

# Swiss Obstetric Ultrasound Guideline



Swiss Society for Ultrasound in Medicine  
Gynaecology and Obstetrics Section

# **Swiss Obstetric Ultrasound Guideline**

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Obstetric Ultrasound Standards Committee, Swiss Society for Ultrasound in Medicine (SGUM)

Approved by the enlarged executive board of the Swiss Gynaecology and Obstetrics Society (SGGG)



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# 1 Introduction

## 1.1 Obstetric ultrasound scanning in Swiss law

Article 13 of the Swiss Federal Patient Care Services Regulations (KLV), revised version of 26 June 2008, requires health insurance funds to cover two ultrasound scans in every normal pregnancy. After a thorough preprocedural discussion and counselling interview, which must be documented, the first scan is performed at 11 to 14 weeks of gestation and the second at between 20 and 23 weeks. Additional scans can be performed at the physician's discretion in high-risk pregnancies. Scanning can be performed only by obstetric ultrasound-accredited physicians, and always in compliance with the present Guideline.

This Guideline was developed in 1997 by a standards commission, revised in 2011, and approved by the Swiss Society for Ultrasound in Medicine (SGUM) and Swiss Gynaecology and Obstetrics Society (SGGG).

## 1.2 Aims

The aims of ultrasound scanning in normal pregnancy are to:

- identify the site of implantation
- confirm the presence of a live fetus
- diagnose multiple pregnancy
- determine gestational age
- plot growth using fetal growth charts
- assess fetal lie
- review fetal morphology
- determine the position and morphology of placenta and umbilical cord
- estimate amniotic fluid volume
- assess uterus and adnexa

## 1.3 Potential benefits

Meta-analyses have shown the following benefits of obstetric ultrasound [1]:

- avoidance of unnecessarily induced labour
- reduction in the complication rate of multiple pregnancies
- reduced maternal morbidity and mortality in placenta praevia
- monitoring of high-risk pregnancies
- early detection of abnormal growth and malformations (chromosomal aberrations)

Further studies are likely to show additional benefits:

- avoidance of unnecessary pregnancy checks and hospitalisations
- reduced parental anxiety and uncertainty
- enhanced bonding

However, ultrasound is a diagnostic procedure, with benefits that depend entirely on drawing the correct conclusions from the results. This may explain why particular ultrasound studies have failed to show any significant advantage in perinatal outcome [1,2].

## 1.4 Potential adverse effects

### 1.4.1 Technical safety

Sound waves have a thermal and mechanical impact on biological tissue that depends on instrument output and target tissue. Acoustic output is usually markedly less than  $100 \text{ mW/cm}^2$ , meaning that it is unlikely to have any short- or long-term adverse effects on mother or child. However, it can increase up to  $720 \text{ mW/cm}^2$ , in particular with Doppler ultrasound. The thermal and mechanical effects of acoustic output are expressed by the thermal and mechanical indices (TI, MI; Figure 1), each of which should if possible be less than one. As a matter of principle, the as-low-as-reasonably-achievable (ALARA) rule should apply in every ultrasound scan [3].

#### B-mode

Acoustic output is low ( $15\text{--}30 \text{ mW/cm}^2$ ) with no thermal or mechanical effect on maternal or fetal tissue.

#### M-mode

Acoustic output is similar to that of B-mode.



1 Realtime thermal and mechanical indices

#### Doppler ultrasound

Acoustic output can reach  $720 \text{ W/cm}^2$  in spectral Doppler mode and  $200\text{--}300 \text{ mW/cm}^2$  with colour Doppler. Spectral Doppler may significantly increase fetal tissue temperature. Scanning should be kept as short as possible. However, if clinically indicated, it may be repeated throughout pregnancy.

## 3D ultrasound

Since the 3D image is computed from B mode images, similar acoustic output values apply [4].

### 1.4.2 Psychological impact

The psychological impact of ultrasound examination in pregnancy is huge [5]. It can prompt the following reactions:

- anxiety, insecurity, and ambivalence in the presence not only of an actual fetal disorder but also of a suspected disorder (in the extreme case a pregnancy is terminated for suspected malformation)
- resentment and disappointment if a fetal malformation is “missed.”

Appropriate precautions can reduce such negative effects. Expectant mothers must be made aware that not all malformations can be detected prenatally. Good communication with the parents is of the utmost importance. The scanning procedure and its results must be explained in detail. This is the only way of avoiding unrealistic expectations, misinterpretations and insecurity on the part of the parents. Comments such as “the head is rather small today” or “I can’t see the left leg” etc should be avoided. If a fetal abnormality is strongly suspected, the expectant mother must be told, but with the rider that the suspicion is essentially provisional: the finding must always be confirmed at the earliest opportunity by a specialist with sufficient experience in prenatal ultrasound diagnostics.

## 1.5 Quality of the ultrasound examination

Ultrasound examination quality depends primarily on the following factors:

- a) Investigator
- b) Fetus
- c) Amniotic fluid volume
- d) Expectant mother
- e) Ultrasound device

### a) Investigator experience

You should only practise ultrasound if you examine at least 150 patients in 3 years. Regular attendance of continuing medical education courses on obstetric ultrasound goes without saying.

## **b) Fetal factors**

Fetal position and movement have a strong influence on the quality of ultrasound examination. Repositioning the patient or gentle external pressure can sometimes improve an unfavourable fetal position. If malposition prevents adequate assessment and a significant problem is suspected, repeat the examination within 2 weeks. If full fetal assessment remains impossible, refer the patient to a specialist centre. Referral should be immediate if sonomorphology cannot be conclusively assessed after 23 weeks.

## **c) Amniotic fluid volume**

Low amniotic fluid volume (oligohydramnios) impairs assessment of fetal anatomy and decreases the accuracy of fetal biometry. Tell the expectant mother about this problem and document the reduced image quality in her notes.

## **d) Maternal abdominal wall**

In women who are obese or have a history of abdominal surgery ultrasound image quality is markedly impaired. Skin care creams can also hugely detract from image quality. Inform the patient accordingly and document the impaired image quality in her notes.

## **e) Ultrasound device**

Obstetric ultrasound scanners must meet IEC standard 1157. Acoustic velocity is calculated on the assumption of a soft tissue average of 1540 m/s. Distance error (B mode) and time error (M mode) should not exceed 3%. Absolute error in measuring distances <17 mm should not exceed 1.0 mm. The instrument must be able to display at least 256 shades of grey. It should have an image documentation potential ensuring compliance with the mandatory obligation to store records for 10 years (see §1.5.2). Have these specifications confirmed in writing by the manufacturer before purchase. Transabdominal ultrasound is best performed using a multifrequency transducer of at least 2.5 to 5 MHz enabling the requisite frequency to be set up on the instrument according to the examination conditions. Scanning in the third trimester requires a image width of at least 9.5 cm at a depth of 6 cm. Transvaginal multifrequency transducers need a nominal frequency of at least 6 MHz. The instrument must offer targeted magnification.

### **1.5.1 Instrument set-up**

Ultrasound quality depends on using the correct instrument settings for the examination concerned. Ideally ultrasound frequency, image width and dynamic range are preset for each type of examination (e.g. first, second and third trimester scan, fetal echocardiography).

The following settings need to be continuously adjusted while scanning:

- Gain (reduced when displaying echogenic structures, e.g. bone)
- Depth
- Focus
- Zoom (the structure of interest fills the screen)

### 1.5.2 Documentation

Every ultrasound examination should start by recording the precise problem or indication. In the first trimester crown-rump length (CRL), nuchal translucency (NT), biparietal diameter (BPD), the femur and in multiple pregnancies the number of amnions and chorions must be documented in images. Since experience shows that failure to detect defects of the extremities is the commonest ground for litigation, an additional recommendation is to document images of all four limbs, each in their three segments. In the second trimester head circumference, abdominal circumference, femur length and all key parameters of the examination must be documented in images. In addition all deviations from normal must be documented in images and/or on DVD. As a safeguard against complaints, we recommend a checklist approach to the documentation of sonomorphology images (see Appendix) or the use of dedicated documentation software with integrated image storage. Adverse examination conditions (e.g. obesity, oligohydramnios, unfavourable fetal position or structures that cannot be displayed) must likewise be documented. Details on documentation and how to obtain and renew obstetric sonographer accreditation are published separately ([www.sgumgg.ch](http://www.sgumgg.ch), [www.fmh.ch](http://www.fmh.ch)).



2 Inadequate magnification



3 Correctly magnified structure of interest



4 Incorrect ultrasound frequency and focus for depth of penetration



5 Structure of interest revealed by reducing ultrasound frequency

An ultrasound image should possess the following qualities:

- It should clearly show the patient's identity
- In a multiple pregnancy it should be clearly ascribed to a specific fetus
- It should display the structure of interest sharply and in full screen
- The focus zone should encompass the structure of interest
- The image should display the date and time of examination

## 1.6 Pre-ultrasound counselling

KLV art. 13 permits ultrasound examination to take place only after a thorough informational and counselling interview, which must be documented. Examination is broken down into three consecutive phases: “Establishing contact”, “Scanning” and “Post-scan counselling”. Fundamentally, throughout these phases, it is the doctor-patient relationship, in all its affective and cognitive aspects, that forms the psychosocial core of informational and counselling practice.

### Phase 1

Establishing contact with the expectant mother/parents at the informational and counselling interview:

- initiates and establishes a strong doctor-patient relationship. If present, the partner should definitely be involved. The strength of this doctor-patient relationship will be hugely important, in particular if confirming a pathological finding and at the subsequent counselling interview.
- sets the level of information required: patients are often unclear as to what an ultrasound examination involves and why exactly they should have it.
- helps to clarify the brief (e.g. does the patient actually want an investigation?). Ask the patient explicitly what she wants.

- makes your communication behaviour clear (e.g. say directly that you will be making no comments during the examination because it needs all your attention, but that you will deal in detail with all points afterwards). Point to the second monitor and make it clear that it is the same image as is available to the sonographer.
- offers the opportunity of explaining the technique's potential pros, cons and limitations.

It is important not to be over-cautious with the information you impart to the 95% of pregnant women with a normal scan, nor to appear over-surprised by the 5% with an abnormal scan.

We propose a specimen patient information leaflet below:

## Pregnancy ultrasound – what you should know

Ultrasound is the only technique we have for directly observing the unborn child in the womb. It has been used in pregnant women for over 40 years, and there is no evidence as yet of any adverse effect on mother or child. Swiss health insurance funds fully cover routine scanning at around 11 and 20 weeks of gestation, plus (minus an excess) any other scans prescribed by your doctor.

Ultrasound scanning is designed to answer the following questions:

In the first third (‘trimester’) of pregnancy (weeks 11–14 of gestation):

- Is the baby alive and in the right place in the womb?
- When did the pregnancy start? It is very important to be able to date your baby’s age, e.g. in late pregnancy for assessing whether its growth is delayed
- Is it a single or multiple pregnancy?
- Can severe malformation be excluded?
- Does the nuchal translucency (NT) value point to a possible chromosomal disorder (e.g. Down’s syndrome)?

In the second trimester, at weeks 20–23 of gestation:

- Is amniotic fluid volume normal?
- Is your baby growing normally?
- Is any serious malformation present?
- Where is the placenta located?

If the ultrasound scan is normal, you can be pretty certain that everything is really OK. But does a normal scan guarantee a healthy baby? No, it cannot.

Ultrasound is ideal (90% accurate) in detecting very serious problems (that could affect your child’s survival). It is pretty good (75% accurate) at detecting problems that require intensive care and treatment. However, it does not score highly (30% accurate) in detecting minor malformations (e.g. extra fingers), as such details cannot always be visualised. Also we may sometimes detect subtle changes, such as the shape of the head, which themselves have no disease value, but can point to a particular disease. If subsequently we’re able to exclude that particular disease, then this marker loses all significance.

Bear in mind too that some developmental abnormalities only emerge during pregnancy and for that reason may not be detectable in the first half of pregnancy. A normal scan influences your subsequent obstetric care and you may also find it strongly reassuring. If the scan reveals a problem, it provides an important basis for decision-making, both for you and for us. It may, for example, prepare you for the birth of an unwell child. Delivery can be planned at a suitable centre. Occasionally we might be able to treat your unborn child and substantially improve its state of health.

However, an ultrasound may confront you with an ethical dilemma if it reveals a serious fetal abnormality: “Should I continue the pregnancy or have a termination?” Many prefer to evade such dilemmas in general and let Nature take its course.

So please let us know if for personal reasons you would prefer not to be scanned. If anything is unclear or if you have questions we’ll be glad to provide you with more information.

## **Phase 2**

During the scan the sonographer should:

- ensure an appropriate and undisturbed examination setting (e.g. with no telephone calls or interruptions by third parties)
- involve the partner (encouraging contact with the expectant mother and viewing of the second monitor)
- initiate and maintain visual contact with the expectant mother
- take nonverbal communication by both parties into account
- refrain from using medical jargon the patient doesn't understand or from conducting a monologue or specialist exchange with other persons present without including the patient (across her or over her head)
- be aware that the expectant mother and partner derive information from the ultrasound image and from their subjective interpretation of it, but in particular also from the sonographer's emotional reactions (facial expression, gestures, whether verbalised or not, and expressions of affect)
- consider when to disclose an abnormal ultrasound finding; timing depends on the expectant mother's level of information and the nature of the finding. If the expectant mother is already well-informed or an isolated finding is involved, we tend to recommend disclosure during the examination. If she is not well-informed or the finding involves multiple pathology, disclosure during the post-examination interview may be more appropriate.

A number of studies have shown that it is very important for the expectant mother to be able to follow the examination under the best possible conditions [5]. Hence, ideally, the provision of a dedicated second monitor. Alternatively the sonographer's monitor can be rotated so that is also visible by the expectant mother.

## **Phase 3**

The post-scan informational and counselling interview involves:

- creating appropriate conditions for the interview (dedicated room, with sufficient time set aside)
- consolidation of the doctor-patient relationship. The doctor should offer empathy and support
- the use of specific interview techniques in communicating the result (e.g. emotional aspects can first be addressed or the patient asked how she herself sees things). The parents should be fully informed about the result or their child's condition; however, it is for the individual sonographer to decide how much the parents can take in at the time
- acknowledging the emotional reaction of the expectant mother or parents

(perhaps by openly recognising that emotions have a place in the interview and are “normal”)

- a nondirective counselling style that reviews the consequences of the scan result, gives time for decision and sketches out future prospects (perhaps by referring to the next most appropriate medical steps)
- pointers to written information material, parents’ associations, self-help groups and psychological counselling
- the offer of a further counselling interview and fuller explanation of the further medical care.

Always remember that an ultrasound scan is a diagnostic act. Benefit from the examination depends entirely on whether the correct consequences are drawn from the result.

## 2 The 11–14 week scan

This examination is best carried out between 11 0/7 and 14 0/7 weeks when CRL values range from 45 to 84 mm. Begin the examination transabdominally to obtain an overall view. You are less likely to miss a multiple pregnancy and you will gain a better view of the fetus along its longest length. If the patient is obese, the uterus retroverted or image quality poor, transvaginal sonography will be superior to transabdominal sonography, and the bladder will need to be empty. The shorter distance to the target structures enables a higher ultrasound frequency to be used, thus markedly improving image resolution. On the other hand, because the transducer is less manoeuvrable, the fetus is more difficult to display in the correct planes. The 11–14 week scan addresses the following issues:

- a) Exclusion of uterine malformation and genital tumours
- b) Site of implantation
- c) Number of fetuses
- d) Fetal viability
- e) Estimation of gestational age from the CRL
- f) Measurement of nuchal translucency (assuming CRL is 45–84 mm)
- g) Other sonographic markers of aneuploidy
- h) Sonomorphology (head, trunk, extremities)

### **a) Exclusion of uterine malformation and genital tumours**

Start the scan by checking the shape of the uterus (to exclude a bicornuate or septate uterus) and look for myomata and ovarian cysts. The presence of uterine malformation is an indication to extend the examination to the maternal kidneys (to check for duplication, agenesis and reflux).

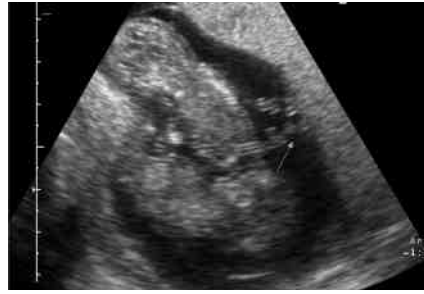
### **b) Site of implantation**

Display the uterus, chorion, chorionic cavity, amnion and fetus(es) in the overview to assess the site of the pregnancy. A gap often persists between the amnion and wall of the chorionic cavity. This is normal up to week 14. The secondary yolk sac lies outside the amnion in the extraembryonic coelom.

### **c) Number of fetuses**

Multiple pregnancy is most easily diagnosed at this stage since fetal cavities and fetuses can be visualised in their totality. It is at this stage in a multiple pregnancy that it is important to determine amnionicity and chorionicity [6]. Later it becomes impossible to do so by ultrasound with sufficient confidence. Two separate amniotic cavities indicate diamniotic twins. Absence of a partition is highly presumptive of a monoamniotic twin pregnancy (Fig. 6), in which case always be sure to exclude Siamese twins. Archive images of the secondary membranes. Try

also to locate the rudimentary umbilical cord on the placenta. If two chorions separate the fetal sacs, forming a triangular shape known as the twin peak or lambda sign, the pregnancy is dichorionic [6]. In addition an amnion membrane is visible in each chorionic cavity (Fig. 7). If no chorion separates the fetal sacs, the pregnancy is monochorionic (Fig. 8). The distinction is important because morbidity and mortality are higher in monochorionic-diamniotic twins than in dichorionic twins, and highest of all in monochorionic-monoamniotic twins (Fig. 6). Growth discrepancy, increased malformation and the twin-twin transfusion syndrome (TTTS) that occurs only in monochorionic multiple pregnancies require dedicated monochorionic pregnancy care in a centre with the resources for treating TTTS by laser coagulation of the vascular anastomoses. Early diagnosis of TTTS requires ultrasound monitoring at no more than 2 weekly intervals between weeks 16 and 24.



6 Monoamniotic twins

#### d) Fetal viability

Assess fetal vitality on the basis of cardiac activity. If none is detected, document the fact by M mode and confirm by a second examination (preferably by a second sonographer).

#### e) Estimating gestational age from CRL

Gestational age is of the greatest importance for all diagnostic and therapeutic measures during pregnancy and delivery. The most accurate method of calculation uses the measure of CRL between 11 and 14 weeks. CRL is the maximum fetal



7 Dichorionic twins: chorion is drawn into the dividing membrane



8 Monochorionic-diamniotic twins: no chorion in the dividing membrane

length from the crown of the head to the rump, measured in a fetus in its natural, unstretched, state (Fig. 9). The CRL value can be used to read off gestational age from a table (see Appendix) or it can be plotted on a computerised chart against reference gestational age calculated from other parameters. The 95% confidence interval (CI) for the biometric determination of gestational age using CRL between 11 and 14 weeks is  $\pm 5$  days. The result thus requires adjustment if sonographic and calculated gestational age differ by more than 5 days. From 12 weeks onwards BPD can also be used to determine sonographic gestational age. In this case the 95% CI is  $\pm 7$  days [7], meaning that the result requires adjustment if sonographic and calculated gestational age differ by more than  $\geq 7$  days.

There are no valid grounds for subsequently adjusting the estimated date of delivery.

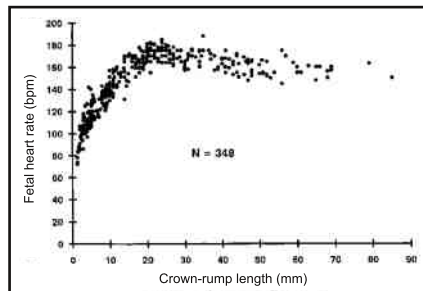
#### f) Measurement of nuchal translucency

Nuchal translucency refers to an accumulation of subcutaneous fluid behind the fetal neck. It can be detected in every fetus. Its thickness peaks at 12–13 weeks, then declines. Increased thickness is an important marker of fetal malformation and chromosomal aberration [8]. If nuchal translucency is increased and the karyotype is normal, cardiac malformations (e.g. ventricular and atrioventricular septal defects, aortic stenosis) and skeletal dysplasia are among the abnormalities that need to be excluded in the second trimester [9].

Nuchal translucency is measured transabdominally or transvaginally by displaying the fetus in the midsagittal plane and magnifying the head and thorax until they fill the entire screen. The fetus is moved, for example by getting the expectant mother to cough, so that the nuchal fold can be clearly demarcated from the underlying amnion.



9 Measurement of crown-rump length



10 Embryonic heart rate vs crown-rump length

The inner anechoic (black) area is measured at the widest point in the frozen image at right angles to the skin (Figs. 11 & 12).

At least three measurements should be taken and the highest value documented. If the parents want trisomy 21 risk assessment, the value can be used to calculate the risk of an affected fetus between weeks 11 and 14 or at term. In women aged 35 or older, with a risk  $\geq 1:380$  at term or  $\geq 1:300$  at the time of the test, Swiss health insurance funds cover karyotyping. Biochemical markers (PAPP A, free  $\beta$  hCG) and the history (previous trisomy) can be incorporated into individual risk assessment. The aim of this first trimester test (FTT) is to provide parents with the best possible basis at this stage for deciding for or against an invasive diagnostic procedure (karyotyping) and in particular to avoid unnecessary intervention. The FTT must be performed as part of a duly audited screening programme.

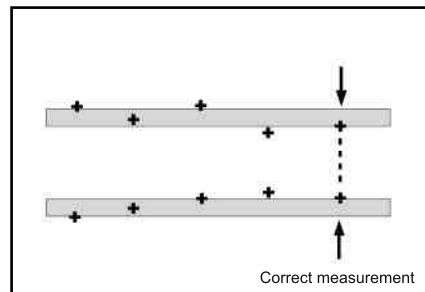
### g) Other, non-routine, sonographic markers of aneuploidy

#### Absent fetal nasal bone

The head is displayed full-screen in the sagittal plane. The nasal bone is visible in the normal fetus as a second echogenic line directly under the fetal skin. Screening for nasal bone absence, in tandem with nuchal translucency, raised hopes of further reducing the number of false-positive cases while maintaining the high detection rate for fetuses with trisomy 21 [10]. Other studies reported conflicting results [11], probably because of the poor reproducibility of nasal bone visualisation [12]. A review by Sonek et al. [13] reported prevalences of absent nasal bone of 1.2% and 68.5% in 17,000 normal and 400 trisomy 21 pregnancies after thorough sonographer training. In 1.5% of all pregnancies the nasal bone could not be reliably reported as present or absent.



11 Nuchal translucency at the correct magnification for measurement



12 Caliper positions for the correct measurement of nuchal translucency

### Heart rate

Heart rate is a potentially simpler marker. An increase in the first trimester above the 99th percentile is an indication of trisomy 13 [14]. A heart rate exceeding 180 bpm between 11 and 14 weeks is considered abnormal.

### Ductus venosus, tricuspid insufficiency

A reversed ductus venosus a wave in the first trimester was observed in only 3.2% of euploid fetuses versus in 66.4%, 58.3%, 55.0% and 75.0% of fetuses with trisomies 21, 18 and 13 and Turner's syndrome, respectively [15]. This marker also requires accredited training and quality instrumentation comprising colour Doppler and pulsed Doppler. A similar finding applies to tricuspid insufficiency, found in 0.9% of euploid fetuses, but in 56% of those with trisomy 21 and in approximately 30% in those with trisomy 18 and trisomy 13 [16].

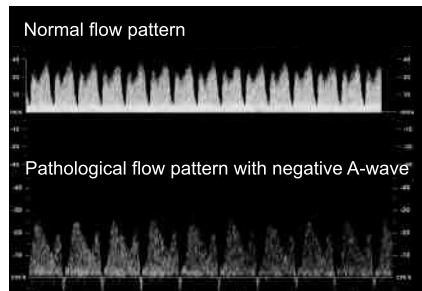
### h) Sonomorphology (head, trunk, extremities)

At no other stage in pregnancy can external morphology be visualised as clearly as at the end of the first trimester. The following abnormalities and anatomical structures should be identified at this stage:

- Exencephaly-anencephaly sequence – The cranial vault is missing in this lethal fetal malformation. BPD is unmeasurable. Fragments of brain tissue may often be found floating in amniotic fluid in the first trimester (Fig. 15).
- Cystic hygroma – A form of lymphoedema that mostly affects the fetal head and neck (posterior triangle). Unlike nuchal translucency, a cystic hygroma is subdivided by septa; some 50% of cases are associated with fetal chromosomal aberrations and malformations [17] (Fig. 16).
- Omphalocele and gastroschisis – Omphalocele cannot be conclusively diagnosed before the end of the 12th week since until this stage many fetuses



13 Demonstration of the fetal nasal bone



14 Ductus venosus

still display physiological herniation of the gut into the base of the umbilical cord (Figs. 43, 44).

- Each of the three segments of all four fetal extremities.

The literature also describes many other malformations that can be detected by the end of the first trimester, albeit at a markedly lower rate than at 20–23 weeks. Since at the 20 week scan the fetus is not always in the optimal position, detailed assessment at 11–14 weeks can raise the overall detection rate, thereby affording a “second” chance. In patients in whom transabdominal examination is difficult (due to obesity, prior abdominal surgery etc), the transvaginal approach is the only option for differential fetal organ diagnostics up to 16 weeks.

If examination conditions are so unfavourable as to preclude conclusive assessment of essential items, the expectant mother should be referred to an ultrasound centre.



15 Exencephaly-anencephaly



16 Cystic hygroma

### 3 The 20–23 week scan

The best time for the second scan is between 20 0/7 and 23 0/7 weeks. The organs are in their definitive positions and have attained a size conducive to targeted sonomorphology. Abnormalities such as developmental disorders and malformations can thus be identified before the fetus reaches the point of extrauterine viability. The transabdominal approach is generally used in the second trimester, complemented by transvaginal sonography to resolve specific issues such as suspected placenta praevia or a fetal part of interest adjacent to the internal os.

The 20–23 week scan focuses on the following:

- a) Fetal position
- b) Fetal viability and movement
- c) Amniotic fluid volume
- d) Position, size and morphology of placenta and umbilical cord
- e) Fetal biometry
- f) Fetal morphology

This examination focuses mainly on fetal anatomy. On the one hand, fetal malformations or conditions can be visualised directly by displaying the individual fetal structures, while on the other ‘soft’ markers (see Table) provide clues to fetal abnormalities (malformation, aneuploidy). At the same time fetal biometry is performed and amniotic fluid volume assessed, along with the position and morphology of the placenta and umbilical cord. The examination starts with an overview of fetal position and viability, amniotic fluid volume and placenta. Biometry is then performed and fetal anatomy assessed at standard planes of section. In practice these two tasks are generally undertaken simultaneously, although for didactic reasons we discuss them separately below.

#### **a) Fetal position**

Fetal position is still unstable at this stage. The only reason for determining it exactly is to aid the localisation of fetal structures.

#### **b) Fetal viability and movement**

Viability is assessed on the dual basis of heart rate and the pattern of fetal movement. Normal movement is variable and harmonious. Stereotypes, jerky movements or the complete absence of movement over a long period indicate a neurological disorder.

### c) Amniotic fluid volume

Amniotic fluid volume in the second trimester is best assessed subjectively. It is termed normal if in transverse section it occupies roughly the same area as the fetus.

Polyhydramnios describes a marked excess of amniotic fluid over the fetus, such that there would be good room for a second fetus in the uterine cavity.

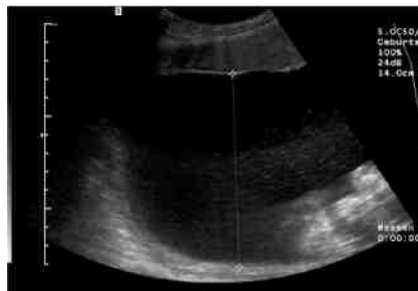
Oligohydramnios is present if the amniotic fluid occupies a markedly smaller area than the fetus and impairs fetal movement. In anhydramnios there is no amniotic fluid separating the fetus from the uterine wall or placenta. In oligohydramnios remember that loops of umbilical cord may simulate pockets of amniotic fluid. They are best differentiated at high magnification or by using colour Doppler ultrasound.

In the third trimester or at term amniotic fluid volume can also be determined semiquantitatively, ideally with the aid of Phelan's four-quadrant index which divides the uterus into four equal quadrants and measures the maximum vertical pocket of amniotic fluid in each, perpendicularly to the examination couch [18]. The sum of these four measurements gives the amniotic fluid index. Normal values range from 10 to 20 cm. A simpler and equally valid method is to measure the single deepest pocket, provided it has a horizontal diameter of at least 1 cm perpendicularly to the examination couch (normal value 2–8 cm) (Fig. 17) [19].

Low or high amniotic fluid volume is often associated with fetal malformation, chromosomal aberration and maternal disease (diabetes, infection, rupture of the membranes).

### d) Position, size and morphology of placenta and umbilical cord

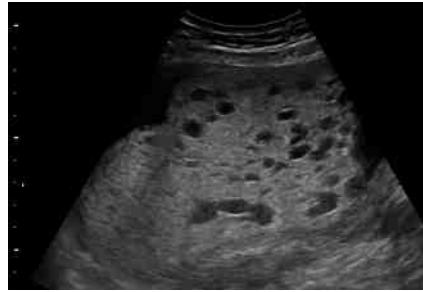
Describe the position of the placenta (anterior wall, posterior wall, fundal, low-lying, placenta praevia). Placenta praevia is unlikely if the placenta is fundal. In the second trimester the placenta covers the internal os in 1–6% of pregnancies, declining to only around 0.5% in the third trimester [20]. If the placenta covers the internal os at 20–23 weeks, confirm or exclude placenta praevia by reviewing its position at 26–30 weeks, even in the absence of vaginal bleeding. A normal placenta is between 2 and 5 cm thick and displays uniform echogenicity. Isolated intraplacental or subamniotic hypoechoic spaces (lacunae) that show blood flow at higher magnification are of no consequence (Fig. 18). A thick uniform placenta is observed in fetal disorders



17 Amniotic fluid volume: largest vertical pocket



18 Placental lacunae



19 Triploid placenta

associated with hydrops, gestational impaired glucose tolerance and infection. A thick heterogeneously echogenic placenta (jelly-like placenta) is often associated with fetal growth retardation and preeclampsia. Thick 'Swiss cheese' placentas are typical of triploidy (Fig. 19). Any placental abnormality requires further evaluation.

The umbilical cord is normally sinuous and comprises two arteries and one vein. An umbilical cord with a single umbilical artery occurs in approximately 1% of pregnancies and is associated with fetal structural or chromosomal abnormalities and growth retardation. The umbilical arteries are readily displayed either side of the bladder using colour Doppler. Always document the number of umbilical vessels.

### e) Fetal biometry

Routine biometry comprises the measurement of fetal head diameter, abdominal diameter and femur length.

Measure the fetal head using an axial section. Locate the reference planes for measuring BPD and occipitofrontal diameter (OFD) by moving the transducer in parallel. The skull should be symmetrically oval. The midline echo is broken at the anterior third by the cavum septi pellucidi. Note the hypoechoic thalamic nuclei either side of the midline echo (Fig. 20). The cerebellum and orbits must not be visible in this plane of section – if they are, the transducer has been tilted caudally or cranially (Fig. 21).

Measure BPD perpendicularly to the midline echo. The standard curve (Appendix) assumes outer to outer measurement by calipers taken from skin to skin. In the absence of a first trimester scan ultrasound measurement of BPD at 20–23 weeks gives the most accurate estimate of gestational age. However, accuracy comes with a 95% confidence interval (CI) of  $\pm 10$ –14 days, which is markedly poorer than the CI of  $\pm 5$  days achieved with CRL in the first trimester.



**20** Reference plane for measuring BPD and OFD



**21** Incorrect measurement plane (the cerebellum should not be visible)

Measure OFD the same way, from the outer frontal to outer occipital margins of the head. Calculate head circumference from the ellipse formula or use the inbuilt ultrasound programme. In oligohydramnios or breech presentation head shape becomes dolichocephalic, resulting in a shorter BPD and longer OFD. Head circumference is consequently little affected. That is why only circumference must be used for assessing head size.

Measure the abdomen in a transverse plane horizontal to the long axis. Starting from the heart move the transducer caudally until reaching the stomach and intrahepatic umbilical vein. The correct level is reached when the umbilical vein can be seen entering the portal venous system in the shortest possible segment well back from the anterior wall (Fig. 22). The plane is horizontal if the section level is circular and displays portions of several ribs. Measure the transverse and anterior-posterior diameters of the abdomen from outer edge to outer edge. Mean the two diameters and calculate abdominal circumference using the formula for a circle. Measurement of both diameters and the use of abdominal circumference to determine size are particularly important because the abdomen cannot always be displayed as a circle due to fetal position and amniotic fluid distribution.



**22** Measurement of the abdomen



**23** Incorrect measurement of the abdomen

Assessment from a single diameter could cause substantial deviation from the actual value in some cases.

The main pitfalls in abdominal measurement include:

- Oblique planes: These produce an elliptical section displaying a long segment of umbilical vein and a single rib (Fig. 23).
- Compression of the fetal abdomen by excessive transducer pressure may substantially distort diameters.

Display the femoral diaphysis its longest dimension. It should be measured with the sound beam as perpendicular as possible to the long axis of the bone (Fig. 24). A parallel beam can have a foreshortening effect due to the high sound conduction velocity in bone, while inclusion of the femoral head and neck has a lengthening effect.

Fetal biometrics are plotted on percentile fetal growth charts. Assuming gestational age was correctly estimated or corrected by the first scan, values should fall within the 5<sup>th</sup> and 95<sup>th</sup> percentile. If the values fall outside the normal range, the first step is to exclude incorrect gestational age. Fetuses normally grow within a percentile band; thus if the measurements of a 20 week fetus are in the 15<sup>th</sup> percentile, you will not expect them to be in the 80<sup>th</sup> percentile at 30 weeks. If fetal biometrics show a substantial upwards or downwards switch of percentile band as pregnancy proceeds, you should always be alert to a growth disorder requiring further investigation.

Since Swiss Federal Patient Care Services Regulations (KLV) make no provision for scanning normal pregnancies in the third trimester, suspected growth disorder needs to be identified promptly on clinical grounds. Westin's symphysis-fundus height (SFH) [21] has proved the best clinical measure, approximately equivalent to fetal CRL (see Appendix for the standard curve). For this reason a baseline measure of SFH should be taken at the 20–23 week scan and plotted on the standard curve, as well as at any subsequent visit during the pregnancy. Deviation of SFH by more than one standard deviation from its percentile band is an indication for additional scanning in the third trimester to assess fetal growth.



24 Measurement of the femoral diaphysis

The following table sets out the differential diagnoses:

Head circumference	Abdominal circumference	Femur	Increased in
↑	Normal	Normal	Hydrocephalus
↓	Normal	Normal	Cytomegaly, chromosome abnormality, toxoplasmosis, spina bifida, microcephaly
Normal	↑	Normal	Macrosomia, infection (hepatomegaly)
Normal - (↓)	↓	Normal - (↓)	Growth retardation, chromosome abnormality
Normal	Normal	↓	Skeletal dysplasia, aneuploidy

#### f) Fetal morphology

In addition to biometry, fetal morphology requires detailed assessment at this stage. This involves systematic examination of the head, trunk and extremities in the standard planes of section.

##### Head

Assess head shape using the same plane as for measuring head circumference. The normal shape is symmetrically oval (Fig. 20). Lemon-like malformation of the vault (lemon sign) is an important marker of spina bifida [22] (Fig. 29). You should be able to visualise the midline echo both frontally and occipitally. Absence of a midline echo may indicate a serious brain disorder (e.g. holoprosencephaly). The cavum septum pellucidum should be displayed in the midline: absence indicates corpus callosum agenesis and requires further investigation. Excessive clarity of brain structures and increased deformability of the cranial vault by transducer pressure indicate abnormal ossification of the cranial vault, as in osteogenesis imperfecta, achondrogenesis or hypophosphatasia.

##### Face

Assess the fetal face in frontal view and profile (Figs. 25 & 26). Retrognathia or frontal bossing (Fig. 28) is associated with various developmental abnormality syndromes. Exclude cleft lip-jaw-palate using a horizontal plane through the upper lip and maxilla (Fig. 27).



25 Face in profile



26 Frontal view of face

### Cerebral ventricles

Display the posterior horn of the lateral ventricle with the choroid plexus on a horizontal plane set somewhat lower than the biparietal plane. The first signs of hydrocephalic dilatation of the cerebral ventricles are seen in the posterior horn of the lateral ventricle. Measure lateral ventricle width at the level of the atrium (Fig. 30). From weeks 14 to 40 this measure is independent of gestational age and consistently less than 10 mm [23,24]. Dilatation of 10–15 mm is considered borderline. Values exceeding 15 mm indicate severe ventriculomegaly or hydrocephalus and gross CNS abnormality or disease. Lateral ventricle dilatation is also associated with trisomy and numerous syndromes [23]. Choroid plexus cysts occur in 1% of fetuses and are somewhat more frequent in trisomy 18 [25], an association which should prompt especially thorough morphological workup. Isolated plexus cysts with no associated developmental malformation have no pathological significance and generally resolve spontaneously during pregnancy [26].



27 Cleft lip-jaw-palate



28 Frontal bossing



29 Lemon sign



30 Measuring the posterior horn of the lateral ventricle

### Cerebellum

We examine the cerebellum on a posteriorly-tilted horizontal plane. The two hemispheres form a figure eight, with the cerebellar vermis between them (Fig. 31). At 20–23 weeks transverse cerebellar diameter in millimetres approximates to gestational age in weeks. Banana-shaped malformation of the cerebellum (banana sign), along with the lemon sign, suggests a neural tube defect [22] (Fig. 32). Posterior to the cerebellum lies the cisterna magna which is 2–10 mm deep from the second trimester onwards, independently of gestational age [24] (Fig. 31). Dilatations of the cisterna magna occur in chromosome disorders (trisomy 18) and Dandy-Walker complex [27]. Obliteration of the cisterna magna is a persistent marker of spina bifida, in contrast to the transient banana sign.

The lemon sign, banana sign and obliteration of the cisterna magna (see above) are the most important markers of spinal abnormality. These signs in the fetal head are an indication for thorough examination of the spine.



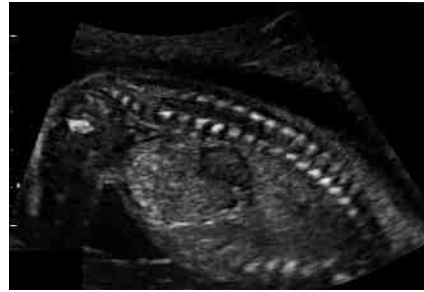
31 Cerebellum, cisterna magna



32 Banana-sign



33 Spine, transverse plane



34 Spine, sagittal plane

### Spine

The spine is examined in three planes at right angles to each other. The vertebral bodies and arches are displayed in the sagittal plane.

The entire spine must be covered by an intact layer of skin and soft tissue (Fig. 34). In the transverse plane the vertebral bodies are anterior and the vertebral arches posterior (Fig. 33). As a result bodies and arches show at two different levels. Caudal to the 12th rib are the five segments of the lumbar spine. The double contour then tapers distally like a pencil tip (Fig. 34). A break in the skin contour or bulging of the skin in the transverse and longitudinal plane indicates spina bifida (Fig. 36). Around 95% of all neural tube defects can be diagnosed in the second trimester [22]. Associated developmental abnormalities are found in approximately 20% of fetuses with a neural tube defect (cleft lip-jaw-palate, musculoskeletal and renal malformations) [28].

### Heart

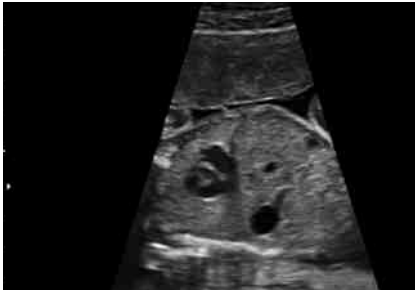
Before examining the heart you must first identify fetal left and right. Then assess the heart in the four-chamber view (Fig. 38) that runs somewhat obliquely at a ventrocaudal to dorsocranial slant. The simplest way to reach this plane is to start



35 Spine, neck



36 Spina bifida

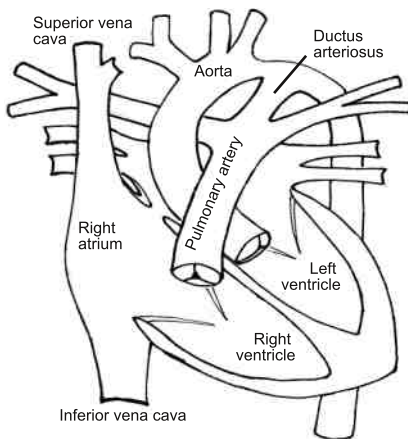


37 Diaphragm



38 Heart, four-chamber view

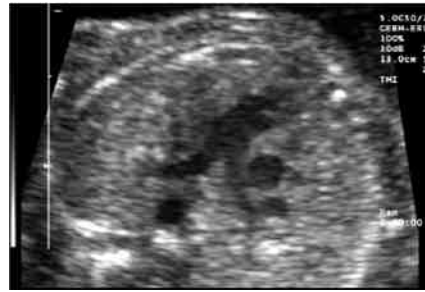
from the plane used to measure abdominal circumference and shift the transducer a little in the cranial direction while tilting it until the heart with its four chambers comes into view. The heart covers an area no more than one third of the total thoracic area and two-thirds of the heart should lie in the left hemithorax. The cardiac axis (through the interventricular septum) runs in the four-chamber view at an angle of approximately  $45^\circ$  from right posteriorly to left anteriorly (Fig. 38). The heart should be symmetrical. The two atria are of approximately equal size, as are the two ventricles. The atria are always smaller than the ventricles. The interventricular septum should be visualised as far as possible on a plane perpendicular to the sound beam and be continuous at ventricular height from posterior to anterior wall. The insertion of the tricuspid valve lies just below that of the mitral valve (Fig. 38). The heart rate should be between 110 and 160/min and regular. The four-chamber view can be complemented by tilting the transducer towards the fetal head to display the outflow tracts of the great vessels. First comes the aorta which must clearly be seen exiting from the left ventricle (Fig. 39).



Tilting the transducer further in the direction of the fetal head brings the pulmonary artery into view, traversing the aorta (Fig. 40). The aorta and vena cava can be seen in transverse section close to the spine. The rest of the thorax is occupied by the lungs which at this stage in pregnancy are somewhat more echogenic than the liver. Pulmonary echogenicity is normally homogeneous. Anechoic areas suggest a diaphragmatic hernia or cystic pulmonary abnormality. In congenital diaphragmatic hernia, which in 90% of cases is left-sided, the heart and



39 Heart, aortic outflow tract



40 Heart, pulmonary artery outflow tract

mediastinum are displaced to the right, resulting in anechoic loops of peristaltic bowel or stomach in the left hemithorax in place of normal lung structure.

The following findings are pathological:

- Collections of fluid around the lungs or heart (pleural or pericardial effusion)
- Abnormal position of the heart (as in diaphragmatic hernia, omphalocele or dextrocardia)
- Too great or too small a cardiac area (as in heart failure or heart defects)
- Asymmetry between left and right atria or ventricles (as in heart defects)
- Asymmetry between atrium and ventricle (as in heart defects)
- Abnormal cardiac rhythm (tachycardia, bradycardia, extrasystoles)
- Intrathoracic hypo or hyperechoic space-occupying lesions (as in diaphragmatic hernia or cystic pulmonary malformations).

Further cardiac investigation requires specialist expertise. Key indications for fetal echocardiography include:

- Increased nuchal translucency in the first trimester in a normal karyotype fetus,
- Congenital heart disease in the expectant mother, her partner or her/their children,
- Diabetes, collagenosis, phenylketonuria or an autosomal dominant disorder in the expectant mother,
- A history of teratogen exposure in early pregnancy,
- Concomitant birth defects or growth retardation,
- A documented chromosomal abnormality,
- Abnormal cardiac morphology or rhythm,
- Non-immune hydrops.

### **Stomach, bowel**

In the reference plane for measuring abdominal circumference the gastric bubble shows as a single anechoic area (Fig. 22). The diaphragm can be tracked in a sagittal plane between the heart and underlying gastric bubble (Fig. 37). Oesophageal atresia should be suspected if the gastric bubble fails to display in repeated scans. If the gastric bubble is very large or a second anechoic area displays next to the gastric bubble (the 'double bubble' that often only comes to light in the third trimester), think of duodenal stenosis (Fig. 41). Oesophageal and small bowel stenosis is generally associated with polyhydramnios, and duodenal stenosis with chromosome aberration. Hyperechoic loops of bowel (similar in density to bone) are seen in cystic fibrosis, infection (cytomegalovirus) and chromosome aberration, as well as after intra-amniotic bleeding, in longstanding oligohydramnios and severe growth retardation.

### **Abdominal wall**

The umbilical cord should be seen to insert at the umbilicus on the fetal abdominal wall (Fig. 42). The commonest abdominal wall defects, omphalocele and gastroschisis, are diagnosed on this plane. In omphalocele the liver and/or stomach and parts of the bowel translocate in front of the fetal abdominal wall. The organs are enclosed in a hernial sac containing the insertion of the umbilical cord (Fig. 44). Omphalocele is often associated with other malformations, chromosome aberrations or syndromes. Gastroschisis is an abdominal wall defect usually found to the right of the umbilicus and associated with herniation of uncovered loops of bowel (Fig. 43). Unlike omphalocele it carries no increased risk of chromosome aberration. The cardinal sign is generally an abdominal circumference at or below the lower limit of normal.

### **Urinary bladder**

In a more caudal direction is the fetal bladder. The feature that most differentiates it from other hypoechoic structures in the lower abdomen is the change in size caused by the 20–30 minute filling and voiding cycle. Alternatively, colour



41 Double bubble



42 Abdominal wall



43 Gastroschisis



44 Omphalocele

Doppler can be used to display the umbilical arteries that run either side of the bladder. A visible bladder with normal amniotic fluid volume is evidence of at least one functional fetal kidney. A persistently voluminous bladder with oligohydramnios requires further investigation. If no bladder is detected during the examination and amniotic fluid volume is normal, exstrophy may be present, in which case tumour-like bulging of the abdominal wall can often be seen between umbilicus and symphysis pubis.

### Kidneys

The kidneys are initially viewed using a paravertebral longitudinal plane. Particular attention should be paid to parenchymal echogenicity in relation to adjacent structures (Fig. 46). If the kidneys cannot be displayed because of poor sound propagation, the renal arteries may need to be visualised using colour Doppler. If each renal pelvis is clearly visible, they should be measured AP using a horizontal plane (Fig. 45). Dilatation of 4–7 mm is considered nonsignificant at 20–23 weeks [29,30]. Values up to 10 mm are considered mild dilatation in the third trimester, and are associated with a mild increase in trisomy risk. Pyeloectasis exceeding 7 mm in the second trimester and 10 mm in the third should prompt



45 Kidney, horizontal plane with renal pelvis AP



46 Kidney, sagittal plane

investigation for further abnormal sonomorphology. Isolated pyeloectasis with normal amniotic fluid volume is an indication for third trimester monitoring and paediatric follow-up.

### Extremities

The first trimester scan should be supplemented by scanning all four extremities in their three segments (e.g. upper arm, lower arm, hand). Visualising the number and position of the fingers is a considerable challenge and is not always successful. Foot length should approximate to femur length. If the tibia, fibula and sole of the foot can be seen on the same plane, the diagnosis is club foot (Fig. 48). Shortening of the long bones is evidence of skeletal dysplasia. A femur length markedly below the 5th percentile is an indication to measure all the long bones. Any abnormality in the shape, position or number of extremities requires detailed further investigation.

NB:

Many fetal malformations undergo dynamic development. Some conditions (e.g. certain heart defects, fetal tumours, infection-induced changes, bowel atresia, hydrocephalus, diaphragmatic hernia, dilatation of the renal pelvis and ureter) only become apparent after 24 weeks and are thus missed in the second trimester scan. Hence the case for third trimester scanning.



47 Dilated bladder in subvesical stenosis (keyhole phenomenon)



48 Club foot

## 4 Indications for non-routine ultrasound scanning

A high-risk pregnancy or inconclusive scan is an indication for further ultrasound investigation or diagnostic workup in a perinatology centre.

### a) Typical indications in the first trimester:

- Vaginal bleeding
- Unelucidated lower abdominal pain, in particular suspected extrauterine pregnancy
- Previous extrauterine pregnancy
- Unelucidated amenorrhoea
- Oligomenorrhoea
- Discrepancy between uterine size on clinical examination and duration of amenorrhoea
- Pregnancy on sterility therapy or directly after discontinuing oral contraception

### b) Typical indications in the second and third trimesters:

- Vaginal bleeding
- Unelucidated lower abdominal pain
- Premature contractions
- Monitoring of fetal lie
- Suspected growth retardation or fetal macrosomia (marked percentile deviation of SFH)
- Decreasing fetal movements
- Monitoring of growth in multiple pregnancy
- Previous fetal abnormality
- Exposure in early pregnancy to medication with a known or suspected association with an increased frequency of fetal malformation
- Infection in pregnancy associated with an increased frequency of fetal malformation
- Gestational disease, e.g. hypertension or diabetes
- Expectant mother with pre-existing disease, e.g. type 1 or 2 diabetes, autoimmune vasculitis (e.g. lupus), nephropathy, epilepsy
- Abnormal serology (abnormal first trimester test, AFP+)
- Expectant mother's desire to avoid invasive investigations
- Low-lying placenta or placenta praevia at 20–23 weeks

Suspected placenta praevia should be monitored vaginally as far as possible as this approach gives a substantially more accurate result. Such monitoring should only be performed by experienced sonographers. So as not to cause bleeding, the transducer must be introduced into the vagina with caution and not too deeply.

**c) Typical indications at delivery:**

- Uncertain lie
- Vaginal bleeding
- No fetal heart on auscultation or cardiotocography
- Dystocia (e.g. unengaged fetal head)
- Retained placenta

**d) Typical postpartum indications:**

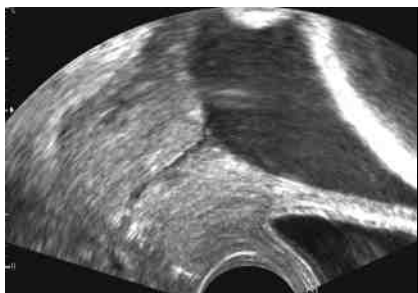
- Postpartum bleeding
- Suspected retained products of conception
- Unelucidated postpartum fever

## 4.1 Measurement of cervical length

No benefit is achieved by routinely measuring cervical length in all pregnant women. If indicated or if there is a risk of premature birth, the cervix should be measured transvaginally, in a longitudinal plane from the internal to the external os. It is important not to compress the cervix with the vaginal transducer since the length will otherwise be overestimated. Measuring the cervix in a woman with a very full bladder may also result in an overestimate. If the internal os has started to funnel only the closed part of the cervix should be measured. Measurement of the width and depth of the funnel is not thought to have any predictive value for early delivery [31,32].

Possible indications for measuring cervical length:

- Premature contractions
- Multiple pregnancy
- Previous premature delivery
- Previous cone biopsy



49 Measurement of cervical length



50 Funneling

The following table plots the probability (%) of premature delivery before 35 weeks against cervical length and the week in which it was measured [39].

		Weeks of gestation													
		15	16	17	18	19	20	21	22	23	24	25	26	27	28
Cervical length (mm)	0	70	69	68	66	65	64	63	62	60	59	58	56	55	54
	5	63	61	60	59	58	56	55	54	52	51	50	48	47	46
	10	55	53	52	51	49	48	47	45	44	43	42	40	39	38
	15	47	45	44	43	41	40	39	38	36	35	34	33	32	31
	20	39	37	36	35	34	33	31	30	29	28	27	26	25	24
	25	31	30	29	28	27	26	25	24	23	22	21	20	19	19
	30	25	24	23	22	21	20	19	19	18	17	16	16	15	14
	35	19	18	18	17	16	15	15	14	13	13	12	12	11	11
	40	15	14	13	13	12	12	11	11	10	10	9	9	8	8
	45	11	11	10	10	9	9	8	8	8	7	7	7	6	6

## 4.2 Doppler ultrasound

Doppler ultrasound provides important additional information on fetal status in certain clinical situations. Meta-analyses have shown that monitoring high-risk pregnancies by Doppler ultrasound of the umbilical artery lowers not only perinatal mortality but also the obstetric intervention rate [33]. Colour Doppler ultrasound can provide additional information for assessing fetal sonomorphology. If this is not among the facilities available, the case should be referred to a specialist centre.

Common indications for obstetric Doppler ultrasound include:

- Suspected intrauterine growth retardation
- Gestational hypertension/pre-eclampsia
- Previous pregnancy with growth retardation or intrauterine fetal death
- Previous pre-eclampsia/eclampsia
- Abnormal fetal heart rate
- Reasonable suspicion of fetal malformation/fetal disease
- Management of alloimmunisation during pregnancy
- Discordant growth or amniotic fluid volume in multiple pregnancy
- Maternal infection (e.g. parvovirus B19)
- Pre-existing maternal disease of vascular relevance, e.g. hypertension, nephropathy, type I or II diabetes, autoimmune disease or a coagulopathy.

Obstetric Doppler ultrasound standards were developed by a joint Swiss-German committee and have been adopted in this form for Switzerland [34].

### **4.3 3D/4D ultrasound**

3D/4D ultrasound is currently used in the differential diagnosis of certain malformations. Studies have yet to show whether this imaging modality is superior to 2D ultrasound in screening for certain malformations. For the American Institute of Ultrasound in Medicine the main benefit of 3D ultrasound is greater accuracy in the assessment of neural tube defect severity. It also markedly improves the detection rate of facial cleft in high-risk pregnancies [35,36]. In addition 3D ultrasound is believed to simplify visualisation of midline structures in the fetal brain (e.g. corpus callosum) compared to its 2D counterpart [37,38].

## 5 Appendix

### Frequency of chromosome aberrations in newborns

Balanced translocation	1:500
Unbalanced translocation	1:2000
Pericentric inversion	1:100
Trisomy 21	1:700
Trisomy 18	1:3000
Trisomy 13	1:5000
47, XXY (Klinefelter)	1:1000 boys
47, XYY	1:1000 boys
47, XXX	1:1000 girls
45, X	1:5000 girls

Ultrasound abnormality	Trisomy 21	Trisomy 18	Trisomy 13	Triploidy maternal	45,X
<b>Kopfform</b>	Brächycephaly	Strawberry shape			
<b>Brain</b>		Choroid plexus cysts, corpus callosum agenesis, enlarged cisterna magna	Holoprosencephaly, microcephaly	Hydrocephalus	
<b>Face</b>	Absent nasal bone	Facial clefts, micrognathia	Facial clefts, cyclopla	Micrognathia	
<b>Nuchal transparency (Ø;mm)</b>	>3	>4	>5		>7, large hygroma
<b>Heart</b>	Arteriovenous channel, echogenic focus	Various cardiac defects	Various cardiac defects	Various cardiac defects	
<b>Thorax, diaphragm</b>		Diaphragmatic hernia			Pleural effusion
<b>Abdominal wall</b>			Omphalocele		
<b>Kidneys</b>	Mild hydronephrosis		Polycystic kidneys		Horseshoe kidney
<b>Bowel</b>	Duodenal atresia	Oesophageal atresia, echogenic bowel			Ascites
<b>Spine</b>		Meningomyelocele		Meningomyelocele	
<b>Extremities</b>	Slightly shorter femur, sandal gap, clinodactyly, hypoplastic fifth finger	Shortened long bone, radius aplasia, overlapping fingers, club foot, rocker bottom feet	postaxiale Polydaktylie	Syndactyly	
<b>Growth</b>		Early severe growth retardation	Early severe growth retardation	Early severe growth retardation	

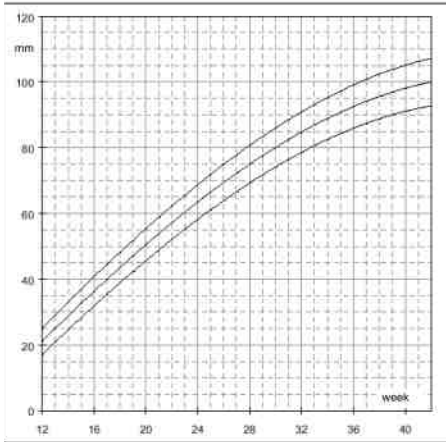


Name: \_\_\_\_\_  
 Born: \_\_\_\_\_  
 Gravida: \_\_\_\_\_ Para: \_\_\_\_\_

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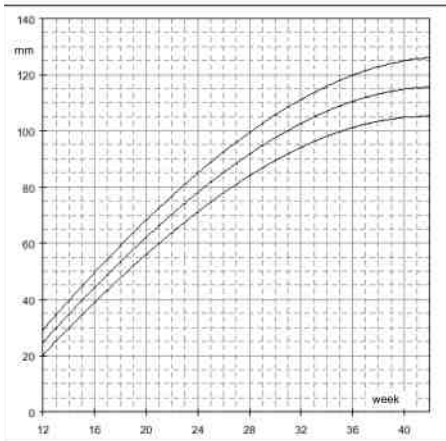
**Cranial biometry / Reference ranges**

**Biparietal diameter (BPD)**

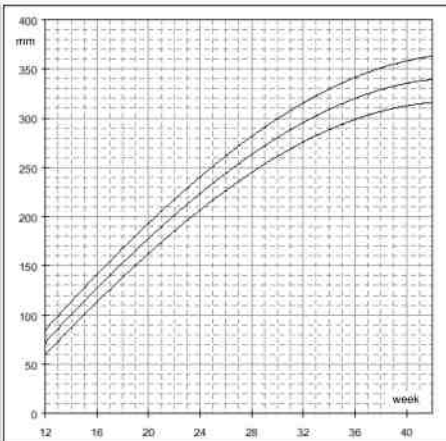


Cranial biometry centiles (mm)									
week	AD			AC			FL		
	5 <sup>th</sup>	50 <sup>th</sup>	95 <sup>th</sup>	5 <sup>th</sup>	50 <sup>th</sup>	95 <sup>th</sup>	5 <sup>th</sup>	50 <sup>th</sup>	95 <sup>th</sup>
12	17.0	21.0	25.0	20.2	24.6	29.1	59.7	72.1	84.9
13	20.8	24.9	29.0	24.9	29.6	34.3	73.3	86.1	98.9
14	24.5	28.7	32.9	29.6	34.5	39.4	86.7	99.9	113.1
15	28.2	32.5	36.8	34.3	39.3	44.4	99.9	113.5	127.0
16	31.8	36.2	40.6	38.8	44.1	49.4	112.9	126.8	140.7
17	35.3	39.9	44.4	43.2	48.7	54.2	125.6	139.9	154.2
18	38.8	43.5	48.1	47.6	53.2	58.9	138.1	152.7	167.4
19	42.2	47.0	51.7	51.8	57.7	63.5	150.2	165.2	180.3
20	45.6	50.4	55.3	55.9	62.0	68.1	162.1	177.5	192.9
21	48.8	53.8	58.8	59.9	66.2	72.4	173.6	189.4	205.2
22	52.0	57.1	62.2	63.7	70.2	76.7	184.9	201.0	217.1
23	55.1	60.3	65.5	67.5	74.1	80.8	195.7	212.2	228.7
24	58.1	63.4	68.7	71.1	77.9	84.8	206.2	223.1	240.0
25	61.1	66.5	71.9	74.5	81.6	88.7	216.4	233.6	250.9
26	63.9	69.4	74.9	77.8	85.1	92.4	226.1	243.7	261.3
27	66.6	72.2	77.8	80.9	88.4	95.9	235.5	253.4	271.4
28	69.2	74.9	80.7	83.9	91.6	99.3	244.4	262.7	281.1
29	71.7	77.6	83.4	86.7	94.6	102.5	252.9	271.6	290.3
30	74.1	80.1	86.0	89.3	97.4	105.5	260.9	280.0	299.1
31	76.4	82.5	88.5	91.8	100.1	108.4	268.4	287.9	307.3
32	78.6	84.7	90.9	94.1	102.5	111.0	275.5	295.3	315.1
33	80.6	86.0	93.1	96.1	104.6	113.5	282.1	302.2	322.4
34	82.5	88.9	95.3	98.0	106.9	115.8	288.1	308.7	329.2
35	84.3	90.8	97.3	99.7	108.6	117.8	293.6	314.5	335.5
36	86.0	92.6	99.1	101.1	110.4	119.7	298.6	319.9	341.2
37	87.5	94.2	100.9	102.4	111.9	121.3	303.0	324.6	346.3
38	88.9	95.7	102.5	103.4	113.1	122.8	306.8	328.8	350.9
39	90.1	97.0	103.9	104.2	114.1	124.0	310.0	332.4	354.8
40	91.2	98.2	105.2	104.7	114.8	124.9	312.6	335.4	358.2
41	92.1	99.2	106.3	105.1	115.3	125.6	314.6	337.7	360.9
42	92.9	100.1	107.3	105.1	115.6	126.1	315.9	339.4	363.0

**Occipitofrontal diameter (OFD)**



**Head circumference (HC)**



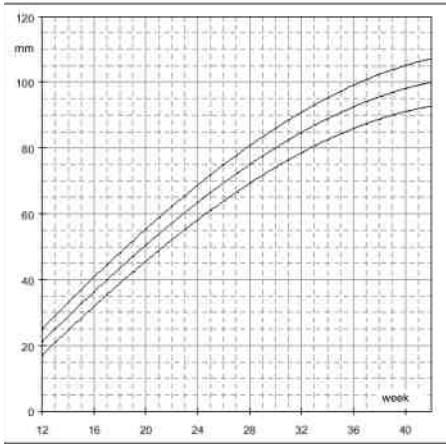
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Name: \_\_\_\_\_  
 Born: \_\_\_\_\_  
 Gravida: \_\_\_\_\_ Para: \_\_\_\_\_

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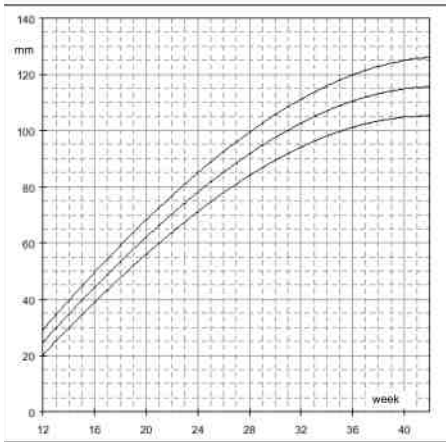
**Cranial biometry / Reference ranges**

Biparietal diameter (BPD)

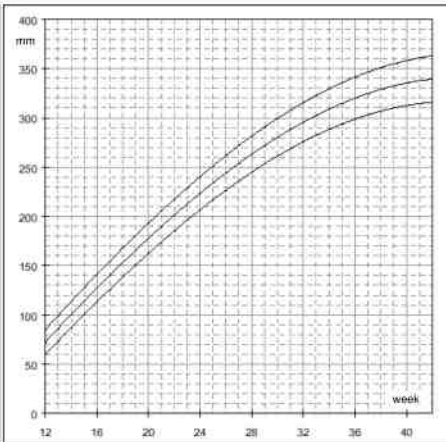


Cranial biometry centiles (mm)									
week	AD			AC			FL		
	5 <sup>th</sup>	50 <sup>th</sup>	95 <sup>th</sup>	5 <sup>th</sup>	50 <sup>th</sup>	95 <sup>th</sup>	5 <sup>th</sup>	50 <sup>th</sup>	95 <sup>th</sup>
12	17.0	21.0	25.0	20.2	24.6	29.1	59.7	72.1	84.9
13	20.6	24.9	29.0	24.9	29.6	34.3	73.3	86.1	98.9
14	24.5	28.7	32.9	29.6	34.5	39.4	86.7	99.9	113.1
15	28.2	32.5	36.8	34.3	39.3	44.4	99.9	113.5	127.0
16	31.8	36.2	40.6	38.8	44.1	49.4	112.9	126.8	140.7
17	35.3	39.9	44.4	43.2	48.7	54.2	125.6	139.9	154.2
18	38.8	43.5	48.1	47.6	53.2	58.9	138.1	152.7	167.4
19	42.2	47.0	51.7	51.8	57.7	63.5	150.2	165.2	180.3
20	45.6	50.4	55.3	55.9	62.0	68.1	162.1	177.5	192.9
21	48.8	53.8	58.8	59.9	66.2	72.4	173.6	189.4	205.2
22	52.0	57.1	62.2	63.7	70.2	76.7	184.9	201.0	217.1
23	55.1	60.3	65.5	67.5	74.1	80.8	195.7	212.2	228.7
24	58.1	63.4	68.7	71.1	77.9	84.8	206.2	223.1	240.0
25	61.1	66.5	71.9	74.5	81.6	88.7	216.4	233.6	250.9
26	63.9	69.4	74.9	77.8	85.1	92.4	226.1	243.7	261.3
27	66.6	72.2	77.8	80.9	88.4	95.9	235.5	253.4	271.4
28	69.2	74.9	80.7	83.9	91.6	99.3	244.4	262.7	281.1
29	71.7	77.6	83.4	86.7	94.6	102.5	252.9	271.6	290.3
30	74.1	80.1	86.0	89.3	97.4	105.5	260.9	280.0	299.1
31	76.4	82.5	88.5	91.8	100.1	108.4	268.4	287.9	307.3
32	78.6	84.7	90.9	94.1	102.5	111.0	275.5	295.3	315.1
33	80.6	86.9	93.1	96.1	104.8	113.5	282.1	302.2	322.4
34	82.5	88.9	95.3	98.0	106.9	115.8	288.1	308.7	329.2
35	84.3	90.8	97.3	99.7	108.6	117.8	293.6	314.5	335.5
36	86.0	92.6	99.1	101.1	110.4	119.7	298.6	319.9	341.2
37	87.5	94.2	100.9	102.4	111.9	121.3	303.0	324.6	346.3
38	88.9	95.7	102.5	103.4	113.1	122.8	306.8	328.8	350.9
39	90.1	97.0	103.9	104.2	114.1	124.0	310.0	332.4	354.8
40	91.2	98.2	105.2	104.7	114.8	124.9	312.6	335.4	358.2
41	92.1	99.2	106.3	105.1	115.3	125.6	314.6	337.7	360.9
42	92.9	100.1	107.3	105.1	115.6	126.1	315.9	339.4	363.0

Occipitofrontal diameter (OFD)



Head circumference (HC)



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Name: \_\_\_\_\_

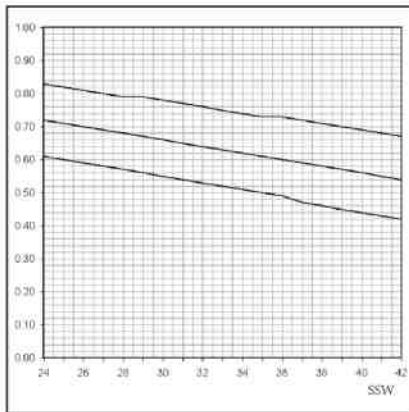
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Gravida: \_\_\_\_\_ Para: \_\_\_\_\_

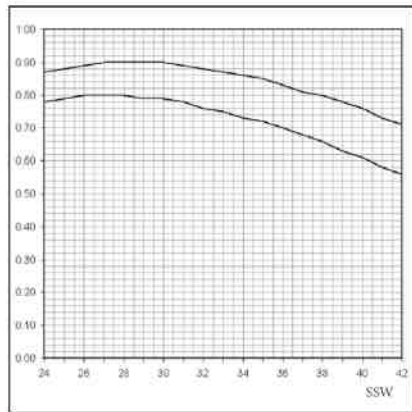
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## Reference Resistance Indices

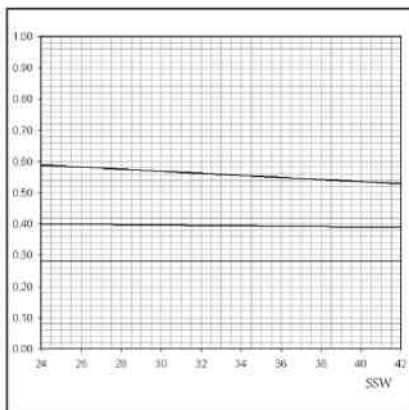
Umbilical artery



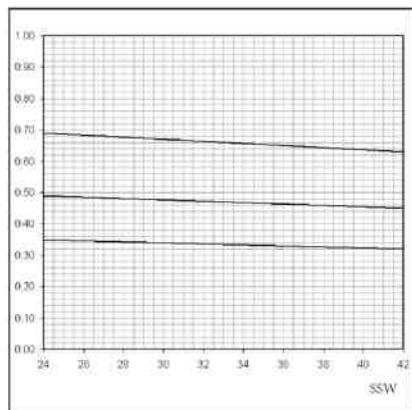
Fetal middle cerebral artery



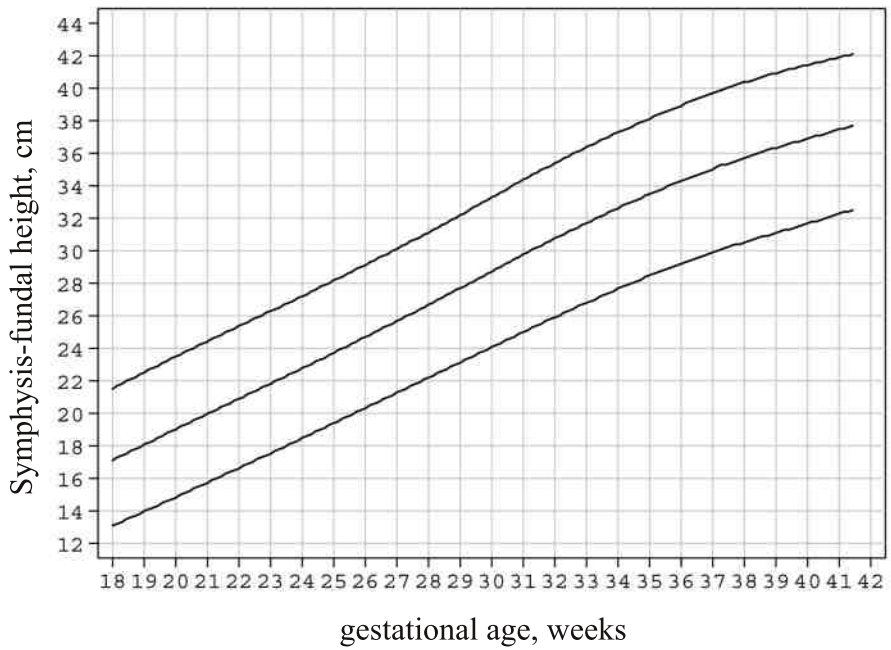
Placental uterine artery



Non-placental uterine artery



## Symphysis-fundal height - Reference curve 5<sup>th</sup>, 50<sup>th</sup> und 95<sup>th</sup> percentile



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