# Prenatal assessment of gestational age, date of delivery, and fetal weight

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## INTRODUCTION

Ultrasonography has advanced obstetric practice by enabling relatively detailed assessment of the fetus, including an accurate estimate of gestational age when performed before 22+0 weeks of gestation. This information is invaluable because most diagnostic and management decisions during pregnancy are strongly influenced by consideration of fetal development, which closely correlates with fetal age.

Fetal biometric measurements used to calculate gestational age and estimated date of delivery ("due date" or EDD) will be reviewed here. Other issues related to obstetric ultrasound, such as safety, techniques, and components of the examination, are reviewed separately. (See "Overview of ultrasound examination in obstetrics and gynecology".)

## TERMINOLOGY

- **Gestational age** – The discussion of gestational age in this topic is based on time since the last menstrual period (LMP), which is also called "menstrual age."

  By contrast, the "postconception age" or "embryonic age" is based on the time since conception, and thus it is 14 days less than the gestational or menstrual age in a woman with a 28-day menstrual cycle. The terms "postconception" and "embryonic age" are not used clinically when discussing pregnancy but are used by embryologists and dysmorphologists to describe early developmental events.

- **Estimated date of delivery (EDD)** – The EDD is 280 days from the onset of the LMP and 266 days from date of conception. Only 4 percent of women deliver on their EDD, in part because of the limitations of methods used to estimate gestational age, but also because of natural biologic variation in the pace of fetal maturation and the timing of natural delivery [1].

## BEST ESTIMATE OF DELIVERY DATE

For most pregnancies, the best estimate of the delivery date is based on sonography if sonography was performed before 22+0 weeks of gestation when this estimated date of delivery (EDD) differs from that calculated (calculator 1) from menstrual dating by more days than expected, as described in the table (table 1). If no ultrasound examination is performed by 22+0 weeks, the pregnancy is considered suboptimally dated. (See 'Suboptimally dated pregnancies' below.)

Crown-rump length (CRL) measured in the first trimester (0 to 13+6 weeks), if available, is the most accurate sonographic method of determining the EDD. First-trimester CRL is more accurate than any second-trimester (14+0 to 27+6 weeks) biometric parameter used for gestational age assessment because there is less biologic variation in fetal measurements in the first trimester than later in gestation. It is also more accurate than mean sac diameter.

The EDD derived from the earliest sonographic assessment of gestational age (CRL up to 13+6 weeks or fetal biometry at 14+0 to 21+6 weeks) becomes the patient's EDD, and this EDD is not changed by subsequent ultrasound examinations. (See 'First-trimester gestational age assessment' below and 'Crown-rump length' below.)

Two special clinical scenarios are:

- **Twin pregnancies** – For twin pregnancies, if there is a discrepancy between the twins in biometric measurements, the general consensus is that the EDD should be based on the measurements for the larger twin [2,3].
- **In vitro fertilization (IVF) pregnancies** – For pregnancies conceived by IVF, the EDD may be based on factors other than sonography and LMP. (See 'Assigning an estimated date of delivery to pregnancies conceived by assisted reproduction' below.)

## CLINICAL ASSESSMENT OF GESTATIONAL AGE

Gestational age can be estimated based on history, using the date of the last menstrual period (LMP) to calculate the estimated date of delivery (EDD), and physical examination.

**Naegele's rule** — Naegele's rule is a simple method of pregnancy dating. The EDD is calculated by counting back three months from the LMP and adding seven days. As an example, if the LMP is February 20, then the EDD will be November 27. If the LMP is May 28, then the EDD will be March 4. This method assumes the patient has a 28-day menstrual cycle with fertilization occurring on day 14.

Several factors limit the diagnostic performance of EDD based on the LMP date [4-6]:

- Many women do not have regular 28-day cycles due to variability in the length of the follicular phase, thus ovulation often does not occur on day 14.
- There are small variations in the duration of time between fertilization and implantation.
- Early pregnancy bleeding or recent use of hormonal contraceptives may lead to an incorrect assumption of the date of the LMP.
- Many women are not certain of the date of their last period.
- Women who rely on recall rather than written or electronic documentation of their LMP tend to show digit preference, most commonly the 15$^{th}$ day of the month [7].
- Women who conceive while breastfeeding may have lactational amenorrhea.
- Leap years, when they occur, have a minor effect.

In addition, women who rely on date of sexual intercourse to estimate date of conception can be off by a few of days since the oocyte can be fertilized up to 24 hours after ovulation and sperm are capable of fertilization up to five days after entering the female genital tract [8].

**Uterine size** — On physical examination, the pregnant uterus is soft and globular. The size-gestational age correlation is learned by experience and is often described in terms of fruit (eg, for singleton pregnancies: 6 to 8 week size = plum, 8 to 10 week size = orange, 10 to 12 week size = grapefruit), despite the imprecision of this terminology.

The uterus remains a pelvic organ until approximately 12 weeks of gestation, when it becomes sufficiently large to palpate abdominally just above the symphysis pubis. At approximately 16 weeks, the uterine fundus is palpable midway between the symphysis pubis and umbilicus, and at approximately 20 weeks it is palpable at the umbilicus. After 20 weeks, the symphysis-to-fundal height in centimeters should correlate with the week of gestation.

In the absence of other dating information, uterine enlargement two fingerbreadths above the umbilicus suggests the fetus is at a gestational age at the limit of viability, if neonatal intensive care is available. This crude estimate of gestational age can be clinically useful for decision-making in an emergency, such as maternal cardiac arrest.

Importantly, leiomyoma, obesity, multiple gestation, and other factors affecting uterine size or the ability to palpate the uterus (eg, retroverted position) reduce the diagnostic performance of physical examination-based gestational age assessment.

## SONOGRAPHIC ASSESSMENT OF GESTATIONAL AGE

Ultrasound estimates of gestational age are based on the assumption that gestational sac size, embryo size (eg, crown-rump length [CRL]), and the size of fetal parts (eg, cranium, long bones, abdomen) correlate with age. When there is a reason that a biometric parameter might incorrectly correlate with age, then that value is excluded from gestational age estimates. For example, femur length (FL) would be excluded from gestational age estimates in a fetus with skeletal dysplasia, while biparietal diameter (BPD) would be excluded in a fetus with massive hydrocephalus. (See 'Approach to discordant biometry markers' below.)

**Indications** — We recommend performing an ultrasound examination before 22+0 weeks of gestation routinely on all pregnant women because early ultrasound estimation is superior to dating based on the last menstrual period (LMP) or physical examination and also provides information about fetal development.

If sonography is performed selectively, sonographic estimation of gestational age is essential when:

- Menstrual cycles are irregular (vary by ≥7 days)
- LMP is unknown or uncertain
- The patient conceived while using hormonal contraception
- Uterine size on physical examination differs from that predicted by the LMP

**Choice of ultrasound technique** — First-trimester sonograms can be performed via the transvaginal (TVS) and/or the transabdominal (TAS) route. In the earliest stages of pregnancy, TVS generally provides clear and accurate images while TAS may be unable to even detect an intrauterine gestation [9]. Therefore, TVS is recommended for evaluation of the gestational sac and other early embryonic structures (eg, yolk sac, earliest identification of cardiac activity). Measurement of CRL in the first trimester is easier with TVS than with TAS, but not more accurate for determining gestational age [10].

TAS is used for second- and third-trimester biometry since the uterus enlarges into the mid and upper abdomen and the fetus is larger.

**Limitations of sonographic assessment of gestational age** — Factors that can reduce the diagnostic performance of sonographic gestational age assessment include poor quality images, multiple gestation, fetal position, fetal anomalies, and biologic variation.

Sonographic dating results in a small downward estimation of gestational age more often than an upward estimation [11] since delayed ovulation (after day 14) appears to occur more often than early ovulation. As a result, ultrasound examination tends to move the estimated date of delivery (EDD) to a later date than that calculated from menstrual dating. Thus, populations assigned an EDD by routine sonographic examination have a lower rate of induction for postterm birth than those assigned an EDD by menstrual dating (18 versus 31 per 1000); however, they also have a trend toward more low birth weight (<2500 g) deliveries (3.3 versus 2.8 percent) [12].

**First-trimester gestational age assessment** — First-trimester (up to 13+6 weeks) sonographic assessment of CRL is the most accurate method of estimating gestational age [12-20]. Although the gestational sac size is the earliest parameter that can be measured for assessment of gestational age (see 'Gestational sac' below), the CRL is a more accurate indicator of gestational age. Therefore, when the embryonic pole is evident in the gestational sac, CRL is measured to determine the EDD, the EDD derived from the earliest measurement of CRL becomes the patient's EDD, and this EDD is not changed based on subsequent biometry.

Some providers do not measure CRL to establish gestational age until cardiac activity is seen. Others will measure the CRL before cardiac activity is observed and use this measurement for estimating the EDD, but have the patient return for another ultrasound in approximately one week to exclude pregnancy loss.

**Crown-rump length** — Key points of gestational age assessment by measurement of the CRL include the following:

- When the embryo is evident, CRL ≤8+6 weeks of gestation is the most accurate biometric parameter for pregnancy dating (±5 days). The accuracy of the CRL falls slightly with a margin of error of ±7 days at 9+0 to 13+6 weeks.
- When CRL is <25 mm, gestational age (in days) = CRL (mm) + 42 [21].
- If CRL is >84 mm, BPD (or head circumference [HC] [22]) should be used for assessment of gestational age [22-25].

By definition, the CRL is the longest straight-line measurement of the embryo measured from the outer margin of the cephalic pole to the rump (image 1) [26,27]. A length of at least 5 mm routinely allows visualization of the embryo (image 2), but some embryos as small as 2 to 3 mm can be seen [28].

Standard practice is to take the mean of three CRL measurements [29]. Tables have been formulated to estimate gestational age for each numeric measurement of CRL up to 120 mm [26,30-32]. These tables vary because they are based on a variety of equations. A 2014 systematic review [33] suggested use of one of four equations for calculating gestational age from CRL [14,26,34,35]. Subsequently, an international standard for ultrasound dating of pregnancy based on CRL measurement was developed by the International Fetal and Newborn Growth Consortium for the 21$^{st}$ Century and is available online at INTERGROWTH-21 [36].

CRL becomes less accurate for prediction of EDD as gestation advances because of normal biologic differences in embryologic development and variations in anatomic positioning of the fetal head and torso [37,38].

Rarely, CRL is different from expected by LMP because of first-trimester growth delay, but there may be discrepancies due to karyotype abnormalities or anencephaly. (See "Diagnosis and outcome of first-trimester growth delay".)

**Other methods** — Although gestational sac size can be used to estimate gestational age, we recommend **not** using this measurement to calculate EDD. EDD is more accurate when a repeat ultrasound is performed later in gestation and the calculation can be based on CRL of an embryo with cardiac activity.

**Gestational sac** — Key points of gestational age assessment by TVS of the gestational sac include:

- The gestational sac is clearly visible at 4.5 to 5 weeks of gestation, with a double decidual sign appearing at 5.5 to 6 weeks (image 3).
- Gestational age (days) = mean sac diameter (MSD) in mm + 30.
- MSD is accurate to ±5 to 7 days, but is not sufficiently precise for accurately dating of pregnancies because nonviable pregnancies have a measureable MSD.

**Appearance** — The gestational sac is the first sonographic sign of an intrauterine pregnancy [29], and should be seen by 4.5 to 5 weeks of gestation [39]. It appears as a small, fluid-filled, sac-like structure eccentrically located within the endometrium. This structure and its echogenic rim represent the chorionic cavity, implanting chorionic villi, and associated decidual tissue [40].

The sonologist should be cautious when making the presumptive diagnosis of a gestational sac in the absence of a definite embryo or yolk sac. Without these findings, an intrauterine fluid collection could represent a pseudogestational sac related to an ectopic pregnancy. In the absence of an embryo or yolk sac, findings that increase the likelihood of an intrauterine gestational sac are an echogenic rim, eccentric position in the endometrium, and a "double decidual sac sign." The double sac sign refers to an intrauterine fluid collection surrounded by two concentric echogenic rings (image 3), and the "intradecidual sign" refers to a fluid collection with an echogenic rim located within a markedly thickened decidua on one side of the uterine cavity, with deviation of the central endometrial echo; both are related to intrauterine pregnancy [41,42]. These two signs are primarily used to help determine whether intrauterine fluid in a woman with a positive pregnancy test represents an intrauterine gestational sac (ie, positive double sac or intradecidual sign) or bleeding related to extrauterine pregnancy (intrauterine fluid centrally located within the endometrial cavity without a double sac or intradecidual sign). They are not used for calculating EDD, and their absence does not exclude intrauterine pregnancy (ie, do not assume ectopic pregnancy if an intrauterine sac does not have these characteristics) [43,44].

As the gestation progresses, the sac (chorionic cavity) enlarges. The appearance and thickness of the decidua basalis changes over time until it can no longer be identified at 10 weeks of gestation [45]. The decidua capsularis becomes stretched and ultimately merges with the decidua parietalis.

The shape of the sac may change from a circular to an irregular appearance on serial examinations. This may be indicative of various physiologic and anatomic factors (ie, uterine contractions, enlarged bladder, fibroids, implantation bleeds) or may be a sign of a failed pregnancy. (See "Pregnancy loss (miscarriage): Risk factors, etiology, clinical manifestations, and diagnostic evaluation", section on 'Imaging'.)

**Diameter** — Initial dating measurements are based on sac diameter when no embryo is evident within the gestational sac. To correctly measure sac diameter, the cursors should be placed on the sac itself and should not include the echogenic region surrounding the gestational sac [29].

Gestational age based upon gestational sac measurements can be calculated in several ways. One standardized formula that is frequently used is the mean sac diameter (MSD), which is derived by calculating the mean of the three perpendicular sac diameter measurements [46-49]. The gestational age can then be determined by consulting the table showing gestational age according to MSD (table 2). The table should not be used when CRL is measurable.

A simplified method of estimating gestational age is to calculate the sum of 30 plus the sac diameter in millimeters. This number is equivalent to the gestational age in days. As an example, if the sac diameter is 5 mm, the calculated age would be estimated at 35 days (30+5) or five weeks [29,46,50,51].

A gestational sac size of 2 to 3 mm is the smallest diameter that can be clearly visualized within the uterine cavity and correlates with a gestational age of approximately four weeks and one to three days [50,52,53]. The early gestational sac grows by approximately 1 mm per day, or 7 mm per week.

Gestational sac measurement is less accurate later in pregnancy when >14 mm [46] and when the embryonic/fetal pole can be identified [28]. Therefore, it is used for dating only very early pregnancies, before CRL length can be measured. MSD should never be used to establish an EDD or gestational age beyond approximately 7 weeks, when an embryonic pole should be visible.

### First-trimester sonographic milestones

**Yolk sac** — Key points regarding TVS of the yolk sac include:

- The yolk sac first becomes visible at 5 weeks of gestation and normally degrades between 10 to 12 weeks.
- Yolk sac diameter correlates poorly with gestational age, so it is not used for estimating gestational age and EDD.

The yolk sac is the first anatomic structure to appear within the gestational sac and provides confirmation of an intrauterine pregnancy. It is spherical with a sonolucent center and echogenic periphery (image 4) [29].

The yolk sac can be noted initially at the beginning of the 5th week of gestation (MSD approximately 5 mm), although it may not appear until the MSD approaches 8 mm [39,54,55]. By identifying the yolk sac, the embryonic disc (ie, the thickened region along the outermost margin of the yolk sac) is also located [46,54,56,57]. The embryonic disc becomes visible at 1 to 2 mm in length, which correlates with a gestational age of approximately six weeks [21,58-60].

Reasonable criteria for an abnormal gestation are MSD of ≥8 mm with an absent yolk sac [54]. However, because of patient and sonographer variability, this sac size should not be taken as an absolute threshold for diagnosis of an abnormal pregnancy. Either correlation with human chorionic gonadotropin (hCG) and/or sonographic follow-up should be obtained if an initial evaluation of pregnancy shows an 8 mm empty sac (no yolk sac or embryonic disk). Because of the wide normal variation in yolk sac size and appearance, a small, large, or irregular yolk sac is at best weakly predictive of spontaneous abortion [61-65]. To be confident of nonviable pregnancy, neither a yolk sac nor an embryonic pole should be visible by the time the mean sac diameter is 25 mm [66]. (See "Ultrasonography of pregnancy of unknown location".)

Yolk sac diameter is calculated by taking the average of three measurements obtained with the calipers placed at the center of the yolk sac wall [62]. Tables are available correlating yolk sac diameter and gestational age, but the correlation is poor [67].

The yolk sac continues to grow to a maximum diameter of approximately 6 mm by 10 weeks of gestation [61,62,68]. During this natural progression, the yolk sac migrates to the periphery of the chorionic cavity and becomes undetectable sonographically by the end of the first trimester [61,62,68,69].

**First detection of cardiac activity** — If the embryo is visible but too small to measure adequately, detection of cardiac activity (movie 1) establishes a gestational age of 5.5 to 6 weeks [55].

**Second- and third-trimester gestational age assessment**

**Use of multiple biometric markers** — The four standard biometric parameters used to estimate gestational age if the initial ultrasound examination is in the second trimester (14+0 to 27+6 weeks) or third trimester (28+0 weeks to delivery) are BPD, HC, abdominal circumference (AC), and FL [70]. These measurements should never be used to change an EDD determined in the first trimester by CRL, since the latter is more accurate. Instead, they are used to determine whether fetal size is within the normal range or restricted, accelerated, or asymmetric based on the previously calculated EDD.

With advancing pregnancy, human error and normal variation in fetal size can result in over- or underestimation of gestational age. After the first trimester, regression equations using the four standard biometric parameters minimize, but do not eliminate, these problems and yield the best estimation [71,72]. The ideal biometric assessment incorporates the least number of images with the highest potential for accuracy. When multiple biometric parameters were compared, the best test performance with the least variability was obtained with the four standard biometric measures (BPD, HC, FL, and AC) described below [71,73]. A two biometric parameter (HC and FL) approach showed similar test performance as the four parameter approach for predicting gestational age before 22+0 weeks of gestation; variability was slightly higher later in pregnancy [73-75]. The addition of a fifth parameter, such as length of the radius, did not further improve test performance [73]. Therefore, the four measures of BPD, HC, FL, and AC has remained the standard formula for estimating gestational age in the second and third trimesters.

**Approach to discordant biometry markers** — The estimation of gestational age based on one biometric marker may be significantly different from that calculated from the others. A thorough evaluation is warranted to determine the etiology of the discordant measurement. As an example, there may be a fetal abnormality, such as hydrocephalus, distorting the HC or BPD, and gastroschisis with exteriorized bowel may distort the AC. After a careful assessment to determine potential clinical significance of a discordant marker, it is usually appropriate to omit a single discordant marker from the gestational age calculation.

Additional measurements may be useful when there is more than one biometric discrepancy. If the four routine parameters do not correlate, choosing which measurements are most accurate for dating purposes can be a difficult task. Incorporating other parameters may be useful in this setting. As an example, the transverse cerebellar diameter (in millimeters) correlates with gestational age up to 22 weeks of gestation [76]: When standard biometry is inconclusive, this additional measurement may help to clarify the situation. However, as with all parameters discussed, the accuracy of additional measurements is age-dependent with significant variability in late pregnancy.

### Biometric markers

**Biparietal diameter** — The BPD is the best-studied biometric parameter [31,74,77-82] because it is highly reproducible. We agree with guidelines from national organizations that recommend using BPD for gestational age assessment when the CRL is >84 mm (14+0 weeks of gestation) and CRL for gestational age assessment when CRL is ≤84 mm [23-25]. The margin of error for pregnancies ≤13+6 weeks of gestation is shown in the table (table 1). Significant variation after 22 weeks is likely due to large normal biologic variation in fetal shape and size with advancing gestational age [79,83,84].

The BPD is measured on a plane of section that intersects both the third ventricle and thalami (image 5) [28,85]. This standardized method of measurement helps to ensure reproducibility among examiners. To further enhance test performance, the calvarium should appear smooth and symmetrical in the plane of section. The appropriate image can be obtained by positioning the abdominal transducer perpendicular to the fetal parietal bones [28]. The cursors are then placed on the outer edge of the proximal skull and the inner edge of the distal skull. This length represents the BPD [28,85,86].

HC may be more reliable than BPD in determining gestational age when there are variations in skull shape, such as dolichocephaly or brachycephaly [87].

**Cephalic index** — The fetal cranium may not always display a traditional shape, particularly with breech presentations, oligohydramnios, premature rupture of the membranes, and neural tube abnormalities. Head compression or distortion from these conditions may result in an abnormal cranial conformation (eg, dolichocephaly) that lowers test performance of the BPD for gestational age estimation [28,88,89]. In these cases, the cephalic index (CI) should be measured.

CI refers to the ratio of the BPD and the occipitofrontal diameter (OFD) multiplied by 100 [28]. The standard CI range for normal-shaped craniums approximates one standard deviation from the mean (>74 or <83) [87]. Therefore, if the CI measurement approaches the outer limits of the normal range, the use of the BPD for estimation of gestational age is not accurate [87,90]. In these cases, HC (discussed below) is recommended for cranial assessment because it provides a good estimate of gestational age despite the fetus' irregular cranial structure [87].

**Head circumference** — Measurement of the fetal HC provides a good estimate of gestational age on routine sonograms, but also is useful in the clinical setting of growth disorders or variations in skull shape when other measures may not perform well [71-73,77,83,91,92]. In most fetuses, a HC more than two standard deviations below the mean represents the lower end of the distribution in a normal population, while HC more than three standard deviations below the mean is more strongly associated with a pathologic condition. (See "Microcephaly in infants and children: Etiology and evaluation".)

Margin of error for pregnancies ≥14+0 weeks is shown in the table (table 1). Some studies have demonstrated superiority of HC when compared with the BPD [71-73,77,84,91]. As with other biometric measures, significant variation after 22 weeks is likely due to large normal biologic variation in fetal shape and size with advancing gestational age [74,77,78,84].

The correct plane for the image passes through the thalami and third ventricle, and is similar to the plane for the BPD. However, additional intracerebral landmarks that must be visualized to obtain the appropriate measurement include the cavum septum pellucidum (image 6) anteriorly and the tentorial hiatus posteriorly [28]. This view depicts the greatest anterior-posterior length of the cranium and resembles an "arrow" with the anterior portion appearing as tail feathers, the third ventricle and Sylvian aqueduct as the shaft, and the actual arrowhead comprised of the ambient and quadrigeminal cisterns and the tentorial hiatus [28]. The standard view should not include the cerebellum or the lateral cerebral ventricles.

The calvarium should always appear symmetrical in the image. HC measurements are obtained by placing the cursors on the outer margins of the calvarium bilaterally [28], in contrast to BPD measurements, which extend from the inner calvarium on one side to the outer calvarium on the other side. By using the computerized ellipse function, the ultrasound machine will assist in the approximation of the outer perimeter of the calvarium. It is important to avoid measuring the outer margin of the skin overlying the scalp since doing so will falsely increase the HC.

**Femur length** — The FL can be measured as early as 10 weeks of gestation because of its size and echogenicity [28]. The margin of error for pregnancies ≥14+0 weeks is shown in the table (table 1). As with other biometric measures, significant variation after 22 weeks is likely due to large normal biologic variation in fetal shape and size with advancing gestational age [71,73,84,93-96].

Even though FL is a simple "one-dimensional" image, errors in measurement often occur [75,97,98]. The transducer should be aligned along the long axis of the femoral bone [28]. The femur closest to the transducer (the "upside" femur) should be the one measured. The proper view is obtained by visualizing either the femoral head or the greater trochanter at the proximal end of the femur and the femoral condyle at the distal end [97]. The calipers should be placed at the junction of bone and cartilage (image 7) to measure only ossified bone [97]. They should not contain the femoral head [99]. Including nonossified portions of the femur and not visualizing the full femur (femoral head/greater trochanter to femoral condyle) are the major sources of error in gestational age assessment by FL. The former overestimates gestational age and the latter underestimates gestational age.

Average FL appears to vary slightly among ethnic groups (shorter in Asian and longer in Black compared with White/Hispanic individuals), and has been noted as early as the end of the first trimester [100-102]. Short femurs may be a normal finding or a marker of aneuploidy (eg, trisomy 21). Severely shortened (<5$^{th}$ percentile) or abnormal appearing femurs in the second trimester suggest a skeletal dysplasia or early-onset fetal growth restriction [103-105]. (See "Approach to prenatal diagnosis of the lethal skeletal dysplasias", section on 'Definition of short femur' and "Sonographic findings associated with fetal aneuploidy", section on 'Shortened long bones'.)

**Abdominal circumference** — The AC appears to have a slightly lower ability to predict gestational age early in the second trimester than the BPD, HC, and FL [71-73,84]. Some of the variability may be due to error in ultrasound technique, along with natural biologic variations. The margin of error for pregnancies ≥14+0 weeks is shown in the table (table 1). As with other biometric measures, significant variation after 22 weeks is likely due to large normal biologic variation in fetal shape and size with advancing gestational age [84,106].

Due to the wide margin of error, AC is more often used for estimations of fetal weight and interval growth evaluations rather than gestational age assessment. However, the AC can be a valuable additional measure for dating during the second trimester, especially in fetuses with cranial or limb abnormalities.

Measuring the AC is challenging since the abdomen is not symmetrical, not as echogenic as the cranium and femur, and changes during fetal breathing and other movement [28]. Therefore, the AC is not as easily measured. The image is taken at the level of the largest diameter of the fetal liver, denoted by the point of union of the right and left portal veins, which has a "hockey stick" appearance (image 8A-B) [107]. This plane was chosen because the size of the liver correlates well with overall fetal growth. The correct plane can be confirmed by visualizing the umbilical segment of the left portal vein in its shortest length. If the cross-section through the fetal abdomen is skewed caudally, this vein will appear in a longer image [28]. Two additional guidelines for correct measurement are: (1) positioning the transducer perpendicularly to the fetal abdominal wall and (2) visualizing the symmetrical appearance of the lower ribs [28]. The fetal stomach is typically visualized on the AC view. The measurement is taken by placing four calibration points around the abdomen on the skin edge, not the rib cage (image 8B). This will improve test performance while reducing the risk of underestimation of the AC [28]. The ultrasound machine will approximate the AC. Another method is to use the electronic ellipse function on the ultrasound machine.

**Other biometric parameters** — Other less-commonly used biometric parameters include but are not limited to the intra- and interorbital diameters [108], transverse cerebellar diameter (image 9) [76,109,110], clavicle length [111], foot length [112,113], and length of long bones of the extremities [28,93,108,111,112,114-116]. These measures tend to have slightly wider ranges of variability in comparison with standard parameters during the early second trimester, and once again, there is marked variability late in the gestation. Therefore, the value of these additional measurements is questionable, except when fetal anomalies (eg, omphalocele, anencephaly) preclude use of standard biometric parameters.

**Third-trimester sonographic milestones of fetal maturity** — There are several signs suggestive of fetal maturity that can be observed sonographically and correlated with gestational age when an early ultrasound examination has not been performed or menstrual dates are unknown or uncertain. As an example, the femoral epiphyseal and proximal tibial ossification centers are well visualized by 32 and 35 weeks of gestation, respectively [117-121]. The proximal humeral epiphysis also appears in the late third trimester and correlates with fetal lung maturity and gestational age [118,119]. However, identification of such landmarks of maturation of the bony skeleton cannot be incorporated into actual biometric evaluation of gestational age. They are merely visual aids to help establish fetal maturity in late pregnancy.

**Calculators, gestational wheels, and apps** — Calculators that determine EDD and current gestational age are widely available (calculator 1 and calculator 2) and should be used instead of traditional mechanical gestational wheels. Electronic techniques, such as apps available for download to cell phones, appear to be more accurate than these wheels.

In a study of 31 mechanical gestational wheels from a variety of sources, the largest discrepancy was four days short of the EDD predicted by Naegele's rule, two of the wheels yielded EDDs that differed from each other by seven days, and wheels from the same source did not agree with each other [122]. In this study all 20 apps gave an EDD consistent with Naegele's rule and all corrected for a leap year, while none of the mechanical gestational wheels made this adjustment.

However, others have found that a high proportion of gestational age apps are also inaccurate [123]. Clinicians and patients should be aware of this possibility when using a gestational age app, and clinicians should test the accuracy of the app they use. The American College of Obstetricians and Gynecologists offers an EDD calculator app free of charge [124].

## SUBOPTIMALLY DATED PREGNANCIES

The American College of Obstetricians and Gynecologists considers pregnancies "suboptimally dated" in the absence of an ultrasound examination before 22+0 weeks of gestation confirming or revising the estimated date of delivery (EDD) [125]. If the first ultrasound examination is performed at ≥22+0 weeks of gestation and discordant with menstrual dates, it is inappropriate to rely solely on a single set of the usual biometric parameters for assessment of gestational age. A single late examination cannot reliably distinguish between a pregnancy that is misdated and younger than expected and a pregnancy that is complicated by fetal symmetric growth restriction.

In these cases, serial measurements three to four weeks apart can be helpful. Normal interval growth supports the sonographic estimate of gestational age, while suboptimal interval growth suggests a growth-restricted fetus who may be further along in gestation than predicted by biometry. Accelerated fetal growth suggests a large for gestational age fetus who may be less far along than predicted by biometry. Thus, serial examinations in this setting allow the clinician to make a more reliable clinical assessment of the EDD.

In some cases, very early fetal growth restriction rather than inaccurate menstrual dating may be the reason for a discrepancy between an early ultrasound and menstrual dating (or dating based on conception using assisted reproductive technologies) [74], although this is uncommon [126-128]. When an EDD is revised because of smaller than expected size of the fetus on an ultrasound examination before 22 weeks, we suggest a follow-up ultrasound to evaluate fetal growth over time and make sure this finding was not due to early growth restriction.

## ASSIGNING AN ESTIMATED DATE OF DELIVERY TO PREGNANCIES CONCEIVED BY ASSISTED REPRODUCTION

When the conception/fertilization date is known with certainty, as with assisted reproduction, the estimated date of delivery (EDD) can be calculated based on this date. Online calculators and apps are available for calculating EDD and gestational age [129,130]. The patient/clinician enters one of the following dates, as appropriate: date of ovulation, date of egg retrieval, date of insemination, and date of cleavage stage (day 3) or blastocyst (day 5) transfer.

Assuming the EDD is 280 days from the onset of the last menstrual period and 266 days from date of conception in a natural cycle, then in a fresh in vitro fertilization cycle, the EDD can be calculated by adding 266 days to the date of egg retrieval/fertilization (ie, 14 + 266 = 280). In a cycle using a frozen cleavage stage embryo (day 3 embryo), the EDD can be calculated by adding 263 days to the date of embryo transfer to account for three days of embryo culture (ie, 17 + 263 = 280). In a cycle using a frozen blastocyst stage embryo (day 5 embryo), the EDD can be calculated by adding 261 days to the date of embryo transfer.

## SONOGRAPHIC ASSESSMENT OF FETAL WEIGHT

Sonographic estimation of fetal weight is available on machine biometry packages in the second trimester. However, sonograms performed for the purpose of estimated fetal weight (EFW) are not typically useful until the age of viability, at approximately 24 weeks of gestation.

**Performance** — Investigators have developed at least 30 formulas to calculate EFW. Variables in the formulas include measurement of biparietal diameter, head circumference, abdominal circumference (AC), and/or femur length. The two most popular formulas are Warsof [131] with Shepard modification [132] and Hadlock [133,134]. These formulas are included in most ultrasound equipment packages. We suggest use of the modified Hadlock formula, which requires measurement of the head, abdomen, and femur, because its mean absolute percentage error is small and more reproducible than other formulas. There is no strong evidence that formulas that use additional biometric parameters (eg, thigh circumference) are more accurate than those using three parameters, while formulas that use only one or two biometric parameters are less accurate. Use of three-dimensional ultrasound may improve estimation of fetal weight, but data are limited and inconsistent [135,136].

In a systematic review of studies that compared birth weight with ultrasound EFW by 11 formulas, no formula was consistently superior and the random error in fetal weight estimation exceeded 14 percent of birth weight in 5 percent of fetuses [137]. Both intraobserver and interobserver variability was large.

In addition to the formula used, other factors potentially affecting the accuracy of EFW include:

- Gestational age (formulas are most accurate at term) [138,139].
- Growth restriction or macrosomia (formulas are most accurate in normal weight range) [138,139] – The mean and standard deviation of error in EFW appear to be greater for small (<1000 g) and large fetuses (in the >90$^{th}$ percentile for weight at term) [137,140,141]. In large fetuses, underestimation of weight is more common than overestimation, whereas in small fetuses, overestimation is more common. In a meta-analysis of studies on the accuracy of ultrasound biometry in the prediction of macrosomia (birth weight >4000 g), likelihood ratios were

5.7 (95% CI 4.3-7.6) for a positive test and 0.48 (95% CI 0.38-0.60) for a negative test, using Hadlock's method of estimating fetal weight [142].

Diagnosis of fetal growth acceleration and restriction are discussed in detail separately. (See "Fetal macrosomia" and "Fetal growth restriction: Screening and diagnosis".)

- Low-quality images – Reports are varied with respect to effect of obesity, oligohydramnios, polyhydramnios, and fetal position on accuracy of fetal weight assessments [143-147].
- Multiple fetuses [148-150] – EFW formulas for twins are the same as those used for singletons, but are less accurate in twins. Possible reasons include the technical difficulty of obtaining correct ultrasound views in multiple gestations and "perinatal switch," whereby twin A in utero is not the first twin to deliver. In one retrospective cohort study of 4280 singleton and 586 twin fetuses delivered within 48 hours of an ultrasound examination, weight predictions were within 10 percent of actual birth weight in 62 percent of singletons versus 50 percent of twins and within 15 percent of actual birth weight in 82 percent of singletons versus 69 percent of twins.
- Race, ethnicity, and fetal sex, which affect birth weight distribution, so an appropriate table for the population should be used, if available [102,151,152].
- Variability in fetal adiposity.
- Fetal anomalies in which the biometric measurements are increased or decreased by the fetal malformation (eg, abdominal wall defects, severe hydrocephaly, microcephaly, skeletal dysplasia) and do not truly reflect the fetal weight. In these cases, an EFW formula that does not involve the anomalous anatomy is used.
- Operator experience.
- Quality of equipment.

**Fetal weight distribution by gestational age** — One example of fetal weight distribution by gestational age is provided in the table (table 3); several such tables exist and are slightly different depending on the population studied. An international standard (INTERGROWTH-21$^{st}$) has also been developed for fetuses (table 4) [153] and newborns (table 5) [154].

**Magnetic resonance imaging** — Several studies have evaluated magnetic resonance imaging (MRI) for EFW and found that this technique, which is based on measurement of total fetal body volume, performs better than two-dimensional (2D) ultrasound [155,156]. In one literature review, EFW by MRI had a mean or median relative error of 2.6 to 3.7 percent when performed within one week of delivery, whereas the relative error for 2D ultrasound was 6.3 to 11.4 percent for the same fetuses [155]. In one of the included studies, compared with ultrasound, MRI detected more large for gestational age neonates (≥95$^{th}$ percentile: 98 versus 67 percent) and small for gestational age neonates (≤10$^{th}$ percentile: 100 versus 78 percent) at a fixed false-positive rate of 10 percent. Three-dimensional ultrasound may perform better than 2D ultrasound because it incorporates thigh volume in the EFW calculation.

Barriers to routine clinical use of MRI for EFW at this time include cost and availability. In addition, an improvement in pregnancy outcome needs to be established before adopting a new approach to fetal weight assessment.

## SOCIETY GUIDELINE LINKS

Links to society and government-sponsored guidelines from selected countries and regions around the world are provided separately. (See "Society guideline links: Prenatal care".)

## SUMMARY AND RECOMMENDATIONS

- The estimated date of delivery (EDD) can be calculated without tools by counting back three months from the last menstrual period (LMP) and adding seven days. (See 'Naegele's rule' above.)

- For most pregnancies, the best estimate of the delivery date is based on sonography if sonography was performed before 22+0 weeks of gestation and this EDD differs from that calculated (calculator 1) from menstrual dating by more than expected, as described in the table (table 1). If no ultrasound examination is performed by 22+0 weeks, the pregnancy is suboptimally dated.

  Crown-rump length (CRL) measured in the first trimester (up to 13+6 weeks), if available, is the most accurate sonographic method of determining the EDD. It is accurate within ±5 to 7 days, depending on when the measurement is obtained. (See 'Best estimate of delivery date' above.)

- For twin pregnancies, if there is a discrepancy between the twins in biometric measurements, the general consensus is that the EDD should be based on the measurements for the larger twin. (See 'Best estimate of delivery date' above.)

- A pregnancy is "suboptimally dated" in the absence of an ultrasound examination showing a CRL or fetus with cardiac activity before 22+0 weeks of gestation confirming or revising the EDD. (See 'Suboptimally dated pregnancies' above.)

- Calculators that provide EDD and current gestational age based on ultrasound examination and/or LMP are widely available (calculator 1 and calculator 2) and are more accurate than traditional mechanical gestational wheels. (See 'Calculators, gestational wheels, and apps' above.)

- The embryonic pole can be visualized at approximately six weeks of gestation. CRL should be used to estimate gestational age up to 84 mm (14 weeks of gestation), and the biparietal diameter (BPD) should be used for CRL measurements >84 mm. CRL is accurate within ±5 days at ≤8+6 weeks of gestation and within ±7 days at 9+0 to 13+6 weeks. (See 'Crown-rump length' above.)

- The gestational sac is the earliest sonographic landmark of pregnancy and can be visualized at 4.5 to 5 weeks by transvaginal ultrasound (table 6). Measurement of the gestational sac diameter (MSD) allows early estimation of gestational age, but should not be used to calculate the EDD or to calculate gestational age when an embryonic pole is visible. The sum of 30 and the sac size in millimeters is equivalent to the gestational age in days. (See 'Gestational sac' above.)

- After the first trimester, the preferred biometric measurements for assessment of gestational age are a combination of BPD, head circumference (HC), femur length (FL), and abdominal circumference (AC). Prior to 16 weeks, the accuracy of BPD, HC, FL, and AC for estimating gestational age is ±7 days, but this gradually falls to three to four weeks in the third trimester (table 1). (See 'Sonographic assessment of gestational age' above.)

- Fetal biometry at ≥22+0 weeks of gestation is not sufficiently accurate to change menstrual dating without correlative sonographic follow-up. Serial measurements over three to four weeks may be helpful. Normal interval growth supports the sonographic estimate of gestational age, while suboptimal interval growth suggests a growth-restricted fetus who may be further along in gestation than predicted by biometry. Accelerated fetal growth suggests a large for gestational age fetus who may be less far along than predicted by biometry. (See 'Suboptimally dated pregnancies' above.)

- When the conception/fertilization date is known with certainty, as with assisted reproduction, the EDD can be calculated based on this date. Online calculators and apps are available for calculating EDD and gestational age. (See 'Assigning an estimated date of delivery to pregnancies conceived by assisted reproduction' above.)

- Ultrasound estimates of gestational age are based on the assumption that size correlates with age. When there is a reason that a biometric parameter might not correlate with age, then that value is excluded from gestational age estimates. Measurements of additional biometric parameters may be useful when there are biometric discrepancies. (See 'Sonographic assessment of gestational age' above and 'Approach to discordant biometry markers' above.)

- In pregnancies with an unknown or uncertain LMP and late first sonogram, ossification of the distal femoral epiphysis suggests a fetal age of at least 32 weeks, and ossification of the proximal tibial and humeral epiphyses suggests a fetal age of at least 35 weeks. (See 'Third-trimester sonographic milestones of fetal maturity' above.)

- Fetal weight is estimated using formulas that incorporate measurements of BPD, HC, AC, and/or FL. (See 'Sonographic assessment of fetal weight' above.)



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Topic 5391 Version 48.0

## GRAPHICS

### Reassigning EDD based on date-ultrasound discrepancy

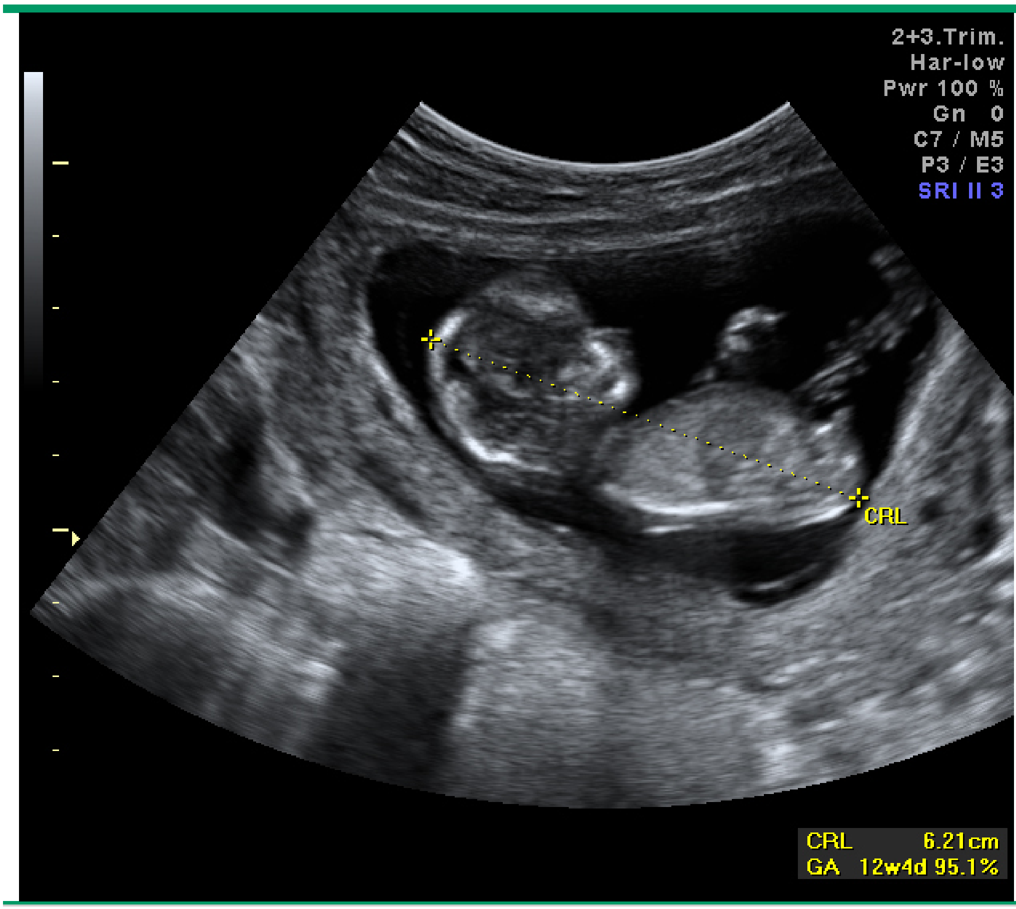
| Gestational age (weeks+days) based on the first day of LMP | Change LMP-based EDD to ultrasound-based EDD if ultrasound-based gestational age differs from LMP-based gestational age by more than: |
|---|---|
| ≤8+6 | 5 days |
| 9+0 to 13+6 | 7 days |
| 14+0 to 15+6 | 7 days |
| 16+0 to 21+6 | 10 days |
| 22+0 to 27+6 | 14 days |
| ≥28+0 | 21 days |

EDD: estimated date of delivery; LMP: last menstrual period.

*Data from: American College of Obstetricians and Gynecologists. Committee Opinion No 700: Methods for Estimating the Due Date. Obstet Gynecol 2017; 129:e150.*

Graphic 97246 Version 7.0

### Crown rump length




CRL: crown rump length; w: weeks of gestation; d: days; GA: gestational age.

*Courtesy of Courtney D Stephenson, DO.*

Graphic 94938 Version 2.0

### Measurement of embryo in gestational sac

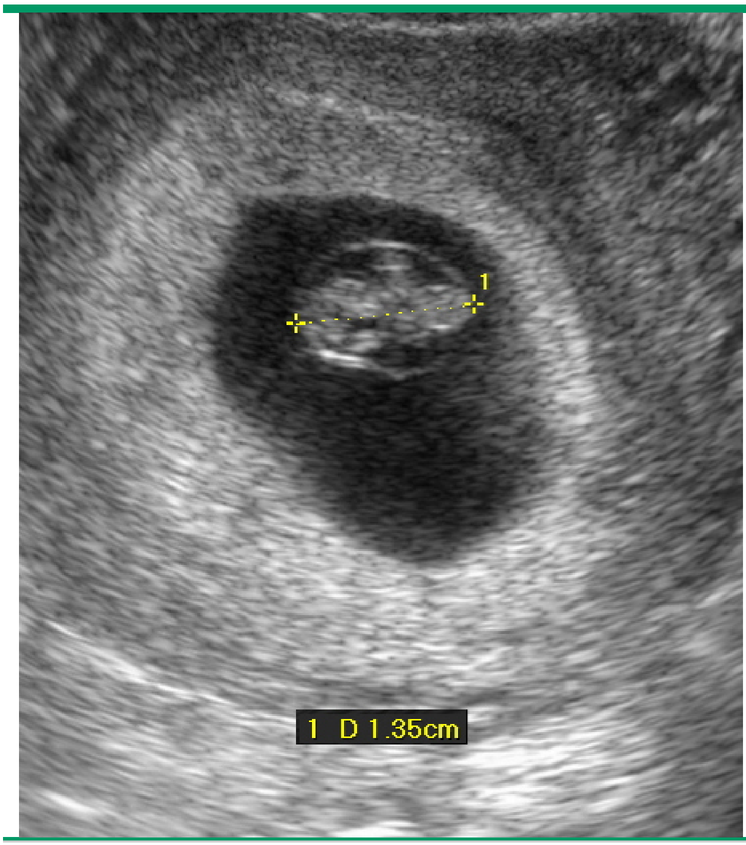
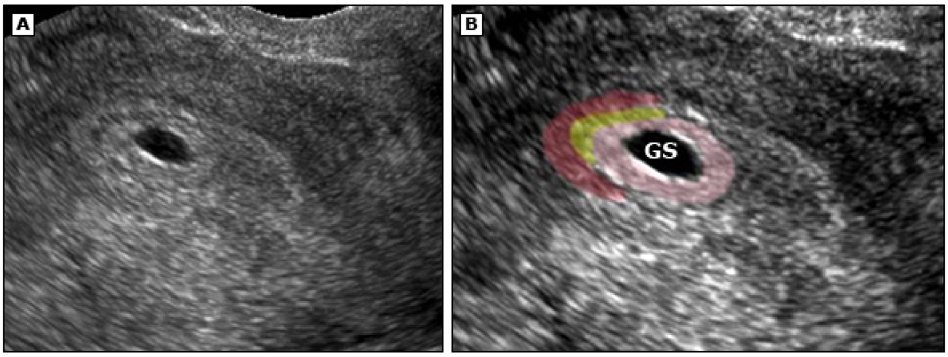



Image of an early gestational sac demonstrating the early embryo. Calipers are placed at both ends of the embryo measuring the longest length from the "crown to the rump" giving the crown-rump length. This measurement is used for dating the pregnancy. Surrounding the embryo is the developing amnion as shown by the hyperechoic circular line.

*Courtesy of Thomas Shipp, MD.*

Graphic 71198 Version 3.0

## Early IUP with double decidual sac sign




Transvaginal ultrasound shows an early intrauterine pregnancy with double decidual sac sign. Image B is a color overlay of the structures that contribute to the appearance, including the GS, surrounded by the decidua capsularis (light pink), partially surrounded by the decidua parietalis (dark pink). In between these two layers is a small amount of fluid (yellow).

IUP: intrauterine pregnancy; GS: gestational sac.

Graphic 95553 Version 2.0

### Determination of gestational age based on mean sac diameter

| Mean sac diameter (mm) | Mean gestational age (weeks) | Gestational age (days) | | |
|---|---|---|---|---|
| | | Mean | 95% confidence interval | 95% prediction interval |
| 2 | 5 | 34.5 | 34.2-35.5 | 31.6-38.2 |
| 3 | 5.1 | 35.8 | 35.2-36.3 | 32.5-39.1 |
| 4 | 5.2 | 36.6 | 36.1-37.2 | 33.3-39.9 |
| 5 | 5.4 | 37.5 | 37-38 | 34.2-40.8 |
| 6 | 5.5 | 38.4 | 37.9-38.9 | 35.1-41.7 |
| 7 | 5.6 | 39.3 | 38.9-39.7 | 36-42.6 |
| 8 | 5.7 | 40.2 | 39.8-40.6 | 36.9-43.5 |
| 9 | 5.9 | 41.1 | 40.7-41.4 | 37.8-44.3 |
| 10 | 6 | 41.9 | 41.6-42.3 | 38.7-45.2 |
| 11 | 6.1 | 42.8 | 42.5-43.2 | 39.5-46.1 |
| 12 | 6.2 | 43.7 | 43.4-44 | 40.4-47 |
| 13 | 6.4 | 44.6 | 44.3-44.9 | 41.3-47.9 |
| 14 | 6.5 | 45.5 | 45.2-45.8 | 42.2-48.7 |
| 15 | 6.6 | 46.3 | 46-46.6 | 43.1-49.6 |
| 16 | 6.7 | 47.2 | 46.9-47.5 | 44-50.5 |
| 17 | 6.9 | 48.1 | 47.8-48.4 | 44.8-51.4 |
| 18 | 7 | 49 | 48.6-49.4 | 45.7-52.3 |
| 19 | 7.1 | 49.9 | 49.5-50.3 | 46.6-53.2 |
| 20 | 7.3 | 50.8 | 50.3-51.2 | 47.5-54 |
| 21 | 7.4 | 51.6 | 51.2-52.1 | 48.3-54.9 |
| 22 | 7.5 | 52.5 | 52-53 | 49.2-55.8 |
| 23 | 7.6 | 53.4 | 52.9-53.9 | 50.1-56.7 |
| 24 | 7.8 | 54.3 | 53.7-54.8 | 51-57.6 |
| 25 | 7.9 | 55.2 | 54.6-55.7 | 51.9-58.5 |
| 26 | 8 | 56 | 55.4-56.7 | 52.7-59.4 |
| 27 | 8.1 | 56.9 | 56.3-57.6 | 53.6-60.3 |
| 28 | 8.3 | 57.8 | 57.1-58.5 | 54.5-61.1 |
| 29 | 8.4 | 58.7 | 58-59.4 | 55.4-62 |
| 30 | 8.5 | 59.6 | 58.8-60.4 | 56.2-62.9 |

Mean diameter of gestational sac and corresponding estimates of gestational age.



Graphic 94449 Version 3.0

### Yolk sac

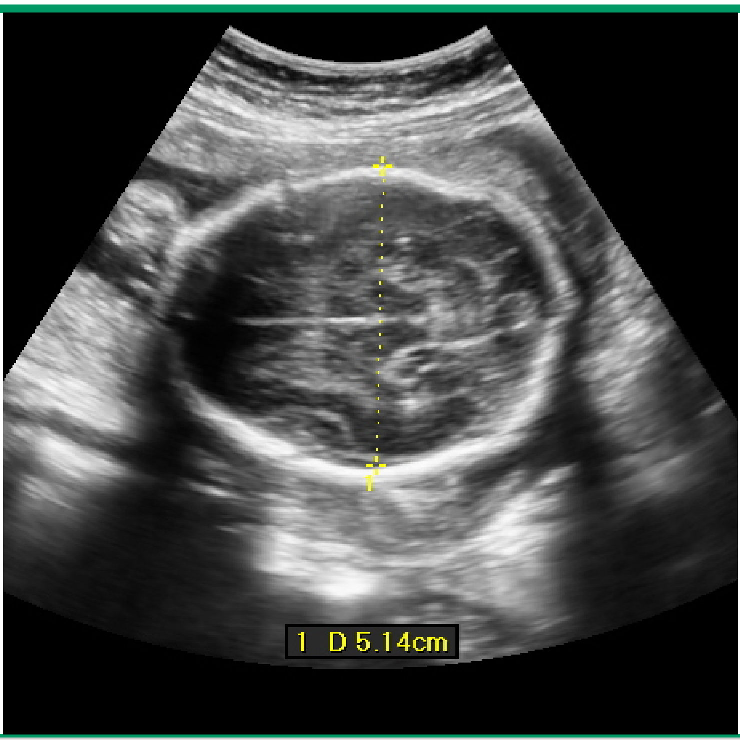

Image of an early gestational sac containing a yolk sac and early embryo. The yolk sac is the circular hyperechoic structure adjacent to the embryo.

YS: yolk sac.

*Courtesy of Thomas Shipp, MD.*

Graphic 65928 Version 4.0

**Measurement of fetal biparietal diameter**

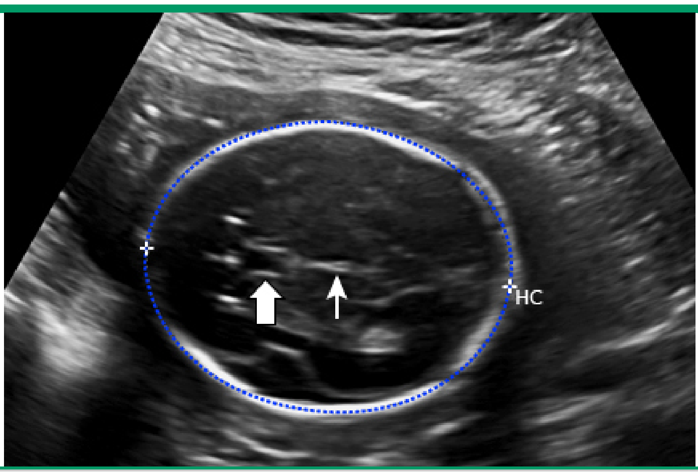



Axial image of the fetal head of a second-trimester fetus at the level of the thalami. The thalami are symmetrical, and the midline of the fetal brain is identified. The calipers are placed on the leading portions of the cranium for measurement of the biparietal diameter. This level is generally the largest transverse diameter of the cranium and is used for estimation of gestational age and fetal weight.

*Courtesy of Thomas Shipp, MD.*

Graphic 56629 Version 3.0

## Cavum septum pellucidum



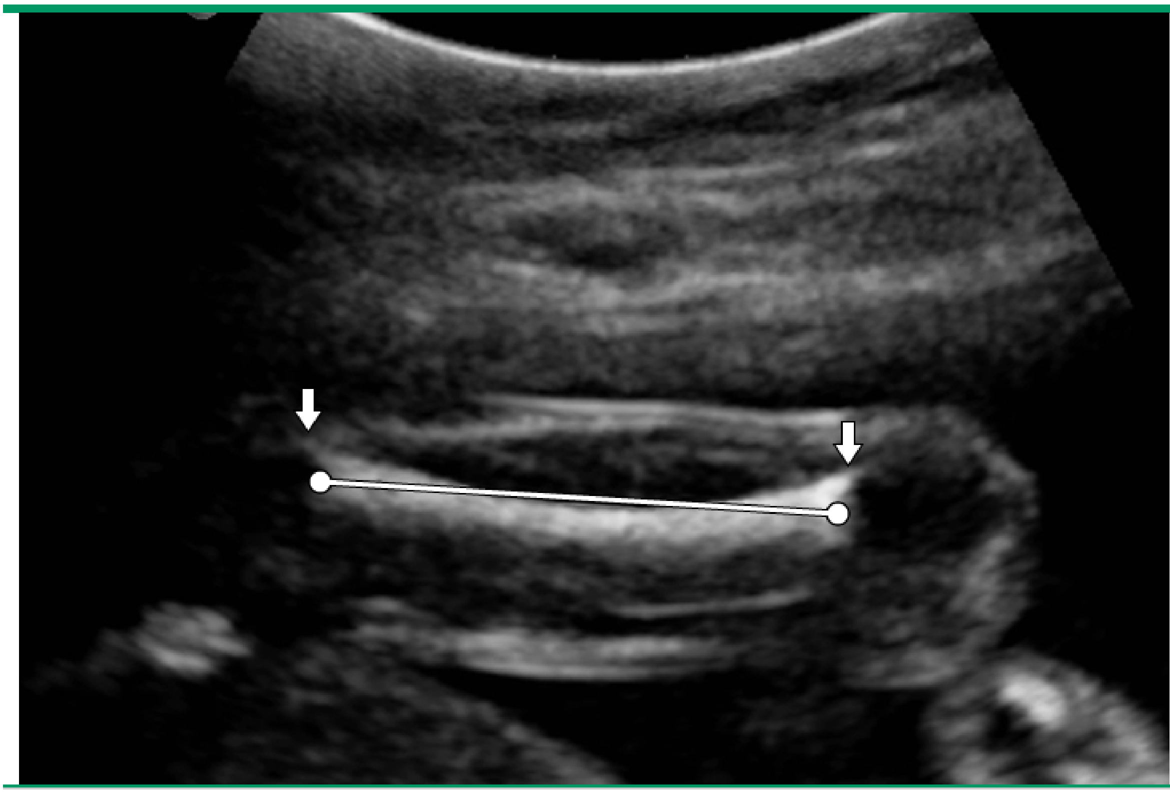

Axial view of the fetal head at the level used to measure the biparietal diameter and head circumference. The cavum septum pellucidum (large arrow) and slit-like third ventricle (short arrow) are indicated.

HC: head circumference.

*Courtesy of Andrew P MacKenzie, MD.*

Graphic 51474 Version 5.0

**Fetal femur length**

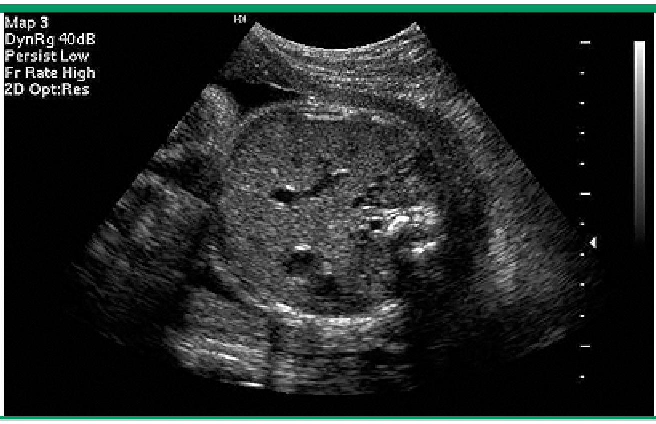


Femur (diaphysis) length measurement: The transducer is optimally aligned; the long axis of the femur is aligned perpendicular to the beam with both ends of the diaphysis visualized. The calipers are placed at each end of the ossified diaphysis without including the specular reflection of the distal epiphyseal cartilage (thick arrows). To ensure the maximum length is obtained, the specular reflectors from the smooth surface of the lateral aspect of the femoral epiphyseal cartilage (thick arrows) should be visible at both ends but not included as part of the measurement of the diaphysis (line).

*Courtesy of Phyllis Glanc, MD.*

Graphic 50944 Version 5.0

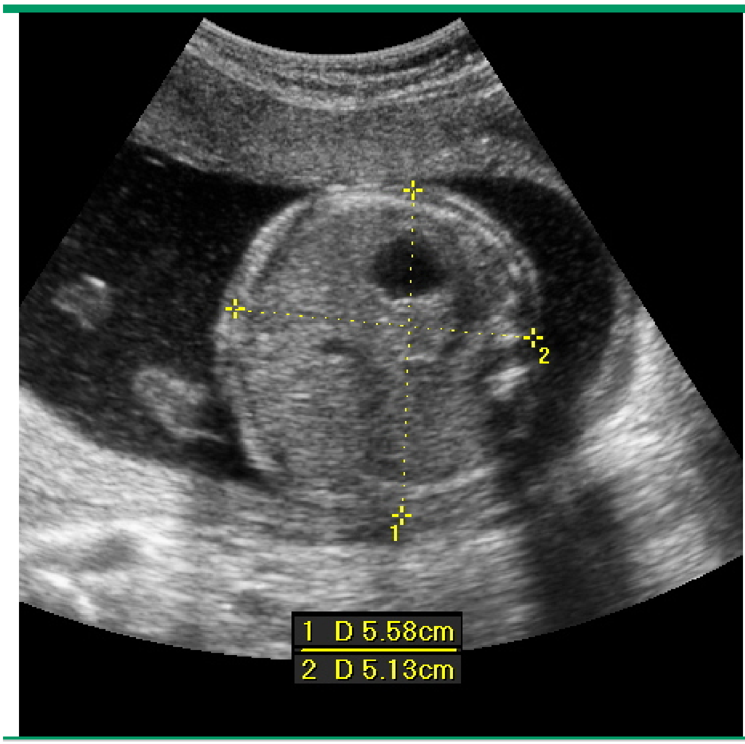
**Image of abdominal circumference**




*Courtesy of Jacques Abramowicz, MD.*

Graphic 74022 Version 2.0

### Measurement of fetal abdominal diameters




Axial image of the fetal abdomen of a late second-trimester fetus. This measurement is taken at the level of the fetal stomach, liver, and umbilical vein. Calipers are used to measure the diameters of the fetal abdomen. These measurements can be averaged, or an abdominal circumference can be calculated. These measurements are used to assess gestational age and especially fetal weight.

*Courtesy of Thomas Shipp, MD.*

Graphic 52505 Version 4.0

## Transverse cerebellar diameter on fetal ultrasound


Gray-scale fetal ultrasound through the calvarium shows a transverse measurement of the cerebellum of 2.05 cm (20.5 mm), which corresponds to an estimated gestational age of 20 weeks and 6 days, concordant with the gestational age based on the last menstrual period.

*Courtesy of Lachlan McG Smith, MD.*

Graphic 95414 Version 1.0

**Birth weight percentiles by gestational age based on 2011 United States National Center for Health Statistics data**

| Week of gestation | 5th percentile | 10th percentile | 50th percentile | 90th percentile | 95th percentile |
|---|---|---|---|---|---|
| 24 | 539 | 567 | 680 | 850 | 988 |
| 25 | 540 | 584 | 765 | 938 | 997 |
| 26 | 580 | 637 | 872 | 1080 | 1180 |
| 27 | 650 | 719 | 997 | 1260 | 1467 |
| 28 | 740 | 822 | 1138 | 1462 | 1787 |
| 29 | 841 | 939 | 1290 | 1672 | 2070 |
| 30 | 952 | 1068 | 1455 | 1883 | 2294 |
| 31 | 1080 | 1214 | 1635 | 2101 | 2483 |
| 32 | 1232 | 1380 | 1833 | 2331 | 2664 |
| 33 | 1414 | 1573 | 2053 | 2579 | 2861 |
| 34 | 1632 | 1793 | 2296 | 2846 | 3093 |
| 35 | 1871 | 2030 | 2549 | 3119 | 3345 |
| 36 | 2117 | 2270 | 2797 | 3380 | 3594 |
| 37 | 2353 | 2500 | 3025 | 3612 | 3818 |
| 38 | 2564 | 2706 | 3219 | 3799 | 3995 |
| 39 | 2737 | 2877 | 3374 | 3941 | 4125 |
| 40 | 2863 | 3005 | 3499 | 4057 | 4232 |
| 41 | 2934 | 3082 | 3600 | 4167 | 4340 |
| 42 | 2941 | 3099 | 3686 | 4290 | 4474 |

Table constructed using United States National Center for Health Statistics data from 2011 for live born singleton neonates between 500 and 6000 grams without malformations. Gestational age was based on the obstetric estimate of gestational age included in the revised 2003 United States birth certificate, which, when available, incorporates ultrasound dating information.

*From: Duryea EL, Hawkins JS, McIntire DD, et al. A revised birth weight reference for the United States. Obstet Gynecol 2014; 124:16. DOI: 10.1097/AOG.0000000000000345.*


Graphic 56847 Version 10.0

## Regression equations for calculating fetal weight

| | |
|---|---|
| **Head circumference** | |
| Mean | $-28{\cdot}2849 + 1{\cdot}69267 \times GA^2 - 0{\cdot}397485 \times GA^2 \times \log(GA)$ |
| SD | $1{\cdot}98735 + 0{\cdot}0136772 \times GA^3 - 0{\cdot}00726264 \times GA^3 \times \log(GA) + 0{\cdot}000976253 \times GA^3 \times \log(GA)^2$ |
| **Biparietal diameter** | |
| Mean | $5{\cdot}60878 + 0{\cdot}158369 \times GA^2 - 0{\cdot}00256379 \times GA^3$ |
| SD | $\exp(0{\cdot}101242 + 0{\cdot}00150557 \times GA^3 - 0{\cdot}000771535 \times GA^3 \times \log(GA) + 0{\cdot}0000999638 \times GA^3 \times \log(GA)^2)$ |
| **Occipitofrontal diameter** | |
| Mean | $-12{\cdot}4097 + 0{\cdot}626342 \times GA^2 - 0{\cdot}148075 \times GA^2 \times \log(GA)$ |
| SD | $\exp(-0{\cdot}880034 + 0{\cdot}0631165 \times GA^2 - 0{\cdot}0317136 \times GA^2 \times \log(GA) + 0{\cdot}00408302 \times GA^2 \times \log(GA)^2)$ |
| **Abdominal circumference** | |
| Mean | $-81{\cdot}3243 + 11{\cdot}6772 \times GA - 0{\cdot}000561865 \times GA^3$ |
| SD | $-4{\cdot}36302 + 0{\cdot}121445 \times GA^2 - 0{\cdot}0130256 \times GA^3 + 0{\cdot}00282143 \times GA^3 \times \log(GA)$ |
| **Femur length** | |
| Mean | $-39{\cdot}9616 + 4{\cdot}32298 \times GA - 0{\cdot}0380156 \times GA^2$ |
| SD | $\exp(0{\cdot}605843 - 42{\cdot}0014 \times GA^{-2} + 0{\cdot}00000917972 \times GA^3)$ |

Equations for the estimation of the mean and SD (in mm) of each fetal biometry measurement according to exact gestational age (in weeks). All log are natural logarithms.

SD: standard deviation; GA: exact gestational age.

*Reproduced from: Papageorghiou AT, Ohuma EO, Altman DG, et al. International standards for fetal growth based on serial ultrasound measurements: the Fetal Growth Longitudinal Study of the INTERGROWTH-21st Project. Lancet 2014; 384:869. Table used with the permission of Elsevier Inc.* 

Graphic 107121 Version 1.0

## International birth weight centiles

| Boys | | | | | | | Girls | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number of observations | Centiles for birth weight (kg) | | | | | | Number of observations | Centiles for birth weight (kg) | | | | |
| | | 3rd | 10th | 50th | 90th | 97th | | | 3rd | 10th | 50th | 90th | 97th |
| 33 weeks | 34 | 1.18 | 1.43 | 1.95 | 2.52 | 2.82 | 33 weeks | 17 | 1.20 | 1.41 | 1.86 | 2.35 | 2.61 |
| 34 weeks | 48 | 1.45 | 1.71 | 2.22 | 2.79 | 3.08 | 34 weeks | 65 | 1.47 | 1.68 | 2.13 | 2.64 | 2.90 |
| 35 weeks | 128 | 1.70 | 1.95 | 2.47 | 3.03 | 3.32 | 35 weeks | 114 | 1.71 | 1.92 | 2.38 | 2.89 | 3.16 |
| 36 weeks | 323 | 1.93 | 2.18 | 2.69 | 3.25 | 3.54 | 36 weeks | 293 | 1.92 | 2.14 | 2.60 | 3.12 | 3.39 |
| 37 weeks | 857 | 2.13 | 2.38 | 2.89 | 3.45 | 3.74 | 37 weeks | 803 | 2.11 | 2.33 | 2.80 | 3.32 | 3.60 |
| 38 weeks | 2045 | 2.32 | 2.57 | 3.07 | 3.63 | 3.92 | 38 weeks | 1802 | 2.28 | 2.50 | 2.97 | 3.51 | 3.78 |
| 39 weeks | 3009 | 2.49 | 2.73 | 3.24 | 3.79 | 4.08 | 39 weeks | 2869 | 2.42 | 2.65 | 3.13 | 3.66 | 3.94 |
| 40 weeks | 2568 | 2.63 | 2.88 | 3.38 | 3.94 | 4.22 | 40 weeks | 2523 | 2.55 | 2.78 | 3.26 | 3.80 | 4.08 |
| 41 weeks | 1179 | 2.76 | 3.01 | 3.51 | 4.06 | 4.35 | 41 weeks | 1195 | 2.65 | 2.89 | 3.37 | 3.92 | 4.20 |
| 42 weeks | 206 | 2.88 | 3.12 | 3.62 | 4.17 | 4.46 | 42 weeks | 224 | 2.74 | 2.98 | 3.46 | 4.01 | 4.30 |
| Total | 10397 | .. | .. | .. | .. | .. | Total | 9905 | .. | .. | .. | .. | .. |

International standards for newborn weight by gestational age and sex from the Newborn Cross-Sectional Study of the INTERGROWTH-21st Project. Table shows smoothed centiles for birth weight of boys and girls according to exact gestational age.

kg: kilogram.

*Reproduced from: Villar J, Cheikh Ismail L, Victoria CG, et al. International standards for newborn weight, length, and head circumference by gestational age and sex: the Newborn Cross-Sectional Study of the INTERGROWTH-21st Project. Lancet 2014; 384:857.* 

Graphic 96940 Version 3.0

**Timing of first appearance of gestational landmarks on transvaginal ultrasound examination**

| Landmark | First appearance on transvaginal ultrasound examination |
|---|---|
| Gestational sac | 4.5 to 5 weeks |
| Yolk sac | 5 weeks |
| Cardiac activity | 5.5 to 6 weeks |
| Measurable crown-rump length | 6 weeks |

The yolk sac is visible when the mean gestational sac diameter (MSD) is 8 mm and fetal cardiac activity can be observed when MSD is 16 mm. For transabdominal sonograms, the corresponding MSDs are larger than 20 and 25 mm, respectively. MSD = (length + height + width of the gestational sac)/3. In addition, MSD(mm)+30 = gestational age(days).

Graphic 83304 Version 6.0

## Contributor Disclosures

**Andrew P MacKenzie, MD** Nothing to disclose **Courtney D Stephenson, DO, FACOG** Nothing to disclose **Edmund F Funai, MD** Nothing to disclose **Deborah Levine, MD** Nothing to disclose **Vanessa A Barss, MD, FACOG** Nothing to disclose

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