemorrhage, fracture of clavicle or other bones, facial nerve injury, brachial plexus injury, stay greater than five days in the special care nursery).

Severe neonatal morbidity (includes any of the following: grade IV retinopathy of prematurity, bronchopulmonary dysplasia, mechanical ventilation greater than 48 hours, intestinal perforation due to necrotising enterocolitis, grade III or IV intraventricular haemorrhage, subdural or cerebral haemorrhage, spinal cord injury, neonatal seizures,

placement of chest tube, documented neonatal sepsis, stay more than 30 days in the special care nursery).

Perinatal mortality of twins.

Only the six primary outcome measures will be used for subgroup analysis.

Search methods for identification of studies

Electronic searches—We searched the Cochrane Pregnancy and Childbirth Group's Trials Register by contacting the Trials Search Co-ordinator (February 2008).

The Cochrane Pregnancy and Childbirth Group's Trials Register is maintained by the Trials Search Co-ordinator and contains trials identified from:

1. quarterly searches of the Cochrane Central Register of Controlled Trials (CENTRAL);
2. weekly searches of MEDLINE;
3. handsearches of 30 journals and the proceedings of major conferences;
4. weekly current awareness alerts for a further 44 journals plus monthly BioMed Central email alerts.

Details of the search strategies for CENTRAL and MEDLINE, the list of handsearched journals and conference proceedings, and the list of journals reviewed via the current awareness service can be found in the 'Specialized Register' section within the editorial information about the [Cochrane Pregnancy and Childbirth Group](#).

Trials identified through the searching activities described above are each assigned to a review topic (or topics). The Trials Search Co-ordinator searches the register for each review using the topic list rather than keywords.

We did not apply any language restrictions.

Data collection and analysis

All potential studies were identified as outlined in the search strategy. All three review authors were involved in assessing studies for inclusion and in data extraction. Two review authors independently assessed the trials for methodological quality. The reason for exclusion of any trial was clearly stated. The trials were not assessed blinded and the review authors knew the author's name, institution, source of the publication and results when applying inclusion criteria. We resolved disagreements by discussion until consensus was reached. We sought additional information from some of the trialists by personal communication.

In earlier versions of this review, data extraction was performed by a principal review author and double checked for discrepancies with the co-author. For the additional trial included in this update, one author (T Dowswell) carried out data extraction and both the other authors (L Bricker and JP Neilson) checked the data; where data were unclear, we reached

consensus by discussion. We performed statistical analysis using the Review Manager software (RevMan 2008).

Assessment of risk of bias—Two review authors independently assessed risk of bias for each study using the criteria outlined in the Cochrane Handbook for Systematic Reviews of Interventions (Higgins 2008). We resolved any disagreement by discussion.

(1) Sequence generation (checking for possible selection bias): We described for each included study the methods used to generate the allocation sequence in sufficient detail to allow an assessment of whether it should produce comparable groups.

We assessed the methods as:

- adequate (any truly random method, e.g. random number table; computer random-number generator);
- inadequate (odd or even date of birth; hospital or clinic record number); or
- unclear.

(2) Allocation concealment (checking for possible selection bias): We described for each included study the method used to conceal the allocation sequence and assessed whether intervention allocation could have been foreseen in advance of, or during, recruitment.

We assessed the methods as:

- adequate (e.g. consecutively numbered sealed opaque envelopes);
- inadequate (open random allocation; unsealed or nonopaque envelopes, alternation, date of birth);
- unclear.

(3) Blinding (checking for possible performance bias): With interventions such as ultrasonography it may not be feasible to blind women and clinical staff to group allocation. Where there was any attempt to blind outcome assessors, this has been noted.

We have assessed the methods as:

- adequate, inadequate or unclear for participants;
- adequate, inadequate or unclear for personnel;
- adequate, inadequate or unclear for outcome assessors.

(4) Incomplete outcome data (checking for possible attrition bias through withdrawals, dropouts, protocol deviations): We have described for each included study the completeness of outcome data for each main outcome, including attrition and exclusions from the analysis. We have stated whether attrition and exclusions were reported, the numbers (compared with the total randomised participants), reasons for attrition or exclusion where reported, and any re-inclusions in analyses which we have undertaken.

We have assessed the methods as:

- adequate (e.g. where there were no missing data, or low levels of missing data and where reasons for missing data are balanced across groups);
- inadequate (e.g. where there are higher levels of missing data or attrition is not balanced across groups);
- unclear (e.g. where there is insufficient reporting of attrition or exclusions to permit a judgement to be made).

(5) Selective reporting bias: We have described for each included study how the possibility of selective outcome reporting bias was examined by us and what we found.

We have assessed the methods as:

- adequate (where it is clear that all of the study's prespecified outcomes and all expected outcomes of interest to the review have been reported);
- inadequate (where not all the study's prespecified outcomes have been reported; one or more reported primary outcomes were not prespecified; outcomes of interest are reported incompletely and so cannot be used; study fails to include results of a key outcome that would have been expected to have been reported);
- unclear.

(6) Other sources of bias: We have described for each included study any important concerns we had about other possible sources of bias; for example, where there was a potential source of bias associated with a particular aspect of study design.

Measures of treatment effect—We have carried out statistical analysis using the Review Manager software (RevMan 2008). We have used fixed-effect meta-analysis for combining data in the absence of high levels of heterogeneity. Where there was unexplained heterogeneity this has been noted, and we have used a random-effects model in the analysis.

Dichotomous data—For dichotomous data, we have presented results as summary risk ratios with 95% confidence intervals.

Continuous data—For continuous data, we have used the mean difference if outcomes have been measured in the same way between trials. We used the standardised mean difference to combine trials that measured the same outcome, but using different methods.

Subgroup and sensitivity analysis—If data had been available, we would have performed subgroup analyses as follows.

1. low-risk versus unselected populations;
2. purpose of ultrasound examinations (e.g. to detect intrauterine growth retardation, malpresentation, or to carry placental grading or to assess the placental site).

If the findings of any of the above subgroup analyses for the primary outcome measures had been significant, we would have extended the analysis to include all outcome measures.

We performed sensitivity analyses on the basis of quality of randomisation.

RESULTS

Description of studies

See: Characteristics of included studies; Characteristics of excluded studies.

See 'Characteristics of included studies' tables below.

Eight trials comprising 27,024 women were included (Alesund 1999; Belfast 2003; Glasgow 1984; New Zealand 1993; Perth 1993; Peterborough 1987; RADIUS 1993; Trondheim 1984). Longer term outcomes from the Alesund 1999 and Trondheim 1984 trials have been combined, and described in a series of papers by Salvesen and colleagues (Norway 1992).

Ultrasound examination options differed between trials, with some offering no routine scans at any time in pregnancy to the control group, some offering routine scans to all participants earlier in pregnancy (before 24 weeks' gestation), and some offering routine scan at all stages of the trial, but only revealing results of late pregnancy ultrasound (after 24 weeks' gestation) for the study groups.

Three trials (Alesund 1999 (Norway); RADIUS 1993 (USA); Trondheim 1984 (Norway)) offered routine ultrasound in the second and third trimesters versus selective ultrasound. In the New Zealand 1993 trial, all women had second trimester ultrasound scans, and only the study group underwent further third trimester ultrasound. In the Belfast 2003 (UK) trial all women had a first trimester scan while the study group had additional scans at 30 to 32 weeks and 36 to 37 weeks. In the Glasgow 1984 (UK) trial, all women were offered second and third trimester ultrasound, but the results of third trimester ultrasound were revealed only for the study group. In the Peterborough 1987 (UK) trial, all women had routine second and third trimester ultrasound, but placental grading at third trimester ultrasound was revealed only for the study group. In the Perth 1993 (Australia) trial, all women had routine second trimester ultrasound scans, and only the study group were offered serial ultrasound screening thereafter.

The trials evaluated different aspects of third trimester ultrasound. Two trials (Glasgow 1984 (UK); New Zealand 1993) addressed ultrasound screening for small for dates. The Peterborough 1987 (UK) trial addressed the value of placental grading as an adjunct to routine third trimester ultrasound scan. The Belfast 2003 trial examined the impact of two third trimester scans which assessed liquor volume, fetal weight and placental maturity. The RADIUS 1993 (USA) trial was the only study which reported in detail, detection of fetal abnormalities at routine third trimester ultrasound scan. The Perth 1993 (Australia) trial combined repeated ultrasound scan for fetal biometry and amniotic fluid assessment with Doppler ultrasound, and the data were therefore analysed in a separate comparison (serial ultrasound and Doppler ultrasound versus selective ultrasound), and were also included in

another Cochrane review entitled 'Routine Doppler ultrasound in pregnancy' (Bricker 2007b).

The results of the review should be considered in the light of these different factors, as the specific nature of the ultrasound regimens may have had some effect on the outcome measures.

Childhood developmental outcomes were measured in the Perth 1993 study and in the Alesund and Trondheim trials (the longer term outcomes from the latter two trials have been combined (Norway 1992)).

Risk of bias in included studies

The methodological quality in general was good. The Glasgow 1984 (UK) study was 'quasi-randomised' with allocation according to hospital number, and this had the potential to introduce bias. The assessment of bias in the included studies has been set out in the risk of bias tables following the 'Characteristics of included studies' tables.

Effects of interventions

There were no or few data available for some of the prespecified outcome measures, particularly maternal and neonatal outcomes. A number of outcome measures which were not prespecified were included, namely post-term delivery, birthweight less than fifth centile (less than third centile was prespecified, but there were no data), moderate neonatal morbidity, severe neonatal morbidity and perinatal mortality specifically of twin babies. In this update we have also examined longer term outcomes including school performance at eight to nine years of age.

Subgroup analyses were not performed due to the small number of included studies, and hence limited data.

For a number of the comparisons there was considerable heterogeneity. Where heterogeneity was substantial (over 50%), we have used a random-effects model, and in view of high levels of heterogeneity these results should be interpreted with caution (Analysis 1.1; Analysis 1.4; Analysis 1.5; Analysis 1.14; Analysis 1.18; Analysis 1.20; Analysis 1.23; Analysis 1.26).

Routine ultrasound after 24 weeks' gestation versus no/concealed or selective ultrasound after 24 weeks' gestation—There were no differences between groups in the rates of women having further ultrasound scans, in antenatal admissions or in other tests of fetal wellbeing. Neither was there a significant difference in obstetric interventions, such as induction of labour and instrumental deliveries. There was a slightly increased caesarean section rate in the screened compared to the comparison group and this finding approached statistical significance (risk ratio (RR) 1.06, 95% confidence interval (CI) 1.00 to 1.13, $P = 0.07$).

Screened groups were less likely to deliver post-term (after 42 weeks' gestation) (RR 0.69, 95% CI 0.59 to 0.81). Preterm delivery rates and birthweight data were similar in study and

control groups. Overall, perinatal mortality including or not including congenital abnormalities was no different. There was also no difference in perinatal mortality of twins. Only two studies reported separate data for stillbirths and neonatal deaths in congenitally normal fetuses or neonates (Glasgow 1984 (UK); Peterborough 1987 (UK)). The Peterborough 1987 (UK) data have suggested a reduction in the stillbirth rate if placental grading is incorporated into routine third trimester ultrasound scan (RR 0.05, 95% CI 0.00 to 0.90).

Neonatal interventions such as resuscitation, ventilation and admission to special care, were no different in screened or revealed versus control groups. Neither was there a difference in five minute Apgar scores. The only study reporting moderate and severe neonatal morbidity (RADIUS 1993 (USA)) showed no difference between study groups.

There were no differences between screened and control groups for any childhood development outcomes measured at eight to nine years including physical development, language, speech and intelligence (Perth 1993; Norway 1992). The findings from these studies have not been combined in meta-analysis as outcomes were measured at different time points or using different tools, or both. There was some evidence of increased non-right handedness for children exposed to ultrasound in the follow up from the Alesund and Trondheim trials, but as these findings have not been replicated they may have occurred by chance (Norway 1992).

Psychological and other maternal outcomes were not reported in any of the included studies.

Sensitivity analysis: One of the trials examining ultrasound after 24 weeks' gestation used a quasi-randomised design with poor allocation concealment (Glasgow 1984). We conducted a sensitivity analysis, removing this trial from each comparison where it contributed data to see if this would make any difference to the direction of findings, or to the size of the treatment effect. Removing this study made little difference to the results; it did not change the direction of findings and, as it was a relatively small study, made little difference to the size of the treatment effect even for those outcomes where only a small number of trials contributed data.

Serial ultrasound and Doppler ultrasound versus selective ultrasound—This comparison includes published and unpublished data from the Perth 1993 study (Australia). The results of this trial showed no significant difference between the two groups in antenatal admissions or other tests of fetal wellbeing. Neither was there a significant difference in obstetric interventions, such as induction of labour, instrumental deliveries and caesarean section. More babies in the screened group were of birthweight less than tenth centile (RR 1.36, 95% CI 1.10 to 1.68), and less than third centile (RR 1.66, 95% CI 1.10 to 2.51). There was no difference in other indices of perinatal or neonatal outcome.

DISCUSSION

The ultrasound scan protocols in each trial varied. It is difficult to assess the effect of scans before 24 weeks' gestation on the outcome measures. For example, the finding of a

reduction in post-term delivery in the screened group of the RADIUS 1993 (USA) study is probably due to better gestational age assessment at the 18 to 20 week scan. Furthermore, the reason for routine ultrasound scan after 24 weeks' gestation differed amongst trials. Ideally, subgroup analyses according to the reason for the scan would resolve the possible difference in outcomes according to the diagnostic approach, but there are not enough studies to perform meaningful subgroup analyses. The results of the meta-analysis should be viewed in this light.

Whilst the most accurate approach to assessment of the effect of routine late pregnancy ultrasound would be trials where the intervention is late pregnancy ultrasound alone, no such trials exist. The fact that assessment of most parameters at late pregnancy ultrasound are based on gestational reference data, which in turn rely on accurate gestational dating in early pregnancy, further compounds this issue. Therefore, it is neither realistic, nor pragmatic, to consider routine late pregnancy ultrasound in isolation, and the included studies probably reflect existing practice.

Meta-analysis of the data shows very little difference between groups in antenatal, obstetric and neonatal interventions apart from a small increase in the caesarean section rate in the screened group. Overall perinatal mortality was no different, for all fetuses or neonates, and twin pregnancies. Although there was some heterogeneity in perinatal mortality overall ($I^2 = 38\%$), there was increased heterogeneity in perinatal mortality corrected for abnormality ($I^2 = 58\%$). This was due to the Peterborough 1987 (UK) trial data that suggested a significant reduction in the number of congenitally normal stillbirths. This trial is unique in that it is an evaluation of placental grading as an adjunct to routine late pregnancy ultrasound. The authors state that this observation was not a formal prior hypothesis and may be an overestimate of the true effect of the test. In view of the nature of the trial, i.e. single centre and limited power to assess perinatal outcome (2000 participants), and the fact that it was performed over two decades ago (1987), this finding needs to be revisited in future research.

There was no overall difference in the incidence of babies being small-for-gestational age at birth (less than tenth percentile), comparing experimental and control groups (RR 0.98, 95% CI 0.74 to 1.28), but there was high heterogeneity ($I^2 = 70\%$), mainly due to the findings of the Belfast 2003 study. Whilst, theoretically, there is some potential scope to decrease the incidence of small-for-dates babies at birth by recognition of fetal growth restriction through ultrasound screening, and early planned delivery, it seems unlikely that this intervention could have a strong effect on this particular outcome.

In the Perth 1993 (Australia) trial there was an unexpected finding of significantly higher intrauterine growth restriction in the serial ultrasound and Doppler examination group (i.e. the intensive group). The authors state that while this may have been a chance finding, it is possible that frequent exposure to ultrasound may have influenced fetal growth. This finding was not associated with increased perinatal morbidity and mortality, and follow up of these children at one year of age found that the difference was no longer discernible (Newnham 1996). The authors stress the need for further investigation of the effects of frequent ultrasound exposure on fetal growth. Furthermore, if this were a true effect, the modality responsible (Doppler ultrasound versus realtime ultrasound) would need to be elucidated.

More recent data from this trial reporting findings for children at eight years of age found no negative effect associated with serial ultrasound in terms of physical size or speech, language and neurological development (Newnham 2004).

Long-term follow up of children from the Norwegian studies revealed no positive or negative effects of exposure to ultrasound in children aged eight to nine years although there was an association between exposure to ultrasound in utero and non-right handedness. This finding may be a chance one, but merits further investigation (Alesund 1999; Norway 1992; Trondheim 1984).

The RADIUS 1993 (USA) trial was the only study which addressed detection of fetal anomalies in the third trimester. The overall fetal anomaly detection rate in this trial was poor, at 35%. After 24 weeks' gestation, 34/156 (22%) anomalous fetuses were detected in the screened group, and 10/155 (6.5%) anomalies were detected in the control group. However, the better detection rate in the screened group did not translate into an improvement in infant survival.

Few of the trials addressed long-term neurodevelopmental outcome and none examined maternal psychological outcome, and it is arguable that these are the most important outcomes. Exposure of the expectant mother to uncertainty and possible anxiety about the health of her baby has implications which may be far reaching. In addition, perinatal survival does not automatically translate into long-term success, as little is known about the longterm prognosis of the in utero compromised fetus.

AUTHORS' CONCLUSIONS

Implications for practice

There is no evidence that routine ultrasound in late pregnancy improves perinatal outcome. Its use may increase the rate of caesarean section, and hence the risk of iatrogenic morbidity. As a result of this review, it is not clear what aspects of late pregnancy ultrasound may be valuable in centres where it is undertaken. However, placental grading may be useful, and perhaps should be considered in late pregnancy ultrasound, whether routine or selective.

Implications for research

There is a lack of data about the potential psychological effects of routine ultrasound in late pregnancy, and the effects on both short- and long-term neonatal and childhood outcome. Future studies should address these issues along with the effect of ultrasound on operative delivery rates.

Based on the available data about the value of placental grading, future research of late pregnancy ultrasound should include assessment of placental texture.

Acknowledgments

Mrs Lixia Dou, Cochrane Pregnancy and Childbirth Group, The University of Liverpool, provided much valued help with the assessment of risk of bias for the studies included in this updated review.

Professor A M Weindling (Professor of Perinatal Medicine, The University of Liverpool) for advice on neonatal outcome measures.

Prof SH Eik-Nes, Drs KA Salvesen, LJ Vatten and O Okland have provided unpublished results from the Alesund trial. Professor J Newnham and Dr Sharon Evans have provided unpublished results from the Perth trial.

SOURCES OF SUPPORT

Internal sources

- NHS R&D Health Technology Assessment Programme, Grant number 93/30/03, UK.
- The University of Liverpool, UK.

External sources

- National Institute for Health Research, UK.

NIHR NHS Cochrane Collaboration Programme Grant Scheme award for NHS-prioritised centrally-managed, pregnancy and childbirth systematic reviews:CPGS02

CHARACTERISTICS OF STUDIES

Characteristics of included studies [ordered by study ID]

Alesund 1999

Methods	Randomisation by sealed envelopes.	
Participants	Nearly all women in that geographical area, including those with 'high-risk' pregnancies. Recruitment 1979-1981. 1628 women	
Interventions	Routine ultrasound examination at 18 weeks (biparietal diameter measured) and 32 weeks (biparietal diameter and mean abdominal diameter) with additional examination at 36 weeks' gestation if fetus small-for-gestational age and/or presenting by breech - versus selective examination for clinical indications only	
Outcomes	Obstetric interventions (antepartum and intrapartum) for singleton pregnancies only. Perinatal outcome indices for all pregnancies (including multiple pregnancies)	
Notes	This trial was reported in letter form only in 1984. It subsequently became clear that there were inconsistencies in results, and the data were subsequently re-analysed. The data entered in this review are derived from more recent unpublished and published reports	
<i>Risk of bias</i>		
Item	Authors' judgement	Description
Adequate sequence generation?	Unclear	Not stated.
Allocation concealment?	Unclear	Described as "sealed envelope".
Blinding? Women	No	Not feasible.
Blinding? Clinical staff	No	Not feasible.
Blinding? Outcome assessors	No	Not feasible.
Incomplete outcome data addressed? All outcomes	Yes	The data could be re-included.
Free of selective reporting?	Yes	Selective outcome reporting bias not apparent.

Free of other bias?	No	More smokers in screened group; historical study.
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Belfast 2003

Methods	Randomised controlled trial. Randomisation by sealed, numbered envelopes
Participants	Women recruited at 30 weeks' gestation assessed at low risk with singleton pregnancy and dates confirmed by 18-20 weeks' anomaly scan Exclusion criteria: known medical or obstetric problems or known fetal anomaly 1998 women recruited over a 21 month period.
Interventions	Assessment 30-32 weeks and at 36-37 weeks by a midwife as part of routine care with midwife estimate of fetal size, presentation, position and amniotic fluid volume. In addition, the study group had ultrasound examinations by the specially trained midwife to assess liquor volume, fetal weight and placental maturity. The comparison group had selective ultrasound examinations if indicated
Outcomes	Small-for-gestation age at birth, admission to special care and antenatal interventions
Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Yes	Computer generated (restricted to achieve group balance).
Allocation concealment?	Yes	Sealed, numbered envelopes.
Blinding? Women	No	Not feasible.
Blinding? Clinical staff	No	Not feasible.
Blinding? Outcome assessors	No	Not feasible.
Incomplete outcome data addressed? All outcomes	Yes	Good follow up for most outcomes.
Free of selective reporting?	Unclear	Difficult to interpret the results relating to the main outcome
Free of other bias?	Yes	

Glasgow 1984

Methods	Pseudorandomisation according to last digit in hospital number
Participants	877 women attending the hospital antenatal clinic between 34-36.5 weeks' gestation with uncomplicated singleton pregnancies, i.e. low-risk pregnancies
Interventions	All women had an ultrasound examination < 24 weeks' gestation for gestational dating. All had further ultrasound scan at 34-36.5 weeks' gestation to measure crown rump length and trunk area, but in the study group the two measurements were multiplied and the results plotted and reported in the case notes (i.e. revealed). Further management was the responsibility of the clinical staff. No requests for control group measurements to be revealed occurred, but this option was available to clinicians

Outcomes	Obstetric interventions (antepartum and intrapartum) and perinatal outcome indices	
Notes	This study addressed ultrasound screening for small for dates	
<i>Risk of bias</i>		
Item	Authors’ judgement	Description
Adequate sequence generation?	No	Described as allocated “from their hospital index numbers”.
Allocation concealment?	No	See above.
Blinding? Women	No	Not feasible.
Blinding? Clinical staff	No	Not feasible.
Blinding? Outcome assessors	No	Not feasible.
Incomplete outcome data addressed? All outcomes	Unclear	Small loss to follow up.
Free of selective reporting?	Yes	Selective outcome reporting not detected.
Free of other bias?	Unclear	There were more participants from social class V in the reported group

New Zealand 1993

Methods	Randomised by women selecting one of a number of envelopes (< 6) containing a computer-generated random 1 or 2 and a study number	
Participants	All pregnant women who attended antenatal clinic < 24 weeks' gestation, i.e. unselected population. Multiple pregnancies excluded once diagnosed (and study numbers reused). 1527 women	
Interventions	All women had a dating scan 16-24 weeks' gestation. Study group had a further scan at 32-36 weeks' gestation (ideally 34 weeks' gestation) which aimed to detect small-for-gestational-age fetuses, and if estimated fetal weight fell below the 20th centile for gestation, this was reported and additional scans recommended but not arranged. Clinicians were able to order further scans for the control group if clinically indicated	
Outcomes	Mainly perinatal outcome indices. Number of further ultrasound scans	
Notes	Scan to detect small-for-gestational age.	
<i>Risk of bias</i>		
Item	Authors' judgement	Description
Adequate sequence generation?	Unclear	Described as "randomised controlled trial".
Allocation concealment?	Unclear	Not stated.
Blinding? Women	No	Not feasible.
Blinding? Clinical staff	No	Not feasible.
Blinding? Outcome assessors	No	Not feasible.
Incomplete outcome data addressed?	Unclear	Not stated.

All outcomes

Free of selective reporting?	Unclear	No information provided.
Free of other bias?	Unclear	No information provided.

Norway 1992

Methods	Combined findings from the Trondheim and Alesund trials for childhood developmental outcomes
Participants	Alesund - nearly all women in that geographical area, including those with 'high-risk' pregnancies. Recruitment 1979-1981. 1628 women Trondheim - 1009 pregnant women in Trondheim attending for antenatal care between 1979-1980
Interventions	Alesund - routine ultrasound examination at 18 weeks (biparietal diameter measured) and 32 weeks (biparietal diameter and mean abdominal diameter) with additional examination at 36 weeks' gestation if fetus small-for-gestational age and/or presenting by breech - versus selective examination for clinical indications only Trondheim - study group offered ultrasound examinations at 19 weeks' and 32 weeks' gestation
Outcomes	Follow up of singletons at 8-9 years including teacher assessed school performance, along with assessments of reading, speech and intelligence scores
Notes	This is not strictly a separate study, but findings from the Alesund and Trondheim trials were combined for long-term follow up

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Unclear	Not stated (both studies).
Allocation concealment?	Unclear	Sealed envelopes.
Blinding? Women	No	Not feasible.
Blinding? Clinical staff	No	Not feasible.
Blinding? Outcome assessors	Unclear	Not stated.
Incomplete outcome data addressed? All outcomes	Unclear	2011 of 2824 eligible followed up.

Perth 1993

Methods	Sealed envelopes.
Participants	2834 singleton pregnancies. Criteria for recruitment were gestational age 16-20 weeks, sufficient proficiency in English, expected to deliver at the hospital and an intention to remain in Western Australia so that childhood follow up would be feasible
Interventions	The 'regular' group had an ultrasound examination at 18 weeks for fetal biometry, subjective amniotic fluid assessment and placental morphology and location, and any further scans in pregnancy were conducted on clinicians request. The 'intensive group' had the aforementioned ultrasound examination, plus an amniotic fluid index and continuous wave Doppler ultrasound of the umbilical artery and an arcuate artery within the placental vascular bed at 18, 24, 28, 34 and 38 weeks' gestation. The Doppler ultrasound parameter reported was

	systolic/diastolic ratio. Results of these examinations were recorded in the hospital chart, but no clinical management guidance was given	
Outcomes	Obstetric interventions (antepartum and intrapartum) and perinatal outcome indices	
Notes	The published study reports the results overall, but little data are available for extraction. The authors were contacted and provided unpublished data	
<i>Risk of bias</i>		
Item	Authors' judgement	Description
Adequate sequence generation?	Yes	Described as "computer-generated random numbers".
Allocation concealment?	Unclear	Described as "sealed envelopes".
Blinding? Women	No	Not feasible.
Blinding? Clinical staff	No	Not feasible.
Blinding? Outcome assessors	No	Not feasible.
Incomplete outcome data addressed? All outcomes	Unclear	Some loss to follow up in both groups. "13 were lost to follow up in the intensive group of the trial and 20 in the regular" care group
Free of selective reporting?	Yes	Selective outcome reporting bias not detected.
Free of other bias?	Yes	Other bias not detected.

Peterborough 1987

Methods	Randomisation by opaque sealed envelopes.	
Participants	2000 pregnant women attending the ultrasound department for routine third trimester scans, including multiple pregnancies	
Interventions	All women were offered routine early pregnancy ultrasound and 2 routine scans in the third trimester. Placental grading was performed at the routine third trimester scan. The results of placental grading in the study group were revealed, and the control group concealed. Clinical management in both groups was left entirely to the clinician responsible for care	
Outcomes	Obstetric interventions (antepartum and intrapartum) and perinatal outcome indices	
Notes	This study addresses the value of placental grading at routine third trimester ultrasound	
<i>Risk of bias</i>		
Item	Authors' judgement	Description
Adequate sequence generation?	Unclear	Described as “randomly allocated to 1 of 2 groups”.
Allocation concealment?	Yes	Described as “a correspondingly numbered, sealed, opaque envelope”
Blinding? Women	No	Not feasible.
Blinding? Clinical staff	No	Not feasible.

Blinding? Outcome assessors	No	Not feasible.
Incomplete outcome data addressed? All outcomes	Yes	No losses to follow up.
Free of selective reporting?	Yes	Selective outcome reporting not detected.
Free of other bias?	Yes	No other bias apparent.

RADIUS 1993

Methods	Randomisation by microcomputer after stratification by practice site. Intention to treat	
Participants	15151 pregnant women who did not have “an indication for ultrasonography” based on uncertain gestational age, previous or index pregnancy complication, medical disorder. Therefore, those eligible were at low risk of adverse pregnancy outcome, and comprised 40% of the total population	
Interventions	Ultrasound screen at 18-20 weeks’ and 31-33 weeks’ gestation, versus selective ultrasonography	
Outcomes	Perinatal outcome indices. The primary outcomes were perinatal mortality and moderate/ severe neonatal morbidity	
Notes		
<i>Risk of bias</i>		
Item	Authors’ judgement	Description
Adequate sequence generation?	Yes	Described as “computer-generated randomisation sequence”.
Allocation concealment?	Unclear	Not stated.
Blinding? Women	No	Not feasible.
Blinding? Clinical staff	No	Not feasible.
Blinding? Outcome assessors	Unclear	Not feasible.
Incomplete outcome data addressed? All outcomes	Unclear	252 women lost to follow up.
Free of selective reporting?	Yes	Selective outcome reporting bias not detected.
Free of other bias?	Yes	No other bias detected.

Trondheim 1984

Methods	Randomised by sealed-envelope method.	
Participants	1009 pregnant women in Trondheim attending for antenatal care between 1979-1980	
Interventions	Study group offered ultrasound examinations at 19 weeks and 32 weeks" gestation	

Outcomes	Obstetric interventions (ante partum and intra partum) and perinatal outcome indices	
Notes	Some data only presented for singletons (mean birthweight, birthweight < 10th centile, low birthweight, neonatal resuscitation, admission to special care, Apgar scores)	
<i>Risk of bias</i>		
Item	Authors' judgement	Description
Adequate sequence generation?	Unclear	Not stated.
Allocation concealment?	Unclear	Described as sealed envelopes.
Blinding? Women	No	Not feasible.
Blinding? Clinical staff	No	Not feasible.
Blinding? Outcome assessors	Yes	Neonatal outcome assessment blinding - yes. Pregnancy outcome assessment blinding - no.
Incomplete outcome data addressed? All outcomes	Unclear	Small loss to follow up.
Free of selective reporting?	Yes	Selective outcome reporting bias not detected.
Free of other bias?	Yes	Other bias not apparent.

Characteristics of excluded studies [ordered by study ID]

Study	Reason for exclusion
Belanger 1996	Brief abstract. No usable data.
Hendrix 2000	Compared clinical versus ultrasound estimates of birthweight in terms of accuracy. Did not include review outcomes
Morrison 1992	Brief abstract. No usable data.
Ong 2001	Study not undertaken.
Owen 1994	Brief abstract. No usable data.
Secher 1986	The methodology is unclear as all suspected LGA fetuses were to be referred to an obstetrician for further evaluation. However, suspected LGA in 26 such fetuses included in the final analysis was not reported to clinicians primarily because they were part of another randomised study. The other randomised trial (Secher 1987) was also not included - see reasons in this table.
Secher 1987	In this study, third trimester ultrasound was used to identify a group of uncomplicated pregnancies where there was ultrasound suspicion of poor intrauterine growth, but no clinical suspicion of poor growth. Only these pregnancies were randomised. The revealed group underwent serial tests of fetal wellbeing (non-stress CTG and serum oestriol and placental lactogen) and fetal growth and management was planned depending on the results of the tests. Therefore, the study assesses the value of various tests of fetal wellbeing if fetal growth retardation is suspected, rather than the value of routine third trimester ultrasound alone
Wladimiroff 1980	The primary aim of this study was to assess the ability of third trimester ultrasound in detecting small and large-for-dates infants, and no clinical outcomes were evaluated

CTG: cardiotocograph

LGA: light-for-gestational age

DATA AND ANALYSES

Comparison 1 Routine ultrasound > 24 weeks vs no/concealed/selective ultrasound > 24 weeks

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Antenatal admission	4	5396	Risk Ratio (M-H, Random, 95% CI)	1.07 [0.80, 1.43]
2 Number of days in hospital (mean, standard deviation (SD))	1	877	Mean Difference (IV, Fixed, 95% CI)	0.10 [0.07, 0.13]
3 CTG (cardiotocograph)	1	2000	Risk Ratio (M-H, Fixed, 95% CI)	1.02 [0.97, 1.06]
4 Further ultrasound scan/s	2	2536	Risk Ratio (M-H, Random, 95% CI)	0.91 [0.43, 1.89]
5 Induction of labour	6	22663	Risk Ratio (M-H, Random, 95% CI)	0.93 [0.81, 1.07]
6 Instrumental delivery	4	5884	Risk Ratio (M-H, Fixed, 95% CI)	1.04 [0.92, 1.18]
7 Caesarean section	5	21035	Risk Ratio (M-H, Fixed, 95% CI)	1.06 [1.00, 1.13]
8 Elective caesarean section	4	5884	Risk Ratio (M-H, Fixed, 95% CI)	1.09 [0.89, 1.34]
9 Emergency caesarean section	4	5884	Risk Ratio (M-H, Fixed, 95% CI)	1.11 [0.92, 1.33]
10 Preterm delivery < 37 weeks' gestation	2	17151	Risk Ratio (M-H, Fixed, 95% CI)	0.96 [0.85, 1.08]
11 Post-term delivery >42 weeks' gestation	2	17151	Risk Ratio (M-H, Fixed, 95% CI)	0.69 [0.59, 0.81]
12 Gestation at delivery (mean, SD)	2	2877	Mean Difference (IV, Fixed, 95% CI)	-0.16 [-0.26, -0.06]
13 Birthweight (mean, SD)	4	19710	Mean Difference (IV, Fixed, 95% CI)	-0.47 [-15.49, 14.54]
14 Birthweight < 10th centile	4	20293	Risk Ratio (M-H, Random, 95% CI)	0.98 [0.74, 1.28]
15 Birthweight < 5th centile	2	2404	Risk Ratio (M-H, Fixed, 95% CI)	1.18 [0.81, 1.74]
16 Low birthweight < 2.5 kg	3	4510	Risk Ratio (M-H, Fixed, 95% CI)	0.92 [0.71, 1.18]
17 Neonatal resuscitation	4	6533	Risk Ratio (M-H, Fixed, 95% CI)	0.95 [0.82, 1.10]
18 Neonatal ventilation	2	3004	Risk Ratio (M-H, Random, 95% CI)	0.64 [0.23, 1.77]
19 Admission to special care baby unit	4	6539	Risk Ratio (M-H, Fixed, 95% CI)	0.95 [0.79, 1.14]
20 Apgar score < 7 at 5 minutes	4	5889	Risk Ratio (M-H, Random, 95% CI)	0.89 [0.41, 1.93]
21 Moderate neonatal morbidity	1	15281	Risk Ratio (M-H, Fixed, 95% CI)	0.97 [0.81, 1.16]
22 Severe neonatal morbidity	1	15281	Risk Ratio (M-H, Fixed, 95% CI)	1.03 [0.78, 1.36]
23 Perinatal mortality	7	24276	Risk Ratio (M-H, Random, 95% CI)	0.94 [0.55, 1.61]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
24 Stillbirths	5	21708	Risk Ratio (M-H, Random, 95% CI)	1.11 [0.29, 4.26]
25 Neonatal deaths	5	21708	Risk Ratio (M-H, Fixed, 95% CI)	1.04 [0.58, 1.85]
26 Perinatal mortality (excluding congenital abnormalities)	5	21734	Risk Ratio (M-H, Random, 95% CI)	0.88 [0.36, 2.17]
27 Stillbirths (excluding congenital abnormalities)	2	2902	Risk Ratio (M-H, Fixed, 95% CI)	0.05 [0.00, 0.90]
28 Neonatal deaths (excluding congenital abnormalities)	2	2902	Risk Ratio (M-H, Fixed, 95% CI)	1.99 [0.18, 21.96]
29 Perinatal mortality (twins)	3	314	Risk Ratio (M-H, Fixed, 95% CI)	0.63 [0.24, 1.66]

Comparison 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 CTG (cardiograph)	1	2834	Risk Ratio (M-H, Fixed, 95% CI)	1.01 [0.93, 1.09]
2 Induction of labour	1	2834	Risk Ratio (M-H, Fixed, 95% CI)	1.02 [0.92, 1.14]
3 Caesarean section	1	2834	Risk Ratio (M-H, Fixed, 95% CI)	0.89 [0.76, 1.03]
4 Elective caesarean section	1	2834	Risk Ratio (M-H, Fixed, 95% CI)	0.95 [0.77, 1.17]
5 Emergency caesarean section	1	2834	Risk Ratio (M-H, Fixed, 95% CI)	0.82 [0.64, 1.05]
6 Gestation at delivery (mean, SD)	1	2834	Mean Difference (IV, Fixed, 95% CI)	-0.10 [-1.21, 1.01]
7 Birthweight (mean, SD)	1	2834	Mean Difference (IV, Fixed, 95% CI)	-25.0 [-67.53, 17.53]
8 Birthweight < 10th centile	1	2834	Risk Ratio (M-H, Fixed, 95% CI)	1.36 [1.10, 1.68]
9 Birthweight < 3rd centile	1	2834	Risk Ratio (M-H, Fixed, 95% CI)	1.66 [1.10, 2.51]
10 Low birthweight (< 2.5 kg)	1	2834	Risk Ratio (M-H, Fixed, 95% CI)	1.14 [0.85, 1.52]
11 Very low birthweight (< 1.5 kg)	1	2834	Risk Ratio (M-H, Fixed, 95% CI)	1.27 [0.65, 2.49]
12 Neonatal resuscitation	1	2834	Risk Ratio (M-H, Fixed, 95% CI)	0.98 [0.92, 1.05]
13 Neonatal ventilation	1	2834	Risk Ratio (M-H, Fixed, 95% CI)	0.67 [0.41, 1.09]
14 Admission to special care baby unit	1	2834	Risk Ratio (M-H, Fixed, 95% CI)	0.95 [0.68, 1.31]
15 Apgar score < 7 at 5 minutes	1	2834	Risk Ratio (M-H, Fixed, 95% CI)	0.77 [0.46, 1.27]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
16 Neonatal intraventricular haemorrhage	1	2834	Risk Ratio (M-H, Fixed, 95% CI)	0.80 [0.22, 2.98]
17 Perinatal mortality	1	2834	Risk Ratio (M-H, Fixed, 95% CI)	0.59 [0.30, 1.17]
18 Stillbirths	1	2834	Risk Ratio (M-H, Fixed, 95% CI)	0.84 [0.36, 1.93]
19 Neonatal deaths	1	2834	Risk Ratio (M-H, Fixed, 95% CI)	0.30 [0.08, 1.09]
20 Neonatal death (excluding congenital abnormalities)	1	2834	Risk Ratio (M-H, Fixed, 95% CI)	0.40 [0.08, 2.06]

Analysis 1.1

Comparison 1 Routine ultrasound > 24 weeks vs no/concealed/selective ultrasound > 24 weeks, Outcome 1 Antenatal admission

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound > 24 weeks vs no/concealed/selective ultrasound > 24 weeks

Outcome: 1 Antenatal admission

Analysis 1.2
Comparison 1 Routine ultrasound > 24 weeks vs no/
concealed/selective ultrasound > 24 weeks, Outcome 2
Number of days in hospital (mean, standard deviation
(SD))

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound > 24 weeks vs no/concealed/selective ultrasound > 24 weeks

Outcome: 2 Number of days in hospital (mean, standard deviation (SD))

Analysis 1.3
Comparison 1 Routine ultrasound >24 weeks vs no/
concealed/selective ultrasound >24 weeks, Outcome 3
CTG (cardiotocograph)

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 3 CTG (cardiotocograph)

Analysis 1.4

Comparison 1 Routine ultrasound >24 weeks vs no/ concealed/selective ultrasound >24 weeks, Outcome 4 Further ultrasound scan/s

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 4 Further ultrasound scan/s

Analysis 1.5

Comparison 1 Routine ultrasound >24 weeks vs no/ concealed/selective ultrasound >24 weeks, Outcome 5 Induction of labour

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 5 Induction of labour

Analysis 1.6

Comparison 1 Routine ultrasound >24 weeks vs no/ concealed/selective ultrasound >24 weeks, Outcome 6 Instrumental delivery

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 6 Instrumental delivery

Analysis 1.7

Comparison 1 Routine ultrasound >24 weeks vs no/ concealed/selective ultrasound >24 weeks, Outcome 7 Caesarean section

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 7 Caesarean section

Analysis 1.8

Comparison 1 Routine ultrasound >24 weeks vs no/ concealed/selective ultrasound >24 weeks, Outcome 8 Elective caesarean section

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 8 Elective caesarean section

Analysis 1.9

Comparison 1 Routine ultrasound >24 weeks vs no/ concealed/selective ultrasound >24 weeks, Outcome 9 Emergency caesarean section

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 9 Emergency caesarean section

Analysis 1.10
**Comparison 1 Routine ultrasound >24 weeks vs no/
 concealed/selective ultrasound >24 weeks, Outcome 10**
Preterm delivery < 37 weeks' gestation

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 10 Preterm delivery < 37 weeks' gestation

Analysis 1.11
**Comparison 1 Routine ultrasound >24 weeks vs no/
 concealed/selective ultrasound >24 weeks, Outcome 11**
Post-term delivery >42 weeks' gestation

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 11 Post-term delivery >42 weeks' gestation

Analysis 1.12
**Comparison 1 Routine ultrasound >24 weeks vs no/
 concealed/selective ultrasound >24 weeks, Outcome 12**
Gestation at delivery (mean, SD)

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 12 Gestation at delivery (mean, SD)

Analysis 1.13
**Comparison 1 Routine ultrasound >24 weeks vs no/
 concealed/selective ultrasound >24 weeks, Outcome 13**
Birthweight (mean, SD)

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 13 Birthweight (mean, SD)

Analysis 1.14
**Comparison 1 Routine ultrasound >24 weeks vs no/
 concealed/selective ultrasound >24 weeks, Outcome 14**
Birthweight <10th centile

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 14 Birthweight <10th centile

Analysis 1.15
**Comparison 1 Routine ultrasound >24 weeks vs no/
 concealed/selective ultrasound >24 weeks, Outcome 15**
Birthweight <5th centile

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 15 Birthweight <5th centile

Analysis 1.16
**Comparison 1 Routine ultrasound >24 weeks vs no/
 concealed/selective ultrasound >24 weeks, Outcome 16**
Low birthweight <2.5 kg

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 16 Low birthweight <2.5 kg

Analysis 1.17
**Comparison 1 Routine ultrasound >24 weeks vs no/
 concealed/selective ultrasound >24 weeks, Outcome 17**
Neonatal resuscitation

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 17 Neonatal resuscitation

Analysis 1.18
**Comparison 1 Routine ultrasound >24 weeks vs no/
 concealed/selective ultrasound >24 weeks, Outcome 18**
Neonatal ventilation

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 18 Neonatal ventilation

Analysis 1.19
**Comparison 1 Routine ultrasound >24 weeks vs no/
 concealed/selective ultrasound >24 weeks, Outcome 19**
Admission to special care baby unit

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 19 Admission to special care baby unit

Analysis 1.20

Comparison 1 Routine ultrasound >24 weeks vs no/ concealed/selective ultrasound >24 weeks, Outcome 20 Apgar score <7 at 5 minutes

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 20 Apgar score <7 at 5 minutes

Analysis 1.21

Comparison 1 Routine ultrasound >24 weeks vs no/ concealed/selective ultrasound >24 weeks, Outcome 21 Moderate neonatal morbidity

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 21 Moderate neonatal morbidity

Analysis 1.22

Comparison 1 Routine ultrasound >24 weeks vs no/ concealed/selective ultrasound >24 weeks, Outcome 22 Severe neonatal morbidity

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 22 Severe neonatal morbidity

Analysis 1.23

Comparison 1 Routine ultrasound >24 weeks vs no/ concealed/selective ultrasound >24 weeks, Outcome 23 Perinatal mortality

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 23 Perinatal mortality

Analysis 1.24

Comparison 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks, Outcome 24 Stillbirths

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 24 Stillbirths

Analysis 1.25

Comparison 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks, Outcome 25 Neonatal deaths

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 25 Neonatal deaths

Analysis 1.26
**Comparison 1 Routine ultrasound >24 weeks vs no/
 concealed/selective ultrasound >24 weeks, Outcome 26**
Perinatal mortality (excluding congenital abnormalities)

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 26 Perinatal mortality (excluding congenital abnormalities)

Analysis 1.27
**Comparison 1 Routine ultrasound >24 weeks vs no/
 concealed/selective ultrasound >24 weeks, Outcome 27**
Stillbirths (excluding congenital abnormalities)

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 27 Stillbirths (excluding congenital abnormalities)

Analysis 1.28
**Comparison 1 Routine ultrasound >24 weeks vs no/
 concealed/selective ultrasound >24 weeks, Outcome 28**
Neonatal deaths (excluding congenital abnormalities)

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 28 Neonatal deaths (excluding congenital abnormalities)

Analysis 1.29
**Comparison 1 Routine ultrasound >24 weeks vs no/
 concealed/selective ultrasound >24 weeks, Outcome 29**
Perinatal mortality (twins)

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 1 Routine ultrasound >24 weeks vs no/concealed/selective ultrasound >24 weeks

Outcome: 29 Perinatal mortality (twins)

Analysis 2.1

Comparison 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound, Outcome 1 CTG (cardiograph)

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound

Outcome: 1 CTG (cardiograph)

Analysis 2.2

Comparison 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound, Outcome 2 Induction of labour

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound

Outcome: 2 Induction of labour

Analysis 2.3

Comparison 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound, Outcome 3 Caesarean section

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound

Outcome: 3 Caesarean section

Analysis 2.4

Comparison 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound, Outcome 4 Elective caesarean section

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound

Outcome: 4 Elective caesarean section

Analysis 2.5

Comparison 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound, Outcome 5 Emergency caesarean section

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound

Outcome: 5 Emergency caesarean section

Analysis 2.6

Comparison 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound, Outcome 6 Gestation at delivery (mean, SD)

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound

Outcome: 6 Gestation at delivery (mean, SD)

Analysis 2.7

Comparison 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound, Outcome 7 Birthweight (mean, SD)

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound

Outcome: 7 Birthweight (mean, SD)

Analysis 2.8

Comparison 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound, Outcome 8 Birthweight < 10th centile

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound

Outcome: 8 Birthweight < 10th centile

Analysis 2.9

Comparison 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound, Outcome 9 Birthweight < 3rd centile

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound

Outcome: 9 Birthweight < 3rd centile

Analysis 2.10

Comparison 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound, Outcome 10 Low birthweight (<2.5 kg)

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound

Outcome: 10 Low birthweight (<2.5 kg)

Analysis 2.11

Comparison 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound, Outcome 11 Very low birthweight (< 1.5 kg)

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound

Outcome: 11 Very low birthweight (< 1.5 kg)

Analysis 2.12

Comparison 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound, Outcome 12 Neonatal resuscitation

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound

Outcome: 12 Neonatal resuscitation

Analysis 2.13

Comparison 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound, Outcome 13 Neonatal ventilation

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound

Outcome: 13 Neonatal ventilation

Analysis 2.14

Comparison 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound, Outcome 14 Admission to special care baby unit

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation))

Comparison: 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound

Outcome: 14 Admission to special care baby unit

Analysis 2.15

Comparison 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound, Outcome 15 Apgar score < 7 at 5 minutes

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound

Outcome: 15 Apgar score < 7 at 5 minutes

Analysis 2.16

Comparison 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound, Outcome 16 Neonatal intraventricular haemorrhage

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound

Outcome: 16 Neonatal intraventricular haemorrhage

Analysis 2.17

Comparison 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound, Outcome 17 Perinatal mortality

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound

Outcome: 17 Perinatal mortality

Analysis 2.18

Comparison 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound, Outcome 18 Stillbirths

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound

Outcome: 18 Stillbirths

Analysis 2.19

Comparison 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound, Outcome 19 Neonatal deaths

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound

Outcome: 19 Neonatal deaths

Analysis 2.20

Comparison 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound, Outcome 20 Neonatal death (excluding congenital abnormalities)

Review: Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Comparison: 2 Serial ultrasound and Doppler ultrasound vs selective ultrasound

Outcome: 20 Neonatal death (excluding congenital abnormalities)

WHAT'S NEW

Last assessed as up-to-date: 27 May 2008.

Date	Event	Description
13 May 2009	Amended	No changes - republished to fix technical problem.

HISTORY

Protocol first published: Issue 2, 1999

Review first published: Issue 1, 2000

Date	Event	Description
28 May 2008	New search has been performed	We updated the search in February 2008 and identified an additional trial (Belfast 2003). We updated the methods, included risk of bias tables and updated the analyses. There are some small changes in the results but there are no substantial changes to the conclusions
28 May 2008	New citation required but conclusions have not changed	A new author joined the review team to prepare this update.
26 February 2008	Amended	Converted to new review format.
5 February 2007	Amended	Review withdrawn from publication.

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* Indicates the major publication for the study

PLAIN LANGUAGE SUMMARY

Routine ultrasound in late pregnancy (after 24 weeks' gestation)

Ultrasound can be used in late pregnancy to assess the baby's condition when there are complications, but carrying out scans on all women is controversial. Scans can be used in late pregnancy to detect problems which may not otherwise be apparent, such as abnormalities in the placenta, in the fluid surrounding the baby, or in the baby's growth. If such problems are identified this may lead to changes in care and improved outcome for babies. At the same time, screening all women may mean that interventions are increased without benefit to mothers or babies. Scans are popular, but women may not fully understand the purpose of their scan and may be either falsely reassured or unprepared for adverse findings. Based on existing evidence, routine ultrasound, after 24 weeks gestation, in low-risk or unselected women does not provide any benefit for mother or baby. Eight studies that randomised 27,024 women to screening or a control group (no or selective ultrasound, or ultrasound with concealed results) contributed to the review. The quality of trials was satisfactory. There were no differences between groups in the rates of women having additional scans, antenatal admissions, preterm delivery, induction of labour, or instrumental deliveries although the rate of caesarean section increased slightly with screening. For babies, birthweight, condition at birth, interventions such as resuscitation, and admission to special care were similar between groups. Infant survival, with or without congenital abnormalities, was no different with and without routine screening, and childhood development at eight to nine years was similar in the three trials that measured it. None of the trials reported on psychological effects for mothers of routine ultrasound in late pregnancy.