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Planning management and delivery of the growth-restricted fetus

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A B S T R A C T

A uniform approach to management of fetal growth restriction (FGR) improves outcome, prevents stillbirth, and allows appropriately timed delivery. An estimated fetal weight below the tenth percentile with coexisting abnormal umbilical artery (UA), middle cerebral artery (MCA), or cerebroplacental ratio Doppler index best identifies the small fetus requiring surveillance. Placental perfusion defects are more common earlier in gestation; accordingly, early-onset (≤32 weeks of gestation) and late-onset (>32 weeks) FGR differ in clinical phenotype. In early-onset FGR, progression of UA Doppler abnormality determines clinical acceleration, while abnormal ductus venosus (DV) Doppler precedes deterioration of biophysical variables and stillbirth. Accordingly, late DV Doppler changes, abnormal biophysical variables, or an abnormal cCTG require delivery. In late-onset FGR, MCA Doppler abnormalities precede deterioration and stillbirth. However, from 34 to 38 weeks, randomized evidence on optimal delivery timing is lacking. From 38 weeks onward, the balance of neonatal versus fetal risks favors delivery.

Introduction

Fetal growth restriction (FGR) is a physical manifestation of a number of etiologies including placental dysfunction. The key issues in the management of a pregnancy complicated by FGR are the

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identification of the fetus at greatest risk for deterioration, the utilization of the most appropriate surveillance approach, and determination of the delivery threshold. There is good evidence that a uniform management to diagnosis and management of FGR consistently produces better outcome than is reported in observational studies that rely on a range of diagnostic, surveillance, and delivery criteria [1–6]. One important challenge that affects all aspects of management is the phenotypic variation of FGR across gestational age. The aim of this article is to review the clinical phenotype of placenta-based FGR and the main aspects of the management components in these patients.

Clinical phenotype of fetal growth restriction and gestational age

FGR evolves from a preclinical phase to clinically apparent growth delay and may eventually progress to fetal deterioration. Normal fetal growth and development relies on the placental delivery of nutrients, as well as transplacental gas and fluid exchange [7]. Decreased transplacental glucose and nutrient transfer, due to a reduction in either active transport mechanisms or abnormal placental perfusion, can lead to FGR. Because hepatic glycogen stores are depleted under these circumstances, growth of the abdominal circumference (AC) decelerates. A decrease in transplacental fluid transfer or impaired fetal fluid uptake in the setting of abnormal umbilical venous blood flow may accompany or predate nutritional deficiency and is associated with oligohydramnios [8–10]. Increased blood flow resistance in the maternal uterine arteries [11–13] or the fetal umbilical arteries [14] indicates that the vascular mechanisms that are important for maternal nutrient delivery or fetal nutrient uptake and waste exchange are deficient. When transplacental gas transfer becomes abnormal, leading first to hypoxemia and then hypercarbia, additional fetal responses such as decreased activity [15,16], decreased blood flow resistance [17,18], or increased peak systolic velocity [19,20] in the middle cerebral artery (MCA) may be observed. The aspects of placental function, which are predominantly affected, determine the clinical phenotype of FGR at the time of diagnosis and progression as placental dysfunction worsens. Placental lesions that are associated with underperfusion in the fetal and maternal compartments are more common at earlier gestational age [21–23]. Although placental pathology probably changes over the continuum of gestational age, expert opinion considers FGR presenting before 32 weeks as “early onset” and thereafter as “late onset” [24].

Early-onset FGR

With a higher prevalence of villous perfusion abnormalities, decreased umbilical artery (UA) end-diastolic velocity (EDV) proportional to the degree of flow impairment is more commonly observed in early-onset FGR [25,26]. It is the rate of increase in UA blood flow resistance and specifically how rapidly EDV is lost that determines the rate and degree of fetal deterioration [26–28]. In the preterm FRG fetus with increased UA blood flow resistance, MCA brain sparing may be present or develop as a sign of progressive cardiovascular responses to placental dysfunction [26,29–31]. Further increasing UA blood flow resistance, worsening acidemia, and superimposing cardiac dysfunction eventually can lead to abnormal precordial venous Doppler parameters [26,27,30,32,33]. This degree of cardiovascular deterioration typically precedes an abnormal biophysical profile score or stillbirth (Fig. 1) [33–35]. The latency from diagnosis to late cardiovascular changes may range between 4 and 6 weeks and is determined by the rate at which UA-EDV is lost and by the gestational age [26,36].

Late-onset FGR

Owing to the higher prevalence of villous diffusion abnormalities and a lesser degree of perfusion abnormalities, late-onset FGR may present with little or no UA index elevation but rather uterine artery Doppler index increase or a decrease in umbilical venous volume flow [37]. Despite the seemingly “normal” placental function in the presence of a normal UA Doppler index, MCA brain sparing or a decrease in the cerebroplacental Doppler ratio (CPR) may be observed documenting decreased placental O_2 transfer [26,30,35,38,39]. In the clinical progression, a decreased CPR progressing to brain sparing can be observed [40]. Additional signs of deterioration preceding stillbirth include a decline in amniotic fluid volume or abnormal fetal heart rate parameters (Fig. 2) [30,35]. Because UA Doppler is

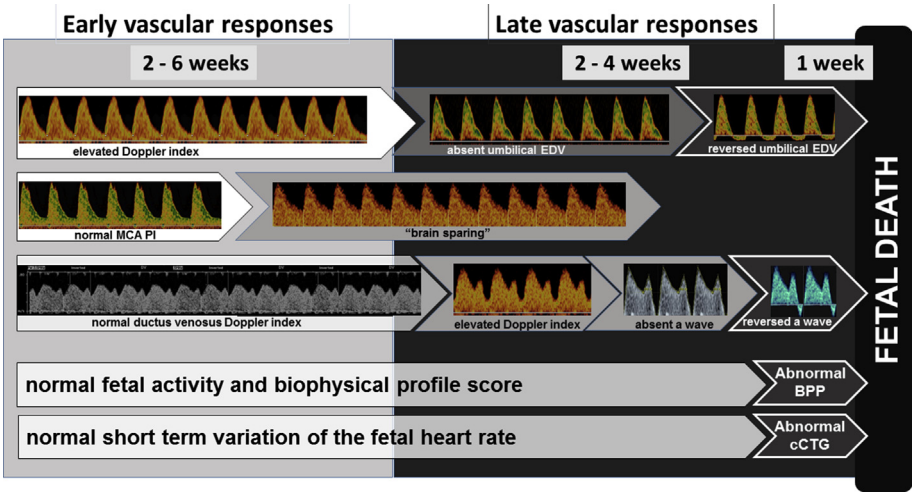

Fig. 1. Clinical evolution of early-onset fetal growth restriction. The figure illustrates the typical clinical progression of surveillance abnormalities in fetal growth restriction (FGR) diagnosed before 32 weeks of gestation. An increase in the umbilical artery Doppler index indicates a decrease in the villous vasculature and therefore a perfusion defect in the placenta. The loss of umbilical artery end-diastolic velocity and a subsequent increase in venous Doppler indices are the key indicators of progression of placental dysfunction and advancing fetal deterioration, respectively. Because the majority of early-onset FGR occurs before maturation of fetal heart rate reactivity, the computerized cardiotocogram (cCTG) or the biophysical profile (BPP) are the most biophysical parameters to assess fetal well-being. Reversal of the ductus venosus a-wave is strongly associated with a subsequently abnormal BPP or stillbirth if the fetus remains undelivered.

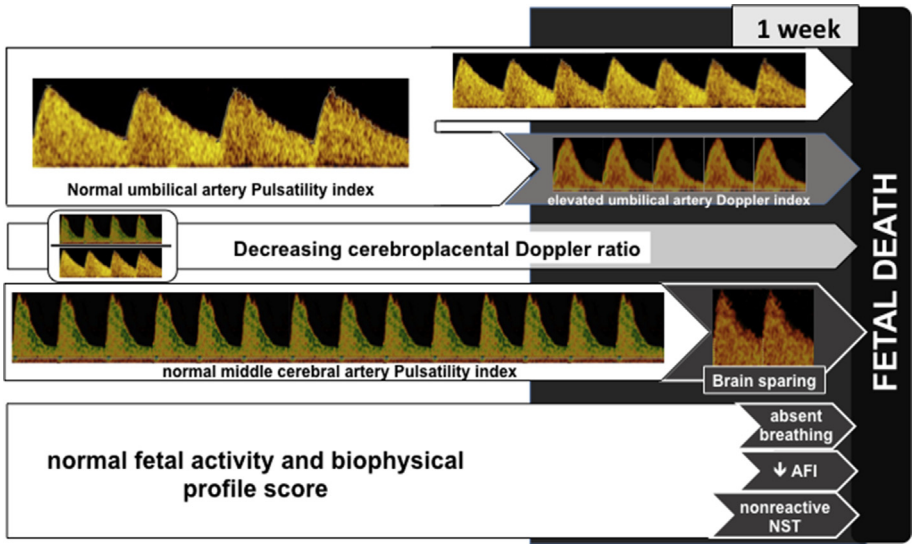

Fig. 2. Clinical evolution of late-onset fetal growth restriction. The figure illustrates the typical clinical progression of surveillance abnormalities in fetal growth restriction diagnosed after 32 weeks of gestation. Because of the lower prevalence of significant placental perfusion defects, umbilical artery Doppler index may be normal at diagnosis. As the cerebroplacental Doppler ratio numerically amplifies mild increase in the umbilical artery Doppler index with coexisting mild decrease in the middle cerebral artery (MCA) Doppler, it may be abnormal at diagnosis and might progressively decline. Isolated MCA brain sparing increases the risk for stillbirth within 4–7 days. Biophysical abnormalities that are consistent with deterioration include components of the biophysical profile score: fetal breathing, decreasing amniotic fluid index (AFI), and loss of previously obtained fetal heart rate reactivity on the nonstress test (NST).

mostly normal, the latency from diagnosis to delivery may be up to 9 weeks and is determined by the rate of progression in cerebral blood flow abnormalities [26,35,40].

Identification of the small fetus at greatest risk for compromise

Fetal growth delay that is due to restricted nutrient transfer across the placenta typically leads to sequential lagging of AC and head circumference (HC) growth, finally leading to a decrease in the sonographically estimated fetal weight (SEFW) [7]. Given these relationships between placental dysfunction and size, the tenth, fifth, or third percentiles for the AC or SEFW may be chosen for the diagnosis of FGR. Utilizing the AC alone as a diagnostic cutoff is the most sensitive approach, but it is less specific and may include constitutionally small but normally grown fetuses. Choosing an SEFW below the tenth, fifth, and third percentiles successively increases the specificity of identifying FGR. Most national societies agree on the tenth percentile for the SEFW as a diagnostic cutoff for small for gestational age. The disadvantage of this cutoff is the inclusion of a variable number of normal constitutionally small fetuses that do not require surveillance. Using an SEFW less than the third percentile or a decreased AC growth rate is more likely to identify "true FGR," [41] but it has the disadvantage that less severe forms of FGR at risk for deterioration or stillbirth are missed [13,14,42].

Including other parameters of placental dysfunction, such as oligohydramnios and abnormal placental and cerebral Doppler, carries the benefit of identifying the small fetus at risk for prenatal deterioration. Accordingly, such an approach is not only designed to improve diagnosis of true FGR but also to select patients who require fetal surveillance. The relative benefit of adding either oligohydramnios or abnormal UA Doppler at different fetal size cutoffs was most systematically evaluated in the PORTO study [43]. To capture placental dysfunction across the phenotype of early- and late-onset FGR, inclusion of the uterine and especially MCA Doppler is required [13,36,40,43,44]. The diagnostic approach using a combination of biometry and Doppler parameters is illustrated in Fig. 3.

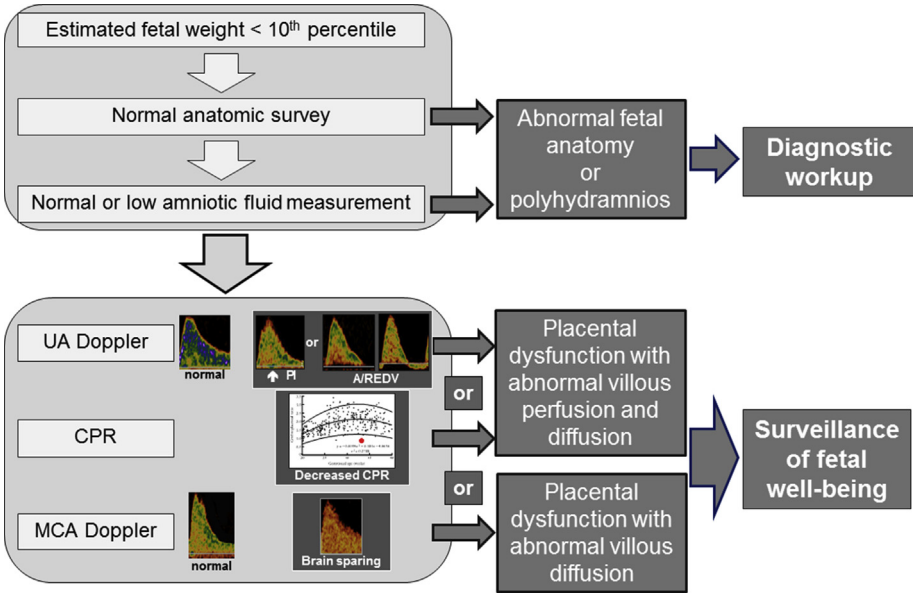

Fig. 3. Diagnostic approach to identify the small fetus requiring surveillance. In a fetus with an estimated fetal weight below the 10th percentile, a detailed fetal anatomic survey should be performed. The presence of fetal anomalies or polyhydramnios is suggestive of other underlying mechanisms and should prompt appropriate diagnostic workup. In the anatomically normal fetus with normal or decreased amniotic fluid volume, an increased umbilical artery Doppler index, a decreased cerebroplacental Doppler ratio (CPR), or a decreased middle cerebral artery (MCA) Doppler index all suggest placental dysfunction. Small fetuses with any of these Doppler abnormalities are at risk for deterioration and require antenatal surveillance.

Surveillance of fetal well-being in the growth-restricted fetus

The goal of fetal surveillance tests is the accurate estimation of the risk for hypoxemia, prelabor acidemia, or stillbirth, as well as the rate of clinical deterioration. These estimates are required to make decisions on delivery timing and to choose the appropriate interval to the next surveillance visit. Fetal deterioration in FGR can manifest itself in Doppler, amniotic fluid, fetal heart rate, and biophysical parameters; yet the correlation with acid–base balance has predominantly been studied considering each testing modality in isolation [45].

In principle, the fetal pH drops proportional to the reduction of EDV, and acidemia is therefore most prevalent when EDV is absent or reversed [46–50]. However, because UA Doppler may be associated with a wide range of additional Doppler and biophysical abnormalities, its consideration in isolation has an inconsistent relationship with pH [47,51,52]. Decrease in the cerebroplacental Doppler ratio or MCA Pulsatility index is associated with a decrease in fetal pH by two standard deviations [52–54]. Studies that evaluated the relationship between MCA Doppler and pH in late-onset FGR have done this for intrapartum fetal distress or neonatal acidosis rather than prelabor acid–base status [55,56]. However, even near term, addition of cerebral Doppler adds little accuracy to the pH prediction because a range of additional surveillance parameters may be abnormal [47,53,57]. Because abnormal venous Doppler occurs in the setting of advanced placental dysfunction in early-onset FGR, it has to date provided the most consistent relationship with declining pH in this subset of patients. An increase in precordial venous indices is associated with a decrease in umbilical venous pH by approximately 4 standard deviations [56,58–60].

When heart rate analysis is utilized in the FGR fetus, a reactive cardiotocogram (CTG) virtually excludes hypoxemia, while a nonreactive CTG is associated with a wide range of pH values [15,16,61]. Acidemia and in particular a cord artery pH < 7.20 at birth is most accurately predicted by a short-term variation below 3.5 ms in the computerized CTG (cCTG) [62–65].

The relationship between biophysical variables and fetal pH resembles the observations made for Doppler, as each individual component (tone, gross body movement, breathing movement, amniotic fluid volume, and heart rate reactivity) is independently altered by hypoxemia [15,61,66] but their combined consideration in a composite score best predicts pH and outcome [16,67,68]. An abnormal BPS of 4 or less is associated with a mean pH of less than 7.20 and a score of less than 2 has a 100% sensitivity for acidemia [70–72]. It is noteworthy that the biophysical parameters, especially loss of tone and movement, have a closer association with pH than the Doppler parameters (Fig. 4). Furthermore, this relationship is consistent across gestational age until term and independent of the underlying fetal disease [16].

Integrated fetal testing is based on the recognition that FGR may present with significant variations in the clinical evolution that are inadequately captured by utilizing one surveillance modality alone [47,53]. The trial of umbilical and fetal flow in Europe (TRUFFLE) compared outcomes of early-onset FGR, which were managed by cCTG alone, with those that had combined monitoring with ductus venosus (DV) Doppler and cCTG [69]. In the two arms managed with DV Doppler, between 23% and 33% of participants were delivered for “rescue” cCTG criteria. The trial confirmed that combined surveillance led to better composite short-term and 2-year developmental outcome [69].

The translation of the TRUFFLE findings into uniform acceptance of combined surveillance will pose challenges, as the cCTG is not as widely available as Doppler and biophysical profile scoring. In preterm FGR, it has been demonstrated that combined surveillance where the cCTG is substituted with biophysical variables provides equivalent prediction of the delivery pH [70]. When a combined monitoring approach is utilized, loss of fetal gross body movement in the fetus with minimal UA-EDV and elevated DV Doppler index is an accurate predictor of a cord artery pH below 7.20 [71]. The additional loss in fetal tone is strongly associated with a pH < 7.00 or a base excess <-12 [74]. It is important to recognize that the TRUFFLE study provides level 1 evidence on the surveillance approach and delivery criteria for early-onset FGR. There is no comparable evidence for the management approach in late-onset FGR, especially with respect to Doppler-based surveillance.

Selecting the appropriate surveillance frequency

In the fetus that does not yet meet delivery criteria, ongoing surveillance is required for re-evaluating fetal deterioration, and to determine if there is a need for intervention. The growth

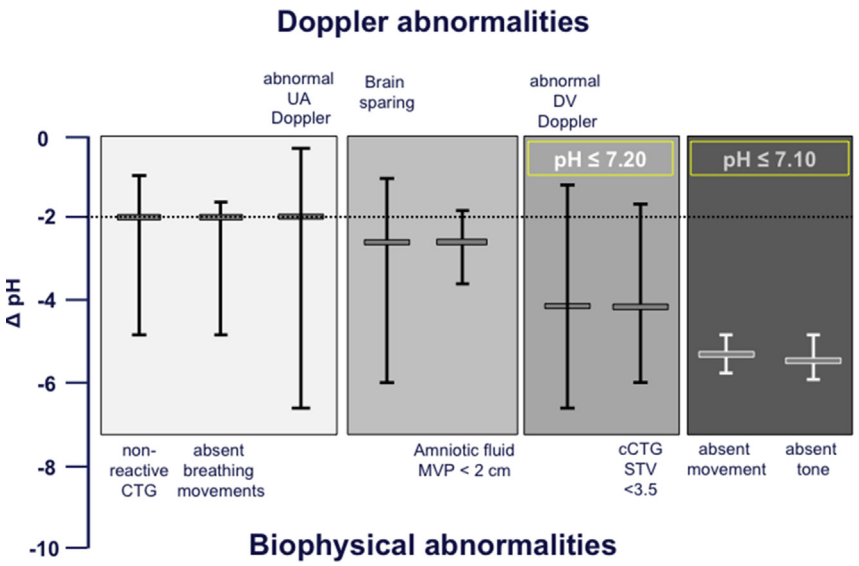

Fig. 4. Fetal surveillance parameters and pre-labor acid–base status. A diagrammatic representation of pH deviation from the mean gestational age (ΔpH) with abnormal test results in various antenatal tests including cardiotocography (CTG), computerized CTG (cCTG), amniotic fluid volume maximum vertical pocket (MVP), umbilical artery (UA) absent end-diastolic velocity, and ductus venosus (DV) Doppler index. It is of note that abnormal Doppler findings are associated with a wider distribution of pH abnormalities than biophysical parameters. Abnormal DV Doppler, or a cCTG short-term variation below 3.5 ms (cCTG STV), are associated with a mean pH below 7.20 and therefore can serve as a surveillance "safety net" for each other. Loss of fetal movement and tone is associated with a pH below 7.10 and in the absence of any explaining factors are considered absolute delivery indications.

restriction intervention trial (GRIT) demonstrated that delayed delivery was associated with less prematurity-related immediate mortality and less developmental delay [4,72]. However, delay in delivery was associated with significantly higher stillbirth rate highlighting the importance to choose surveillance intervals that are appropriate for the degree of fetal deterioration [36]. Unfortunately, the optimal surveillance pattern remains the object of much debate and research has primarily focused on intervention thresholds. There is no general consensus between national guidelines on the appropriate frequency of testing, and they are based on expert opinion of key authors because there is no high-quality evidence to guide practice.

In the authors' opinion, it is best to institute longitudinal surveillance starting at 24–26 weeks with integrated fetal testing, including multi-vessel Doppler examination, cCTG if available, and assessment of fetal activity through biophysical profile scoring [45,73–75]. The monitoring frequency needs to be increased when there are additional signs of deterioration until the delivery threshold is reached. It is critical to recognize that signs of clinical acceleration differ according to the gestational age when FGR is diagnosed. In early-onset FGR, it is the loss of UA-EDV that predisposes to venous Doppler abnormalities and the latter in turn to an abnormal biophysical profile score. UA absent EDV (AEDV) typically evolves over 4–6 weeks after diagnosis, and when this occurs, the average time to develop late decelerations is 2 weeks [27,32,36]. The daily rate of new cCTG abnormalities meeting delivery thresholds is 5% and unpredictable by the Doppler abnormalities and therefore requiring a more frequent surveillance frequency [79]. Once forward velocities in the DV become absent or reversed, fetal survival of longer than 1 week is unlikely [76].

In late-onset FGR, an increase in the UA PI and a decrease in the CPR or in the MCA PI may present themselves as signs of clinical acceleration. The latency to delivery is longer and may be up to 9 weeks. CPR or MCA Doppler abnormalities may occur even if the UA Doppler is normal [36,40,41]. MCA Doppler deterioration can occur unanticipated at a median of 4 days before stillbirth [36] and therefore is the most important Doppler parameter to guide monitoring intervals. The suggested surveillance frequencies are summarized in Table 1.

Table 1
Suggested minimum surveillance frequency prior to the delivery threshold.

Early-onset fetal growth restriction	Minimum surveillance frequency
Elevated UA Doppler PI (>2 SDs above GA mean), no other testing abnormality	every 2 weeks Doppler, weekly BPS or cCTG
Low MCA PI or CPR	weekly Doppler with BPS or cCTG
UA absent end-diastolic velocity (AEDV)	consider admission, twice weekly Doppler with BPS or cCTG
UA reversed end-diastolic velocity (REDV), increased DV Doppler indices, or oligohydramnios (maximum vertical fluid pocket <2 cm)	admission, 3 times per week Doppler with BPS, daily CTG or cCTG
Absent/reversed DV a-wave	daily Doppler with BPS or cCTG in preparation for delivery
Late-onset fetal growth restriction	
Elevated UA Doppler PI (>2 SDs above the mean for gestational age), no other abnormality	weekly Doppler with BPS
Low MCA PI or CPR	2 to 3 times/week Doppler with BPS

UA = umbilical artery, PI = pulsatility index, GA = gestational age, BPS = biophysical profile score, MCA = middle cerebral artery, CPR = cerebroplacental ratio, cCTG = computerized cardiotocogram, DV = ductus venosus.

Gestational epochs and their impact on outcome

In pregnancies complicated by FGR, there are absolute delivery criteria. Among these, maternal delivery criteria apply independent of gestational age. Fetal criteria are also independent of gestational age once it has been decided if active management for fetal status is desired (Table 2). This requires special consideration between 24 and 26 weeks gestation. In the absence of these absolute delivery criteria, the threshold that favors delivery is determined by the fetal risks of continued pregnancy weighed against the neonatal risks that follow delivery. In the absence of maternal delivery indications, deterioration in fetal well-being and the risk for stillbirth are the primary fetal risks favoring delivery. The principle neonatal risks that follow delivery are major complications such as bronchopulmonary dysplasia, high-grade intraventricular hemorrhage and necrotizing enterocolitis, and neonatal death. Neonatal risks decrease with advancing gestational age, and therefore, the threshold to favor delivery based on fetal indications can be lowered as pregnancy advances. When considering neonatal risks, the following important epochs are recognized.

24–26 weeks – Periviability

During these gestational ages, the anticipated neonatal survival for FGR neonates is below 50% and the rate of major neonatal complications is as high as 80% [5,77–79]. This is associated with small size at birth, challenging resuscitation, and the degree of prematurity that impacts tolerance to low Apgar scores and contributes to complication rates [80–83]. The anticipated increase in neonatal survival per day gained in utero is 2%, and additional factors that favor survival is a birthweight of >500 g. Because of the poor neonatal prognosis, delivery is primarily indicated for maternal disease such as pre-eclampsia with severe features. Before delivery for fetal indications, multidisciplinary consultation with

Table 2
Absolute delivery criteria.

Maternal condition such as pre-eclampsia with severe features
Obstetric emergencies requiring delivery
Abnormal cCTG short-term variation
<2.6 ms 26–28.6 weeks
<3.0 ms 29–32.0 weeks
<3.5 ms after 32 weeks
Abnormal biophysical profile score of 4 or less

neonatologists may be beneficial to give the parents a better understanding of the neonatal challenges following delivery. In addition to absolute maternal delivery criteria, fetal triggers listed in Table 2 apply if active management is elected [33,35,36,68,84].

26–34 weeks – advancing gestational age carries significant benefit

From 26 weeks onward, neonatal survival exceeds 50% on average and increases steadily with advancing gestation (Fig. 5). There is significant variation in the expected rate of survival at discharge up to 30 weeks of gestation with the best results reported by the TRUFFLE RCT and lower rates found in an observational Dutch study [3,85]. Between 26 and 28 weeks of gestation, the increase in survival per day gained in utero ranges is approximately 2% per day (Range 1.0%–2.1%). Thereafter, the daily gain in survival decreases to 0.7% per day (range 0.4%–0.9%), as survival consistently reaches 90% or above from 30 weeks of gestation onward [3,5,6,89].

In contrast to survival projections, there is a greater agreement in the projection of major morbidities between studies [3–5,75,89]. Although survival may exceed 50%, 70% or more of neonates born between 26 and 27 weeks may experience major morbidities (Fig. 6). There is a significant improvement in the rate of intact survival from 28 weeks onward with a steady further increase thereafter. This contributes to the observation that deterioration in fetal status does not independently impact short-term morbidity before 28 weeks of gestation [5,77].

In addition to improving survival, the impact of FGR and the delivery circumstances on neurodevelopment has been a significant focus of attention [86]. Lagging head growth, degree of placental dysfunction, and the gestational age at delivery are the primary determinants of neurodevelopment, and there is a significantly higher rate of cerebral palsy (8% versus 0%) and short-term developmental abnormalities (14% versus 5%) for FGR neonates delivered before 30 weeks of gestation [4,91]. This is in part attributable to the impact of neonatal morbidities and may in part be alleviated by administering antenatal steroids to enhance lung maturation [87,91]. It is this positive impact and the overall reduction in neonatal morbidity that favors administering steroids for FGR pregnancies delivered before 34 weeks [88].

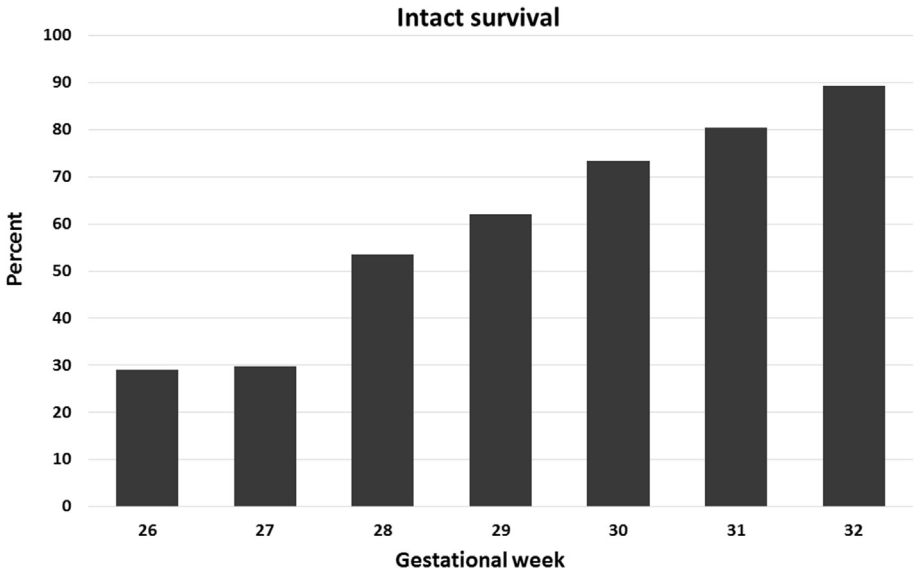

Fig. 5. Expected survival by gestational week. The graph displays the average, best, and worst estimates for expected survival of growth-restricted fetuses based on the studies by Baschat et al. [5], Torrance et al. [85], and Lees et al. [3]. There is significant variance in the projections until 30 weeks of gestation. After that, expected survival is consistently above 90%. The gain in survival per day in utero is greatest between 26 and 28 weeks and drops thereafter.

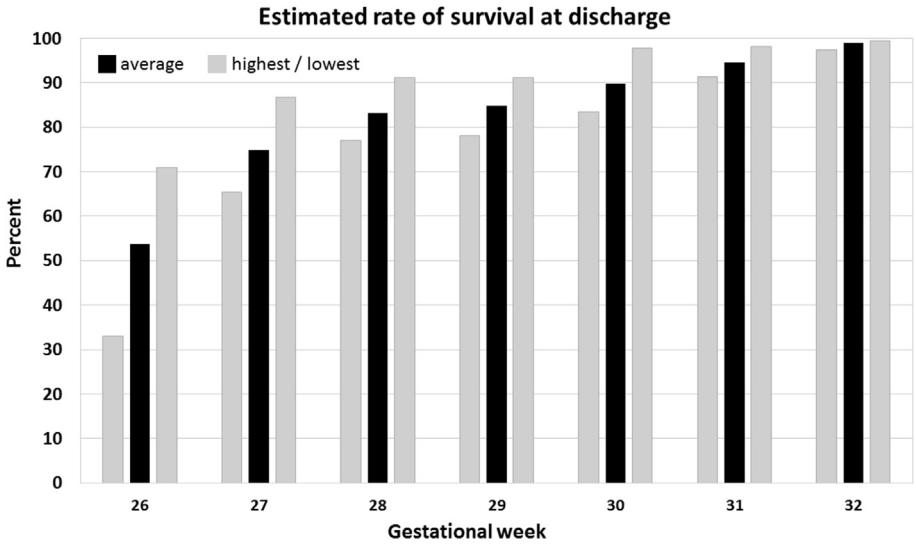

Fig. 6. Intact survival by gestational age at delivery. The graph displays the average estimate for expected intact survival of growth-restricted fetuses based on the studies by Baschat et al. [5], Torrance et al. [85], and Lees et al. [3]. Intact surveillance indicates the absence of significant respiratory, intracranial, and gastrointestinal morbidity. In contrast to the survival data, there is no significant variance in the projections between the three studies.

34–38 weeks – the late preterm FGR fetus

After 34 weeks, survival is expected to be close to 100% [2,35,89] and the primary concern following delivery is the need for admission to the neonatal intensive care unit. Owing to the subtle clinical picture that accompanies fetal deterioration near term, an increased clustering of stillbirths is observed, which increases significantly after 37 weeks of gestation [36,90,91]. In addition to the increasing risk of stillbirth, there is also an increased rate of fetuses that experience significant slowing of the head growth impacting neurodevelopment when pregnancies continue beyond 38 weeks of gestation [92].

Delivery criteria at different gestational epochs

Observational and randomized trials have established that delaying delivery in the preterm growth-restricted fetus with the intention to gain gestational age should be the primary goal of management [45,81,93,94]. With this premise in mind, the TRUFFLE RCT has established delivery criteria for early-onset FGR presenting between 26 and 32 weeks of gestation. In this gestational age window, an absent or reversed DV a-wave, cCTG safety criteria (Table 2), or an abnormal biophysical profile score of 4 or less are indications for delivery. Using combined Doppler and cCTG monitoring, the rate of intact survival is 95% and mortality or developmental impairment at the age of 2 years is observed in 5% of the infants [72]. Delivery between 32 and 34 weeks is recommended when UA-EDV is reversed. After 34 weeks of gestation, UA-EDV requires delivery.

There are no randomized intervention trials that have evaluated the most appropriate delivery trigger for FGR presenting between 34 and 38 weeks of gestation, which do not meet the above delivery criteria or the absolute criteria listed in Table 2. Some national societies recommend delivery for a decreased MCA PI during these gestational ages, especially in the small fetus with normal UA Doppler [95,96].

The Disproportionate Intrauterine Growth Intervention Study at Term (DIGITAT) [2] showed that among women with suspected intrauterine growth restriction at 36–41 weeks, a policy of labor induction affects neither the rate of adverse neonatal outcomes nor the rates of instrumental vaginal

delivery or cesarean section, indicating that both approaches are acceptable. The consensus view from the DIGITAT is that the optimum time for induction in SGA with normal Doppler study is at 38 weeks because it is associated with the lowest stillbirth and neonatal morbidity rates [2,93,95].

Summary

A uniform approach to the diagnosis of placenta-based FGR, the application of antenatal surveillance that is tailored to the severity of the condition, and the prospective identification of appropriate delivery thresholds improves outcome. Early-onset FGR is more likely to present with marked placental blood flow abnormalities and significant cardiovascular findings as deterioration progresses. FGR with a later onset in gestation may have minimal or no elevation in placental flow resistance and subtle signs of deterioration. An estimated fetal weight below the tenth percentile with coexisting abnormal UA, MCA, or cerebroplacental ratio Doppler index best identifies the small fetus in need of antenatal surveillance. In early-onset FGR, the degree of UA Doppler abnormality determines clinical acceleration, while abnormal DV Doppler precedes deterioration of biophysical variables and stillbirth. The surveillance frequency should be primarily guided by these parameters. In late-onset FGR, MCA Doppler abnormalities precede deterioration and stillbirth and are the primary factors that aid in determining surveillance frequency. The degree to which fetal deterioration may be tolerated is dependent on gestational age. Because the preterm growth-restricted fetus benefits significantly from delivery at a later gestational age, late DV Doppler abnormalities trigger delivery. Between 30 and 34 weeks of gestation, UA abnormalities can be considered as delivery triggers. However, from 34 to 38 weeks, randomized evidence on optimal delivery timing is lacking. From 38 weeks onward, the balance of neonatal versus fetal risks favors delivery even in the fetus with normal surveillance parameters.

Practice points

- In fetal growth restriction diagnosed before 32 weeks of gestation, delaying delivery until definitive gestational age criteria are met offers better outcome. In these fetuses, criteria for delivery include absent forward flow during atrial systole in the ductus venosus, cCTG short-term variation below 3.5 ms, absent tone, and movement or maternal indications for delivery.
- Fetuses with an estimated fetal weight below the tenth percentile with either abnormal umbilical artery Doppler and low cerebroplacental Doppler ratio or low middle cerebral artery Doppler index require surveillance of fetal well-being.
- At 38 weeks, indicated delivery of the small fetus does not have any adverse neonatal impacts and avoids fetal effects of ongoing placental insufficiency.

Research agenda

- Delivery criteria for FGR fetuses between 34 and 38 weeks of gestation.
- Effective intervention for FGR

Conflicts of interest

The author has no conflict of interest to report.

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