



Te Whatu Ora
Health New Zealand

Small for Gestational Age and Fetal Growth Restriction in Aotearoa New Zealand

He Aratohu Ritenga Haumanu mō te Tōhuatanga Kōpiri me te Pakupaku Rawa

A clinical practice guideline: evidence summaries

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Purpose of the evidence statements

The evidence statements support the 2023 clinical practice guideline, *Small for Gestational Age and Fetal Growth Restriction in Aotearoa New Zealand He Aratohu Ritenga Haumanu mō te Tōhuatanga Kōpiri me te Pakupaku Rawa: A Clinical Practice Guideline* by providing additional detail to support each recommendation.

The clinical practice guideline aims to reduce rates of stillbirth and neonatal mortality and morbidity associated with fetal growth restriction (FGR) by standardising care across Aotearoa New Zealand. The guideline:

- provides evidence-based best practice recommendations for screening, diagnosing and managing small for gestational age (SGA) and FGR in singleton pregnancies
- focuses on placental insufficiency, which is the most common cause of FGR
- is not a comprehensive guide for managing chromosomal and anatomical abnormalities, but contains aspects relevant to those pregnancies
- was developed with consideration of equity, hauora Māori and te ao Māori
- supersedes previous guidelines on SGA and FGR used in Aotearoa New Zealand, including the New Zealand Maternal Fetal Medicine Network's 2014 guideline
- recognises that even with optimal screening practices, up to approximately 60% of SGA babies are detected and 40% or more are not detected.^{1,2}

The clinical practice guideline reflects international best practice. The FGR Guideline Development Panel interpreted literature and developed recommendations specifically for Aotearoa New Zealand and its model of maternity care.^a Information about the evidence review can be found in Appendix 1: Process to develop the clinical practice guideline and the evidence statements.

The clinical practice guideline should be read in conjunction with *Ngā Paerewa Health and disability services standard 8134:2021* and the corresponding sector guidance for birthing units and in-patient or private hospital services.³ *Ngā Paerewa*, alongside the sector guidance, contains information about best practice maternity and neonatal service provision.

^a Panel members were Dr Ngaire Anderson (Chair), Anna Francis, Dr Chris McKinlay, Claire MacDonald, Horiana Thompson, Katarina Komene, Dr Kirsten Gaerty, Martin Necas, and Dr Rachael McEwing.

The term SGA refers to an estimated fetal weight (EFW) or birthweight < 10th customised centile.

The term FGR refers to fetal growth that is abnormally reduced (that is, less than expected due to pathology).

Most, but not all, fetuses and neonates with FGR are SGA, while some SGA fetuses and neonates are not growth restricted.

Summary of changes

	NZMFMN 2014 guideline ¹	The 2023 guideline
Definition of early-onset SGA or FGR	< 34 weeks' gestation	< 32+0 weeks' gestation
Suspicion of SGA	AC < 5th centile	AC < 10th centile based on the Australasian Society of Ultrasound Medicine fetal biometry chart, with centile documented in report
	Discrepancy between HC and AC	Removed from diagnosis of FGR
Slowing of fetal growth	Reduction in EFW percentile \geq one third or reduction in AC of > 30 centiles or a change in AC of < 5 millimetres over 14 days	Decline in EFW > 30 centiles \geq 28 weeks' gestation or decline in AC > 30 centiles \geq 28 weeks' gestation
Risk factors for SGA and FGR	PAPP-A < 0.4 MoM (if performed)	Removed
	Maternal age > 40 years	Major risk factor: Maternal age \geq 40 years (nulliparous) Minor risk factor: Maternal age \geq 40 years (multiparous)
	Not defined	Addition of minor risk factors

Schedule of growth scans for those with SGA or FGR risk factors		Addition of screening schedule for those with three or more minor risk factors
MCA Doppler and CPR in late-onset FGR	MCA and CPR used for monitoring of late-onset FGR	Only CPR used for monitoring late-onset FGR
Definition of neonatal FGR	Not defined	See <i>Recommendation 44</i>

AC = abdominal circumference; CPR = cerebroplacental ratio; EFW = estimated fetal weight; FGR = fetal growth restriction; HC = head circumference; MCA = middle cerebral artery; MoM = multiple of medians; NZMFMN = New Zealand Maternal Fetal Medicine Network; PAPP-A = pregnancy-associated plasma protein-A; SGA = small for gestational age.

Need for these evidence statements

FGR affects approximately 5 to 10% of all pregnancies.⁴ FGR is associated with several adverse pregnancy outcomes, including maternal and neonatal morbidity, perinatal death and longer-term adverse health outcomes in childhood and beyond.^{5–9} Even with optimal screening, FGR can be difficult to detect but fetuses and neonates who are SGA have an increased chance of being growth restricted. SGA is a commonly used surrogate measure of FGR. Despite receiving much international attention, consensus is lacking on the definition, diagnosis and management of FGR.

Causes of FGR

The aetiology (or cause) of FGR can be attributed to one or more placental, maternal or fetal disorders that impair normal fetal growth.¹⁰ The most common underlying cause of FGR involves poor placental perfusion due to abnormal placental development. Placental histological findings include maternal or fetal vascular under-perfusion (such as infarction, fibrin deposition or thrombosis) and/or inflammatory pathologies (such as chorioamnionitis or chronic villitis).¹¹

Contributory maternal factors relating to poor placental perfusion include cigarette smoking, illicit drug use (including methamphetamines), maternal vascular and inflammatory conditions (such as chronic hypertension, chronic renal impairment and diabetes mellitus) and autoimmune conditions (such as antiphospholipid syndrome).¹² Often no maternal antecedents are identified.

More than 90% of FGR occurs late in pregnancy and is associated with placental insufficiency.¹³ When FGR presents early in pregnancy, an increased chance of fetal anomalies exists, including chromosomal anomalies (such as triploidy and trisomy 13 or 18), gene deletions or duplications, structural malformations or intrauterine infections such as rubella, cytomegalovirus (CMV) or toxoplasmosis.^{14,15} FGR may also be associated with maternal exposure to teratogens (including alcohol or other drugs)^{16,17} or severe placental-mediated disease.

The clinical practice guideline and these evidence statements focus on screening for and diagnosing and managing placental-mediated FGR, as it is the most common cause of inadequate fetal growth.

Risks for the fetus or neonate

FGR pregnancies are considered complex because of the associated higher rates of perinatal morbidity and mortality. In Aotearoa New Zealand, decreasing birthweight is associated with increasing risk.

- The perinatal mortality rate among SGA pregnancies is 8.7 per 1,000 births compared with 1.9 per 1,000 births in those with a weight appropriate for gestational age (AGA) (that is, estimated fetal weight (EFW) or birthweight between the 10th and 90th centile).¹⁸
- Neonates with a birthweight < 5th centile have a perinatal mortality rate of 12.3 per 1,000 births compared with 4.9 per 1,000 births among neonates with birthweights from the 5th to the 10th centile¹⁸
- While most FGR babies are also SGA, not all are: perinatal mortality and adverse perinatal outcomes steadily increase with decreasing birthweight centile from approximately the 25th centile.¹⁹

FGR is associated with both iatrogenic and spontaneous preterm birth. Iatrogenic preterm birth is the main management approach to prevent stillbirth in pregnancies with severe, early-onset FGR, as no therapies exist that improve placental perfusion and fetal growth. Iatrogenic preterm birth may also be required for maternal reasons, particularly coexisting pre-eclampsia. FGR also compounds prematurity-associated risks with higher rates of complications such as bronchopulmonary dysplasia, intraventricular haemorrhage and necrotising enterocolitis when compared with AGA preterm neonates.²⁰

Compared with AGA neonates, neonates with FGR are more likely to have low cord arterial pH, a low Apgar score and higher rates of hypoxic ischaemic encephalopathy.^{5,21} Additionally, neonates with FGR have more early neonatal complications such as hypoglycaemia and hypothermia.²¹ In the longer term, neonates with a history of FGR have been shown to have, on average, poorer neurodevelopmental outcomes and higher

rates of non-communicable diseases such as obesity, hypertension and diabetes than normally grown, gestation-matched peers.^{7–9,22}

Risks for those who are pregnant

As the most common cause of FGR is placental insufficiency, pregnancy complications with related pathophysiology such as pre-eclampsia and placental abruption occur more frequently in FGR-affected pregnancies. As one of the key management recommendations for SGA and FGR is expedited by induction of labour (IOL) or caesarean birth, pregnant women/people have a higher chance of iatrogenic early birth and operative birth for fetal reasons.²³

When FGR is suspected, additional antenatal fetal and maternal monitoring is recommended (such as increased frequency of antenatal visits and ultrasound scanning). Suspected FGR may be associated with psychological stress and anxiety.^{24,25} No Aotearoa New Zealand studies have investigated the antenatal and postnatal psychological and/or social impacts of an SGA and/or FGR diagnosis on the pregnant woman/person and their whānau, but a study investigating pregnant women/people's experiences of SGA or FGR pregnancy is under way.^b

Pregnant women/people who have given birth to an FGR baby are at increased risk of cardiovascular disease (CVD) such as chronic hypertension and ischaemic heart disease, particularly following early-onset FGR.^{26–28} In subsequent pregnancies, an increased risk also exists of recurrence of FGR and other placental-mediated complications (such as hypertensive disorders of pregnancy, including pre-eclampsia).^{29,30} Information about CVD risk is in Evidence summary: Maternal postnatal management.

Value of identifying FGR fetuses

While antenatal identification of FGR fetuses is challenging, an approximate 60% reduction in the risk of stillbirth exists for pregnant women/people when FGR is recognised antenatally.^{31–33} Health practitioners make difficult choices when trying to balance the risks and benefits of prolonging fetal development when evidence of FGR exists compared with preterm birth and the associated adverse outcomes.^{34–36} Additionally, approximately 5% of pregnancies identified antenatally as SGA are not SGA at birth.^{37,38} It is important to consider the implications for whānau of pathologising a normal pregnancy due to a false positive diagnosis of FGR.

^b This is the Developing Digital Tools to Improve Health Literacy For Women and Whānau Affected by Pregnancy Disorders study. Associate Professor Jo James is conducting the study at the University of Auckland.

Conceptualising FGR in te ao Māori

Wāhine Māori have higher rates of SGA than many other ethnic groups in Aotearoa New Zealand.^{39–41} These differences are likely to reflect clinical and social risk factors rather than ethnicity itself. A 2004 study found wāhine Māori in the most deprived areas of Aotearoa New Zealand have a two-fold increase in the risk of SGA compared with wāhine Māori in the most affluent areas (OR 2.02; 95% CI 1.59, 2.56).⁴¹ While this study did not investigate SGA risk factors, wāhine Māori (particularly younger wāhine), have higher cigarette smoking rates in pregnancy. A 2012 Auckland study found wāhine Māori were approximately 1.4 times more likely to have an SGA baby than European women (OR 1.37; 95% CI 1.19, 1.57)³⁹ in unadjusted analyses. However, this association was due to confounding with other clinical risk factors, including smoking, number of previous children (parity), socioeconomic status and other medical conditions (aOR 1.04; 95% CI 0.89, 1.22). These risks are disproportionately experienced by Māori due to the effects of colonisation such as unequal access to resources and the social determinants of health. This highlights the need for more to be done to address the health and socioeconomic inequities affecting wāhine Māori and which underlie higher SGA rates.

The literature review supporting the clinical practice guideline (see **Error! Reference source not found.**) did not identify te ao Māori or other indigenous conceptualisations of FGR, but wāhine Māori are key participants in a current study to better understand experiences of having an SGA or FGR pregnancy.^b It is hoped that this study will provide more information about conceptualisation of SGA and FGR in te ao Māori.

Tiriti o Waitangi

Giving effect to the Pae Ora (Healthy Futures) Act 2022 can be demonstrated by practically applying the principles of te Tiriti o Waitangi as articulated by the courts and Waitangi Tribunal.⁴² Applying the principles to maternity and neonatal service delivery is an obligation enabling Māori to express their mana motuhake and ensures that Māori receive high-quality, culturally safe care and achieve equitable health outcomes.⁴³ Using the principles to work effectively and respectfully with Māori requires maternity and neonatal services and health practitioners to demonstrate the principles of te Tiriti in their day-to-day practice.

Principles of te Tiriti

The principles of te Tiriti provide the framework for maternity and neonatal providers and health practitioners providing services to Māori. How these principles apply to maternity and neonatal services is supported by *Ngā Paerewa*, in particular, **1.1 Pae ora healthy futures**.³

The Waitangi Tribunal concluded that the persistent health inequities that Māori experience were the consequence of the failure to apply the principles of te Tiriti at structural, organisational and health practitioner levels of the health and disability sector. Giving effect to te Tiriti requires health practitioners to know and understand the principles of te Tiriti and to capably apply them in partnership with Māori in their day-to-day maternity and neonatal clinical practice.

The five **principles of te Tiriti** for the health and disability sector are as follows.

- **Tino rangatiratanga:** Health practitioners support the right of Māori to receive effective maternity and neonatal care. A person's decisions are a continuation of a much older, Māori collective endorsed practice of sovereignty over one's health and wellbeing and the health and wellbeing of their whānau.
- **Equity:** Health practitioners can contribute to equitable maternity and neonatal health outcomes for Māori by ensuring, at a minimum, that maternity and neonatal outcomes match those of other New Zealanders. Equitable maternity and neonatal outcomes will be achieved when health practitioners implement the clinical practice guideline's recommendations in ways that give effect to the principles of te Tiriti, relevant professional competencies and *Ngā Paerewa*.³
- **Active protection:** Health practitioners share evidence-based information about maternity and neonatal outcomes so Māori can make decisions and prepare themselves to uphold their tikanga or cultural practice (for example, karakia, rongoā and support people). Health practitioners actively support Māori to make decisions by providing quality evidence-based information, free from bias and judgement.
- **Options:** Health practitioners ensure Māori have maternity and neonatal care that enables them to uphold their tikanga or cultural practice regardless of where a birth takes place. Processes must complement a Māori person's mana or inherent authority and dignity, support their tikanga or cultural practice, and be culturally safe as defined by Māori.
- **Partnership:** Health practitioners work in partnership with Māori, including a person's whānau (if requested). A partnered approach to the process and decision-making ensures Māori can enact their rangatiratanga or self-determine their futures while exercising mana motuhake or authority over their bodies and reproductive health.

Health service providers and health practitioners must consider their commitment to deliver equitable services and meet obligations under te Tiriti. For further information on cultural safety, see Appendix 2: Cultural safety.

Equity

In Aotearoa New Zealand, people have differences in health outcomes that are not only avoidable but are unfair and unjust.⁴⁴ Differences in the structural determinants of health

and wellbeing (for example, disadvantages in income, employment, education and housing as well as multiple forms of discrimination) negatively affect people's health but people have little control over these determinants. Health inequities – like inequitable maternity and neonatal outcomes – are the result of avoidable structural determinants in our communities.⁴⁵ When health practitioners understand the structures that create inequitable maternity and neonatal outcomes, they can use different approaches and resources to achieve equitable outcomes.

Achieving equitable maternity and neonatal outcomes for Māori happens when service providers and health practitioners:

- understand the structures that create disadvantage for Māori
- are supported to implement the clinical practice guideline recommendations in ways that give effect to the principles of te Tiriti, as well as meeting professional competencies and adhering to ***Ngā Paerewa***.³

Other population groups in Aotearoa New Zealand also experience inequities that are unfair and unjust. Achieving equitable maternity and neonatal outcomes for all happens when maternity service providers and health practitioners:

- understand the structures that create disadvantage for those groups
- are supported to implement the clinical practice guideline in ways that give effect to the rights of those groups while also meeting professional competencies and *Ngā Paerewa*.³

Lastly, health practitioners should be aware that many people in Aotearoa New Zealand conceptualise anatomy, pregnancy, gender, sexuality, reproduction, contraception and birth in different ways according to their worldviews. Therefore, health practitioners should use proven health literacy practices to communicate effectively with everyone using their services.⁴⁶ For sector guidance, see *Ngā Paerewa* 1.4 E whakautetia ana ahau | I am treated with respect and Criterion 1.4.2.

Good practice recommendations for equity

Four good practice recommendations for equity are as follows.

- Health practitioners should be aware that different cultures and religions conceptualise anatomy, pregnancy, sex, birth and the postnatal period in different ways and should adapt their language and approach accordingly.
- Maternity and neonatal service providers should ensure pregnant women/people whose babies may be SGA and/or affected by FGR and their whānau have culturally safe opportunities for discussion, reflection and debriefing where necessary.
- Maternity and neonatal service providers should monitor rates of SGA and FGR and rates of antenatal screening and outcomes by ethnicity so they can monitor equity, identify variations in outcome, and then identify and implement areas for quality improvement based on this analysis.
- Cost should not be a barrier to clinically indicated growth scans, and health services should ensure funded ultrasound services are available to pregnant women/people who cannot afford to pay privately.

Evidence summary:

Definition and classification

Under normal conditions, fetal growth capacity exceeds uteroplacental capacity. Fetal growth is, therefore, normally constrained.

FGR is abnormal fetal growth (that is, growth that is less than would be expected for typical maternal constraint).¹⁰ In clinical practice, an EFW < 10th centile (SGA) is used to identify pregnancies where the fetus is suspected to be growth restricted. Severe FGR is an EFW or birthweight < 3rd centile.

FGR is commonly due to placental insufficiency or, less commonly, fetal disorders or maternal medical conditions.¹⁰ FGR can be difficult to identify because there is no clear method to determine individual fetal growth potential. Clinically, FGR manifests as a slowing of fetal growth, which cannot be assessed at a single point in time. Therefore, FGR is defined using a combination of fetal size, fetal growth, and fetal and maternal Doppler assessment.

Fetuses and neonates who are SGA (by any reference standard) are at increased risk of stillbirth and adverse perinatal outcome due to the association with FGR. This coarse definition inevitably includes those who are not growth restricted and misses some growth restricted fetuses who are > 10th centile even when their growth trajectory has slowed. Ultrasound fetal biometry measurements also have a range of intra- and inter-observer variability leading to an error of approximately $\pm 15\%$.⁴⁷ For these reasons, additional investigation using fetal and maternal Doppler studies and serial assessments of fetal growth can identify those at greatest risk of FGR.

Counselling when there is a diagnosis of FGR

When counselling pregnant people and whānau with antenatal identification of SGA or FGR, it is important to convey the associated uncertainties. Where there is severe FGR or abnormal Dopplers, the diagnosis of FGR is more secure. Otherwise, it remains important to consider that identification of SGA is based on fetal biometry that has an inherent error. While managing a pregnancy based on the observed EFW is recommended, it is possible that a neonate identified as SGA antenatally has a birthweight > 10th centile or could be smaller than estimated.³⁷

Fetal growth references and standards

Internationally, no consensus exists for the specific growth standard or birthweight reference that best identifies normal fetal growth and, consequently, abnormal growth.

Birthweight references include data on newborn size from all pregnancies, normal and complicated. The frequency of complications in a population can bias or alter the reference range. Birthweight references also under-diagnose FGR due to the association between FGR and preterm birth.⁴⁸

Birthweight standards include data on newborn size from pregnancies considered at low risk for abnormal fetal growth.^c Standard populations, despite having a lower risk of obstetric complications, may still include neonates with FGR and those born preterm.

Fetal growth standards, as with birthweight standards, describe serial fetal ultrasound biometric measurements, including EFW in pregnant women/people considered to be at low risk for FGR. Some fetal growth standards exclude maternal and fetal conditions occurring in pregnancy,^{49,50} whereas others do not.

^c For example, the INTERGROWTH 21st birthweight standard included only women with a singleton pregnancy, with a BMI 18.5 to 24.9 kg/m², aged 18 to 35 with an absence of adverse environmental and nutritional conditions.⁴⁹ The standard excluded smokers and those with short stature, medical disorders, an abnormal obstetric history or an unreliable estimate of gestational age. The centres contributing to the INTERGROWTH 21st standard also had liberal use of delayed cord clamping. Standard populations, despite having a lower risk of obstetric complications, may still include neonates with FGR and those born preterm.

While standards are often claimed to be universally prescriptive, they do not account for normal maternal constraint. Constraint is the degree to which fetal growth is normally influenced by uteroplacental capacity. Uteroplacental capacity is determined by maternal characteristics such as height and weight, which affect EFW.^{d 52,53}

Customised fetal weight centiles represent modelled EFW standard curves for a term optimal weight in the absence of pathology,⁵⁴ specific to key maternal characteristics known to influence physiological constraint (that is, maternal height, weight, parity and ethnicity).^{55,56} Customised fetal weight centiles, therefore, represent an 'individualised' fetal growth standard (also known as a gestation-related optimal weight (GROW) curve).

Applying different growth standards to general obstetric cohorts can change classification of SGA for many infants. For example, in a multi-ethnic cohort from Auckland, use of the International Fetal and Newborn Growth Consortium for the 21st Century (INTERGROWTH 21st) birthweight standard classified 4.5% of neonates as SGA (compared with 12% when a customised standard was used).⁶ INTERGROWTH 21st SGA rates ranged from 2.9% for babies of women of Pacific ethnicities to 13% for babies of women of Indian ethnicity. Within the same cohort, the World Health Organization (WHO) fetal growth standard classified 9.7% of neonates as SGA, but only 6.5% in women of Pacific ethnicities compared with 23% in women of Indian ethnicity.¹⁰

This pattern of difference in SGA classification between ethnicities has been reported in other international obstetric cohorts.^{57,58} It does not necessarily reflect risk of adverse outcomes. Fetuses and neonates classified as SGA by customised centiles are at higher risk of stillbirth⁵⁸ and neonatal morbidity and mortality^{6,10} compared with those who are SGA by INTERGROWTH 21st or WHO standards. The INTERGROWTH 21st development team has stated that the cut-off (centile) to define increased risk should be assessed using a perinatal risk-based approach.⁵⁹ This means the definition of SGA by INTERGROWTH 21st may not be the 10th centile as the standard was derived using a 'healthy pregnancy' approach. However, at a 10th centile definition, the INTERGROWTH 21st standard misses approximately 7% of small at-risk fetuses, who have a two-fold increased risk of stillbirth or adverse neonatal outcome.^{6,59}

Defining FGR

Internationally, FGR is variously defined. With a lack of clear evidence on what constitutes an antenatal diagnosis of FGR, an international consensus-based definition of early-onset and late-onset FGR was developed in 2016 using a Delphi process.⁶⁰ The International Society of Ultrasound in Obstetrics and Gynecology (ISUOG) and the International

^d Regional and/or ethnic variation in maternal constraint explains why the INTERGROWTH 21st birthweight standard has an average birthweight of 2.8 kg in India compared with 3.5 kg in the United Kingdom.⁴⁹ Similarly, the WHO fetal growth standard found significant differences in EFW by maternal age, height, weight and parity.⁵¹ The National Institute of Child Health and Human Development presented fetal growth standards separately for women from White, Black, Hispanic and Asian ethnic backgrounds.⁵⁰

Federation of Gynaecology and Obstetrics (FIGO) have adopted this consensus decision.^{61,62} It combines fetal size measurements (EFW and/or abdominal circumference (AC)) and maternal and/or fetal Doppler studies (uterine artery (UtA), umbilical artery (UA) and middle cerebral artery (MCA)). It does not recommend a specific growth chart and does not provide advice around slowing of fetal growth measurements in late-onset FGR. The Society for Maternal Fetal Medicine (SMFM) guideline,⁶³ published after the consensus-based definition,⁶⁰ did not adopt that definition, instead defining FGR as an EFW < 10th or AC < 10th centile.

A single study on perinatal outcomes using the consensus-based definition⁶⁰ for late FGR showed an increased chance of adverse neonatal outcome (RR 2.0; 95% CI 1.2, 3.3) compared with a definition of EFW < 10th centile of the widely used Hadlock ultrasound reference⁵⁴ (RR 1.1; 95% CI, 0.6, 1.8), although neither definition had good predictive ability (consensus FGR area under curve (AUC) 0.53; EFW < 10th AUC 0.50).⁶⁴ Further confirmatory studies are needed to assess the consensus definition of FGR and perinatal outcomes.

Early-onset compared with late-onset FGR

FGR that occurs early in pregnancy is uncommon. The incidence is approximately 0.5 to 1.0% of all pregnancies. Early-onset FGR is usually more severe than late-onset FGR with higher rates of UA Doppler abnormalities, placental pathology and co-existing hypertensive disorders of pregnancy.⁶⁵ In the Trial of Randomized Umbilical and Fetal Flow in Europe (TRUFFLE), a trial of management of early-onset FGR, hypertensive morbidity presented in 73% of pregnancies. Of these, 49% had pre-eclampsia, 22% had haemolysis, elevated liver enzymes and low platelets (HELLP) syndrome, 29% had gestational hypertension and 0.4% had eclampsia.⁶⁶ Early-onset FGR also has an association with fetal anomalies.

Pregnant women/people with early-onset FGR should be:

- considered for tertiary review, including a detailed anatomy scan, serology for CMV, rubella (if not immune) and toxoplasmosis and discussion on additional invasive testing for aneuploidy and genetic conditions (see *Recommendations 22* and *23*)
- monitored closely for the development of hypertensive disorders of pregnancy.

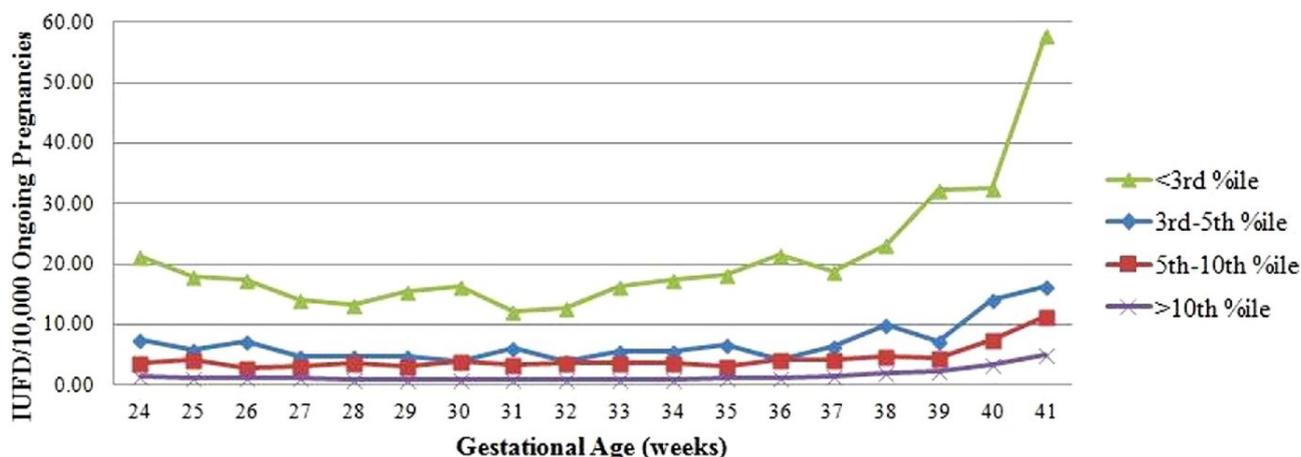
Most FGR presents later in pregnancy and approximately 80% of neonates with FGR are identified at term. This is 8 to 15% of all pregnancies.¹³ Late-onset FGR is associated with less-severe growth restriction, (usually) normal UA Doppler studies and fewer hypertensive complications.^{13,65}

The gestation at which these phenotypes change occurs at approximately 32 to 34 weeks' gestation.^{11,65} Consensus among the contributing guidelines that informed the clinical practice guideline is that early-onset FGR should be defined as onset < 32+0 weeks' gestation.^{60–63,67}

Fetal size

The degree of growth restriction, or deviation from normal growth, is predictive of outcome. The smallest fetuses and neonates have the highest risk of complications.^{18,68} Consensus exists that fetuses with a substantial growth deviation (that is, severe FGR; an EFW or AC < 3rd centile) are growth restricted by definition. These fetuses are unlikely to be small due to physiological maternal constraint and have the highest rates of adverse outcomes, including perinatal death^{1,60-63,67} (see Error! Reference source not found.).

Figure 1: Risk of intrauterine fetal (IUFD) death in SGA fetuses⁶⁸



Both an EFW < 10th centile and AC < 10th centile are independent predictors of an SGA neonate. Consensus exists among contributing guidelines for the inclusion of AC < 10th centile in the assessment of FGR.^{60-63,67} Guidelines recommend the use of local fetal biometry charts as no one chart is superior to another. A 2017 systematic review showed an AC or EFW < 10th centile after 24 weeks' gestation performed equally well at predicting a neonate with SGA.⁶⁹ A 2019 systematic review and meta-analysis of third trimester ultrasound > 32 weeks' gestation for prediction of late-onset FGR (21 studies, 80,663 participants) confirmed that an EFW or AC < 10th centile individually predicted neonatal SGA, with modelled sensitivities for AC of 78% and EFW of 54% at a 10% false positive rate.⁷⁰

Accuracy of the EFW ultrasound measurement

Fetal weight can be estimated from various combinations of standard fetal biometry measurements such as head circumference (HC), AC, biparietal diameter and femur length. The modelling accuracy of EFW depends on the accuracy of each individual biometry component. While including a greater number of parameters may improve EFW accuracy, it has the potential to multiply errors from single-parameter measurements. Most EFW models require measurement of the AC, which can be technically difficult.

While numerous EFW formulas have been developed, the Hadlock three-parameter formula (HC, AC and femur length) has consistently demonstrated favourable performance

since its introduction in 1985.^{71–73} A 2018 systematic review of 11 EFW formulae found that the three-parameter Hadlock formula was most accurate when compared to actual birthweight.⁷² The Hadlock four-parameter formula (biparietal diameter, HC, AC and femur length) had comparable accuracy to the three-parameter formula, but not superiority.⁴⁷

EFW remains an estimate of fetal size, with an inherent intra- and inter-observer variability of 10 to 15%.⁴⁷ In smaller fetuses, EFW tends to have a positive bias (as assessed in studies comparing EFW within one to two weeks of birth).^{37,72} This means ultrasound EFW is more likely to under-diagnose than over-diagnose SGA. Importantly, while maternal obesity makes fetal biometry measurements more technically challenging, EFW accuracy is similar between pregnant women/people of normal weight and those with obesity.^{37,74,75}

Ultrasound EFW remains the best way to estimate fetal size. Because of the inherent errors in EFW assessment, the minimum acceptable time interval between growth scans is two weeks. When estimating fetal growth velocity, scans should be at least three weeks apart to minimise false positive diagnoses of FGR.^{67,76}

Slowing of growth

Slowing of fetal growth is indicative of FGR, but at least two measurements are required to assess fetal growth velocity. It is particularly difficult to identify fetuses who are FGR but not SGA. Adding to this challenge is the inherent uncertainty (error margin) in fetal size assessment by ultrasound.⁴⁷ The consensus-based definition of FGR reflects this uncertainty in that it defines slowing of growth in late-onset FGR as EFW or AC crossing more than two quartiles on growth centiles, but it does not provide clarity on the timeframe over which this decrease may occur.⁶⁰

The consensus-based definition⁶⁰ of slowing fetal growth has been:

- adopted unchanged by the 2021 FIGO FGR best practice advice document⁶¹
- endorsed by ISUOG with a clarification that slowing of growth is a fall between consecutive ultrasound scans in the third trimester of > 50 centiles.⁶²

The 2014 Royal College of Obstetricians and Gynaecologists (RCOG) guideline defines slowing of growth by stating that an increase in AC of < 5 millimetres over 14 days is suggestive of FGR.⁶⁷ Other international guidelines discuss slowing of growth without defining it.⁷⁷

In 2022, Hugh and Gardosi developed a fetal weight projection model to define growth velocity in the third trimester.⁷⁸ The Hugh and Gardosi model used data from more than 100,000 singleton pregnancies with two or more ultrasounds performed in the third trimester. Ultrasound indications related to maternal risk factors for FGR. The Hugh and Gardosi model projects an expected weight based on the centile of the previous EFW measurement and calculates percentage deviation of EFW. It defines interval-specific and gestation-specific thresholds for percentage EFW deviation for predicting large for

gestational age and SGA at birth based on partial receiver operating characteristic (ROC) curve analysis, restricted to a false positive rate of 10% (specificity 90%). Fetuses with an EFW deviation below the lower threshold had an increased risk of:

- SGA (RR 1.95; 95% CI 1.92, 1.99)
- stillbirth (RR 2.19; 95% CI 1.84, 2.53)
- an Apgar score of < 7 at five minutes (RR 1.18; 95% CI 1.01, 1.32)
- neonatal intensive care unit (NICU) admission (RR 2.25; 95% CI 2.08, 2.43)
- neonatal death (RR 2.28; 95% CI 1.60, 3.13).

This model assesses EFW growth only and does not use change in AC growth. The Hugh and Gardosi model was assessed for potential use in Aotearoa New Zealand. While this model has substantial advantages over existing definitions of slowing of fetal growth, it has not yet been validated for an Aotearoa New Zealand population. Practical barriers to implementation exist at this time. Additional evidence supporting this model of EFW projection and tools for implementation should be considered when they become available or when the clinical practice guideline is next updated.

When considering fetal AC growth, the Pregnancy Outcome Prediction study (3,977 nulliparous participants) showed that a decrease in AC growth velocity (measured as gestational age adjusted z-scores) between the mid-trimester scan at around 20 weeks' gestation and the third trimester was associated with adverse perinatal outcome, but only in SGA fetuses (n = 562; RR 1.96; 95% CI 1.21, 3.19).⁷⁹

In AGA fetuses (EFW ³ 10th centile), a decline in EFW or AC fetal growth trajectory has been associated with increased antenatal, intrapartum and postnatal indicators of placental insufficiency.^{80,81} In a study of 308 nulliparous women in the third trimester (between 28 and 36 weeks' gestation), a > 30 centile decline in EFW was associated with an increase in risk of abnormal cerebroplacental ratio (CPR) (ratio of MCA to UA) (RR 2.80; 1.25, 6.25) and a non-significant increase in neonatal acidosis (UA pH < 7.15; RR 2.34; 95% CI 0.89, 6.14).⁸¹ The study reported similar associations when AC growth velocity declined > 30 centiles. When evaluated from 20 and 36 weeks' gestation, the same pattern was observed with a > 30 centile decrease in EFW (abnormal CPR RR 2.23; 95% CI 1.11, 4.36, UA pH < 7.15; RR 2.38; 1.11, 4.93; placental weight < 10th centile RR 2.66; 1.75, 3.96).⁸⁰ Between 20 to 28 weeks' gestation, declining EFW or AC was not associated with adverse outcomes.

Doppler studies in the diagnosis of FGR

Doppler studies of the maternal uterine, placental and fetal circulations contribute to the diagnosis and management of FGR as they provide an indirect assessment of placental function and fetal wellbeing. While Doppler studies are important to assess a small fetus, SGA fetuses with normal fetoplacental Doppler investigations are still more likely to have

histological placental under-perfusion,⁸² fetomaternal haemodynamic changes⁸³ and a greater chance of requiring caesarean section for fetal compromise compared with AGA fetuses.⁸⁴ This implies that growth-restricted fetuses are not always identified by Doppler ultrasound.

Umbilical artery Doppler in the diagnosis of FGR

UA Doppler monitoring for SGA and FGR is universally recommended.^{61,63,77,85}

Flow through the UA reflects placental haemodynamics by assessing resistance to placental blood flow. Worsening UA Doppler parameters are associated with increasing perinatal morbidity and mortality.⁸⁶ Approximately one-third of the villous placental circulation needs to be damaged before an increase in placental resistance is observed, as evidenced by an increase in the UA pulsatility index (PI).⁸⁷ As the villous loss continues, the UA end-diastolic velocity progresses to:

- absent end-diastolic flow (AEDF), with approximately 50% loss of villous placental circulation
- reversed end-diastolic flow (REDF), with approximately 70% loss of villous placental circulation.⁸⁷

Abnormal UA Doppler studies are predominantly associated with early-onset FGR,⁶⁵ with the degree of UA Doppler abnormality corresponding closely with the chance of deterioration in fetal condition and associated risk of stillbirth.^{86,88,89}

In late-onset FGR, abnormal UA Doppler studies are uncommon,⁶⁵ but a normal UA Doppler finding does not exclude placental vascular insufficiency. This is reflected in findings that SGA fetuses with normal UA Doppler studies have a higher risk of neonatal morbidity (such as increased rates of caesarean birth for fetal compromise, neonatal acidosis, and admission to NICU) compared with non-SGA fetuses.^{4,65,90,91} The placentae of SGA fetuses with normal UA Doppler studies show high rates of pathology related to under-perfusion or chronic vasculitis: 78% have pathology compared with 25% of AGA fetuses.⁸² Therefore, SGA fetuses with normal UA Doppler studies are not low-risk and further monitoring is advised (see *Recommendation 28*).

An abnormal UA Doppler can also occur in the presence of fetal anomalies, including abnormal karyotype (such as triploidy). Careful review of fetal anatomy is warranted, particularly when FGR is diagnosed early in pregnancy.

Fetal middle cerebral artery Doppler and cerebroplacental ratio in the diagnosis of FGR

The fetal response to even mild hypoxaemia is to prioritise blood flow to the cerebral circulation. This is reflected in a lowering of cerebral vascular resistance and increased cerebral blood flow. The most used vessel to measure cerebral blood flow in the fetus is the MCA. The MCA PI can be divided by the concurrently measured UA PI to give the

CPR. Both the CPR and MCA PI decrease in response to fetal hypoxaemia, reflecting placental insufficiency even in the absence of UA Doppler abnormalities.⁹² As the CPR can become abnormal with mild decreases in MCA or increases in UA Doppler that are still within normal ranges, CPR is a more sensitive indicator of fetal hypoxaemia than MCA Doppler alone.⁹³

Longitudinal studies in late-onset SGA pregnancies have shown approximately 15% of fetuses develop an abnormal MCA by term, while 20% of fetuses develop an abnormal CPR.⁹⁴ MCA and CPR studies can be used in the diagnosis and monitoring of late-onset FGR and are recommended in the consensus-based definition of FGR⁶⁰ and by RCOG, ISUOG and FIGO, but not by SMFM.^{61–63, 67} The SMFM guideline definition of FGR does not include Doppler studies.⁶³

An abnormal CPR or MCA Doppler (< 5th centile) in SGA fetuses is associated with adverse perinatal outcomes,^{95,96} including perinatal death,^{89,97} fetal acidosis, admission to NICU, emergency operative birth for intrapartum fetal compromise^{84,91,98} and abnormal child neurodevelopment.^{99–101} Evidence suggests CPR correlates better with adverse outcome than MCA correlates.⁹⁶

An abnormal fetal cerebral blood flow in AGA fetuses may be associated with undetected FGR. In a retrospective study of 7,944 fetuses with growth parameters performed at mid-trimester and > 35 weeks' gestation, abnormal CPR was associated with low AC growth velocity (aOR 2.10; 95% CI 1.71, 2.57), including among AGA fetuses (aOR, 1.76; 95% CI 1.34, 2.30).¹⁰² This is consistent with other study findings that higher rates of abnormal CPR and fetal acidosis exist among AGA fetuses with slowing fetal growth (AC or EFW) in the third trimester.^{80,81} Regardless of fetal size, abnormal CPR is associated with operative birth for fetal compromise,^{102,103} poor neonatal acid-base status¹⁰⁴ and neonatal unit admission.¹⁰²

Although a low CPR is associated with a variety of adverse outcomes, its performance as a screening test in AGA pregnancies without clinical concern of slowing of growth is relatively poor. No evidence supports routine Doppler evaluation in AGA fetuses. The Ratio37 study, which is recruiting in Europe, aims to determine whether CPR Doppler plus fetal biometry at 36 to 37 weeks' gestation can reduce perinatal mortality by selecting women for IOL, including IOL in AGA fetuses with an abnormal CPR at 37 weeks' gestation.¹⁰⁵ This will provide further data on the use of the CPR in AGA pregnancies.

Uterine artery Doppler in the diagnosis of FGR

UtA Doppler studies assess placental function from the maternal side. Increased UtA resistance reflects a failure of extravillous cytotrophoblast invasion and transformation of the spiral arteries. It is associated with histological changes of placental malperfusion.^{106,107} An abnormal UtA Doppler (mean PI > 95th centile and/or bilateral notching) is almost pathognomonic of placental insufficiency. In early-onset SGA, an

abnormal UtA Doppler is diagnostic of FGR due to the strong association between placental malperfusion and early-onset placental-mediated disease.^{60–63,67,77}

Unlike other Doppler parameters, UtA Doppler does not show progression throughout the third trimester.⁹⁴ This means UtA Doppler studies **do not need to be repeated** after the initial FGR assessment. Evidence about using UtA Doppler studies for risk stratification for FGR (and pre-eclampsia) is on page 30 of this document.

The utility of UtA Doppler to predict outcomes in late-onset SGA fetuses is debated. A 2020 meta-analysis of abnormal third trimester UtA Doppler for the prediction of adverse perinatal outcome in SGA fetuses (n=3,461) showed abnormal UtA Doppler was associated with:

- a composite adverse perinatal outcome (OR 4.38; 95% CI 2.15, 8.93)
- admission to a NICU (OR 4.21; 95% CI 3.30, 5.37)
- caesarean birth for intrapartum fetal compromise (OR 2.03; 95% CI 1.41, 2.92)
- a five-minute Apgar score of < 7 (OR 3.18; 95% CI 1.05, 9.60)
- neonatal acidosis (OR 1.60; 95% CI 0.93, 2.72)
- perinatal death (OR 23.33; 95% CI 3.16, 172.04).¹⁰⁸

The highest area under the ROC curve related to perinatal death (0.90) and the lowest for composite perinatal outcome (0.66). This shows an overall modest prediction of adverse outcome. Abnormal UtA Doppler appears to have a similar predictive ability for adverse outcomes as an abnormal CPR.^{97,108} As with CPR, there are no prospective studies on outcomes in late-onset FGR where birth is based on an abnormal UtA Doppler.

While abnormal UtA Doppler is not part of the consensus-based definition of late-onset FGR,⁶⁰ the FIGO best practice FGR document describes assessment of the UtA Doppler as part of the initial investigation of suspected FGR.⁶¹ If abnormal results are returned, it classifies this as ‘early Doppler changes’ recommending close fetal monitoring. ISUOG also recommends UtA Doppler in late-onset SGA and FGR assessment, while SMFM does not (the RCOG guideline was developed before relevant literature was published).^{62,67}

Symmetrical compared with asymmetric growth restriction

The fetal AC is often the first measurement to slow in FGR. A single AC measurement cannot give an assessment of an AC growth trajectory, yet a discordance between HC and AC centile on a single scan may be an indicator of slowing AC growth. Among SGA and FGR pregnancies, the ratio of HC to AC has not been found to be an independent predictor of adverse outcomes.^{109,110} However, data on outcomes in AGA pregnancies is

lacking. A discordance between HC and AC is not part of the definition or monitoring of FGR in any of the contributing guidelines.

Oligohydramnios

Oligohydramnios is defined as a four-quadrant amniotic fluid index \leq 5 centimetres, or a deepest vertical amniotic fluid pocket \leq 2 centimetres.¹¹¹ Use of the deepest pocket reduces overdiagnosis of oligohydramnios and is preferred.¹¹²

Amniotic fluid production from the second trimester onwards is dominated by fetal urine production. A redistribution of blood flow away from the fetal kidneys in the presence of hypoxaemia can cause oliguria and declining amniotic fluid volume. However, this is typically a late sign in the FGR fetus and other features such as severe FGR, abnormal Doppler or abnormal cardiotocograph (CTG) assessment may already be present.¹¹³

Oligohydramnios may be independent of FGR and associated with rupture of membranes. Low amniotic fluid volume on ultrasound should lead to detailed clinical assessment. Oligohydramnios is associated with an increased rate of intrapartum fetal heart rate (FHR) abnormalities, the need for caesarean birth and low 5-minute Apgar score, but not acidosis at birth.¹¹⁴

There is a paucity of data on the significance of oligohydramnios in FGR management. The PORTO study (Prospective Observational Trial to Optimize Pediatric Health in Intrauterine Growth Restriction), which included more than 1,100 pregnancies with FGR, reported that amniotic fluid volume abnormalities did not independently increase the risk for adverse outcome.¹¹⁵ While oligohydramnios should be considered as part of the overall clinical picture, the consensus is that it is not a specific diagnostic or management feature of FGR.^{61–63,67,77}

Recommendations: Definition and classification

Definition and classification recommendations		Evidence level	Grade of recommendation	Rationale
1	Assess EFW and birthweight using customised centile standards.*	2+	C	Customised SGA better identifies at-risk fetuses and neonates than population-based SGA definitions, particularly among Aotearoa New

				Zealand's diverse ethnicities. Use of a single customised reference supports consistent national practice and audit. ²
2	Define SGA as EFW or birthweight < 10th centile.	1++	A	This reflects the internationally accepted definition of SGA.
3	Define FGR using a combination of fetal size, fetal growth, and fetal and maternal Doppler assessment: <ul style="list-style-type: none"> • Early-onset FGR is diagnosed < 32+0 weeks' gestation • Late-onset FGR is diagnosed ≥ 32+0 weeks' gestation. 	2+	C	For further definition of early-onset and late-onset FGR, see Table 1.
4	Define slowing of fetal growth as a decline in EFW or AC of > 30 centiles at ≥ 28+0 weeks' gestation. If there is a decline in growth < 28 weeks' gestation, consider a further growth scan in two to three weeks' time. Where possible, electronic plotting is recommended to improve accuracy and reduce transcription errors.	3	D	The threshold to define FGR based on a decrease in EFW or AC remains unclear. ^{†,60,81} Slowing of fetal growth is not a standalone criterion to define FGR. Growth scans performed at least three weeks apart minimise false positive diagnoses associated with the inherent error within fetal biometry measurements. Timing of scans should be tailored to the individual clinical scenario.

5	<p>When FGR is suspected (EFW or AC < 10th centile, or slowing of fetal growth), perform these Doppler parameters:</p> <ul style="list-style-type: none"> • UA Doppler¹¹² • UtA Doppler mean PI and assessment of notching – assess only once¹¹² <p><i>See Recommendation 11 for UtA Doppler in FGR risk assessment</i></p> <ul style="list-style-type: none"> • MCA Doppler PI ≥ 32+0 weeks' gestation.¹¹² <p>Report only CPR.</p> <p>If Doppler studies are normal, perform a repeat growth scan to assess fetal growth trajectory.</p>	<p>2-</p> <p>1+</p> <p>2+</p> <p>2+</p>	<p>C</p> <p>A</p> <p>C</p> <p>C</p>	<p>The customised EFW centile should be plotted at the earliest possible opportunity to minimise delays in diagnosis and subsequent care. This is usually performed by the LMC or referrer.‡</p> <p>If possible, assessment of customised EFW at the time of ultrasound allows additional Doppler studies to be performed concurrently if required. This minimises delays and return scanning for Doppler assessment.</p> <p>Doppler studies provide an indirect assessment of placental function and fetal wellbeing.</p> <p>UtA Doppler (abnormal if mean PI > 95th centile and/or bilateral notching) does not show progression in the third trimester. A single measurement can be performed at the time of diagnosis.</p> <p>International consensus on the use of MCA Doppler in late-onset FGR is lacking. SGA fetuses with abnormal MCA and/or CPR have higher rates of adverse perinatal outcome.^{92,93}</p>
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				<p>CPR has a stronger association with adverse outcome than MCA has.</p> <p>Growth scans performed at least three weeks apart minimise false positive diagnoses associated with the inherent error within fetal biometry measurements.</p>
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AC = abdominal circumference; CPR = cerebroplacental ratio; EFW = estimated fetal weight; FGR = fetal growth restriction; GROW = gestation-related optimal weight; MCA = middle cerebral artery; PI = pulsatility index; SGA = small for gestational age; UA = umbilical artery; UtA = uterine artery.

* Customised centiles for Aotearoa New Zealand are available online at GROW-App NZ (<https://nzaws.growservice.org/App/Account/Login>) and are incorporated into the BadgerNet platform.

† The promising Hugh and Gardosi model of fetal growth assesses customised EFW gain as percentage deviation from expected.⁷⁸ It can be used to assess growth trajectory over a shorter time frame. This model should be investigated further in the Aotearoa New Zealand context, including implications for implementation.

‡ Radiology providers do not have the required clinical information to create a customised antenatal chart, which is recommended at booking.

Table 1: Definition for early and late-onset FGR in the absence of congenital anomalies⁶⁰

Early-onset FGR Diagnosed < 32+0 weeks' gestation	Late-onset FGR Diagnosed ≥ 32+0 weeks' gestation
EFW customised or AC < 3rd centile or UA with absent or reversed end-diastolic flow or EFW customised or AC < 10th centile plus one or more of: <ul style="list-style-type: none"> • UA Doppler PI > 95th centile • UtA Doppler mean PI > 95th centile or bilateral notching (perform only once at the time of diagnosis). 	EFW customised or AC < 3rd centile or Two or more of: <ul style="list-style-type: none"> • EFW customised or AC < 10th centile • slowing of fetal growth: decline in EFW or AC of > 30 centiles from 28+0 weeks' gestation onwards* • any of: <ul style="list-style-type: none"> - UA Doppler PI > 95th centile or - CPR < 5th centile or - UtA mean PI > 95th centile or bilateral notching (perform only once at the time of diagnosis).

AC = abdominal circumference; CPR = cerebroplacental ratio; EFW = estimated fetal weight; FGR = fetal growth restriction; PI = pulsatility index; UA = umbilical artery; UtA = uterine artery.

* If there is decline in EFW or AC of > 30 centiles before 28 weeks' gestation in the absence of early-onset FGR, consider another growth scan in two to three weeks. If the fetal growth trajectory between the last two scans is normal, the AC and EFW is > 10th centile, the fetus is not suspected to be growth restricted and further growth scans should follow risk factor screening recommendations (see Table 5).

Evidence summary: Risk assessment for the development of FGR and interventions to reduce risk

The ability to predict and potentially prevent FGR is highly desirable. Much effort has been directed at developing screening and risk assessment tools but, overall, prediction of FGR remains poor. Risk assessment at antenatal booking with re-evaluation throughout the pregnancy is the best way to identify pregnancies with an increased chance of developing FGR. This allows targeted preventative interventions (such as lifestyle modifications or starting low-dose aspirin therapy from 12+0 to 16+6 weeks' gestation) and close pregnancy monitoring for the development of FGR.

Risk assessment

Clinical risk factors associated with FGR

Clinical risk factors for placental-mediated FGR are those associated with an increased likelihood of abnormal placentation and subsequent placental insufficiency. Reported clinical risk factors are consistent across international guidelines^{61,67,116} and are consistent with those used in primary studies to define participants who have a high risk of developing SGA or FGR.¹² All guidelines recommend that women with risk factors for FGR undergo additional investigations and a serial ultrasound growth assessment.^{60–63,67,77} The RCOG guideline is the only guideline to explicitly classify risk factors into major (OR RR > 2.0) and minor categories.⁶⁷ Major clinical risk factors for SGA and FGR are listed in Table 2.

Fetuses with a velamentous or marginal cord insertion^{117,118} or an isolated finding of a two-vessel cord (single UA) may have higher rates of SGA and FGR.³⁰ However, findings about these associations are not consistent across studies and differences in definitions and heterogeneity between studies have made meta-analyses difficult.^{30,119}

Pregnant women/people who have multiple minor risk factors are likely to have an increased risk of FGR compared with those who have a single minor risk factor, but the magnitude of the additional risk is not clear. The OR and RR cannot be added together to give an overall risk assessment. The RCOG guideline recommends additional surveillance of women with three or more minor risk factors, as it is 'likely to constitute a significant risk for the birth of a[n] SGA neonate'.⁶⁷

Table 2: Major risk factors for SGA and FGR (OR or RR > 2.0)^{67,120}

Maternal demographics	Maternal medical history
Maternal age \geq 40 years (nulliparous) Continued smoking \geq 16 weeks' gestation (> 10 per day) Recreational drug use	Chronic hypertension*† Diabetes with vascular disease*† Renal impairment*† Antiphospholipid syndrome*†
Previous pregnancy history	Current pregnancy risk
Previous SGA or FGR pregnancy*† Previous hypertensive disorder of pregnancy*† Previous stillbirth†	Heavy bleeding < 20 weeks Pre-eclampsia or gestational hypertension Antepartum haemorrhage or placental abruption

FGR = fetal growth restriction; OR = odds ratio; RR = relative risk; SGA = small for gestational age.

* Low-dose aspirin is recommended, starting 12+0 to 16+6 weeks' gestation, taken at night. For further advice about the use of low-dose aspirin and calcium, see the *Diagnosis and Treatment of Hypertension and Pre-eclampsia in Pregnancy in Aotearoa New Zealand* guideline.¹²¹

† Risk factors for early-onset FGR include previous FGR birth < 32 weeks' gestation, previous hypertensive disease with birth < 34 weeks' gestation, significant maternal medical disease and previous stillbirth (particularly early gestation or associated with FGR).

Table 3: Minor risk factors for SGA and FGR (OR or RR < 2.0)^{67,120,122-124}

Maternal demographics	Maternal medical history
Nulliparity Maternal age \geq 40 years (multiparous) Smoking one to 10 cigarettes per day	Conception via assisted reproductive technology BMI \geq 30 kg/m ² or < 18.5 kg/m ²
Previous pregnancy history	Current pregnancy risk

Short (< 6 months) or long (> 60 months) interpregnancy interval	Placenta praevia Low gestational weight gain [‡]
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BMI = body mass index; FGR = fetal growth restriction; OR = odds ratio; RR = relative risk; SGA = small for gestational age.

[‡] Low gestational weight gain (GWG) can be considered when a woman/person's weight gain (compared to pre-pregnancy or early pregnancy) at any given gestation is not on track to reach minimum recommended GWG for her/their BMI category by end of pregnancy. For further information about total weight gain recommendations for each BMI category, see Table 4.

Biomarkers to assess the risk of developing FGR

The placenta releases factors into the maternal circulation that can be measured early in pregnancy. No evidence exists that these biomarkers have sufficient sensitivity or specificity to predict FGR. Biomarkers are not recommended for routine pregnancy screening.^{63,67,125}

Angiogenic-associated biomarkers, such as placental growth factor and soluble fms-like tyrosine kinase-1, have been associated with adverse pregnancy outcome, including pre-eclampsia and SGA.¹²⁶ Biomarker associations are stronger when FGR is associated with pre-eclampsia and/or with early-onset disease consistent with the severity of placental disease.¹²⁶ Biomarkers do not perform better than or significantly improve prediction models based on clinical risk factors, with or without Uta Doppler studies.¹²⁷

Pregnancy-associated plasma protein-A (PAPP-A) is produced by the syncytiotrophoblast layer of the placenta from early pregnancy. It is routinely tested as a component of first trimester combined screening for Down syndrome and other conditions.¹²⁸ Low levels of PAPP-A have been associated with adverse pregnancy outcomes, including SGA. A 2017 meta-analysis of 32 studies and 175,240 pregnancies found that PAPP-A levels < 5th centile were associated with neonatal SGA (OR 2.08; PPV 18%).¹²⁹ A stronger association existed when PAPP-A levels were < 1st centile (OR 3.4; PPV 28%). Most pregnant women/people with low PAPP-A will have a normal pregnancy outcome.¹²⁹ Low PAPP-A lacks specificity as an SGA risk factor and is no longer reported by the National Screening Unit. It has been removed from the list of major risk factors in the clinical practice guideline.

Ultrasound markers to assess the risk of developing FGR

Several different ultrasound markers have been investigated as potential screening tools for SGA or FGR. These include Uta Doppler studies and placental parameters (morphology and volume). While these markers are positively associated with SGA or FGR, their predictive ability remains too low to recommend them for routine screening in low-risk pregnant women/people.^{61,63}

Evidence about the role of Doppler studies in diagnosing FGR is in **Error! Reference source not found.**

Routine uterine artery Doppler studies to assess the risk of developing FGR

Abnormal UtA Doppler studies performed in the first and second trimester have an association with subsequent FGR.¹³⁰ An abnormal UtA is better at predicting early-onset FGR than late-onset FGR. Prediction is also enhanced when FGR develops with pre-eclampsia.

A 2018 prospective cohort study of 4,610 nulliparous women found that a raised UtA PI at 11+0 to 13+6 weeks' gestation combined with maternal characteristics predicted 64% of preterm and 20% of term SGA infants at a false positive rate of 10%.¹³¹ Another study investigated outcomes in 11,667 women randomised to second trimester UtA Doppler investigations and increased surveillance if UtA Doppler was abnormal.¹³² While approximately 60% of early-onset FGR (and pre-eclampsia) was detected with an abnormal UtA screen, no differences in perinatal or maternal complications were observed.

A 2008 systematic review and meta-analysis concluded that UtA Doppler studies performed in the second trimester performed better than those performed in the first trimester but had poor predictive value for FGR in low-risk women. Results for low-risk women with an abnormal PI or notching in the second trimester were 23% sensitivity for FGR, 94% specificity and a positive likelihood ratio of 3.9 (95% CI 3.0, 4.7).¹³⁰

Targeted uterine artery Doppler studies for those with risk factors for early-onset FGR

In the subgroup of pregnant women/people who have significant clinical risk factors for early-onset FGR, UtA Doppler screening in the second trimester may help to differentiate between those who have a high risk of developing early-onset severe FGR (and/or pre-eclampsia) and those who have a lower risk.^{133,134} In the 2008 meta-analysis, prediction of FGR improved among high-risk women. Results for high-risk women with an abnormal PI or notching in the second trimester were 68% sensitivity for FGR, 81% specificity and a positive likelihood ratio of 3.6 (95% CI 2.0, 5.1).¹³⁰ A negative test could also differentiate women who had a lower risk (negative likelihood ratio 0.40; 95% CI 0.14, 0.65).¹³⁰ A high negative predictive value is consistent across other studies of UtA Doppler screening in the second trimester.¹³⁴

The use of UtA Doppler studies at 20 to 24 weeks' gestation to predict risk of FGR in high-risk women is recommended by RCOG, but not recommended by FIGO.^{61,67} Neither SMFM nor ISUOG addressed screening.^{62,63}

Integrated risk assessments to identify pregnancies with a high risk of developing FGR

Integrated models of testing incorporating multiple individual risk parameters that alone are insufficiently accurate to predict either SGA or FGR have been investigated. Models include various combinations of maternal demographics, clinical risk factors, maternal mean arterial blood pressure, UtA Dopplers and biomarkers. Studies have involved serial evaluations throughout pregnancy.¹³⁵ While promising, no models have been sufficiently accurate or validated and cannot be recommended for routine screening to determine FGR risk. Biomarkers and predictive models should be actively reviewed the next time the clinical practice guideline is updated.

Public health and periconception interventions to reduce FGR

Public health measures that encourage people to enter pregnancy in optimum health will help to prevent FGR at a population level and are recommended by all guidelines contributing to the Aotearoa New Zealand clinical practice guideline.^{61–63,67} Ideally, those considering pregnancy should receive healthy lifestyle advice about diet (varied and including green leafy vegetables and fruit),^{136,137} taking regular moderate exercise and entering pregnancy with a healthy body mass index (BMI).^{135,138} Public health messages and measures need to target all people of reproductive age because approximately 53% of all pregnancies are unplanned in Aotearoa New Zealand.¹³⁹

Lifestyle interventions and advice

Maternal pre-pregnancy weight

Those who are underweight at the start of pregnancy (BMI < 20 kg/m²) have an increased risk of an SGA pregnancy. This risk is higher when population-based SGA definitions are used (OR 1.4; 95% CI 1.3, 1.6) compared with customised SGA definitions that account for maternal height (OR 1.2; 95% CI 1.1, 1.3).¹²³

Obesity is increasingly prevalent among populations of pregnant women/people. In the past, obesity was considered protective against SGA when defined using a population birthweight standard.¹⁴⁰ Recent studies of risk factors for customised SGA showed that women with obesity have higher rates of neonates with SGA,^{39,123,136} which in part may explain the higher perinatal morbidity and mortality seen in these women. Pregnant women/people with obesity are more likely to have pre-existing hypertension and diabetes and are more likely to develop gestational hypertension and pre-eclampsia, which are associated with SGA and FGR.¹⁴⁰

Unfortunately, public health measures to reduce obesity in high-income countries have not been successful. Preconceptual non-surgical interventions tend to be resource-intensive and achieve only modest weight loss (3 to 6 kg) and are not associated with long-term benefit or improvement in pregnancy outcomes.¹⁴¹

Gestational weight gain

Gestational weight gain (GWG) is an important independent modifier of pregnancy risk. The most commonly used reference for optimum GWG is the 2009 US Institute of Medicine recommendations.¹⁴² These recommendations include lower GWG targets for women with an increased BMI and have been adopted by the Ministry of Health (Manatū Hauora).

Table 4: US Institute of Medicine recommendations for gestational weight gain by pre-pregnancy BMI¹⁴²

Body mass index	Total weight gain (kg)
Underweight (< 18.5 kg/m ²)	12.5 – 18.0
Normal weight (18.5 – 24.9 kg/m ²)	11.5 – 16.0
Overweight (25.0 – 29.9 kg/m ²)	7.0 – 11.5
Obese (≥ 30.0 kg/m ²)	5.0 – 9.0

BMI = body mass index

Pregnant women/people with GWG lower than the US Institute of Medicine recommendations have an approximately 40 to 80% increased risk of having a neonate who is SGA, regardless of BMI.^{122,124,143} Traditionally, the strongest association between low GWG and SGA defined by population references is in women who are underweight at the start of pregnancy.¹⁴³ While this association is likely to be similar for customised SGA, this relationship has not been verified.

Folic acid supplementation

Folic acid supplementation of at least 800 micrograms per day is recommended for anyone planning pregnancy in Aotearoa New Zealand.¹⁴⁴ Folic acid should be taken for at least four weeks before conception and for 12 weeks after conceiving to reduce the risk of neural tube defects.¹⁴⁴ Those who have a previous or family history of neural tube defects, have insulin-treated diabetes, have a BMI > 30 kg/m² or are taking folate antagonising medications should take five milligrams per day of folic acid.¹⁴⁵

Evidence suggests preconceptual, but not post-conceptual, folic acid supplementation may reduce SGA and FGR. A 2014 systematic review and meta-analysis of 188,796 singleton births showed preconceptual folic acid supplementation of 400 micrograms per day resulted in a 25% reduction in risk of having a neonate with birthweight < 5th centile (aOR

0.75; 95% CI 0.61, 0.92). There was no significant association with birthweight if folic acid started after conception (aOR 0.82; 95% CI 0.63, 1.06).¹⁴⁶ A 2016 study of prospectively collected cohort data (N = 240,954) reported a 19% reduced risk of SGA (RR 0.81; 95% CI 0.70, 0.95) in women using preconceptional folic acid and reported no reduction in risk for those who began supplementation post-conception (RR 0.95; 95% CI 0.83, 1.09).¹⁴⁷ In the prospective SCOPE study (Screening for Pregnancy Endpoints), preconceptional folic acid was associated with reduced risk of SGA (aOR 0.82; 95% CI 0.67, 1.00, $p=0.047$), with folic acid taken to 15 weeks' gestation also associated with an increase in customised birthweight centile.¹⁴⁸

Folic acid may have additional benefit in protecting against SGA past the first trimester, but further studies are required.

As over half of all pregnancies in Aotearoa New Zealand are unplanned, most pregnancies are not supplemented with preconceptional folic acid.¹³⁹ To partially address this, the Aotearoa New Zealand Government mandated folic acid fortification of non-organic wheat flour used for bread-making by mid-2023. Some bread sold in Aotearoa New Zealand is already fortified voluntarily alongside other foods such as breakfast cereals, some fruit and vegetable juices, dairy milk alternatives and certain liquid meal supplements. This fortification will go some way to reducing the population risk of FGR and neural tube defects, but periconceptional folic acid supplementation is still recommended to ensure a minimum effective dose is taken.

Cigarette smoking

Cigarette smoking is a well-known modifiable risk factor for SGA and FGR (as well as perinatal morbidity and mortality).¹⁴⁹ Risks of complications increase with the number of cigarettes smoked in a 'dose-dependent' manner.¹⁵⁰ Smoking cessation at any gestation is beneficial. However, those who stop smoking early in pregnancy (< 15 weeks' gestation) have a risk of having an SGA pregnancy that is the same as non-smokers.¹⁵¹

Smoking rates

Smoking rates in Aotearoa New Zealand are highest among wāhine Māori (particularly in those who are younger and those who are pregnant). Pregnancy is a time of high motivation to stop smoking, and interventions to increase smoking cessation can be effective. Smoking cessation resources and programmes should focus on engaging the young and wāhine Māori.¹⁵² Incentive-based programmes are used in Aotearoa New Zealand with evidence suggesting these are most effective at decreasing smoking rates, as measured by non-smoking rates both at the end of pregnancy and postnatally.¹⁵³ A pilot study of smokefree incentives in Counties Manukau used a 12-week incentive programme for Māori and Pacific Island women (and their whānau) who continued to smoke during pregnancy, complementing existing behavioural support and medication, resulted in a 65% quit rate at four weeks and 60% at 12 weeks. Unfortunately, data on pregnancy outcomes

is not available. Smoking cessation programmes are associated with improved birth outcomes, including higher birthweight.^{154,155}

Environmental exposure to tobacco smoke, or second-hand smoking, has a variety of well-understood associations with infant and child health, but it is also associated with reduced fetal growth in a dose-dependent manner.^{156–158} Pregnant women/people should be advised to minimise second-hand tobacco smoke, including household, social and work exposures.

Nicotine replacement therapy and electronic nicotine delivery systems

Nicotine replacement therapy (in the form of patches, lozenges or gum) is recommended as part of an integrated approach to support smoking cessation in pregnancy.¹⁵⁷ The efficacy of nicotine replacement therapy alone in reducing smoking rates in pregnancy is not proven,^{160,161} and is likely best as part of an incentive programme as above. Nicotine replacement therapy provides a lower overall dose of nicotine to the pregnancy and avoids the other harmful substances in cigarette smoke.

Electronic nicotine delivery systems (ENDS – e-cigarettes and vaping) have become more available and been promoted as safer than cigarette smoking, including during pregnancy. Specifically, ENDS are recommended as an aid to stop cigarette smoking but are not recommended for non-smokers. The short-term and long-term effects of ENDS in pregnancy have not been established. Rates of SGA may be no different among ENDS users compared with cigarette smokers, and other harms are unknown.^{163–165} While there are theoretical advantages to ENDS over cigarette smoking, complete cessation of all nicotine-containing products is the ideal goal in pregnancy, as nicotine itself is implicated in adverse health outcomes. More research on ENDS and pregnancy outcomes is required.

Advice on stopping smoking during pregnancy is in the *New Zealand Guidelines for Helping People Stop Smoking*.¹⁶⁶

Recreational drug use, including cannabis

The prevalence of recreational drug use in pregnancy is hard to estimate, and the impact of substances on pregnancy can be difficult to separate from the socioeconomic disadvantage that often accompanies recreational drug use. Substances such as methamphetamine and cocaine, which have a direct vasoconstrictive action, have been strongly associated with adverse pregnancy outcomes, including FGR.^{167,168} People who continue to use these substances generally require significant additional support, including close fetal monitoring for the development of FGR and other potential complications.^{167,168}

In Aotearoa New Zealand, cannabis is the most widely used illegal, recreational drug but prevalence of its use in pregnancy is largely unknown.¹⁶⁹ Cannabis users are often also cigarette smokers, meaning the impact of cannabis alone on pregnancy is harder to assess. A Canadian cohort study of cannabis use in pregnancy identified that 1.4% of the

660,000 participants self-reported using cannabis in pregnancy. Cannabis use was associated with a 53% increase in FGR (birthweight < 3rd centile RR 1.53; 95% CI 1.45, 1.61) and an increased risk of preterm birth, placental abruption and neonatal morbidity.¹⁷⁰

Other interventions

There is either insufficient evidence or little to no difference in the rate of SGA associated with the following interventions during pregnancy:

- calcium supplementation^{67,171} (calcium supplementation is recommended for prevention of hypertensive disorders in those with risk factors for SGA and FGR – see low-dose aspirin and the *Diagnosis and Treatment of Hypertension and Pre-eclampsia in Pregnancy in Aotearoa New Zealand*)¹²¹
- caffeine reduction¹⁷²
- supplementation with omega 3 fatty acid,¹⁷³ zinc,¹⁷⁴ vitamin C¹⁷⁵ or vitamin E¹⁷⁶
- treating periodontal disease¹⁷⁷
- routine antioxidant supplementation.¹⁷⁸

Primary care models to reduce FGR

Antenatal care schedules enable the early identification of risk factors or complications in pregnancy, including FGR. Inadequate antenatal care (including booking care late in pregnancy) has been associated with increased rates of adverse outcomes, including SGA.¹⁷⁹ Fewer antenatal visits (particularly later in pregnancy) may also lead to missed opportunities to screen for and identify pregnancy complications such as FGR.

Midwifery-led care may be particularly advantageous for pregnant women/people with high socioeconomic deprivation or complex health and/or social needs, including relating to substance use or mental illness.¹⁸⁰ Those with high socioeconomic deprivation and high levels of psychosocial stress (including mental health disorders) appear to have an increased risk of SGA.^{12,181} The midwifery model of care with continuity of caregiver and longer appointment times may influence outcomes in this group.¹⁸⁰ A 2016 Cochrane systematic review showed that women who received midwife-led continuity models of care were less likely than those in other care models to experience labour intervention and more likely to be satisfied with their care, although no differences in most adverse outcomes, including low birthweight, were identified.¹⁸²

Kaupapa Māori periconceptual initiatives that reduce FGR

The literature search found no specific research on kaupapa Māori periconceptual initiatives to reduce inequities in FGR.

Data on wāhine Māori experiences of maternity care are scarce but available evidence suggests overall lower levels of satisfaction with care compared with non-Māori. In particular, this finding relates to being unable to access culturally appropriate maternity care. This may help to explain overall lower engagement with antenatal care among wāhine Māori compared with other ethnic groups, despite wāhine Māori having a higher likelihood of experiencing complex pregnancy. Rural areas often have fewer culturally appropriate maternity providers than urban areas, potentially exacerbating challenges with antenatal care engagement.¹⁸³

Cultural connection, culturally safe and accessible maternity care to increase engagement has the potential to improve outcomes for wāhine Māori, including a reduction in modifiable risk factors for FGR.

Interventions for those with an increased chance of FGR

Lifestyle interventions such as smoking cessation, healthy diet, exercise and managing GWG are important for everyone, but are particularly important for those who have an increased chance of having a pregnancy affected by FGR. Other options include therapies such as low-dose aspirin or heparin.

Low-dose aspirin

Most studies with evidence on therapies that reduce the rate of FGR have been interventions primarily to prevent pre-eclampsia, with SGA or FGR investigated as a secondary outcome. Low-dose aspirin (100 to 150 milligrams per day) started at or before 16 weeks' gestation reduces the risk of developing pre-eclampsia in those with pre-eclampsia risk factors, while also reducing the risk of SGA and FGR.¹⁸⁴⁻¹⁸⁷

A 2017 meta-analysis of randomised trials of low-dose aspirin compared to placebo (N = 20,000 participants with risk factors for pre-eclampsia), showed:

- low-dose aspirin initiated \leq 16 weeks' gestation almost halved the risk of FGR (RR 0.56; 95% CI 0.44, 0.70, n = 5,130)
- no impact on FGR if low-dose aspirin was initiated $>$ 16 weeks' gestation (RR 0.95; 95% CI 0.86, 1.05, n = 15,779).¹⁸⁵

Consistent with this finding, a large individual participant data meta-analysis (31 randomised trials; N = 32,217 women at risk of pre-eclampsia) with low-dose aspirin initiated $<$ 16 weeks' gestation resulted in a reduced risk of FGR (RR 0.76; 95% CI 0.61, 0.94; 13 trials, n = 6,393 women). There was no significant effect when low-dose aspirin started $>$ 16 weeks' gestation (RR 0.95; 95% CI 0.84, 1.08; 18 trials, n = 14,996 women).¹⁸⁶

FIGO and RCOG recommend low-dose aspirin to prevent pre-eclampsia in those with major risk factors for pre-eclampsia.^{61,67} The SMFM guideline does not recommend aspirin use but did not grade its recommendation.⁶³ Low-dose aspirin was considered out of the scope of the ISUOG guideline.⁶² Given the shared pathophysiology of pre-eclampsia and FGR, the safety of aspirin in pregnancy and the evidence of benefit, low-dose aspirin (100 milligrams per day, taken at night) is recommended to reduce the risk of FGR for those with a high risk of developing pre-eclampsia or those who have had a previous FGR pregnancy. Low-dose aspirin should be started between 12+0 to 16+6 weeks' gestation. There is evidence of improved efficacy when low-dose aspirin is taken at night.¹⁸⁸

While calcium supplementation does not reduce the risk of FGR,^{67,171} it decreases the risk of hypertensive disorders of pregnancy in those with pre-eclampsia risk factors. Many of these pregnant women/people will also have FGR risk factors and should be recommended 1 gram of elemental calcium in the diet from booking to birth.¹²¹

Low molecular weight heparin

Heparin (alone or in combination with low-dose aspirin) has been investigated as a therapy with anticoagulant, anti-inflammatory and pro-angiogenic properties. High-quality trials show no beneficial effect of low molecular weight heparin on pre-eclampsia or on SGA or FGR outcomes. For example, the high-quality *Enoxaparin for Pre-eclampsia and Intrauterine Growth Restriction* trial randomised 149 women at very high risk of placental-mediated complications (including a high proportion of women with previous FGR) to standard high-risk care or high-risk care plus enoxaparin. Heparin had no beneficial effects on pre-eclampsia or on SGA or FGR,^{189,190} Low molecular weight heparin is not recommended for prevention of SGA or FGR. Pregnant women/people with previous thrombosis or antiphospholipid syndrome should be managed with low molecular weight heparin as per local guidelines.

Recommendations: Risk assessment for the development of FGR and interventions to reduce risk

Risk assessment and intervention recommendations		Evidence level	Grade of recommendation	Rationale
6	Inform women/people considering pregnancy of periconception lifestyle advice, including	4	GPP	Those entering pregnancy with a BMI 18.5 kg/m ² to 25 kg/m ² have the lowest chance of having an SGA

	a healthy diet, regular moderate exercise, and entering pregnancy at as healthy a weight as possible.			pregnancy. Rates of SGA increase as BMI moves further from the healthy weight range (u-shaped curve). Higher rates of pre-existing hypertension and diabetes are experienced by people with obesity.
7	Advise women/people considering pregnancy to supplement diet with daily folic acid.	2++	B	Pre-conceptual folic acid supplementation may reduce the risk of FGR as well as neural tube defects.
8	Advise women/people to stop cigarette smoking and other recreational drug use (including cannabis) before pregnancy. Follow advice about supporting smoking cessation as set out in the <u>New Zealand Guidelines for Helping People Stop Smoking</u> . ¹⁶⁶	1+ 4	A GPP	Stopping tobacco use < 15+0 weeks' gestation decreases the chance of FGR.
9	Perform a clinical risk assessment for FGR for pregnant women/people in early pregnancy. Continue to screen for the development of new clinical risk factors throughout pregnancy.	2+ 4	B GPP	Risk factors for FGR pregnancies may be present at booking or may develop as pregnancy progresses. Timely identification enables appropriate ultrasound growth assessment and management.
10	Do not use biomarkers or integrated risk assessments as screening tools for FGR	2+	C	There is limited evidence that biomarkers or early pregnancy Dopplers have sufficient sensitivity or

	(combinations of clinical risk factors, biomarkers and early pregnancy ultrasound parameters).			specificity to accurately predict FGR.
11	In pregnancies with risk factors for early-onset FGR , perform mean UtA Doppler PI with assessment of notching at 20 to 24 weeks' gestation.	2+	C	An abnormal UtA Doppler PI at mid-pregnancy, combined with maternal characteristics is better at predicting early-onset FGR (and pre-eclampsia) compared with late-onset FGR.
12	Offer low-dose aspirin to pregnant women/people who have had a previous FGR pregnancy or who have a major risk factor for pre-eclampsia. <i>Low-dose aspirin 100 milligrams per day taken at night, starting between 12+0 to 16+6 weeks' gestation until 36 weeks' gestation.</i>	1+	B	Pregnant women/people with major risk factors for pre-eclampsia have a reduced risk of FGR (and pre-eclampsia) when taking low-dose aspirin. They also benefit from calcium supplementation to reduce the risk of hypertensive disorders of pregnancy. For further advice about risk factors for hypertension and pre-eclampsia in pregnancy and the use of low-dose aspirin and calcium, see the <i>Diagnosis and Treatment of Hypertensions and Pre-eclampsia in Pregnancy in Aotearoa New Zealand</i> guideline. ¹²¹
13	Do not use low molecular weight heparin for the prevention of FGR.	2++	A	High-quality trials show that heparin provides no beneficial moderating effect on the risk of developing pre-eclampsia

				or SGA and FGR outcomes.
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BMI = body mass index; FGR = fetal growth restriction; GPP = good practice point; SGA = small for gestational age; UtA = uterine artery.

Evidence summary:

Antenatal screening for FGR

Antenatal screening for FGR is challenging. Antenatal detection rates range from 20% to 60%, depending on the screening tool and definition used.^{2,59,191,192} Screening methods include clinical evaluation through routine serial fundal height examination or serial ultrasound scanning in pregnant women/people with risk factors for FGR.

Routine assessment to detect FGR

Fundal height assessment

Abdominal palpation with a measured fundal height is universally recommended as a routine clinical assessment tool to detect a suspected small fetus. All international guidelines recommend serial measurements starting from 24 to 26 weeks' gestation.^{61-63,67,77}

Abdominal palpation is a non-invasive and inexpensive assessment tool but it has poor sensitivity or specificity for detecting SGA. In a meta-analysis of 34 observational studies, performed in mainly low to middle income countries, fundal height had a sensitivity of 58% and a specificity of 87% for predicting birth weight < 10th centile.¹⁹¹

Fundal height has significant inter-observer and intra-observer variation. Using standardised measurement techniques and serial measurement by the same health practitioner may improve predictive accuracy.^{67,193,194} An assessment of pre-workshop and post-workshop teaching at multidisciplinary workshops in Aotearoa New Zealand evaluated the value of standardised fundal height measurement. Fifty participants performed pre-workshop fundal height measurements on a model, with the variation in measurement ranging from + 10 centimetres to - 5 centimetres compared with the actual measurement. Over-measurement was common. Variation in measurement immediately

post-workshop ranged from + 3 centimetres to - 1 centimetres. Almost all (92%) of measurements were within 1 centimetres of the actual measurement.¹⁹³

Fundal height assessment is less likely to be predictive in the presence of factors that influence the accuracy of measurement. The RCOG guideline recommends serial ultrasound assessment of fetal size in women with a BMI ≥ 30 kg/m², large fibroids or polyhydramnios.⁶⁷ The FIGO guideline also noted that fundal height accuracy is limited with these factors present but does not specifically recommend management options.^{61,76}

There is a paucity of data on SGA and FGR detection rates based on customised compared with standardised fundal height charts. A single-centre trial, published in abstract, found women randomised to the use of a customised compared with standard fundal height chart had a lower rate of stillbirth (N = 3,993; 0.05% compared with 0.4%, $p=0.039$).¹⁹⁵ Guidelines recommending the use of customised EFW references also recommend that fundal height be plotted on a customised fundal height chart.

In Aotearoa New Zealand, customised antenatal charts are either embedded in maternity software or printed and fundal height is plotted manually. If the serial fundal height measurements show 'reducing velocity' or any measurement is < 10th centile, ultrasound for fetal growth assessment is recommended.^{67,77} The previous NZMFMN guideline defined slow fundal height growth as > 30 centile decrease, based on expert opinion.¹ The RCOG and FIGO guidelines do not define slowing of fundal height,^{61,67} but the American College of Gynaecologists and Obstetricians and SMFM recommend using fundal height measurement, where the fundal height in centimetres estimates the gestational age in weeks.¹⁹⁶ If the fundal height is > 3 centimetres discrepant from the gestational age in weeks, an ultrasound examination is recommended.¹⁹⁶

The Perinatal Institute's Growth Assessment Protocol (GAP) programme is a systematic programme of standardised measurement of fundal height using a customised chart, with action points for referral for ultrasound fetal growth assessment (fundal height < 10th centile or decrease in serial fundal height trajectory). The GAP programme in Aotearoa New Zealand used a > 30 centile decrease in fundal height, using the NZMFMN recommendation.¹ In the United Kingdom, slowing fundal height is defined as growth less than the slope of the 10th centile line on the customised chart.¹⁹⁷ This approach allows for gestation at scan (growth trajectories vary with gestational age with the fastest growth seen in the middle of the third trimester) as well as the scan interval). Outcome data from widespread implementation of the GAP programme has shown a consistent increase in detection of antenatal SGA regardless of the definition of slowing fundal height measurement.^{2,198,199} In Counties Manukau, implementation of GAP resulted in a nearly five-fold increase in detected SGA (23% pre-GAP compared with 58% post-GAP; aOR 4.8; 95% CI 2.82, 8.18).²

The DESiGN Trial is a pragmatic trial of the implementation of GAP in the United Kingdom where maternity units were randomised to GAP care and compared with standard care units. A 2022 publication of trial findings reported that GAP did not impact on the primary

outcome of detection of SGA infants (defined as SGA by both customised and population centiles).²⁰⁰ A reduction occurred in GAP units of:

- stillbirth and perinatal death: stillbirth 7 per 10,000 births (adjusted effect size: -0.07%, 95% CI -0.14%, -0.01%) and perinatal death 9 per 10,000 births (adjusted effect size: -0.09%, 95% CI -0.17%, -0.004%)
- SGA stillbirths: 7.6 per 1000 births (adjusted effect size: -0.76, 95% CI -1.50, -0.03), with SGA babies born on average two days earlier.

Challenges in performing this trial included incomplete GAP implementation in some units, short timeframes from implementation to assessment, and the release of the National Health Service England Saving Babies Lives Care Bundle, which resulted in changes in standard care (as evidenced by ultrasound assessments for EFW increasing in the standard care units from 43.7% pre-randomisation to 75.7% post-randomisation). Overall, the DESiGN trial has shown improved perinatal mortality in units using GAP, even if incompletely implemented.

Routine third trimester ultrasound

While ultrasound fetal size assessment remains the most accurate, no clear evidence exists that routine growth scanning in low-risk pregnant women/people has a positive impact on clinical outcomes.

A 2015 Cochrane review of 13 trials (N = 34,980 participants) did not support universal ultrasound screening of low-risk women, as there were no observed differences in outcomes between screened and non-screened participants. Included studies had significant heterogeneity, including gestation at screening ultrasound (from 24 weeks' onwards) and large differences in study protocol for both the intervention and control groups.²⁰¹ An important finding, confirmed in other studies, was that screening for SGA with routine sonography improves with advancing gestational age and is best near term (from 35 to 37 weeks' gestation),⁷⁰ which is consistent with the observation that most FGR is of late-onset.

The Pregnancy Outcome Prediction study prospectively screened 3,977 nulliparous women for FGR, comparing the detection of neonatal SGA between routine (28 and 36 weeks' gestation blinded research ultrasound scans) and clinically indicated scans.⁷⁹ The study found routine sonography nearly tripled the detection rate of SGA (57% compared with 20%). However, for every additional SGA infant correctly identified by routine scan, approximately two additional results were false positives. Additionally, the risk of neonatal morbidity increased in the subset of SGA fetuses with slow growth of AC only (AC growth velocity in the lowest decile RR 3.9; 95% CI 1.9, 8.1). This highlights the importance of fetal growth velocity and biometry in determining FGR risk.

Routine growth scanning is not recommended for low-risk pregnant women/people.

Serial ultrasound monitoring for those at high-risk of FGR

International guidelines consistently recommend that women who have a high risk of an FGR pregnancy be offered serial ultrasound scans.^{61,77,196} The optimum commencement and timing of screening ultrasounds is not clear. The RCOG recommends serial ultrasound assessment of fetal size for all women with major risk factors starting from 26 to 28 weeks' gestation⁶⁷ (see Table 2 for major risk factors). FIGO recommends that all women who are high-risk have serial monitoring of fetal growth beginning from 24 to 28 weeks' gestation.⁶¹

Women who have previously had an SGA or FGR baby have an overall three-fold to four-fold increased risk of having an SGA baby in a subsequent pregnancy.^{30,67,202} Additionally, those with a previous FGR baby born at < 32 weeks' gestation are more likely to experience recurrent early-onset FGR.²⁰² Consequently, those with risk factors for early-onset FGR should begin ultrasound surveillance of fetal growth earlier in pregnancy. These pregnant women/people should also be considered for UtA Doppler assessment at 20 to 24 weeks' gestation.

A suggested screening schedule for pregnant women/people with risk factors is in Table 5.

Table 5: Recommended screening schedule of growth scans for pregnant women/people with FGR risk factors or unreliable fundal height measurement but with a normally growing fetus

Three or more minor risk factors or unreliable fundal height	Major risk factor for SGA or FGR	One or more risk factors for early-onset FGR
Consider two growth scans: <ul style="list-style-type: none"> at 30 to 32 weeks' gestation and at 36 to 38 weeks' gestation[†] <i>(For example, one scan at 32 weeks' gestation and one scan at 37 weeks' gestation)</i>	Monthly growth scans starting from between 28 and 30 weeks' gestation until birth <i>(For example, one scan at each of 30, 34 and 38 weeks' gestation)</i>	Monthly growth scans starting from between 24 and 26 weeks' gestation until birth plus Consider UtA Doppler study between 20 and 24 weeks' gestation [‡] <i>(For example, one scan at each of 24, 28, 32, 36 and 40 weeks' gestation)</i>

AC = abdominal circumference; BMI = body mass index; EFW = estimated fetal weight; FGR = fetal growth restriction; GPP = good practice point; UtA = uterine artery.

[†] If only one scan is possible, a scan between 36 and 38 weeks' gestation is more likely to identify late-onset SGA or FGR. A single scan cannot assess fetal growth trajectory.

‡ UtA Doppler modifies the risk assessment for early-onset FGR (and pre-eclampsia). Closer maternal and fetal monitoring is recommended in the presence of an abnormal UtA Doppler. A normal UtA Doppler indicates that the development of early-onset FGR (and pre-eclampsia) is unlikely. Individualised clinical assessment of FGR risk may mean more frequent assessment of fetal size is appropriate. If FGR is confirmed, increased growth monitoring is required.

Development of risk factors in pregnancy

Some risk factors (see Table 2 and Table 3) are not present in early pregnancy, but develop as pregnancy progresses. These factors include hypertensive and bleeding complications of pregnancy, both of which are associated with placental pathology. Ongoing review for new FGR risk factors should occur throughout pregnancy. Serial growth assessment at least monthly from the onset of these risk factors is recommended in ongoing pregnancies.

When serial ultrasound assessment should cease

As more than 80% of babies with SGA are born after 37 weeks' gestation²⁰³ and detection of SGA with ultrasound biometry is better closer to term,⁷⁰ serial growth ultrasounds should be continued until birth in pregnancies with a major risk factor (see Table 2).

Recommendations: Antenatal screening for FGR

Antenatal screening for FGR recommendations		Evidence level	Grade of recommendation	Rationale
14	Do not offer routine ultrasound for fetal growth assessment to pregnant women/people without ≥ 1 major or > 3 minor risk factors for FGR.	1+	A	Routine ultrasound can result in increased false positive diagnoses and unnecessary intervention without evidence of improved outcomes. See <i>Recommendation 16</i> for screening where fundal height measurements are unreliable.

15	<p>Recommended screening for pregnant women/people at low risk of FGR (that is, no major and two or fewer minor risk factors) is serial fundal height assessment at each antenatal visit, plotted on a customised fundal height chart, starting at 26 to 28 weeks' gestation. Measurements should be at least two weeks apart.</p> <p>If the plotted fundal height is < 10th centile or if fundal height declines > 30 centiles, refer for ultrasound assessment of fetal growth.</p>	2+	B	There are no published data on the degree of decline in fundal height centile that is associated with an increased risk of FGR.
16	<p>Recommended screening for pregnant women/people where fundal height measurements are unreliable (BMI > 35 kg/m², large or multiple fibroids, polyhydramnios) is ultrasound assessment of fetal size between 30 and 32 weeks' gestation and again between 36 and 38 weeks' gestation.*</p>	4	GPP	If only one scan is possible, a scan between 36 and 38 weeks' gestation is more likely to identify late-onset FGR. A single scan cannot assess fetal growth trajectory.
17	<p>Consider screening pregnant women/people with three or more</p>	4	GPP	When combined, multiple minor risk factors are

	minor risk factors with ultrasound assessment of fetal size between 30 to 32 weeks' gestation and again between 36 to 38 weeks' gestation.*			likely to increase the risk of late-onset FGR. If only one scan is possible, a scan between 36 to 38 weeks' gestation is more likely to identify late-onset FGR. A single scan cannot assess fetal growth trajectory.
18	Recommended screening for pregnant women/people with one or more major risk factors for FGR is monthly ultrasound growth assessments starting between 28 and 30 weeks' gestation until birth.*	3	B	Serial ultrasound monitoring enables early identification of suspected FGR with appropriate assessment and ongoing monitoring.
19	Recommended screening for pregnant women/people with risk factors for early-onset FGR is monthly ultrasound growth assessments starting at 24 to 26 weeks' gestation until birth.*	3	C	Consider more frequent maternal and fetal assessment with abnormal screening UtA Doppler (see <i>Recommendation 11</i>).
20	Ultrasound assessment: <ul style="list-style-type: none"> Plot fetal biometry on an Australasian Society of Ultrasound Medicine chart (electronically if possible) and routinely report AC centile. Use the Hadlock three or four 	4 2+	GPP B	The use of locally developed fetal biometry charts is recommended. ^{53,57,66} The Australasian Society of Ultrasound Medicine fetal biometry charts are the most commonly used standard and using these will support national consistency.

	parameter formulae to calculate EFW in grams and report a customised centile where possible. ⁷¹			
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AC = abdominal circumference; BMI = body mass index; EFW = estimated fetal weight; FGR = fetal growth restriction; GPP = good practice point; UtA = uterine artery.

* More frequent and/or earlier initiation of growth scans may be indicated based on individualised risk assessment (such as the development of an additional risk factor like pre-eclampsia).

Evidence summary:

Antenatal management

Investigations when SGA or FGR is suspected

The clinical practice guideline recommends the following.

a. When SGA or FGR is suspected based on fundal height measurement:

- a growth scan for assessment of fetal biometry be performed (*Recommendation 3 and Table 1*)
- the EFW be plotted on a customised antenatal growth chart at the time of scan to enable additional Doppler assessment as required (*Recommendation 15*)
- fetal biometry be plotted on an Australasian Society of Ultrasound Medicine fetal growth chart (*Recommendation 20*).

b. When SGA is diagnosed or FGR is suspected based on diagnostic criteria, fetomaternal Dopplers are performed:

- UtA Doppler at diagnosis (*Recommendation 5 and Table 1*)
- UA in all cases (*Recommendation 5 and Table 1*)
- MCA Doppler with CPR is calculated after 32+0 weeks' gestation (CPR only reported) (*Recommendation 5*).

c. When SGA or FGR is early-onset or severe:

- consider screening for congenital infection with maternal serology and review the possibility of a genetic cause (*Recommendation 23*)
- refer for tertiary fetal medicine review less than 28+0 weeks' gestation or associated polyhydramnios or fetal malformation (*Recommendation 22*)
- consult with fetal medicine with consideration for referral if 28+0 to 32+0 weeks' gestation (*Recommendation 22*).

History taking

Accurate pregnancy dating is essential for the correct interpretation of EFW. In an otherwise uncomplicated pregnancy, the estimated due date based on last menstrual

period can be confirmed with a scan at 12+0 to 13+6 weeks' gestation (\pm seven days).²⁰⁴ Dating can form a part of the first trimester combined screening.¹²¹ Other first trimester scanning is indicated only if the last menstrual period is unknown, the pregnant woman/person has had a previous ectopic pregnancy or there are clinical concerns in early pregnancy.¹¹²

At the time of SGA or FGR diagnosis, it is worthwhile reviewing risk factors for placental-mediated FGR, including those that may have developed during the current pregnancy (see Table 2 and Table 3 for major and minor risk factors). When FGR is early-onset or severe, history should include a screen for non-placental causes for FGR:

- results of first trimester combined screening or non-invasive prenatal testing (NIPT) (if performed)
- familial genetic disorders
- whether a blood relationship exists between the parents
- screening for congenital fetal infection risk with relevant infection history, including:
 - a febrile illness or rash in pregnancy
 - frequent exposure to young children (for example, childcare and CMV)
 - exposure to domestic animals particularly young animals and their faeces (toxoplasmosis)
 - history of overseas travel to consider the risk of malaria or Zika virus.

Fetal anatomy

Fetal anatomy should be reviewed when FGR is suspected. In late-onset FGR, anatomy from first trimester nuchal translucency and 20-week anatomy scans should be reviewed.

In early-onset FGR, referral to a tertiary centre is recommended, particularly if < 28 weeks' gestation or FGR is severe (see *Recommendation 35*). This is because a significant association exists with fetal or chromosomal abnormalities (especially Trisomy 18/13 or triploidy). A detailed ultrasound under tertiary care will survey anatomy to assess for major structural anomalies, soft markers for aneuploidy, polyhydramnios, oligohydramnios and screening for markers for possible congenital infection (for example, ventriculomegaly, intracranial calcifications, microcephaly, hyperechoic bowel, ascites, hepatosplenomegaly, liver calcifications and hydrops).²⁰⁵ Placental location and morphology can be assessed at this examination.

Doppler studies

Assessment of Doppler blood flow in the maternal uterine and fetal circulations is integral to the diagnosis and management of SGA and FGR. An abnormal UtA, UA, MCA or CPR Doppler is highly suggestive of placental insufficiency in an FGR pregnancy.

Evidence statements on Doppler studies at the time of diagnosis are in **Error! Reference source not found.** Evidence statements on Doppler studies for antenatal management are in Doppler assessments in the monitoring and surveillance of SGA and FGR.

Additional testing

For infectious causes

Maternal serological screening for congenital infections is recommended in the presence of severe or early-onset FGR by both RCOG and FIGO or when infection is possible based on history or ultrasound findings.^{61,67} RCOG and FIGO strongly recommend serological testing for CMV and toxoplasmosis, with screening recommendations for rubella, varicella and syphilis in high-risk populations (see *Recommendations 21 and 23*).^{61,67} A full TORCH screen is not recommended.^{61,67}

For genetic causes

The possibility of a genetic cause for FGR should be considered in early-onset or severe FGR and the option of invasive testing with amniocentesis discussed. Prior aneuploidy screening results, including NIPT, should be reviewed and the limitations of these tests discussed with the pregnant woman/person. Initial testing should be with qfPCR or FISH, and if abnormal, Gband karyotype should be performed. If normal, chromosomal microarray offers a 4 to 10% increased diagnostic yield and should be offered when FGR is unexplained at < 32 weeks' gestation, or if there is any associated fetal abnormality.⁶¹

FIGO has the only contributing guideline that discusses fetal testing.⁶¹ It recommends amniocentesis for karyotype and microarray analysis, particularly if fetal findings suggest genetic abnormality (such as associated polyhydramnios or fetal malformation), regardless of gestational age, and when the results might change management.

While amniocentesis is often performed by fetal medicine services, it may be performed at a local facility, if the pregnancy is not peri-viable and the obstetrician has adequate experience in the procedure and counselling.

Non-Invasive Prenatal Testing

NIPT is a screening test that often reports false negatives. It does not offer an equivalent genetic yield to an amniocentesis with chromosomal microarray, which can detect additional gene duplications or deletions. The role of NIPT in the assessment of FGR is

not established. Ideally, its use should be restricted to the research setting. FIGO has the only guideline that discusses NIPT and does not recommend its use.⁶¹

The use of NIPT in the assessment of early-onset severe FGR may be considered on an individual basis within the fetal medicine service with full counselling on the limitations of this test.

Maternal and fetal monitoring and surveillance of SGA and FGR

Management of FGR that results from fetal causes (such as chromosomal, genetic or infectious causes) should be individualised and managed by a fetal medicine subspecialist in consultation with the parent(s) and/or whānau. The management of these pregnancies is not addressed further in the clinical practice guideline.

In most cases, placental insufficiency is the underlying aetiology (or cause) of FGR.

As there are no effective therapies to treat placental insufficiency, management consists of serial monitoring to assess fetal wellbeing and detect any signs of fetal decompensation that may precede stillbirth.²⁰⁶ The clinical challenge is determining the optimal monitoring strategy to prolong pregnancy (minimising neonatal morbidity and mortality associated with prematurity), while preventing stillbirth.^{5,66} In early onset FGR, poor neonatal outcomes are directly related to gestational age and, albeit to a lesser degree birthweight.⁵ In late-onset FGR, the neonatal and long-term consequences of late preterm or early term birth are weighed against the increasing risk of fetal acidosis and stillbirth with increasing gestational age, particularly in severe FGR.⁶⁸

Fetal monitoring includes:

- maternal monitoring of fetal movements
- Doppler assessments of fetal arterial and (in some early-onset FGR) venous circulations
- CTG
- serial fetal growth assessments
- ultrasound assessment of amniotic fluid volume.

The timing and frequency of assessment depends on gestational age, severity of FGR and the degree of abnormality of Doppler assessments.

Maternal monitoring of fetal movements

Fetal movements are commonly felt by the pregnant woman/person by 16 to 20 weeks' gestation. As the pregnancy progresses, fetal movements develop into distinct behavioural states, including patterns of movements that the pregnant woman/person feels.²⁰⁷ In the presence of progressive fetal hypoxaemia the fetus adopts slower oxygen-consuming behavioural states, including reduced activity.²⁰⁷ As hypoxia progresses, further changes are generally predictable, with cessation of breathing movements followed by a decrease in gross body movements and finally a reduction in fetal tone.²⁰⁸ A reduction in maternally perceived fetal movements can potentially identify a fetus at risk of stillbirth.

Counselling pregnant women/people about normal and reduced fetal movements can be challenging because of the wide variations in normal fetal movement patterns.²⁰⁹ Normal perception of fetal movements in the third trimester is characterised by increasingly strong movements, fetal hiccups and a diurnal pattern with strong fetal movements occurring in the evening.²¹⁰

In an Aotearoa New Zealand multicentre case control study of late stillbirth, perception of 'quiet or light' fetal movement in the evening was associated with a nearly four-fold increase in rate of stillbirth (aOR 3.82; 95% CI 1.57, 9.31).²¹¹ A secondary analysis of fetal movements from an independent participant data meta-analysis of case control studies of risk factors for late stillbirth (n = 851 cases, n = 2,257 controls, five studies) confirmed that women who reported reduced fetal movements had a two-fold increased risk of stillbirth (aOR 2.33; 95% CI 1.73, 3.14). Increasing strength of fetal movements (aOR 0.20; 95% CI 0.15, 0.27), fetal hiccups (aOR 0.45; 95% CI 0.36, 0.58) and multiple episodes of vigorous movement (aOR 0.67; 95% CI 0.52, 0.87) over the previous two weeks were reassuring.²¹² Maternal obesity did not influence a woman's perception of fetal movements, which is consistent with a previous systematic review.²¹² These studies were performed in general maternity populations, so the risk of stillbirth associated with fetal movement concerns may be even higher in FGR pregnancies.

Large prospective population-based studies investigating fetal movement counting compared to standard antenatal care (without fetal movement counting) have not shown a decrease in perinatal mortality with counting.^{213–215} These studies did not specifically investigate fetal movements in FGR pregnancies and did not address the qualitative and physiological aspects of fetal movements such as diurnal patterns.

It is reasonable to provide routine antenatal advice to pregnant women/people about fetal movement because it is not invasive, is inexpensive and may provide a safety-net between outpatient visits.⁶¹ Advice should include clear instructions on what the pregnant

woman/person should do when they perceive reduced movements, including offering prompt CTG assessment.^e

Guidance on managing decreased fetal movements is in the:

- New Zealand College of Midwives' **Assessment and Promotion of Fetal Wellbeing in Pregnancy**²¹⁶
- Stillbirth Centre of Research Excellence's **Clinical practice guideline for the care of women with decreased fetal movements for Women with a Singleton Pregnancy from 28 Weeks' Gestation**.²¹⁷

Doppler assessments in the monitoring and surveillance of SGA and FGR

Umbilical artery Doppler

UA Doppler assessment has been shown to reduce perinatal mortality and is universally recommended in the assessment of SGA and FGR. An abnormal UA Doppler is uncommon in late-onset FGR.⁶⁵

In early-onset FGR, the progression of UA deterioration from elevated resistance (PI > 95th centile) to AEDF and REDF is associated with increasing risk of fetal deterioration and stillbirth. A meta-analysis of 31 studies on risk of fetal death in FGR at < 34 weeks' gestation (N = 5,909 Doppler assessments and 336 fetal deaths) found for:

- AEDF, a weighted OR of fetal death of 3.6 (95% CI 2.3, 5.6)
- REDF, a weighted OR of 7.3 (95% CI 4.6, 11.4).²¹⁸

The time interval between raised UA PI with end-diastolic flow to late fetal cardiovascular changes necessitating birth depends on gestation and severity of underlying placental disease.²¹⁹

Fetal middle cerebral artery Doppler or cerebroplacental ratio

In early-onset FGR, UA Doppler better predicts fetal outcome than MCA Doppler. Therefore, MCA evaluation is not recommended in the assessment of early-onset FGR.

In late-onset FGR, fetal cerebral redistribution of blood flow in response to hypoxia is a more sensitive measure of fetal status than UA Doppler and is associated with increased rates of adverse perinatal outcomes in the FGR fetus. By term, approximately 20% of fetuses with late-onset FGR and a normal UA Doppler have an abnormal CPR, with increasing rates of abnormal CPR with increasing gestation.⁹⁴ Observational studies have

^e Patient information on 'Movements Matter' can be accessed online from the Stillbirth Centre of Research Excellence, Stillbirth and Neonatal Death Alliance, Perinatal Society of Australia and New Zealand: <https://stillbirthcre.org.au/parents/safer-baby/movements-matter/>

suggested that the development of cerebral redistribution in late-onset FGR can be associated with clinical decline that occurs within seven days.^{88,89} In the presence of cerebral redistribution, surveillance of fetal wellbeing two times per week is recommended by FIGO⁶¹ and ISUOG.⁶²

Measuring the MCA PI can be technically challenging, particularly in late gestation when the fetal head descends into the maternal pelvis. Some authors reported poor inter-observer reliability of MCA PI measurements.²²⁰ ISUOG recommends that if birth is planned based on an isolated abnormal MCA or CPR, this test should be repeated and confirmed within 24 hours to avoid false positive results.⁶² In an SGA fetus at > 37+0 weeks' gestation with no other evidence of FGR, it is reasonable to repeat an isolated abnormal CPR in an Aotearoa New Zealand context.

Clinical examples

For an SGA fetus with normal UA, normal UtA, normal interval growth but abnormal CPR for the first time at 37+2 weeks' gestation, repeat CPR within 24 to 48 hours:

- If repeat CPR remains abnormal, plan birth.
- If repeat CPR is normal, perform again in three to four days, and if CPR remains normal (that is, two sequential normal CPRs) manage as SGA without evidence of FGR.

An SGA fetus with normal UA Doppler, normal UtA Doppler but abnormal CPR at 35+0 weeks' gestation fulfils the criteria for FGR: they should have Doppler assessments two times per week. If the CPR normalises over two sequential scans, the fetus is considered SGA not FGR and expectant monitoring can continue.

Ductus venosus Doppler in early-onset FGR

Early-onset FGR is characterised by a greater fetal tolerance to hypoxia when compared with late-onset FGR.²²¹ UA Doppler abnormalities that would trigger birth in late gestation (PI > 95th centile) can often be closely monitored in early-onset FGR, allowing for prolongation of the pregnancy. In the presence of severe UA Doppler abnormalities (AEDF or REDF), assessment of the fetal venous circulation, namely the ductus venosus (DV) PI and waveform, has been shown by TRUFFLE to assist in determining risk of fetal deterioration and, therefore, timing of birth.²²²

Flow in the fetal DV during atrial systole is normally in the forward direction. In the presence of increasing placental vascular resistance and/or reduced cardiac function, there is loss of forward flow leading to a progressive increase in the PI, then loss or reversal of the a-wave.^{88,89,223,224} An absent or reversed DV a-wave is associated with an increased risk of fetal acidosis (OR 4.4; 95% CI 1.2, 17.2)²²⁵ and stillbirth (weighted OR 11.6; 95% CI 6.3, 19.7).²¹⁸ In fetuses with an elevated DV PI, further deterioration can occur rapidly.⁸⁸

When AEDF in the UA is present but the criteria for birth are not met, FIGO and ISUOG recommend DV assessment at least every two to three days, with closer monitoring of those with REDF.^{88,223}

Uterine artery Doppler when FGR is suspected

An abnormal UtA Doppler at the time of FGR diagnosis confirms placental insufficiency in both early-onset and late-onset FGR (see **Error! Reference source not found.**). UtA Doppler studies do not need to be repeated after the initial FGR assessment.

FGR fetuses with an abnormal UtA Doppler have a two-fold increased risk (63% compared with 35%) of subsequently developing abnormal fetal cerebral blood flow, which usually occurs earlier in gestation than those with a normal UtA Doppler.²²⁶ If UtA Doppler is abnormal, FIGO recommends at least weekly Doppler assessment of cerebral blood flow (MCA or CPR).⁶¹

Cardiotocography

Assessment by CTG is universally recommended by all guidelines on FGR.^{61-63,67} The frequency of monitoring depends on gestation and presence of Doppler abnormalities.

The FHR pattern reflects gestational age and fetal oxygenation. At earlier gestations, FHR is more sympathetically driven, leading to a higher baseline rate and less baseline variability. As the fetal parasympathetic nervous system matures, baseline FHR reduces and baseline variability increases.

At extreme preterm gestations (23+0 to 25+6 weeks' gestation), CTG may be technically difficult to achieve and interpret, particularly in FGR pregnancies. Management decisions should be individualised and are highly dependent on Doppler studies, EFW and pregnant woman/person and whānau preferences around active care. Hand-held Doppler auscultation or ultrasound visualisation of the FHR at the time of Doppler studies may be more suitable depending on management goals.

Between 26 and 27+6 weeks' gestation, FHR patterns are more likely to be sympathetically dominant due to the immature fetal autonomic nervous system, so CTG should be interpreted with caution.

Progressive hypoxaemia and acidosis cause the fetus to become less active, which is reflected in the antenatal CTG by a loss of FHR accelerations (loss of reactivity). Baseline variability subsequently reduces, reflecting sympathetic dominance due to increased circulating catecholamines. Finally, unprovoked decelerations indicate a fetus that has little reserve and urgent birth must be considered.^{61,62,227}

While CTG assesses current fetal wellbeing, its ability to predict fetal deterioration in FGR pregnancies is unclear. In general obstetric populations, the stillbirth rate in the week following a normal CTG is 1.9 per 1,000 pregnancies.²²⁸ No high-quality evidence exists to

show that antenatal CTG assessment reduces perinatal death or adverse perinatal outcomes, although this has not been studied in specific FGR populations.²²⁹

The optimum frequency of CTG monitoring in FGR is unclear. In late preterm SGA, the Disproportionate Intrauterine Growth Intervention Trial At Term (DIGITAT) randomised SGA pregnancies > 36 weeks' gestation and compared immediate birth with expectant management. The expectant management group had assessments of maternal condition (blood pressure and urinalysis), CTG and amniotic fluid assessment two times per week.²³⁰ While this trial was underpowered to assess perinatal death, those eligible but who declined to be enrolled in the trial had a perinatal mortality of four out of 452 women (8.8 per 1,000 population), compared with no perinatal deaths in the 329 participants with expectant monitoring (or 321 participants with immediate birth).²³¹ This suggests a schedule of surveillance two times per week for near-term FGR is likely to be safe.

CTG should not be the sole method of monitoring or surveillance of an SGA or FGR pregnancy but it has value when used as part of an integrated monitoring programme (see the following section on integrated FGR monitoring and surveillance).⁶¹

Computerised cardiotocography

Standard visual CTG interpretation has significant interobserver variability,²²⁹ which computerised cardiotocography (cCTG) aims to reduce by using computerised algorithms to interpret FHR parameters such as baseline rate, baseline variability, accelerations and decelerations.²²⁷ cCTG also allows for easier longitudinal assessment of short-term variability (STV). When evaluated in randomised trials, the cCTG shows a non-significant trend towards a decrease in perinatal mortality and caesarean compared with a standard CTG. However, randomised controlled trials (RCTs) are small, underpowered to assess mortality and at high risk of bias.²³²

ISUOG recommends cCTG assessment of STV in the management of early-onset FGR (if available),⁶² FIGO and RCOG recommend cCTG at any gestation (if available),^{61,67} while SMFM recommends standard CTG.⁶³

As per the TRUFFLE trial, at < 29 weeks' gestation, STV is reduced if < 3.5 milliseconds and very low if < 2.6 milliseconds.²³³ At 29 to 32 weeks' gestation, STV is considered reduced if < 4 milliseconds and very low if < 3.0 milliseconds. An STV of < 3.0 milliseconds at any gestation is associated with metabolic acidemia and early neonatal death, with a 77% PPV for fetal acidemia.^{227,234}

Biophysical profile score

The biophysical profile (BPP) score is made up of four ultrasound derived components (fetal breathing movements, gross body movements and tone observed over 30 minutes and amniotic fluid assessment). BPP traditionally includes CTG. Each component of the BPP has a score of 0 or 2, with a score of 4 or less out of 10 considered abnormal. A

modified BPP score involves CTG and amniotic fluid assessment only and is considered abnormal if either test is abnormal.

The BPP score was designed to assess fetal acid-base status, with a score of 4 or less (out of 10) associated with a UA pH < 7.^{208,227} In FGR pregnancies, the BPP has a slightly improved ability to predict fetal acid-base status compared with CTG, with a similar accuracy to cCTG.²²⁷

Full BPP assessment is not widely used in Aotearoa New Zealand as the score is time-consuming to determine and has training and resource utilisation implications. A modified BPP score can be used to screen for fetal wellbeing in the clinic setting without requiring formal ultrasound resources. An abnormal screen should trigger further fetal assessment (such as fetal Dopplers).

As with CTG, BPP assessment has limited ability to predict fetal deterioration. A 2014 study of nearly 1,000 fetuses with FGR monitored with Doppler and biophysical findings, found that 90% of the 47 observed stillbirths occurred within one week of a normal BPP.⁸⁹ BPP, alongside CTG, performs best when combined with other methods of monitoring fetal wellbeing and should not be the only surveillance method of an SGA or FGR fetus.

Integrated FGR monitoring and surveillance

An optimal FGR surveillance strategy depends on gestational age and multiple clinical variables, including severity of growth restriction, presence or absence of abnormal Doppler studies and maternal factors. Clinical judgement should always be used to individualise management.

Early-onset FGR

The TRUFFLE trial provides the best evidence managing severe early-onset FGR.⁶⁶ It informs the guideline recommendations from ISUOG and FIGO.^{61,62} TRUFFLE participants had early-onset FGR (defined as AC < 10th centile with UA Doppler PI > 95th centile) and gestation ranged from 26+0 to 31+6 weeks. Participants were randomised to birth based on one of three criteria (that is, there were three study arms):

- reduced cCTG STV
- early changes in DV (PI > 95th centile)
- late DV changes (no DV a-wave).

Normal FHR STV was defined as > 3.5 milliseconds at 26+0 to 28+6 weeks' gestation and > 4 milliseconds at 29+0 to 31+6 weeks' gestation. Additionally, the study set cCTG safety-net criteria for all three arms (including spontaneous repeated persistent unprovoked FHR decelerations, or STV of < 2.6 milliseconds at 26+0 to 28+6 weeks' gestation and < 3.0 milliseconds at 29+0 to 31+6 weeks' gestation in the DV arms (that is, less than the CTG arm).²²² While there were no overall differences in the proportions of

infants surviving without impairment at age two, infants born based on cCTG criteria alone had higher impairments at age two compared with those born with late DV changes (such as the disappearance of the DV a-wave).²²² The DV groups likely benefitted from the additional cCTG safety-net.

Approximately 70% of pregnancies with early FGR also developed maternal hypertensive complications.⁶⁶ Close surveillance of the pregnant woman/person is also required.

Late-onset FGR

Abnormal UA Doppler studies are uncommon in late-onset FGR. Surveillance and monitoring are guided by severity of growth restriction, abnormal cerebral Doppler parameters and evidence of placental insufficiency (such as an abnormal UtA Doppler). Fetuses who have a low risk of deterioration are SGA without evidence of FGR (that is, EFW and AC ³ 3rd centile with normal fetal and UtA Dopplers).

While maternal hypertensive complications are less common in late-onset FGR, hypertensive disorders are still more common than in the general population. Close surveillance for hypertension should occur. New-onset hypertension in the presence of FGR defines pre-eclampsia.

Fetal monitoring technical considerations

Ultrasound examinations in pregnancy should be performed by qualified operators trained in obstetric ultrasound.¹¹² When making clinical decisions based on ultrasound measurements, it is important to consider the inherent inaccuracy in assessment of fetal biometry, EFW calculation and Doppler parameters. For example, an EFW at the 11th centile does not mean the fetus is not SGA. Borderline or newly abnormal Doppler assessments should be repeated (within 24 to 48 hours) before initiating birth if the case would trigger a decision for birth (particularly preterm birth), if resources allow and it is clinically appropriate.

Timing and mode of birth

The timing and mode of birth depends predominantly on gestational age and an assessment of risk of fetal acidosis or stillbirth, weighed up against the risk of neonatal complications. This decision is guided by the results of fetal monitoring and ultrasound assessment. The decision for birth at very preterm gestations occurs when the fetus may already be experiencing a degree of fetal hypoxia or acidaemia. Therefore, birth should occur via pre-labour caesarean section. At later gestations, FGR is usually less severe and fetal hypoxia or acidosis is less likely so IOL is often reasonable with vigilant fetal monitoring.

Antenatal corticosteroids

Antenatal corticosteroids are universally recommended for pregnancies at risk of preterm birth before 35+0 weeks' gestation.^{61–63,67} Corticosteroids have conclusively been shown to improve neonatal outcomes, including for neonates with FGR.²³⁵

Antenatal corticosteroids, especially betamethasone, can cause transient changes in fetal Doppler, FHR and fetal movements. In FGR pregnancies, Doppler parameters often 'improve'. This includes a transient increase in diastolic blood flow in the UA, which may be a result of feto-placental vasodilation and increased fetal cardiac output.^{236,237} FHR changes include a decrease in baseline variability and decrease in reactivity (number of accelerations), but corticosteroids have no influence on FHR decelerations.^{237–240} Fetal movements, including fetal breathing movements, often decline after corticosteroid administration.^{237,239} All changes return to pre-corticosteroid values within 48 to 72 hours, but this needs to be considered when assessing fetal status after corticosteroid administration.

Magnesium sulphate for fetal neuroprotection

Antenatal magnesium sulphate administration to those at risk of preterm birth < 30+0 weeks' gestation has a proven neuroprotective effect for the neonate, with a decrease in the risk of perinatal mortality, cerebral palsy and gross motor dysfunction.²⁴¹

Specific data on magnesium sulphate in FGR fetuses is lacking.²⁴² However, it is reasonable to extrapolate presumed benefit from the existing literature, particularly as FGR has an independent association with cerebral palsy.⁶¹

Transfer of clinical responsibility for care to a tertiary centre

While neonatal units have clearly defined criteria for referral, FGR increases the neonatal risks associated with prematurity. Neonates with FGR born at preterm gestations are at increased risk of bronchopulmonary dysplasia, necrotising enterocolitis and retinopathy of prematurity, but do not appear to have higher rates of respiratory distress syndrome.²⁴³

Literature on antenatal transfer of preterm FGR pregnancies to tertiary units such as NICUs are limited but can be extrapolated from the general literature on preterm neonatal outcomes. Extremely preterm outborn infants (< 28 weeks' gestation), compared with those born in a tertiary centre, have higher rates of death, neurological injury, cerebral palsy and severe neurodevelopmental impairment, especially cerebral palsy.²⁴⁴ For very preterm infants (28 to 32 weeks' gestation) a 2020 systematic review found insufficient evidence on place of birth to make recommendations,²⁴⁵ but outborn infants born at 29 and 30 weeks' gestation frequently require tertiary transfer for respiratory distress syndrome.²⁴⁶

Timing and mode of birth by gestational age

Absolute indications for birth^{61,62}

- Grossly abnormal CTG or cCTG (for example, unprovoked decelerations, or reduced STV in babies intended for NICU admission):
 - 26+0 to 28+6 weeks' gestation: STV < 2.6 milliseconds
 - 29+0 to 31+6 weeks' gestation: STV < 3.0 milliseconds.
- Severe maternal concerns (for example, pre-eclampsia with uncontrolled hypertension, HELLP syndrome or other end-organ damage).

Extreme preterm (23+0 to 25+6 weeks' gestation)

Decisions on birth should be individualised and made based on maternal and fetal status, probability of intact survival, and in consultation with fetal medicine, neonatology services, parents and whānau. Fetuses assessed as not intended for NICU admission should not be routinely monitored. Advice on providing care at peri-viability ages is available.^{247,248}

Very preterm (26+0 to 29+6 weeks' gestation)

Because the very preterm FGR fetus benefits significantly from prolonging gestation, the trigger for birth is late DV Doppler changes or cCTG abnormalities, as per the TRUFFLE trial.²²² This includes:

- absent or reversed DV a-wave
- reduced cCTG STV < 3.0 milliseconds
- birth should be via pre-labour caesarean.

Some very preterm fetuses with severe FGR may be pre-viable.

Very or moderate preterm (30+0 to 33+6 weeks' gestation)

After 30+0 weeks' gestation, neonatal survival rates are > 90% with progressive decreases in major neonatal complications with increasing gestation.^{5,66} The optimal birth criteria from 32+0 to 35+6 weeks' gestation have not yet been evaluated in randomised trials but results from the TRUFFLE 2 trial are awaited.²⁴⁹

Recommendations are based on expert consensus. Agreement is universal that the presence of severe UA Doppler changes should result in admission and an immediate plan for birth when:

- AEDF is present ≥34+0 weeks' gestation, or
- REDF is present ≥ 32+0 weeks' gestation.

Birth can be considered for AEDF between 32+0 and 33+6 weeks' gestation and for REDF between 30+0 to 31+6 weeks' gestation. Due to the high chance of fetal hypoxia and acidosis in labour, birth should be via pre-labour caesarean.^{61,62,67,77}

Late preterm (34+0 to 36+6 weeks' gestation)

Recommendations relating to late preterm gestations are based on expert consensus. With a raised UA PI > 95th centile (forward flow present) recommendations on gestation at birth vary. Ranges include:

- 34 to 37 weeks' gestation (the FIGO guideline)⁶¹
- 36+0 to 37+6 weeks' gestation (the ISUOG guideline)⁶²
- by or at 37 weeks' gestation (the RCOG and SMFM guidelines).^{67,77}

General guidance on timing of birth also includes consideration of other features of concern such as cessation of growth, oligohydramnios, and reduced fetal movements or for maternal reasons.

Term (≥ 37+0 weeks' gestation)

Timing of FGR birth at term is informed primarily by DIGITAT, a trial that randomised SGA pregnancies (AC or EFW < 10th centile, normal and abnormal UA Dopplers included, cerebral blood flow not measured) to IOL or expectant monitoring between 36+0 and 41+0 weeks' gestation.²³⁰ Mean gestation at birth in the trial's IOL arm was 38+0 weeks; it was 39+4 weeks' gestation in the trial's expectant arm. IOL did not influence caesarean birth rates or neonatal morbidity. Expectant management resulted in a doubling of rates of pre-eclampsia (from 3.7 to 7.9%) and a nearly tripling of babies with a birthweight < 3rd centile (from 12.5 to 30.6%).

Subgroup analyses revealed that lower special care baby unit (SCBU) or NICU admissions in both trial arms when birth occurred after 38+0 weeks' gestation.²⁵⁰ There were no differences in neurodevelopmental outcomes at age two between the two trial arms. The two predictors of abnormal neurodevelopment were admission to NICU (greater in the IOL arm) or severe growth restriction (greater in the trial's expectant arm).²⁵¹ The study estimated the lowest risk of overall neonatal morbidity occurred with birth at 38 weeks' gestation.²⁵⁰ There are no prospective intervention data on outcomes in late-onset SGA when birth is based on abnormal fetal cerebral blood flow.

The TRUFFLE 2 feasibility study reported prospectively that birth asphyxia, fetal mortality and neonatal morbidity rate are higher for fetuses showing cerebral redistribution (abnormal MCA or CPR) compared with those without (15% compared with 9%).⁹⁵ The TRUFFLE 2 project is recruiting participants to determine whether, among suspected FGR fetuses between 32+0 and 36+6 weeks' gestation, birth on the basis of cerebral blood flow redistribution reduces adverse outcome compared with waiting until the fetal heartrate pattern suggests possible hypoxaemia or acidosis on cCTG.²⁴⁹ Outcomes will include a

composite of poor perinatal outcome, death and short-term hypoxia-related morbidity, alongside neurodevelopment outcomes at two years.

An observational cohort study in a single fetal medicine unit in the United Kingdom compared routine birth of SGA pregnancies at 37 weeks' gestation to a strategy of risk stratification and expectant management for low-risk SGA pregnancies.²⁵² All women referred to the fetal medicine unit with a singleton non-anomalous SGA fetus with normal UA between 2014 to 2015 were stratified into low-risk and high-risk SGA pregnancies.^f Those with a high-risk SGA pregnancy were recommended to birth at 37+0 weeks. Low-risk SGA pregnancies were managed expectantly to 40 weeks' gestation. Outcomes were compared with SGA pregnancies from their own unit from 2013 to 2014 where all pregnancies were delivered at 37 weeks' gestation (based on the RCOG guideline of the time). The risk stratification approach, compared with routine care, was associated with a reduction in:

- IOL (66 compared with 54%; OR 0.60; 95% CI 0.37, 0.98)
- caesarean section (40% compared with 24%; OR 0.49; 95% CI 0.29, 0.82)
- NICU or SCBU admission (39% compared with 13%; OR 0.22; 95% CI 0.12, 0.41)
- neonatal composite outcome (22% compared with 9%; OR 0.36, 95% CI 0.18, 0.72).

A corresponding increase occurred in vaginal birth (60% compared with 83%; OR 3.13; 95% CI 1.80, 5.42) and birth > 39 weeks' gestation (20% compared with 35%; OR 2.28; 95% CI 1.33, 3.94).

Late-onset FGR fetuses who are at the highest risk of complications in labour are those with severe FGR or abnormal fetal Doppler. In a prospective study of 509 suspected SGA fetuses (EFW < 10th customised centile \geq 32+0 weeks' gestation), high-risk SGA fetuses^g had higher rates of caesarean birth for non-reassuring fetal status (29.3% compared with 7.9%, $p < .001$) and neonatal acidosis (11.7% compared with 5.0%, $p = .009$) compared with low-risk SGA fetuses. The rates of adverse outcomes in low-risk SGA fetuses were not statistically significantly different from AGA fetuses.²³ It is important to highlight that the caesarean section rate for high-risk SGA was approximately 30%, meaning the predictive value for caesarean in labour in FGR is not sufficient to routinely recommend pre-labour caesarean birth.

Labour induction and fetal surveillance in labour

Cervical ripening and IOL can be achieved with prostaglandins or mechanical methods like balloon catheters. A 2020 systematic review and meta-analysis of adverse intrapartum outcomes in late-onset FGR undergoing mechanical compared with vaginal prostaglandin IOL found limited evidence on the optimal IOL method.²⁵³ Mechanical methods seemed to

^f High-risk SGA pregnancy was defined as an EFW < 3rd percentile, CPR < 5th centile, mean UtA Doppler at the 20 week anatomy scan > 95th centile, PAPP-A < 0.3 MoM in the first trimester, or maternal hypertension.

^g High-risk was defined as EFW < 3rd percentile, abnormal CPR or abnormal UtA Doppler.

be associated with a lower rate of caesarean birth and intrapartum adverse events, but direct comparisons between methods were not possible with low quality studies and considerable clinical heterogeneity. A Cochrane review of IOL in unselected populations (the main indication for IOL was post-dates) compared low dose (50 micrograms) oral misoprostol with mechanical IOL and found that misoprostol may reduce the risk of caesarean section (RR 0.84, 95% CI 0.75 to 0.95; six trials, n = 2993 women; low-certainty evidence) and may make little or no difference to the risk of uterine hyperstimulation with fetal heart rate changes (RR 1.31, 95% CI 0.78 to 2.21; four trials, n = 2828 women; low-certainty evidence).²⁵⁴ Robust data on the optimum method of IOL in FGR pregnancies is lacking.

Continuous CTG monitoring in labour is recommended for all SGA and FGR pregnancies. As FGR fetuses have a higher chance of caesarean birth for non-reassuring fetal status and neonatal acidosis, all guidelines recommend continuous CTG monitoring in labour.^{61,62,67} This should be from the onset of regular uterine activity. While SGA pregnancies with no evidence of FGR are at lower risk of intrapartum complications, these pregnancies still show higher rates of histological placental under-perfusion⁸² and some authors have found a greater chance of caesarean section for fetal compromise compared with AGA fetuses.⁸⁴ Continuous CTG monitoring in active labour for SGA fetuses is recommended.

When in spontaneous labour, early admission is recommended to facilitate continuous CTG monitoring.⁶⁷

Recommendations: Antenatal management

Antenatal management recommendations		Evidence level	Grade of recommendation	Rationale
Actions to be completed by primary maternity services provider				
21	<p>If FGR is suspected, complete an initial assessment:</p> <ul style="list-style-type: none"> confirm gestational age consider risk factors for placental-mediated FGR, including risk factors 	2++	B	These parameters enable the accurate diagnosis and management of FGR, including identification of non-placental causes of FGR.

	<p>that may have developed during pregnancy</p> <ul style="list-style-type: none"> • review antenatal screening for aneuploidy and other conditions (such as MSS1, MSS2 and NIPT), if performed • review ultrasound for fetal biometry and Doppler studies (UA, UtA and CPR if $\geq 32+0$ weeks' gestation) • review ultrasound for fetal anatomy and placental location or morphology. 			
22	<p>Recommend referral for obstetric specialist review for all pregnant women/people with SGA or FGR.</p> <p>Refer or discuss with fetal medicine:</p> <ul style="list-style-type: none"> • early-onset FGR (particularly $< 28+0$ weeks' gestation) • FGR with associated polyhydramnios or fetal malformation, regardless of gestational age. 	4	GPP	<p>Fetal medicine review includes a detailed anatomy survey and discussion of options of genetic testing, including amniocentesis with testing for FISH or qfPCR and, if abnormal, Giemsa-band karyotype. If normal, proceed with microarray. Also consider PCR for infectious agents at the time of invasive testing.</p>

Actions to be completed by specialist maternity services providers				
23	<p>In early-onset or severe FGR (EFW < 3rd centile), consider screening for congenital infection with maternal serology for:</p> <ul style="list-style-type: none"> • CMV (IgG and IgM) • rubella if not clearly immune (IgG and IgM) • syphilis (if higher risk; EIA screen initially) • toxoplasmosis (IgG and IgM). 	2++	B	Services may request LMCs to order these tests as part of their agreed referral pathways. A full TORCH screen is not required in all cases.
24	<p>Clinical management of pregnant women/people with suspected or confirmed FGR includes consideration of gestational age, severity of FGR and multimodality assessment, including cardiotocograph (CTG), ultrasound for fetal biometry and fetal Doppler (UA, CPR, UtA, ± ductus venosus, DV, if indicated).</p>	2+	C	These parameters enable accurate understanding of fetal wellbeing and inform management.
	<p>Do not use CTG assessment in isolation</p>	1+	A	CTG provides an assessment of current fetal wellbeing but has limited ability to predict fetal deterioration.
25	For an isolated finding of abnormal CPR in a term	3	D	SGA without FGR is defined as EFW from 3rd

	SGA fetus without evidence of FGR consider repeating the ultrasound assessment within 24 to 48 hours (if resources allow) to mitigate the possibility of a false positive result, particularly if the result informs a planned birth < 38+0 weeks' gestation.			<p>to < 10th centile, normal fetal and maternal Dopplers, and normal fetal growth.</p> <p>MCA PI measurements have poor inter-observer reliability.</p> <p>To support sonography resources, repeat Doppler studies within a short timeframe should be targeted to Doppler studies (\pm amniotic fluid assessment). Further 'routine' examination of the fetus is not required.</p>
26	Ensure all Doppler studies are performed by operators with appropriate training and expertise in each study to minimise measurement errors.	4	GPP	Technical information on Doppler measurements is detailed in the <u>New Zealand Obstetric Ultrasound Guidelines</u> . ¹¹²
27	Use computerised cardiotocograph (cCTG) where possible rather than CTG in the assessment of early-onset FGR . If cCTG is not available or not used, assess fetal wellbeing using a combination of conventional CTG and fetal Doppler studies.	2+	C	Fetal heart rate (FHR) assessments with cCTG <u>improve</u> interobserver <u>reliability</u> and allow for detailed assessment of STV. cCTG has an inbuilt algorithm for assessing short-term variability (STV). This is different to electronic CTG, which is a digital version of a conventional CTG.
28	Where there is isolated SGA without evidence of	2+	B	SGA without FGR is EFW 3rd to < 10th centile, normal fetal and maternal

	<p>FGR, up to 36+6 weeks' gestation, perform:</p> <ul style="list-style-type: none"> ultrasound for fetal growth, UA Doppler and amniotic fluid volume (\pm CPR if \geq 32+0 weeks' gestation) every two weeks clinical review every two weeks. <p>In addition, from 37+0 weeks' gestation:</p> <ul style="list-style-type: none"> perform weekly clinical review consider weekly ultrasound for UA Doppler, amniotic fluid volume and CPR recommend birth at 40+0 weeks' gestation (and not earlier than 39+0 weeks' gestation) if spontaneous labour has not occurred. 			<p>Dopplers and normal fetal growth.</p> <p>Increase surveillance and/or consider inpatient monitoring if there is oligohydramnios, static or very poor interval growth or suspected pre-eclampsia.</p> <p>Individualise timing of birth recommendations and discuss and agree with the pregnant woman/person, their whānau (if appropriate) and the LMC.</p>
29	<p>Where early-onset FGR occurs with forward flow in the UA, perform:</p> <ul style="list-style-type: none"> at least weekly ultrasound for UA Doppler and amniotic fluid volume at least weekly clinical review and cCTG (or CTG if 	3	C	<p>Increase surveillance and/or consider inpatient monitoring if there is oligohydramnios, static or very poor interval growth or suspected pre-eclampsia.</p>

	<p>cCTG is not available)</p> <ul style="list-style-type: none"> ultrasound for fetal growth every two weeks. 			
30	<p>Where early-onset FGR occurs with absent end-diastolic flow (AEDF) or reversed end-diastolic flow (REDF) in the UA:</p> <ul style="list-style-type: none"> admit to a unit with appropriate neonatal services for inpatient monitoring and birth planning perform at least twice daily cCTG (or CTG if cCTG is not available) and clinical review perform ultrasound for UA, DV Doppler and amniotic fluid volume two to three times every week <p>For AEDF: recommend birth by pre-labour caesarean by 32+0 to 33+6 weeks' gestation.</p> <p>For REDF: recommend birth by pre-labour caesarean by 30+0 to 31+6 weeks' gestation.</p>	2++	A	<p>Do not perform DV Doppler after 34+0 weeks' gestation as fetuses with AEDF or REDF in the UA have met the gestation criteria for birth.</p> <p>Individualise timing of birth recommendations and discuss and include fetal medicine and neonatology input. Discuss and agree recommendations with the pregnant woman/person, their whānau (where appropriate) and the LMC.</p>
31	<p>Where late-onset FGR occurs:</p> <ul style="list-style-type: none"> perform ultrasound for UA, CPR Doppler 	2+	B	<p>Increase surveillance and/or consider inpatient monitoring or earlier birth if clinical concern exists (oligohydramnios, static or</p>

	<p>and amniotic fluid volume two times per week</p> <ul style="list-style-type: none"> perform clinical review and CTG two times per week perform ultrasound for fetal growth every two weeks recommend birth by 38+0 weeks' gestation (usually not before 37+0 weeks' gestation). 			<p>very poor interval growth or suspected pre-eclampsia).</p> <p>Individualise timing of birth recommendations and discuss and agree with the pregnant woman/person, their whānau (if appropriate) and the LMC.</p>
32	<p>Absolute indications for birth are:</p> <ul style="list-style-type: none"> grossly abnormal CTG or cCTG (eg, unprovoked decelerations, or reduced STV in babies intended for neonatal intensive care admission) severe maternal concerns (eg, pre-eclampsia with uncontrolled hypertension, HELLP syndrome or other end-organ damage). 	4	GPP	<p>Reduced STV are:</p> <ul style="list-style-type: none"> 26+0 to 28+6 weeks' gestation: STV < 2.6 milliseconds 29+0 to 31+6 weeks' gestation: STV < 3.0 milliseconds. <p>The definition of grossly abnormal cCTG or CTG aligns with the findings of the TRUFFLE study.⁶⁶</p> <p>Individualise timing of birth recommendations and discuss and agree with the pregnant woman/person, their whānau (if appropriate) and the LMC.</p>
33	<p>Follow the same administration protocols for antenatal corticosteroids (including repeated doses) and magnesium sulphate in</p>	1+	A	<p>Antenatal corticosteroids and magnesium sulphate improve outcomes for FGR neonates.</p>

	<p>FGR pregnancies at risk of preterm birth as for non-FGR pregnancies.</p> <p>Do not delay birth to complete corticosteroids or magnesium sulphate if concern exists about imminent fetal or maternal deterioration.</p>			
34	<p>Following antenatal corticosteroid administration, decisions on birth for presumed fetal compromise should be consultant-led and made with appropriate caution due to corticosteroid effects on FHR.</p>	4	D	<p>Antenatal corticosteroids can cause transient changes in fetal Doppler, FHR and fetal movements that make interpretation of true fetal compromise more difficult.</p>
35	<p>Transfer pregnant women/people with FGR to a hospital with a tertiary neonatal unit if:</p> <ul style="list-style-type: none"> • at risk of birth < 28+0 weeks' gestation • EFW < 1,000 g. <p>Discuss transfer of pregnant women/people to a tertiary service if:</p> <ul style="list-style-type: none"> • at risk of birth at 28 to 32 weeks' gestation • EFW 1,000 grams to 1,500 grams, depending on the local level of neonatal care 	4	D	<p>Antenatal transfer of pregnant women/people with FGR pregnancies at risk of preterm birth improves neonatal outcomes and prevents postnatal tertiary transfer.</p>

	available and consideration of overall risk.			
36	<p>Recommend birth by pre-labour caesarean if there is late UA (AEDF or REDF) or DV Doppler changes, abnormal CTG or contraindications for vaginal birth.</p> <p>Consider induction of labour for most other pregnant women/people with FGR.</p> <p>Consider birth by pre-labour caesarean for maternal indications such as severe pre-eclampsia or HELLP.</p>	4	GPP	FGR alone is not an indication for caesarean.
37	Consider using mechanical methods to induce labour (such as a Foley or balloon catheter).	4	GPP	Mechanical methods may be associated with lower rates of uterine hyperstimulation than vaginal dinoprostone. Low dose oral misoprostol probably has a similar risk of uterine hyperstimulation and may reduce the risk of caesarean compared with mechanical methods, however the certainty of evidence is low. Robust data on the optimum method of IOL in FGR pregnancies are lacking.
38	Recommend continuous CTG monitoring in active labour for all SGA and	4	GPP	While isolated SGA without evidence of FGR carries a lower risk of

	FGR pregnancies (that is, from the onset of regular contractions), including a full discussion of the risks and benefits.		intrapartum compromise than FGR, SGA pregnancies still have higher rates of placental under-perfusion and a greater chance of fetal compromise requiring caesarean birth compared with appropriate for gestational age pregnancies.*
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AEDF = absent end-diastolic flow; cCTG = computerised cardiotocography; CMV = cytomegalovirus; CPR = cerebroplacental ratio; CTG = cardiotocography; DV = ductus venosus; EFW = estimated fetal weight; EIA = enzyme immunoassay; FGR = fetal growth restriction; FHR = fetal heart rate; HELLP = haemolysis, elevated liver enzymes and low platelets; IgG = immunoglobulin G; IgM = immunoglobulin M; IOL = induction of labour; LMC = Lead Maternity Carer; MCA = middle cerebral artery; NIPT = non-invasive prenatal testing; PCR = polymerase chain reaction; PI = pulsatility index; REDF = reversed end-diastolic flow; SGA = small for gestational age; STV = short-term variability; UA = umbilical artery; UtA = uterine artery.

* Respect the pregnant women/person's decision if they decline continuous CTG.

Evidence summary:

Maternal postnatal management

Postnatally, many parents and whānau want to understand why FGR occurred and whether it can be prevented in a future pregnancy. There are also important long-term health considerations for those who have had an FGR baby.

Future cardiovascular disease risk for those who have had an FGR baby

Those who give birth to a baby with FGR or who experience another placental-mediated complication (such as pre-eclampsia) have a well-established increase in long-term cardiovascular risk. A stronger association exists with early-onset CVD. A 2001 retrospective observational study of 130,000 women with 15 to 19 years of follow-up data showed a two-fold increased risk of ischaemic heart disease in women who gave birth to a

low birthweight baby (hazard ratio 1.9; 95% CI 1.5, 2.4, absolute risk increase of 0.2% to 0.44%).²⁸ Pregnancy complications additional to low birthweight increased the CVD risk further: women with a low birthweight baby, preterm birth and pre-eclampsia had a seven-fold increased risk (hazard ratio 7.0; 95% CI 3.3, 14.5).²⁸ These findings have been replicated in other observational studies.^{26,27} Further, the risk of CVD is highest with the smallest babies.²⁵⁵

Other CVD-related morbidities are also higher in those who give birth to an SGA baby, including cerebrovascular events and renal disease such as hypertensive renal disease.^{27,256} The associations seen between SGA or FGR and maternal cardiovascular risk is likely related to both environmental and genetic influences. Strategies to mitigate CVD include routine health and wellbeing advice, maintaining a healthy BMI and regular lifelong screening for cardiovascular complications such as hypertension and hypercholesterolaemia.

Future pregnancy planning

Those who have had a baby with FGR should be counselled about the benefits of entering a subsequent pregnancy in the best possible health and minimising risk factors. This includes providing appropriate general advice on:

- diet
- physical activity
- maintaining a healthy BMI
- optimising underlying medical conditions
- stopping smoking
- pre-pregnancy folic acid supplementation (which is protective)⁶⁷ (*Recommendation 14*).

Providing advice on optimal interpregnancy interval may be appropriate.⁶⁷ In addition, early booking in a subsequent pregnancy allows for confirmation of gestational age, comprehensive assessment of risk factors and initiation of aspirin < 16+6 weeks' gestation.

Risk of recurrence of FGR

The risk of a subsequent pregnancy being affected by FGR depends on several factors, including:

- gestational age at onset
- severity of growth deviation

- concomitant hypertension and pre-eclampsia
- gestation at birth
- presence of maternal underlying disease
- potentially modifiable risk factors such as cigarette smoking.

Histopathological examination of the placenta from the previous pregnancy can provide important information on the risk of recurrence.²⁵⁷

A 2009 population-based observational study of 300,000 births (occurring from 1978 to 1997) examined the recurrence of SGA in a subsequent pregnancy. Those who gave birth to a baby with SGA experienced nearly four-fold increase in rate of SGA in a second pregnancy, compared with those whose first baby was not SGA (24% compared with 6.1%; aOR 3.9; 95% CI 3.7, 4.0).²⁰² This recurrence rate is consistent across population-based studies.^{29,30,202} The chance of recurrence of SGA in a second pregnancy is higher if the first infant was < 5th centile (aOR 5.7; 95% CI 5.4, 6.0).

SGA in a subsequent pregnancy occurs around the same gestational age as it occurred in the first SGA pregnancy.²⁰²

Placental histopathology

Histological evidence of placental insufficiency is not always evident in the placentae of babies with FGR. Some placental pathologies (such as chronic villitis of unknown aetiology, histolytic intervillitis and massive perivillous fibrin deposition) have high recurrence rates in subsequent pregnancies and are associated with significant morbidity and mortality.^{82,257}

Placental histopathology is recommended in other FGR guidelines:

- NZMFMN previously recommended placental histopathology be completed if the cause was unclear (for example, pre-existing maternal disease, cigarette smoking etc.)¹
- FIGO recommends placental histopathology for all FGR births 'where available'.⁶¹

The main types of placental pathologies, the clinical phenotypes associated with these pathologies and their estimated risks of recurrence are summarised in Table 6, which is sourced from the FIGO guideline.⁶¹

Table 6: Placental pathologies, clinical phenotypes and risk of recurrence⁶¹

Placental pathology	Incidence	Common placental findings	Pathophysiology	Phenotype	Risk of recurrence	Recommendations for investigation and prevention in the next pregnancy
Maternal vascular malperfusion (MVM)	Common	Decidual arteriopathy, agglutinated villi, increased syncytial knots, intervillous fibrin deposition, villous infarcts.	Placental malperfusion due to shallow trophoblast invasion and failure of remodelling of spiral arteries.	Early-onset or late-onset fetal growth restriction (FGR), pre-eclampsia, placental abruption.	10 – 25%	Screening for antiphospholipid antibodies may be considered in selected cases of severe early-onset FGR, when placental examination shows features of severe MVM such as especially central or multiple areas of villous infarction Consider aspirin in subsequent pregnancy, especially if associated with pre-eclampsia.
Fetal vascular malperfusion	Relatively common	Avascular villi, chorionic plate or stem villous thrombi,	Most common cause is chronic or intermittent cord obstruction due to	FGR, fetal central nervous system injury, stillbirth.	Low	Consider screening of the infant or the mother/person for hereditary

		obstructive lesions of umbilical cord.	cord compression, entanglement, or hypercoiling. Possible association with hereditary thrombophilia.			thrombophilia. Family history of bleeding disorder or thrombophilia may help to identify those at greatest risk.
Chronic inflammation						
Villitis of unknown aetiology	Relatively common (5 – 10% of term placentae)	Chronic T-cell mediated inflammation of villous stroma.	Maternal graft compared to host response to fetal antigens in the placenta.	Late-onset FGR, abnormal neurodevelopmental outcome, stillbirth.	10 – 50%	-
Chronic histiocytic intervillitis	Rare	Maternal histiocytic infiltrate in the intervillous space	-	Recurrent miscarriages, recurrent severe early-onset FGR, stillbirth	70 – 100%	Suggested interventions include prednisone, hydroxychloroquine, aspirin, low-molecular-weight heparin Associated with increased levels of serum alpha-fetoprotein and alkaline phosphatase

Massive perivillous fibrinoid deposition (maternal floor infarction)	Rare	Large amounts of fibrinoid matrix surrounding villi	Unclear	Recurrent miscarriages, recurrent severe early-onset FGR, stillbirth	10 – 60%	Consider screening for antiphospholipid antibodies, hereditary thrombophilia Anecdotal reports of treatment with aspirin, heparin and intravenous immune globulin.
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Recommendations: Maternal postnatal management

Maternal postnatal recommendations		Evidence level	Grade of recommendation	Rationale
Provided by maternity services in the postnatal period				
39	<p>Send placenta of all FGR babies and (if possible) SGA babies for histopathology.</p> <p>Report histopathology using the Amsterdam workshop consensus criteria²⁴⁸ to identify placental pathologies that have high recurrence rates, particularly for:</p> <ul style="list-style-type: none"> babies with FGR who do not have an obvious identifiable cause <p>or</p> <ul style="list-style-type: none"> severe FGR (< 3rd centile), early-onset FGR and/or preterm birth < 37+0 weeks' gestation. 	3	GPP	<p>A lack of rurally available perinatal pathologists means the placenta may need to be transported to a main centre. This raises concerns about cultural acceptability for some parents and whānau. Providing placental histopathology to those without obvious risk factors for FGR (including those with early-onset, severe growth restriction or preterm birth) may be acceptable given the recurrence risk. Whānau must be offered return of the placenta, given the option of not having it treated with chemicals for preservation, and informed if any portion of the placenta will not be returned to them (for example, if a sample is taken from the placenta for analysis).</p>
40	<p>Tailor counselling about the risk of recurrence of FGR to the woman/person, taking into consideration</p>	4	GPP	<p>This information will help parents and whānau to prepare for any future pregnancies.</p>

	individual risk factors, severity of the FGR, any co-existing pre-eclampsia and any placental histopathology results.			
Provided by general practice-led primary care services				
41	Advise those who have given birth to a baby with FGR of their increased long-term chance of developing cardiovascular disease. Offer cardiovascular health and wellbeing advice, and recommend regular lifelong screening for cardiovascular complications such as hypertension and hypercholesterolaemia to those who have given birth to a baby with FGR.	4 4	GPP GPP	Those who give birth to a baby with FGR or who experience another placental-mediated complication (such as pre-eclampsia) have a well-established increase in long-term cardiovascular risk.

CVD = cardiovascular disease; FGR = fetal growth restriction; GPP = good practice point; SGA = small for gestational age.

Evidence summary:

Diagnosis and management of neonates with FGR

This section focuses on neonates born at $\geq 35+0$ weeks' gestation

Neonates born at < 35 weeks' gestation are usually managed by specialised paediatric or neonatal teams in SCBUs or NICUs. Management for these neonates is not specifically addressed in the clinical practice guideline but the general principles and consequences of FGR in neonates apply regardless of gestation.

As many neonates with FGR are not identified before birth, it is important that all newborn babies are assessed for FGR.²⁵⁹ This allows for preventative care both in the short-term and long-term and for risk management in future pregnancies.

Presentation and diagnosis of neonates with FGR

The diagnosis of FGR in neonates is challenging as anthropometric characteristics vary and there are no pathognomonic features for neonates with FGR. Common signs of FGR include:

- weight and length disproportion (such as, low BMI)
- reduced subcutaneous fat.

In early FGR, the skeleton may be smaller, with the trunk being more affected than the appendicular skeleton (that is, humerus length is relatively preserved).²⁶⁰ HC is often normal, but fontanelle size is frequently increased. Skeletal muscle mass and bone mineral content are usually decreased but are difficult to assess clinically.^{261,262} In late FGR, skeletal size is usually preserved.

The literature search identified no clinical practice guidelines or systematic reviews relating to the diagnosis of FGR in neonates.

Primary studies often use neonatal morbidity to classify neonates who are abnormally small, as FGR is known to be associated with impaired birth transition, resuscitation and admission to NICU or SCBU for respiratory distress, hypoglycaemia, hyperbilirubinaemia and hypothermia. Neonates who are born SGA by customised reference are at increased

risk of neonatal morbidity, with those who are SGA by both customised and population reference (approximately 4% of liveborn infants at term) having the highest risk.¹⁰

Neonates who are SGA by population but not customised reference (approximately 0.5% to 1% of liveborn infants at term) have rates of neonatal morbidity similar to appropriately grown infants.^{10,263,264}

Various indices have been described to identify weight and skeletal disproportion. Across a range of gestations, BMI appears to be the best single measure of weight independent of length,²⁶⁵ and normative data are available.²⁶⁶

Body fat (adipose tissue) in neonates is largely confined to the subcutaneous compartment (~90%). Internal fat deposits do not change substantially in FGR.²⁶⁷ Proportionality measures, such as BMI, have only modest correlation with body fat.²⁶⁸ Therefore, a direct measurement of skin fat (such as skinfold thickness)^{269,270} or whole-body fat (such as air displacement plethysmography) is needed to assess neonatal adiposity. SGA classification by customised reference has moderate predictive value for identification of neonates with low subcutaneous fat.²⁷¹

A neonatometer or large calliper is needed to accurately measure neonatal length. Measurement of crown–heel length by tape measure has wide 95% confidence limits of agreement (-3.1 centimetres to 2.7 centimetres) compared with a neonatometer.²⁷²

Given the lack of consistent criteria, a Delphi process to gather expert consensus defined growth restriction in the neonate as birthweight < 3rd centile by population or customised centiles or at least three out of the following:

- birthweight < 10th centile on population or customised centiles
- HC at birth < 10th centile
- length at birth < 10th centile
- antenatal diagnosis of FGR
- antenatal risk factors (such as hypertensive disorders of pregnancy).²⁷³

Paediatric and neonatal review for neonates with FGR born \geq 35+0 weeks' gestation

While placental insufficiency is the most common cause for FGR, some growth-restricted neonates may have FGR due to other causes for which specific treatment and follow up is required.

There are no large prospective diagnostic studies in neonates with FGR in the absence of placental insufficiency or other confirmed antenatal causes. Multiple retrospective studies in selected groups of asymptomatic neonates with SGA have shown that the yield from testing for congenital infection is very low.^{274–276} Detection rates may be slightly higher for CMV, with several small studies reporting rates of congenital CMV infection in SGA infants of up to 2%^{277,278} compared with an average population rate of 0.6%.²⁷⁹ Urine polymerase chain reaction (PCR) in the first five days after birth is considered the gold standard for diagnosis of congenital CMV,^{280,281} using either cotton balls or urine bags.²⁸² Congenital CMV is the most common cause of non-hereditary sensorineural hearing loss in children.²⁸³ Some evidence exists that treatment with valganciclovir may limit sensorineural hearing loss.^{284–286}

Silver-Russell syndrome is a rare imprinting disorder that should be considered in neonates with non-placental FGR and relative macrocephaly. Infants should be followed for evolving features, including post-natal growth failure, protruding forehead, body asymmetry and feeding difficulties. Molecular testing is complex and generally not indicated at birth. The two most common causes are loss of methylation on chromosome 11p15 and maternal uniparental disomy for chromosome 7.

Screening and treatment to improve neonatal outcomes

FGR is associated with adverse neonatal outcomes, particularly in the immediate postnatal period and first days of age. Approximately half of neonates with FGR develop hypoglycaemia.²⁸⁷ The incidence of other postnatal complications in late preterm or term neonates with FGR has not been well quantified, although in clinical trials of antenatal management for FGR at term or near-term, approximately 11% of neonates with FGR experienced one or more adverse outcomes such as neonatal acidosis, Apgar score < 7 at five minutes, NICU admission, sepsis, hypoglycaemia or perinatal death.²⁸⁸

Among at-risk neonates on a postnatal ward, including neonates with FGR, use of an early warning scored led to earlier recognition of neonatal deterioration and the time to neonatal unit admission was reduced by 4.6 hours.²⁸⁹

A 2019 systematic review and meta-analysis found an association between neonatal hypoglycaemia and a two-fold to three-fold increase in the likelihood of visual-motor problems and executive dysfunction in childhood (low certainty) and a two-fold increase in the likelihood of low educational achievement.²⁹⁰ International consensus on screening and management of neonatal hypoglycaemia is lacking, but experts widely recommend screening of neonates with FGR for 12 to 24 hours after birth.²⁹¹ The *Oral dextrose gel to treat neonatal hypoglycaemia: New Zealand Clinical Practice Guidelines* recommend the use of buccal 40% dextrose gel as primary treatment for neonatal hypoglycaemia (conditional recommendation).²⁹²

A 2021 Cochrane meta-analysis of two studies (N = 2548 infants at risk of developing neonatal hypoglycaemia) found that prophylactic oral dextrose gel (compared with placebo) reduced the risk of hypoglycaemia (RR 0.87; 95% CI 0.79, 0.95; high certainty evidence) and probably reduced the risk of treatment for hypoglycaemia (RR 0.89; 95% CI 0.79, 1.00; moderate certainty evidence), without changing the risk of intravenous treatment for hypoglycaemia (RR 1.01; 0.68, 1.49; moderate certainty evidence) or overall risk of adverse events (RR 1.22; 95% CI 0.64, 2.33; moderate certainty evidence).²⁹³ The long-term effects of prophylactic dextrose gel in neonates with FGR are uncertain. In one trial, children exposed to prophylactic dextrose gel had higher language and motor scores, and reduced risk of low executive function at two years of age.²⁹⁴ In another trial, prophylactic dextrose gel was associated with higher risk of motor delay and lower composite scores for cognitive and language performance at two years of age.²⁹⁵ Follow-up of the children in these studies is ongoing.

Screening and treatment of children after FGR to improve long-term health outcomes

FGR has been identified as a risk factor for adult cardiometabolic disease, although hazard ratios show considerable heterogeneity, with outcomes influenced by the presence of other perinatal risk factors, especially preterm birth and subsequent lifestyle behaviours.^{296,297} A systematic review of the role of screening and treating children with FGR for cardiometabolic risk factors was outside the scope of the clinical practice guideline but may be considered in future updates.

Recommendations: Diagnosis and management of neonates with FGR

Neonatal recommendations		Evidence level	Grade of recommendation	Rationale
42	Calculate a customised birthweight centile for all babies using the GROW app.*	3	D	Customised SGA better identifies at-risk fetuses and neonates than population-based SGA definitions, particularly among Aotearoa New Zealand's diverse ethnicities. Use of a

				single customised reference supports consistent national practice and audit. ²
43	Assess neonates suspected of FGR (that is, customised birth centile ≥ 3 to < 10) by reviewing maternal risk factors for FGR and calculating population cross-sectional z-scores for length, HC and BMI. [†]	3	D	Customised references are available for only birthweight. Cross-sectional population references are needed to assess other anthropometric parameters. Electronic online calculators are available for all neonatal biometry z-scores. LMC and/or secondary services may agree to be responsible for gathering these measurements, depending on local referral pathways.
44	Diagnose FGR in the neonate if one or more of: <ul style="list-style-type: none"> • customised birthweight < 3rd centile • customised birthweight centile from ≥ 3 to < 10 with two or more additional features: <ul style="list-style-type: none"> • BMI z-score $< -1.3^{\ddagger}$ • length z-score $< -1.3^{\ddagger}$ • skin or body fat z-score $< -1.3^{\ddagger}$ (where equipment 	4	D	This definition is a modification of the Delphi expert consensus to ensure consistency with the Growth Assessment Protocol. It recognises low body fat as a key feature of FGR and placental insufficiency as the predominant cause. The inclusion of an antenatal diagnosis of FGR with evidence of placental insufficiency recognises that FGR may occur within the normal birthweight range. Although

	<p>and expertise allow)</p> <ul style="list-style-type: none"> • antenatal diagnosis of FGR • one or more major maternal risk factors for FGR • evidence of placental insufficiency on histology • antenatal diagnosis of FGR and evidence of placental insufficiency (eg, abnormal Doppler studies), even if the customised birthweight is ≥ 10 centile. 			<p>placental histology will not generally be available until the second week after birth, this criterion ensures discharge and clinic diagnoses are as accurate as possible and informs care in a subsequent pregnancy.</p>
45	<p>Arrange paediatric or neonatal review for neonates with FGR and any of:</p> <ul style="list-style-type: none"> • customised birthweight centile < 3 • abnormal first or second trimester maternal screening tests • confirmed or suspected genetic abnormality (eg, dysmorphism, malformation, body asymmetry or disproportionate microcephaly or macrocephaly) • confirmed or suspected congenital 	4	GPP	<p>Neonates with customised birthweight centile < 3 are at greatest risk of transitional problems. They may need ongoing inpatient medical review as well as paediatric or neonatal outpatient follow-up. Neonates with FGR without placental insufficiency are more likely to have a maternal and/or fetal cause. A baby with customised birthweight ≥ 3 centile, with evidence of placental insufficiency and no other issues, does not routinely</p>

	<p>infection (eg, thrombocytopaenia, hepatosplenomegaly, skin rash or disproportionate microcephaly)</p> <ul style="list-style-type: none"> disproportionate microcephaly or macrocephaly (eg, difference between length and HC z-score > 1) poor postnatal growth. 			require a paediatric review.
46	If the baby's length is measured, use a neonatometer, large calliper or measuring mat.	3	D	Accurate measurement of length requires a neonatometer or calliper. A measuring mat will give measurement within 0.5 centimetres if used on a flat surface with two people. Tape measures are not accurate.
Specialist services				
47	Assess neonates suspected of FGR (customised birthweight centile ≥ 3 to < 10th) by measuring skin fat, where equipment and expertise allow.	3	D	Neonates with SGA who have low adiposity are at increased risk of transitional problems after birth. ^{298,299} Direct measurement of neonatal adiposity (skinfold or air displacement plethysmography) is increasingly used as a routine clinical tool, with air displacement plethysmography available at several large maternity centres.

48	<p>Complete the following first-line investigations of neonates with FGR and no clinical evidence of placental insufficiency (ie, abnormal Doppler studies):</p> <ul style="list-style-type: none"> • review routine maternal antenatal serology, including for rubella, HIV and syphilis • consider placental histology (see <i>Recommendation 39</i>) • neonatal <ul style="list-style-type: none"> • FBC • urine CMV PCR <p>Ensure newborn hearing screen is completed.</p>	2-	D	<p>If placental insufficiency is established, alternative diagnoses are rare. In the absence of placental insufficiency, a stepwise approach is recommended, starting with first-line investigations followed by investigation for congenital infections and genetic disorders (as indicated by the clinical features). Positive rubella IgG with negative IgM in later pregnancy does not necessarily exclude primary infection as IgM may clear within a couple of months. A negative syphilis serology screen in early pregnancy does not preclude later primary infection.</p>
49	<p>Complete the following investigations if congenital infection is suspected (such as purpura, hepatosplenomegaly, microcephaly, thrombocytopenia, early jaundice, hearing impairment),:</p> <ul style="list-style-type: none"> • maternal <ul style="list-style-type: none"> • CMV serology (IgG and IgM) • syphilis serology (EIA screen initially) if not 	4	D	<p>Blood CMV PCR is not routinely required but may be considered if the CMV urine is positive, after discussion with an infectious diseases specialist to assess response to anti-viral treatment.</p> <p>Positive maternal CMV or rubella IgG with negative IgM in later pregnancy does not necessarily exclude primary infection as IgM</p>

	<p>tested in third trimester</p> <ul style="list-style-type: none"> • rubella serology (IgG and IgM) if not clearly immune • toxoplasmosis serology (IgG and IgM). • neonatal <ul style="list-style-type: none"> • FBC, LFT, total and conjugated bilirubin • urine CMV PCR • ensure newborn hearing screen is completed • rubella serology (IgG and IgM) if the mother is not clearly immune or negative • syphilis (PCR) if the mother is not clearly negative • toxoplasmosis serology (IgG and IgM) if the mother is not clearly immune or negative • ophthalmology review: cataracts and chorioretinitis • cranial ultrasound: calcifications, ventriculomegaly, cysts • consider abdominal ultrasound 			<p>may clear within a couple of months. A negative syphilis serology screen in early pregnancy does not preclude later primary infection.</p>
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	<p>(hepatosplenomegaly, calcification, ascites) and long bone X-rays.</p> <ul style="list-style-type: none"> • <i>if congenital rubella is confirmed, request blood PCR (EDTA), cerebrospinal fluid PCR and echocardiography</i> • if congenital syphilis is confirmed, request placental PCR, cerebrospinal fluid testing (VDRL) and long bone X-rays • if congenital toxoplasmosis is confirmed, request placental and cerebrospinal fluid PCR. 			
50	<p>If a genetic disorder is suspected, complete the following investigations:</p> <ul style="list-style-type: none"> • molecular karyotype (EDTA) or • if aneuploidy is suspected, FISH and standard karyotype (heparin). <p>Consider consultation with a clinical geneticist.</p>	4	D	<p>If placental insufficiency is well established, alternative diagnoses are rare. In the absence of placental insufficiency, a stepwise approach is recommended, starting with first-line investigations followed by further investigation for congenital infections and genetic disorders as indicated by the clinical features.</p>

51	Monitor neonates with FGR with the New Zealand Newborn Observation Chart and the Newborn Early Warning Score (NOC and NEWS) for ≥ 24 hours.	2+	C	NOC and NEWS have been adopted in most hospitals and are available on the BadgerNet platform.
52	Screen neonates with FGR for hypoglycaemia for 12 to 24 hours. [§]	4	D	FGR is an important risk factor for transitional neonatal hypoglycaemia.

BMI = body mass index; CMV = cytomegalovirus; EDTA = ethylenediaminetetraacetic acid; EIA = enzyme immunoassay; FBC = full blood count; FGR = fetal growth restriction; GAP = Growth Assessment Protocol; GROW = gestation-related optimal weight; HC = head circumference; HIV = human immunodeficiency virus; IgG = immunoglobulin G; IgM = immunoglobulin M; LFT = liver function test; LMC = Lead Maternity Carer; NOC = Newborn Observation Chart; NEWS = Newborn Early Warning Score; PCR = polymerase chain reaction; SGA = small for gestational age.

* Customised centiles for Aotearoa New Zealand are available online at GROW-App NZ (<https://nzaws.growservice.org/App/Account/Login>) and are incorporated into the BadgerNet platform.

† BMI as an indicator of proportionality provides consistency through childhood and beyond. Measures of body composition like fat mass should be referenced to length.^{260,300} Use of BMI allows for partitioning into fat mass index and lean mass index, aiding interpretation.³⁰¹ The Fenton reference or length and HC is the largest cross-sectional reference of neonates from 23+0 to 40 weeks' gestation. It is widely used in Aotearoa New Zealand for monitoring the growth of preterm infants. The Fenton reference is intended to be used with the WHO Child Growth Standard after 50 weeks. Thus, curves from term postmenstrual age have been smoothed to join the WHO Standard.³⁰² The Olsen BMI reference is very large.²⁶⁶ Electronic calculators are available for both references (for example, www.nepios.net) and will be incorporated into the BadgerNet platform.

‡ For assessment of fetal or neonatal growth abnormalities, z-scores are preferred as these reflect the degree of deviation from normal more clearly than centiles. For example, a 40-point drop from the 70th centile is a z-score change of 1, but a 4-point drop from the 5th centile is also z-score change of 1. Z-scores are determined from LMS (Lambda for the skew, Mu for the median, and Sigma for the generalized coefficient of variation) data at each postmenstrual week, which avoids the need to smooth variance and skew that may vary across data sets). A z-score of -1.3 approximates the 10th centile, and a z-score of -1.9 approximates the 3rd centile. Virtually all neonates with a customised centile < 3 also have a population birthweight z-score < -2 . If the population birthweight z-score is -2 to -1.3 and customised birthweight centile is ≥ 10 , the neonate is considered to have excessively constrained in utero growth (that is, low uteroplacental capacity due to physiological factors).

§ Among at-risk neonates who develop transitional hypoglycaemia, 90% present within the first 12 hours after birth. It is unclear whether neonates who are born SGA without FGR have a similar risk of transitional hypoglycaemia. Aotearoa New Zealand clinical practice guidelines for neonatal hypoglycaemia are being developed and will provide evidence-based recommendations for screening neonates who are FGR and/or SGA.

Audit indicators

All suggested audits should include analyses by ethnicity to monitor equity and identify variations in outcome. These can then be utilised to identify and implement areas for quality improvement. Standard audit indicators are shown in Table 7.

Table 7: Standard audit indicators

Audit topic	Indicator
Defining SGA and FGR	Proportion of all pregnancies with a customised fetal growth chart created and used during pregnancy.
	Proportion of all pregnancies identified as SGA or FGR with complete Doppler assessment (UA, CPR, UtA).
	Rate of SGA and FGR diagnosis and detection by ethnicity.
Risk assessment and interventions to reduce FGR risk	Proportion of pregnant women/people who have a risk assessment for FGR at booking.
	Proportion of pregnant women/people who are prescribed low-dose aspirin and who have had a previous SGA or FGR pregnancy or another risk factor where low-dose aspirin is recommended.
	Proportion of pregnant women/people who take pre-pregnancy folic acid.
	Proportion of pregnant women/people who smoke cigarettes who are offered smoking cessation support.
	Proportion of pregnant women/people who smoke cigarettes who quit in pregnancy.
Antenatal screening	Proportion of pregnancies with serial fundal height measurements plotted on a customised antenatal chart.
	Reporting of fetal AC centile on growth ultrasound reports.
	EFW accuracy at an individual and practice or department level. This may include peer review and audit of images or accuracy of EFW compared to birthweight in those where birth occurs shortly after the scan (ie, within one week). ^h
	Proportion of pregnant women/people with risk factors who have appropriately timed ultrasound scans.

^h The following calculator may be helpful: https://www.gestation.net/cse/calculating_scan_errors.htm.

Audit topic	Indicator
	Proportion of pregnant women/people without risk factors who have non-indicated growth scans in the third trimester.
	Proportion of ultrasound scan requests without appropriate clinical information or reason for the scan provided.
	Proportion of babies with AGA birthweight following iatrogenic birth for antenatal diagnosis of SGA (ie, false positive SGA diagnosis).
Antenatal management	Proportion of SGA or FGR pregnancies referred and reviewed antenatally within an appropriate timeframe.
	Proportion of SGA or FGR pregnancies achieving recommended scanning and clinical review frequencies.
	Proportion of antenatally SGA non-FGR babies born $\leq 40+0$ weeks' gestation and their outcomes.
	Proportion of antenatally diagnosed FGR babies born $\leq 38+0$ weeks' gestation and their outcomes.
	Proportion of IOL initiated with mechanical methods in FGR pregnancies.
Maternal postnatal management	Proportion of pregnant women/people who give birth to a neonate with FGR and who receive post-birth counselling on the risk of FGR recurrence and increased rates of long-term CVD.
	Proportion of pregnant women/people with severe FGR or FGR without risk factors with placental histopathology.
Diagnosis and management of neonates with FGR	Proportion of all neonates with a customised birthweight centile.
	Proportion of neonates born SGA who are assessed for FGR.
	Proportion of neonates with FGR in whom FGR is detected antenatally.
	Proportion of neonates with FGR and normal fetoplacental Doppler for whom first-line investigations are completed.
	Proportion of neonates with FGR who have NOC and/or NEWS and hypoglycaemia screening as per national guidelines.
	Rate of neonates with FGR by ethnicity.

AC = abdominal circumference; AGA = appropriate for gestational age; CPR = cerebroplacental ratio; CVD = cardiovascular disease; EFW = estimated fetal weight; FGR = fetal growth restriction; IOL = induction of labour; FGR = fetal growth restriction; NOC = Newborn Observation Chart; NEWS = Newborn Early Warning Score; SGA = small for gestational age; UA = umbilical artery; UtA = uterine artery.

Research recommendations

During the development of the clinical practice guideline, gaps in knowledge were identified. Areas for future research are outlined in this section.

Cultural conceptualisations or experiences of FGR

Researchers could:

- explore te ao Māori conceptualisation of SGA and FGR
- investigate the psychological and/or social impacts of an SGA or FGR diagnosis on whānau
- explore te ao Māori conceptualisation of the histopathological examination of the placenta to inform risk of recurrence of FGR for whānau
- explore the cultural significance of the placenta to ethnic communities in Aotearoa New Zealand, with respect to the conceptualisation of the histopathological examination of the placenta to inform risk of recurrence of FGR for pregnant women/people.

Improving equity

Researchers could investigate:

- ethnic disparity in the rates of neonates with FGR and antenatal screening
- kaupapa Māori initiatives before or during pregnancy to determine effective interventions to reduce inequities in FGR.

Definition and classification of SGA and FGR

Researchers could:

- develop and investigate the clinical utility of customised fetal biometry charts

- investigate the effect of different definitions of FGR on maternal and neonatal short and long-term outcomes
- investigate perinatal and maternal outcomes in AGA pregnancies with slowing AC growth trajectory in the third trimester or with discordant HC and AC centiles
- investigate Hugh and Gardosi's model of customised EFW growth trajectory as a percentage deviation from expected and fetal or neonatal outcomes in an Aotearoa New Zealand context
- investigate the significance of oligohydramnios in the management of FGR.

Risk assessment and interventions to reduce risk

Researchers could investigate:

- the use of biomarkers and integrated risk assessment tools for the prediction of early-onset and late-onset FGR
- short-term and long-term effects of ENDs in pregnancy
- the efficacy of low-dose aspirin for the prevention of FGR in people without risk factors for pre-eclampsia.

Antenatal screening

Researchers could investigate the:

- relationship between customised fundal height decline and risk of FGR, particularly with reference to Hugh and Gardosi's model of customised EFW growth trajectory⁴¹ and whether a similar model decline in customised fundal height predicts FGR
- optimal timing of ultrasound fetal growth assessment in pregnant women/people with major risk factors for FGR
- psychological and/or social impact of being categorised as high risk for SGA or FGR and screened with ultrasound on whānau.

Antenatal management

Researchers could:

- investigate qualitative and physiological aspects of fetal movement and the significance of changes in fetal movement patterns in FGR pregnancies

- investigate mechanical compared to prostaglandin IOL in FGR pregnancies.

Diagnosis and management of neonates with FGR

Researchers could:

- investigate the short-term and long-term health risks for neonates with FGR according to different anthropometric profiles
- investigate outcomes for neonates with FGR who are reviewed by a paediatric or neonatal specialist and those who are not reviewed
- investigate screening for causes of FGR other than placental insufficiency
- investigate postnatal complications in neonates with FGR
- investigate the long-term effects of prophylactic dextrose gel on neonates with FGR
- investigate rates of hypoglycaemia in neonates who are SGA but who do not have FGR.

Appendices

Appendix 1: Process to develop the clinical guideline and the evidence statements

The Accident Compensation Corporation's Neonatal Encephalopathy Taskforce was established in November 2015 to address the growing number of neonatal encephalopathy cases in Aotearoa New Zealand. ACC instituted the development of a national clinical practice guideline on small for gestational age (SGA) and fetal growth restriction (FGR) to contribute to a reduction in the incidence and severity of neonatal encephalopathy. The clinical practice guideline used a multidisciplinary approach to:

- revise and build on the New Zealand Maternal Fetal Medicine Network's 2014 guideline¹
- provide a plan to the Growth Assessment Protocol working group to implement the updated guidance.

The clinical practice guideline reflects international best practice. International literature has been interpreted within the context of Aotearoa New Zealand's model of maternity care (that is, informed decision making with continuity of primary care). Recommendations are based on a systematic review of international evidence. Where evidence is not certain, this is noted and recommendations are based on expert consensus opinion.

The FGR Guideline Development Panel

We wish to acknowledge and thank the FGR Guideline Development Panel for its advice and guidance. Members of the panel were:

- Dr Ngaire Anderson (Chair, Royal Australian and New Zealand College of Obstetricians and Gynaecologists)
- Anna Francis (Family and consumer representative)
- Dr Chris McKinlay (Newborn Clinical Network)
- Claire MacDonald (New Zealand College of Midwives)
- Horia Thompson (New Zealand College of Midwives)
- Katarina Komene (Nga Maia Māori Midwives Aotearoa)

- Dr Kirsten Gaerty (Royal Australian and New Zealand College of Obstetricians and Gynaecologists)
- Martin Necus (Australasian Society for Ultrasound in Medicine)
- Dr Rachael McEwing (Royal Australian and New Zealand College of Radiologists).

Acknowledgements

The panel acknowledges the contributions of Emeritus Professor Lesley McCowan in peer review and quality assurance of the first draft of the new guideline.

Evidence base

Following an outcomes prioritisation process, the panel developed structured clinical questions to inform a detailed evidence review. It agreed a formal systematic review and meta-analysis for each research question was beyond the available resources. Instead, the primary evidence base consisted of guidelines from major international bodies and societies that satisfied the AGREE II framework. For each research question, the panel considered subsequently published systematic reviews and (randomised controlled trials), including whether the additional data strengthened or weakened prior guidance. Where high quality evidence did not exist, the panel considered primary research studies.

Identification and evaluation of published literature

To identify the primary evidence base, external expert Dr Rajesh Kumar Shah undertook a systematic search of the MEDLINE and Google Scholar databases. For questions addressed in the 2014 guideline, the search was limited to evidence published since 2014. The search was restricted to items published in English. The last search occurred in April 2021.

If no systematic reviews or external guidelines were identified in the literature, the panel completed a focused search of MEDLINE and Google Scholar using relevant keywords and MeSH headings.

Two panel members independently assessed the risk of bias of any additional trials using an adaption of ROBINS-I for observational studies of exposures and the AMSTAR 2 critical appraisal tool for systematic reviews. Discrepancies were resolved by discussion or consultation with a third panel member.

Table 8 sets out the four papers that were reviewed and the outcome of that review. Three of the four reviewed papers were included, while Bruun et al.³⁰³ was excluded from contributing to the evidence for the clinical practice guideline.

Table 8: Papers the panel reviewed to determine whether they contributed to the evidence

	Tool	Outcome
Kennedy et al ⁸⁰	CRRH risk of bias tool	Risk of bias – moderate
MacDonald et al ⁸¹	CRRH risk of bias tool	Risk of bias – moderate
Martinez-Portilla et al ¹⁰⁸	AMSTAR 2	Overall confidence – high
Bruun et al ³⁰³	AMSTAR 2	Overall confidence – low

Identification and evaluation of external guidelines

MEDLINE and Google Scholar searches for national or international society guidelines or recommendations on screening, diagnosing or managing SGA or FGR were performed (2014 to present). The panel identified nine external guidelines that addressed one or more of the research questions.

Two panel members blindly evaluated using the AGREE II tool. The panel considered average scores. The panel assessed the published guidelines as having sufficient quality for use in the current guideline if they scored more than 50% for all prioritised domains (scope and purpose, rigour of development, and clarity of presentation).

Stakeholder involvement was not considered a barrier to an evidence-based recommendation, as the current guideline had stakeholder involvement from initiation. Facilitators, barriers and resource implications are likely to differ with different models of healthcare internationally. Therefore, applicability was considered less important. While many guidelines did not explicitly state editorial independence, there is low risk of influence due to the nature of the subject matter.

Four clinical practice guidelines were evaluated as being of sufficient quality for inclusion in the *SGA and FGR Clinical Practice Guideline*. The panel’s assessment is described in Table 9.

Table 9: Guidelines underpinning the *SGA and FGR Clinical Practice Guideline*

Domains	ACR 2019³⁰⁴	FCOG 2015³⁰⁵	FIGO 2021⁶¹	GSGO 2016¹¹₆	ISUOG 2020⁶²	RCOG 2014⁶⁷	SMFM 2020⁶³
1. Scope and Purpose	19%	42%	97%	86%	78%	92%	56%
2. Stakeholder Involvement	50%	36%	75%	58%	36%	39%	31%
3. Rigour of Development	58%	42%	50%	28%	50%	79%	55%

4. Clarity of Presentation	61%	50%	91%	64%	56%	67%	75%
5. Applicability	2%	17%	67%	15%	27%	90%	2%
6. Editorial Independence	92%	50%	63%	54%	50%	100%	54%
Included in the guideline	No	No	Yes	No	Yes	Yes	Yes

ACR = American College of Radiologists; FCOG = French College of Obstetricians and Gynecologists; FIGO = International Federation of Gynecology and Obstetrics; GSGO = German Society of Gynecology and Obstetrics; ISUOG = International Society of Ultrasound in Obstetrics and Gynecology; RCOG = Royal College of Obstetricians and Gynaecologists; SMFM = Society for Maternal Fetal Medicine.

Rating of evidence and grading of recommendations

The certainty of the evidence for each recommendation was rated using a modification of the Royal College of Obstetricians and Gynaecologists' (RCOG) four-level classification system and the strength of recommendations of the Panel was graded using the RCOG A to D grading system (see Table 10), taking account of the evidence level and the directness and applicability of the evidence for the Aotearoa New Zealand context, te Tiriti o Waitangi and issues of geographical access and implementation. In addition, the panel suggested practice points based on the experience and consensus of panel members. All recommendation classifications were agreed to by consensus among panel members.

Table 2: Evidence grading approach

Classification of evidence levels		Grades of recommendations	
1++	High-quality meta-analyses, systematic reviews of RCTs or RCTs with a very low risk of bias	A	At least one meta-analysis, systematic review or RCT rated as 1++ and directly applicable to the target population; or A systematic review of RCTS or a body of evidence consisting principally of studies rated as 1+ directly applicable to the target population and demonstrating overall consistency of results.
1+	Well-conducted meta-analyses, systematic reviews of RCTs or RCTs with a low risk of bias		
1-	Meta-analyses, systematic reviews of RCTs or RCTs with a high risk of bias	B	A body of evidence, including studies rated as 2++ directly applicable to the target population and demonstrating overall consistency of results; or Extrapolated evidence from studies
2++	High-quality systematic reviews of case-control or cohort studies or high-quality case-control or cohort studies with a very low risk of		

	confounding, bias or chance and a high probability that the relationship is causal		rated as 1++ or 1+
2+	Well-conducted case–control or cohort studies with a low risk of confounding, bias or chance and a moderate probability that the relationship is causal	C	A body of evidence, including studies rated as 2+ directly applicable to the target population and demonstrating overall consistency of results; or Extrapolated evidence from studies rated as 2++
2-	Case–control or cohort studies with a high risk of confounding, bias or chance and a significant risk that the relationship is not causal		
3	Non-analytical studies (e.g., case reports, case series)	D	Evidence level 3 or 4; or Extrapolated evidence from studies rated as 2+
4	Expert opinion	GPP	Recommended best practice based on the clinical experience of the guideline development group

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Review

The clinical practice guideline should be reviewed in 2027.

Appendix 2: Cultural safety

Practicing in a culturally safe way is important and a requirement of te Tiriti, particularly the principles of active protection, options, and partnership. It is important health practitioners know that tikanga or correct protocols and practices are often specific to whānau, hapū, rūnanga and iwi and that tikanga is not a 'one size fits all'. Similarly, mātauranga Māori or Māori knowledge is not a single entity; rather there is traditional and contemporary mātauranga Māori. Mātauranga Māori is specific to hapū and iwi environments that include land, seas, waterways, weather systems, the stars, flora and fauna, and things seen and unseen. Well-known forms of mātauranga Māori have been somewhat protected from colonisation by virtue of having been composed or narrated in te reo Māori.

Rangatiratanga or self-determining rights over tikanga and mātauranga Māori is crucial to its safety and survival. For this reason, health practitioners should be careful not to impose their understanding of tikanga or mātauranga Māori onto Māori through maternity care; nor should they assume all Māori are familiar with terms such as tikanga, mātauranga and Te Tiriti. Unfamiliarity with such terms can be experienced by Māori as a diminishment of their mana as expressed by te Tiriti; an outcome that is antithetical to te Tiriti, the clinical practice guideline, and *Ngā Paerewa Health and Disability Services Standard 8134:2021*.³

Health practitioners may find support from their professional association to be helpful in terms of giving effect to the principles of te Tiriti, including:

1. the Medical Council of New Zealand: *He Ara Hauora Māori: A Pathway to Māori Health Equity*³⁰⁶
2. the Midwifery Council of New Zealand: *Statement on Cultural Competence for Midwives*³⁰⁷
3. Ngā Maia Māori Midwives Aotearoa: Turanga Kaupapa, principles that give life and meaning to the midwifery profession's recognition of Māori as tangata whenua and the profession's obligations under te Tiriti (developed by Ngā Maia, and formally adopted by Midwifery Council of New Zealand); see *Midwives' Handbook for Practice*³⁰⁸
4. the Royal Australasian College of Physicians: *Guideline Commentary on Consulting with Māori and their Whānau*.³⁰⁹

Health practitioners may also find it valuable to familiarise themselves with:

5. Māuri Ora Associates: *Best Health Outcomes for Māori: Practice Implications*³¹⁰
6. New Zealand Medical Association: *Improving Māori Health Through Clinical Assessment: Waikare o te Waka o Meihana*³¹¹
7. University of Otago MIHI 501 Health Professionals Course: Application of hui process and Meihana model to clinical practice.

Appendix 3: Abbreviations

AC	Abdominal circumference
ACR	American College of Radiologists
AEDF	Absent end-diastolic flow
AGA	Appropriate for gestational age
aOR	Adjusted odds ratio
AREDF	Absent or reversed end-diastolic flow
AUC	Area under curve
BMI	Body mass index
BPP	Biophysical profile
cCTG	Computerised cardiotocograph
CI	Confidence interval
CMV	Cytomegalovirus
CPR	Cerebroplacental ratio
CTG	Cardiotocograph
CVD	Cardiovascular disease
DIGITAT	Disproportionate Intrauterine Growth Intervention Trial at Term
DV	Ductus venosus
EDTA	Ethylenediaminetetraacetic acid
EFW	Estimated fetal weight
EIA	Enzyme immunoassay
ENDs	Electronic nicotine delivery systems
FBC	Full blood count
FCOG	French College of Obstetricians and Gynecologists
FGR	Fetal growth restriction
FHR	Fetal heart rate
FIGO	International Federation of Gynecology and Obstetrics
GAP	Growth assessment protocol
GPP	Good practice point
GSGO	German Society of Gynecology and Obstetrics
GROW	Gestation-related optimal weight
GWG	Gestational weight gain
HC	Head circumference
HELLP	Haemolysis, elevated liver enzymes and low platelets

HIV	Human immunodeficiency virus
PIgG	Immunoglobulin G
IgM	Immunoglobulin M
INTERGROWTH 21 ST	International Fetal and Newborn Growth Consortium for the 21 st Century
IOL	Induction of labour
ISUOG Gynecology	International Society of Ultrasound in Obstetrics and
LFT	Liver function test
LMC	Lead maternity carer
MCA	Middle cerebral artery
MOM	Multiples of the median
MVM	Maternal vascular malperfusion
NEWS	Newborn Early Warning Score
NICU	Neonatal intensive care unit
NIPT	Non-invasive prenatal testing
NOC	Newborn Observation Chart
NZMFMN	New Zealand Maternal Fetal Medicine Network
OR	Odds ratio
PAPP-A	Pregnancy-associated plasma protein-A
PCR	Polymerase chain reaction
PI	Pulsatility index
PPV	Positive predictive value
RCOG	Royal College of Obstetricians and Gynaecologists
RCT	Randomised controlled trial
REDF	Reversed end-diastolic velocity
ROC curve	Receiver operating characteristic curve
RR	Relative risk
SCBU	Special care baby unit
SGA	Small for gestational age
SMFM	Society for Maternal Fetal Medicine
STV	Short-term variability
TRUFFLE	Trial of Randomized Umbilical and Fetal Flow in Europe
UA	Umbilical artery
UtA	Uterine artery
WHO	World Health Organization

Appendix 4: Te reo Māori kupu

hapū	Kinship group, subtribe
hauora Māori	Holistic view of health and wellbeing
iwi	Extended kinship group, tribe
karakia	Incantation
kaupapa Māori	Māori approach, Māori customary practice, Māori principles
mana	Authority, influence, status
mana motuhake	Autonomy, independence
mātauranga	Knowledge
rangatiratanga	Self-determining rights
rongoā	Medicine or treatment
rūnanga	council, assembly, board
te ao Māori	the Māori worldview
te reo Māori	the Māori language
te Tiriti o Waitangi	The Treaty of Waitangi
tikanga	Correct cultural practice or custom
tino rangatiratanga	Self-determination
wāhine	Women
whānau	Family (in a broad sense)

References

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