Best practice guideline 1 – Prenatal care for twin pregnancies

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The management of twin pregnancies can be challenging to the clinician. Fundamental to all management is the determination of chorionicity. In this guideline, screening for chromosomal abnormalities, monitoring of growth and management of pregnancies with discordant growth, discordant abnormalities and mode and timing of delivery will be outlined.

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This guideline is adapted from international guidelines: ACOG Practice Bulletin No. 231: 2021;[1] SOGC Guideline 260[2] and NICE Guideline [NG137][3] on the management of twin pregnancies to the South African (SA) context.

The diagnosis of multiple pregnancy is critical and should be made as early as possible, in the first or early second trimester, to accurately determine chorionicity.[1]

Monochorionic (MC) twins are at a particularly high risk of complications, including congenital anomalies, prematurity and fetal growth restriction (FGR) and management should involve consultation with a Maternal and Fetal Medicine (MFM) specialist.[4]

Higher-order multiple pregnancies (triplets and more) should always be managed in conjunction with an MFM specialist.

Pregnancy dating

Twins should be dated as follows:

- After assisted reproduction: by oocyte retrieval date (in case of frozen embryo transfer, by the embryonic age at transfer)
- Other pregnancies:
  - by **LARGEST** crown rump length (CRL), ideally when CRL is 45 - 84 mm.[5]
  - if CRL exceeds 84 mm, by **LARGEST** head circumference.[6]

As with singletons, the estimated delivery date (EDD) should NOT be changed once determined by these rules.

Chorionicity and amnionicity determination

Chorionicity and amnionicity should ideally be determined before 13 weeks and 6 days. This should be confirmed, clearly communicated to the patient (and her partner) and documented. If uncertain, an image should be captured for consultation with colleagues.

- If no amniotic membrane is seen between the twins (while scanning in different directions), the patient should be referred to an MFM specialist before 13 weeks and 6 days. This implies either a monoamniotic (MA) twin pregnancy or a monochorionic diamniotic (MCDA) twin pregnancy, with either a membrane in line with the scanning direction or anhydramnios in one sac (Fig. 1). Both require assessment by an MFM specialist.
- Observation of the dividing membrane between two separate placental masses or the presence of a lambda sign (chorionic tissue between the layers of the dividing membrane (Fig. 2)) indicates a dichorionic (DC) twin pregnancy. When ultrasound clearly shows two differing sexes, the pregnancy is DC.
- Chorionicity and amnionicity should be clearly communicated to the patient in understandable but accurate terms such as 'single placenta and single amniotic sac', 'single placenta and two amniotic sacs' or 'two placentas and two amniotic sacs'. Avoid terms, such as 'identical' or 'not identical', as this is difficult to determine and does not contribute to pregnancy management.
- Documentation should include a picture in the clinical notes, with copies provided to the patient and other professionals who may scan the patient later in the pregnancy.
- If chorionicity and amnionicity cannot be determined with certainty, whether transabdominally or transvaginally, refer the patient to an MFM specialist **BEFORE** 13 weeks and 6 days.

Labelling twins

At initial labelling, twin A should be the twin occupying the amniotic sac overlying the internal cervical os.

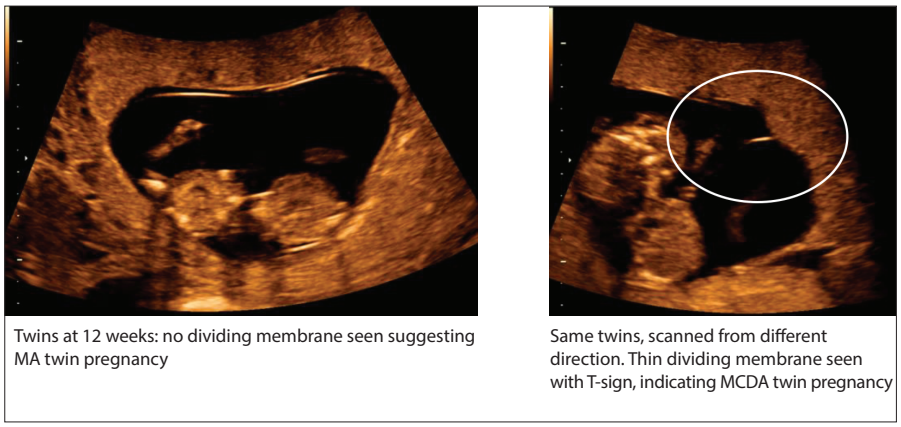
Twins should be labelled with as much information as possible, e.g., twin A is on the maternal left with anterior placenta and marginal cord insertion. Once the sex is known, this can be added, but it should not be the only descriptor.

MA twins are difficult to label unless there is a defining feature, e.g., a single umbilical artery.

As with EDD and chorionicity, labelling should be well documented and clearly communicated. The labels should not be changed, even if twin B later becomes the leading twin.

Screening and testing for chromosomal and structural abnormalities

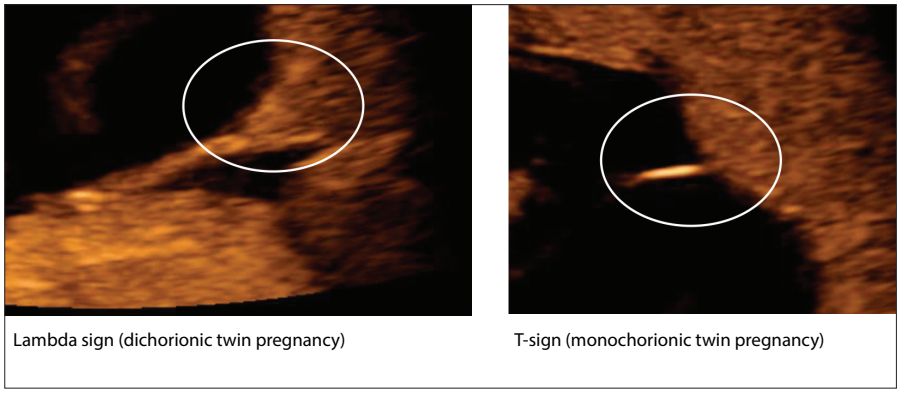
Counselling about prenatal screening and testing in patients with multiple pregnancies is complex and should be done by a professional



Twins at 12 weeks: no dividing membrane seen suggesting MA twin pregnancy

Same twins, scanned from different direction. Thin dividing membrane seen with T-sign, indicating MCDA twin pregnancy

Fig. 1. Ultrasound scans of monochorionic diamniotic twin pregnancy at 12 weeks from 12 different angles. (MA = monoamniotic; MCDA = monochorionic diamniotic.)



Lambda sign (dichorionic twin pregnancy)

T-sign (monochorionic twin pregnancy)

Fig. 2. Determination of chorionicity using Lambda and T-signs.The white circles show the membrane insertion into the placenta.

skilled in these issues, such as a genetic counsellor or MFM specialist. If the patient desires screening for trisomy 21 (and other trisomies), the ideal screening test is the first trimester (T1) combination screening done by a Fetal Medicine Foundation (FMF)-accredited operator.

Biochemistry screening for trisomy 21 can be beneficial but should **NOT** be done:

- in case of a vanishing twin, if the fetal pole is still present when the biochemistry is done.
- without ultrasound, as biochemistry alone is **NOT** accurate in twin gestations.

Cell-free DNA (cfDNA) testing (non-invasive prenatal testing (NIPT)) can be used in twins, with a possibly lower detection rate than in singletons. Consideration should be given to cfDNA tests, as they provide the fetal fraction of both twins. As with biochemistry screening, cfDNA testing should be used with caution, if at all, in the case of a vanishing twin. Such patients should be referred to an MFM specialist to decide on the optimal timing and method of screening.

The increased risk of congenital anomalies in twins and the complexity of prenatal diagnosis and management of (discordant) anomalies warrants referral of all twin pregnancies to an MFM specialist for a T1 anatomical survey, even if the patient has DC twins and does not desire aneuploidy screening.

A detailed second trimester (T2) ultrasound examination should be performed by an experienced (and ideally FMF-accredited) operator. In MC twins (with a higher risk of fetal cardiac anomalies), fetal echocardiography should be performed during the detailed T2 ultrasound examination.

If a (discordant) fetal anomaly is found and the examination was not done by an MFM specialist, the patient should be urgently referred to one.

Invasive testing in twins should only be performed after meticulous labelling by a practitioner skilled in selective feticide in cases of a discordant anomaly.[7,8] If labelling has not been accurate and aneuploidy is found in one twin, the karyotype may need to be repeated to avoid inadvertent feticide of the healthy twin.

Screening for preterm birth

Twin pregnancies are at increased risk of spontaneous preterm delivery, and cervical length measurement is an effective screening tool.[9]

Cervical length should be measured transvaginally at the time of the detailed anatomical evaluation at 18 - 22 weeks' gestation.[10]

If the cervical length is <25 mm, treatment with transvaginal micronised progesterone should be considered.[11]

Cervical cerclage should **NOT** be done routinely but can be considered as an emergency measure if the cervix shortens further or the cervix is dilated on digital examination.

Corticosteroids should **NOT** be administered routinely but should be given to patients between 24 - 34 weeks and 6 days if there is a significant risk of delivery within 7 days.[1]

There is no role for prophylactic tocolysis in multiple pregnancies.

Screening for pre-eclampsia

Twin pregnancies are at increased risk of pre-eclampsia. Screening is recommended to consider prophylactic measures (e.g., aspirin) and to increase surveillance if high risk.

Screening for pre-eclampsia is ideally done by the FMF algorithm, as it has the highest sensitivity and specificity.[12] Other scoring systems, such as those proposed by the Royal College of Obstetricians and Gynaecologists (RCOG), have also been suggested.[13]

Follow-up scan frequency

DCDA twins:

- Late T1 evaluation 11 - 13 weeks (by an FMF-accredited operator)
- Detailed anatomical evaluation at 18 - 22 weeks (by an experienced/FMF-accredited operator)
- Subsequent evaluations should occur every 4 weeks and include fetal biometry, (head and abdominal circumference, femur length, estimated fetal weight

(EFW) (Hadlock)[14] and amniotic fluid evaluation (measuring the deepest vertical pocket (DVP) of amniotic fluid)
- Umbilical artery pulsatility (PI) or resistance index (RI) of each twin should be measured from viability onwards especially if growth is suboptimal or discordant
- The patient should be referred to an MFM specialist, if:
  - a fetal anomaly is found
  - the estimated fetal weights of the twins differ by more than 20% (calculated as the difference between the fetal weights divided by the weight of the heavier twin)
  - oligohydramnios (<2 cm DVP) or polyhydramnios (>8 cm DVP)
  - umbilical artery PI or RI >95th percentile.

MC twins:

- Late T1 evaluation 11 - 13 weeks (by an MFM specialist)
- Two-weekly from 16 weeks for fetal biometry, including head and abdominal circumference, femur length, EFW[14] and amniotic fluid DVP
- The bladder filling and stomach bubble of each twin should be documented at each visit
- Detailed anatomical evaluation with fetal echocardiography at 18 - 22 weeks (by an MFM specialist)
- Measurement of umbilical artery PI or RI of each twin from viability or when discordant amniotic fluid volumes develop
- The patient should be counselled to make contact if she notices symptoms of sudden increased breathlessness, abdominal girth or abdominal discomfort, as these may be symptoms of polyhydramnios and twin-twin transfusion syndrome (TTTS)
- The patient should be referred to an MFM specialist, if:
  - a fetal anomaly is found
  - the EFWs differ by >20%
  - oligohydramnios (<2 cm DVP) or polyhydramnios (> 8cm DVP)
  - umbilical artery PI or RI >95th percentile.
  - the bladder is absent in one of the twins

Ideally, the middle cerebral artery PSV should also be measured at each visit from 20 weeks gestation to detect twin anaemia-polycythaemia sequence (TAPS). However, this complication is rare in MC twins that have not undergone laser therapy and frequent examination of the amniotic fluid volume (to detect TTTS) is much more important.

Other complications during pregnancy

Single intrauterine demise

Single intrauterine demise in a DCDA twin pregnancy leaves the survivor at higher risk of preterm labour. The pregnancy should therefore be followed up with cervical length monitoring.

In MC twins, the demise of one twin may result in the demise of the co-twin (15%) or survival with severe neurodevelopmental abnormalities (>18%).[15,16] These complications are due to acute exsanguination of the survivor into the circulation of the dead co-twin at the time of the first twin's death.[15] These complications **CANNOT** be avoided by immediate delivery or delivery after corticosteroids and such patients should be referred urgently to an MFM specialist.

Twin delivery

Mode of delivery

- Vaginal delivery is appropriate for uncomplicated DCDA and MCDA twins unless there is a specific indication for caesarean delivery
- Caesarean delivery is indicated in MA twins

Timing of delivery

Delivery should be planned at:
- 32 - 34 weeks for uncomplicated MA twins
- 36 - 37 weeks in uncomplicated MC twins
- 37 - 38 weeks in uncomplicated DC twins

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Best practice guideline 2 – Diagnosis and management of fetal growth restriction

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Fetal growth restriction (FGR) represents a significant global health challenge owing to its association with elevated morbidity and mortality rates. One of the primary causes of FGR is placental insufficiency. Early and accurate diagnosis of an affected pregnancy is therefore essential. Continuous and meticulous surveillance throughout the pregnancy helps in tracking the fetus's development, and identifying deteriorations in real-time. A tailored approach to the timing of delivery, balancing the risks and benefits, is vital to improving outcomes.

Evaluation of fetal growth is one of the most important aspects of prenatal care. Impaired fetal growth is associated with increased perinatal morbidity and mortality and long-term adverse infant outcomes. We have developed South African (SA) guidelines for the management of this condition based on the American and British practice guidelines.[1,2]

Definition of and distinction between small-for-gestational-age (SGA) and fetal growth restriction (FGR)

SGA: Abdominal circumference (AC) or estimated fetal weight (EFW) <10th percentile for the appropriate reference range.

FGR: FGR is possible at any growth percentile when there are abnormal fetoplacental Doppler indices OR with an EFW or AC <3rd percentile, even with normal Doppler indices.

Causes of SGA

1. Placental insufficiency (this is FGR; early delivery may be beneficial), which may be associated with maternal medical conditions, such as pre-existing hypertension, diabetes mellitus, renal disease, autoimmune disease, cyanotic cardiac lesion, pre-eclampsia, placental disorders, substance use and abuse and multiple gestation. It can also be idiopathic or be caused by placental chromosomal abnormalities.
2. Umbilical cord abnormalities
3. No placental insufficiency (early delivery usually not beneficial) but with increased risk of adverse outcomes, e.g., teratogen exposure, congenital infection, genetic disorders and structural abnormalities
4. No placental insufficiency (early delivery not beneficial) without increased risk for adverse outcome, the constitutionally small fetus ('normal SGA').

Screening for and diagnosing suboptimal fetal growth

***History*:** Identify women with risk factors for developing FGR associated with pre-eclampsia and consider low-dose aspirin and calcium if indicated.

Symphysis-fundal height (SFH) measurement at each visit. Plot SFH measurement on the gravidogram and assess the trend. If the growth slope is low (below P10, if previously P50) or growth plateaus, perform an ultrasound assessment.

Ultrasound assessment:

- Verify gestational age based on available information
- Measure biometry: biparietal diameter (BPD), head circumference (HC), AC, femur length (FL) and amniotic fluid index (AFI)
- Calculate EFW (Hadlock).[3]
- Use recommended reference ranges for interpretation: Chitty[4] for biometry, INTERGROWTH 21st [5] using the reference range based on EFW calculated using the Hadlock formula, National Institute of Child Health and Human Development (NIHCD)[6] or World Health Organization (WHO)[7] for biometry and EFW. Consider customising for age, parity, height, weight ± race using an online calculator (GROW),[8] especially if the maternal phenotype is very different from the average.
- Rule out structural anomalies, genetic/infective markers

***Doppler studies*:**

- Umbilical artery (UmbA) resistance index (RI) or pulsatility index (PI)[9]
- Uterine artery (UtA) PI[11]
- Middle cerebral artery (MCA) PI in the third trimester[12]
- Cerebroplacental ratio (CPR) (MCA PI/UA PI) in the third trimester[12]
- Ductus venosus (DV) PIV[13]

Diagnosis

Early-onset FGR if <32 weeks **AND**:

- AC or EFW <P3, **OR**
- absent or reversed end diastolic flow (AREDF), **OR**
- AC or EFW P3-10 **WITH** UmbA or UtA RI or PI >P95

Late-onset FGR if >32 weeks **AND**:

- AC or EFW <P3
- AREDF

- AC or EFW P3-10 **WITH** UmbA RI or PI >P95 or CPR <P5 or EFW crossing >50 percentiles

Management

1) *Follow-up of the 'normal' small fetus with normal UmbA RI at a viable gestation (viability by local criteria)*

- Advise on smoking and alcohol cessation, and avoidance of harmful exposures
- Regular blood pressure (BP) measurement and urinalysis to rule out pre-eclampsia
- Two-weekly UmbA Doppler
- Growth scan should not be repeated more frequently than every 14 days
- Use non-stress test (CTG) as an additional assessment tool
- UmbA RI or PI should be the primary surveillance tool for the SGA fetus at early gestation (<32 weeks).

The following are seen as minimum recommendations for surveillance – surveillance may need to be more intensive in individual cases (e.g., with pre-eclampsia) and additional information may be gained from assessing MCA flow.

a) positive end diastolic flow (EDF) with UmbA RI or PI <P95 (assessment of DV flow not indicated) and EFW P3-P10: repeat BP, urinalysis and Doppler 2-weekly (Fig. 3).
If all remains normal (UmbA RI or PI<P95): reassess growth at 36 weeks and perform CTG:

- if normal growth rate + normal AFI, reactive CTG (SGA) and no pre-eclampsia: continue surveillance as above and deliver at 38 - 40 weeks
- Same but if MCA was assessed and MCA PI <P5 or CPR <P5 or <1.11 (mild late FGR): twice weekly CTG and deliver at 37 weeks (perhaps 36 weeks if very low PI)
- if the growth rate is slow, EFW <P3 or oligohydramnios develops but CTG remains reactive (mild late FGR): twice weekly CTG and deliver at 36-37 weeks
- if the growth rate is slow, EFW <P3 or oligohydramnios with a persistently non-reactive CTG on the day of assessment (significant late FGR): deliver.
- Induction of labour for FGR with normal CTG is not contraindicated but continuous CTG during labour is required.

b) If positive end diastolic flow (EDF) with UmbA RI or PI <P95 (assessment of DV flow not indicated) and EFW <P3:
If all remains normal (UmbA RI or PI <P95): reassess growth at 34 weeks and perform CTG:

- if normal growth rate + normal DVP, reactive CTG (mild late FGR) and no pre-eclampsia, reassess at 36 weeks; if all stable, deliver at 36 - 37 weeks.
- if the growth rate is slow or oligohydramnios develops but CTG is reactive at 34 weeks (moderate late FGR), twice weekly CTG and reassess weekly; deliver at 36 - 37 weeks.
- if the growth rate is slow or oligohydramnios develops with persistently non-reactive CTG on the day of assessment (significant late FGR): deliver.

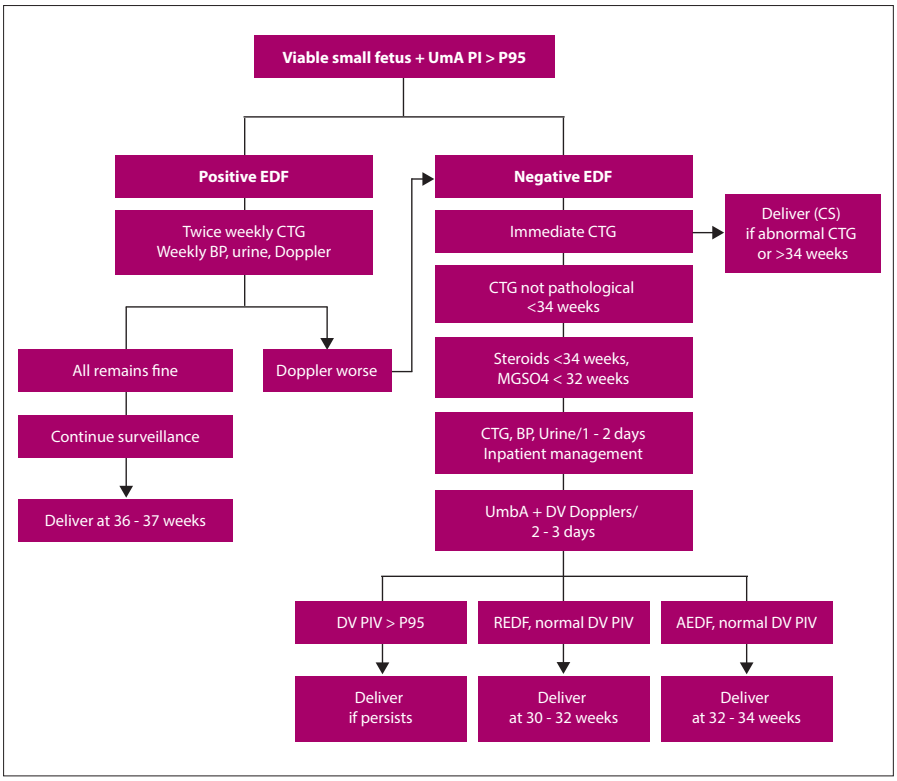

Fig. 3. Management of the viable small fetus with umbilical artery PI > P95. (PI = pulsatility index; UmbA = umbilical artery; EDF = end-diastolic flow; BP = blood pressure; CTG = cardiotocograph; MgSo4 = magnesium sulphate; CS = caesarean section; DV = ductus venosus; PIV = pulsatility index veins; AEDF = absent end-diastolic flow; REDF = reversed end-diastolic flow.)

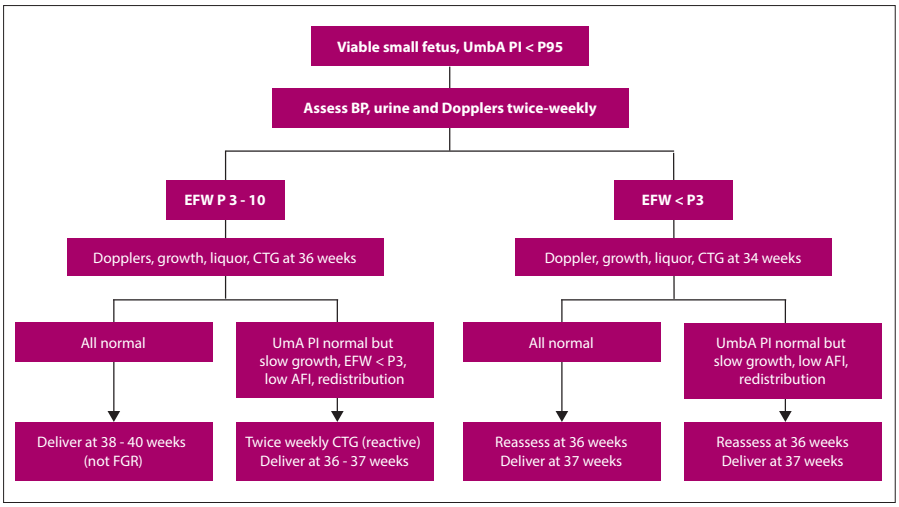

Fig. 4. Management of viable small fetus with umbilical artery PI < P95. (PI = pulsatility index; EFW = estimated fetal weight; BP = blood pressure; CTG = cardiotocograph; UmbA = umbilical artery; AFI = amniotic fluid index.)

Mild FGR: *Mild placental insufficiency with low risk of preterm IUFD (increase surveillance but aim for delivery at term)*
Normal UmbA RI but EFW >P3 with slow growth rate or EFW < P3 with normal growth rate, possibly WITH redistribution (MCA PI < P5) or oligohydramnios BUT normal CTG (must be reactive after 34 weeks)
Moderate FGR: *Moderate placental insufficiency with potential benefit from late preterm or early term delivery (increase surveillance and aim for delivery 35 - 37 weeks)*
UmbA RI > P95 WITH positive EDF, possibly WITH EFW < P3, slow growth rate, redistribution (MCA PI < P5) or oligohydramnios BUT normal CTG (must be reactive after 34 weeks)
Significant FGR: *Severe placental insufficiency with increased risk for preterm IUFD and likely benefit from preterm delivery*
ARED flow or persistently non-reactive CTG after 34 weeks, even if EFW > P3 and/or MCA PI > P5.

2) Follow-up of FGR at viable gestation (by local criteria)

2.1 If positive EDF with UmbA RI or PI >P95:

- Twice weekly CTG (must be reactive if >34 weeks)
- Reassess weekly for signs of pre-eclampsia and manage accordingly
- Reassess Dopplers and amniotic fluid at least weekly and follow the algorithm (Fig. 4) if Dopplers deteriorate to AREDF
- For early FGR, ductus venosus flow should ideally be assessed, hence referral to a MFM specialist is advisable since clinical decisions are critical given severe prematurity
- For late FGR, MCA flow should ideally be assessed
- If ARED flow does not develop, it is useful to consult online calculators that can guide evidence-based management in terms of frequency of surveillance and timing of delivery:
  - https://medicinafetalbarcelona.org/calc/
  - https://fetalmedicine.org/research/manage/sga
- Deliver at 37 weeks due to the 1% stillbirth rate at term, but earlier if aggravating factors develop (pre-eclampsia, persistently non-reactive CTG after 34 weeks, AREDF). Induction of labour is not contraindicated but continuous CTG during labour is required.

2.2 If AEDF:

- Deliver if diagnosed (and confirmed) ≥34 weeks
- If diagnosed <34 weeks:
  - consider antenatal corticosteroids (also magnesium sulphate ($MgSO_4$) for neuroprotection if <32 weeks) provided CTG does not warrant immediate delivery
  - CTG daily
  - reassess clinically and UmbA Doppler 2 - 3 times weekly
  - add DV flow assessment if feasible, otherwise assess venous pulsations in the free umbilical cord
  - deliver no later than 34 weeks, but earlier if aggravating factors develop (preeclampsia, REDF, pathological CTG, persistently abnormal DV flow or pulsatile flow in the umbilical vein)

Elective caesarean section is justified due to the high risk of intrapartum fetal distress.

2.3 If REDF:

- Deliver if diagnosed after 32 weeks
- If diagnosed <34 weeks:
  - consider antenatal corticosteroids (also $MgSO_4$ for neuroprotection if < 32 weeks) provided CTG does not warrant immediate delivery
  - daily clinical review
  - daily CTG
  - repeat Dopplers including DV if feasible 2 - 3 times weekly, but preferably daily
- Normal DV PIV:
  - deliver once there are CTG abnormalities or no later than 32 weeks, whichever comes first
- Abnormal DV PIV:
  - intensive CTG monitoring and reassess DV flow within 12 - 24 hours if CTG is still normal
  - if persistently abnormal DV PI, expedite the delivery if >29 weeks, otherwise continue intensive CTG monitoring, reassess DV Doppler daily and deliver if reversed a-wave or abnormal CTG.

Elective caesarean section is justified due to the high risk of intrapartum fetal distress.

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Best practice guideline 3 – Uses of Doppler ultrasound in obstetrics

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Doppler ultrasound is a crucial tool in obstetrics, enabling healthcare providers to assess fetal and placental circulations effectively. By measuring the direction and speed of blood flow, Doppler technology helps identify potential complications, such as fetal growth restrictions, placental insufficiency, fetal anaemia and abnormal fetal heart patterns. This non-invasive method allows for real-time monitoring of the fetus's well-being, facilitating timely interventions when necessary. Additionally, Doppler studies can provide valuable insights into the haemodynamics of both the mother and fetus, enhancing prenatal care and improving outcomes of complicated pregnancies. Overall, the use of Doppler ultrasound is instrumental in ensuring the health and safety of both the mother and the developing baby.

Advances in technology and understanding of fetoplacental circulation have resulted in the Doppler becoming an invaluable tool in obstetrics.[1] Its use enables the assessment of fetal and placental circulations, allowing diagnosis and monitoring of complicated fetal conditions.[2] The most commonly assessed Dopplers in obstetrics are the umbilical artery (UmbA), middle cerebral artery (MCA), uterine artery (UtA) and ductus venosus (DV).[2]

Safety of Doppler ultrasound at 11 - 13 weeks gestation

The embryonic period is considered to end at 11 weeks gestation. Routine use of Doppler ultrasound at this gestation is not recommended.[3]

During the fetal period, Doppler ultrasound may be used when clinically indicated within the ALARA principle (as low as reasonably achievable). Common clinical indications at this gestation are screening for trisomy and cardiac anomalies.[3] The thermal and mechanical indexes should be checked while scanning (normal values <1 and 5 - 10 minutes,[3] respectively). Highly heat-sensitive tissues, such as bone, may produce more heat and scanning duration should be limited. In the first trimester (T1), the uterine arteries can be scanned safely if the embryo is outside the Doppler beam.[3]

Uses of Doppler

Colour flow/power Doppler mapping

Although colour flow or power Doppler mapping undoubtedly add to the diagnostic value of obstetrical ultrasound, current guidelines do not recommend its routine use in screening.[4] Conditions where it may be useful are listed in Table 1.

Pulsed wave Doppler measurements

Current guidelines do not recommend the routine use of pulsed wave Doppler measurements in screening ultrasound.[3,5] This may change, given the encouraging results of pre-eclampsia prevention trials. Uses of pulsed wave Doppler are listed in Table 2.

Screening and follow-up of fetuses with anaemia

The MCA peak systolic velocity (MCA-PSV) Doppler provides accurate diagnosis and monitoring of fetuses with anaemia as in the case of Rh isoimmunisation.[6] At a PSV of above 1.5 multiples of the mean (MoM) the fetus is considered to have severe anaemia.[7] MCA-PSV has a sensitivity of 100% in detecting moderate-to-severe anaemia with a false positive rate of 12 %.[7,8] post-transfusion, a follow-up MCA-PSV value of 1.69 MoM should be used to decrease the risk of false positive results for severe anaemia.[8]

Screening for pre-eclampsia

Women with risk factors for pre-eclampsia can be screened using the UtA pulsatility index (PI), which is best performed in T1, allowing early commencement of prophylactic low-dose aspirin.[9] There is increasing use of Doppler of the ophthalmic artery, in which changes can precede the onset of preeclampsia and thus be used for screening.[10]

Fetal growth restriction

Fetal growth restriction (FGR) is usually a result of placental insufficiency, the severity of which can be determined by multi-vessel Doppler studies. In early-onset FGR there is sequential deterioration in Doppler flow. Increased resistance in the placenta results in an increased UA resistance index (RI) and PI, which may progress to absent (AEDF) and then reversed (REDF) end-diastolic flow. This is followed by the brain-sparing effect of a reduction in the RI and PI of the MCA, followed by cardiac compromise, evidenced by increased pulsatility index for veins (PIV) and peak velocity for veins (PVIV) in the DV.[11]

For management of early FGR, see Practice Guideline 2.

In late-onset FGR, the use of multivessel Doppler is not as sensitive to determine the timing of delivery. The cerebroplacental ratio (CPR) (MCA-PI/ UA PI) can be used to assess late-onset FGR, where abnormal results are associated with adverse fetal outcomes.[12-14] The MCA-PI is a reflection of fetal hypoxia in late FGR, whereas DV Doppler reflects the acid-base status of these fetuses.[15]

Table 1. Conditions where colour Doppler mapping is clinically useful

Examination	Indications	Professional requirements
Echocardiography	**Maternal indications** Family history: First-degree relative of proband with congenital heart defect Pre-existing metabolic disease (diabetes, phenylketonuria) Maternal infections (parvovirus B19, rubella, coxsackie, toxoplasmosis) Cardiac teratogen exposure (retinoids, phenytoin, carbamazepine, lithium carbonate, valproic acid) Maternal antibodies (Anti-Ro (SSA), Anti-La (SSB)) **Fetal indications** Suspected fetal cardiac anomaly Abnormal fetal karyotype Major extracardiac anomaly Nuchal translucency: ≥3.5 mm before 14 weeks Fetal cardiac rate or rhythm disturbances (persistent bradycardia, tachycardia, irregular heart rhythm)	Accredited by SASUOG for second opinion ultrasound or Certified by FMF in fetal echocardiography or Subspecialist in MFM
Assessment for morbidly adherent placenta	Low anterior placenta with a previous caesarean section Features suggestive of MAP on grey-scale imaging	Accredited by SASUOG for second opinion ultrasound or MFM specialist
Suspected monochorionic twins	Identification of artery-to-artery anastomoses on the placental surface or reversed arterial perfusion in case of sIUFD (possible TRAP sequence)	Accredited by SASUOG for second opinion ultrasound or MFM Specialist
Tumour vascularity assessment	Fetal or placental tumour Suspected AV-malformation Suspicious maternal adnexal mass	Accredited by SASUOG for second opinion ultrasound or MFM specialist
Mapping of other abnormal placental and umbilical cord findings	Vasa praevia, other cord abnormalities	Accredited by SASUOG for second opinion ultrasound or MFM specialist

SASUOG = South African Society of Ultrasound in Obstetrics & Gynaecology; FMF = Fetal Medicine Foundation; MFM = Maternal and Fetal Medicine; MAP = morbidly adherent placenta; IUFD = intrauterine fetal death; TRAP = twin reversed arterial perfusion.

Table 2. Clinically justified uses of pulsed wave Doppler

Examination	Indications	Professional requirements
Ductus venosus (DV) PI or tricuspid valve regurgitation	T1 ultrasound in case of high or intermediate risk (>1:1000) of chromosomal anomalies on T1 biochemical screening, or combination of T1 biochemical and nuchal translucency screening or if no biochemical screening is performed (to allow more detailed risk assessment including DV and tricuspid regurgitation)	FMF accreditation for assessment of DV or tricuspid valve regurgitation
Umbilical artery	Growth restriction (EFW <P10, AC<P5 or crossing percentiles) Risk factors for growth restriction (screening at 24 - 26 weeks, subject to local viability criteria): Preeclampsia Hypertension Previous history Metabolic syndrome (high BMI, diabetes mellitus, hypertension) Low PAPP-A values (<0.4 MoM) in T1 Previously high UA RI	Sonographers, Obstetrician, MFM subspecialists, SASUOG or FMF-accredited general practitioner
MCA	Growth restriction (EFW <P10, AC<P5 or crossing centiles) Increased UA RI or >32 weeks Fetal anaemia • Red cell iso-immunisation • Maternal parvovirus B19 infection Complicated monochorionic twin pregnancies (e.g. suspected or diagnosed TTTS, TAPS or selective IUGR)	SASUOG accreditation for second opinion ultrasound or FMF accreditation for obstetric Doppler evaluation
Uterine artery	(Preferably in T1, otherwise in T2) If assessed in the first trimester reassess in the second trimester as a monitoring tool. High risk of pre-eclampsia or growth restriction, including: Primigravidae Multigravida with previous pre-eclampsia or growth restriction Metabolic syndrome (high BMI, diabetes mellitus, hypertension) Low PAPP-A values (<0.4 MoM) in T1 Pregnancy after assisted reproductive technology	FMF accreditation for uterine artery Doppler evaluation

T1 = 1st trimester; FMF = Fetal Medicine Foundation; DV = ductus venosus; EFW = estimated fetal weight; AC = abdominal circumference; MFM = Maternal and Fetal Medicine; BMI = body mass index; Papp-A = pregnancy-associated plasma protein-A; MoM = multiples of the mean; UA = umbilical artery; RI = resistance index; TTTS = twin-twin-transfusion syndrome = TAPS = twin arterial perfusion syndrome; IUGR = intrauterine growth restriction; T2 = 2nd trimester.

Multi-vessel Doppler assessment and non-stress test (NST) may give information that guides the management, surveillance and intervention for fetuses with FGR.[11]

Screening for aneuploidy and structural defects

In T1 (11 + 0 to 13 + 6 weeks) the DV can be used for screening for T21. An absent A-wave or increased PIV contributes an additional 1% to the detection rate in fetuses with an intermediate risk for T21.[15] In the absence of aneuploidy, a raised DV-PIV occurs in fetuses with cardiac defects.[16]

Assessment of placental vasculature

Doppler ultrasound can add value in the diagnosis and management of placental disease, including placentae accrete spectrum (PAS), vasa previa and placental tumours. The presence of lacunae and bridging vessels across the bladder (railway sign) on colour Doppler is highly suggestive of PAS in patients with a previous caesarean section and an anterior placenta.[17]

Vasa previa can be diagnosed as an abnormal intramembranous blood vessel outside the placenta traversing the cervical os. Its presence, easily diagnosed with colour Doppler, is an indication for caesarean delivery.[17]

Scanning techniques of commonly used Dopplers

Umbilical artery

Impedance to flow is higher on the fetal than on the placental end of the UA. Measurement should be made on a free loop of cord. In multiple pregnancy, it is best to measure at the distal portion of the umbilical cord.[4,5] One should avoid doing umbilical Doppler assessment during breathing or fetal movements.

Middle cerebral artery

The MCA is sampled in the axial view at the level of the wing of the sphenoid bone with the image enlarged to 50% of the screen. [4,7] Colour flow mapping is then applied, the circle of Willis visualised, and the medial third of the anterior branch of the MCA sampled using pulse wave Doppler with an angle on insonation of 0°.[4,5,8,18] Excessive pressure on the fetal skull must be avoided.

Ductus venosus

The DV is best sampled with the fetus in the midsagittal section and the probe tilted slightly to the right. Colour flow mapping should be used to find the funnel shape of the DV that forms a conduit from the umbilical vein to the inferior vena cava. The funnelling of this vessel results in the aliasing of the colour map due to turbulent flow from a step down in the vessel dimension. The wave pattern is triphasic.

Uterine artery

The PI should be used when screening for pre-eclampsia as it is more reliable, reproducible, and stable and does not reach infinity levels like the RI.[19] UA notching is subjective, thereby limiting its use as a reliable screening tool.

In the T1 both transabdominal and transvaginal routes can be used to demonstrate and measure the UA.[9,19,20] The uterus should be visualised in the midsagittal section with a complete demonstration of the cervical canal. The probe should then be tilted laterally to identify the paracervical plexus and the tortuous UA with turbulent flow. In the T1, the gate/sample volume should be set to 2 mm and the angle of insonation maintained at <30°. Both UAs should be sampled.[19]

From 20 weeks, the UAs are demonstrated at the level of the uterovesical angle where it crosses over the external iliac artery. The PI of the UA should be sampled before UA bifurcation. An angle of insonation of <30° should be maintained with a sample volume of two-thirds of the vessel diameter. The velocity should be >60 cm/second, to avoid sampling branches of the artery, which have a lower velocity.[19]

Conclusion

Doppler use in obstetrics is an invaluable tool with diverse applications. When used appropriately and correctly, it can reduce morbidity and mortality in both mother and fetus.

A list of accredited MFM practitioners in SA is available on the SASUOG website:www.sasuog.org.za

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