Original Article

Different Methods For Estimation Of Gestational Age

Nadia M. Madkour, Badeea S. Soliman, Dalia Zakareya Hussein, Ahmed Hassan El-Massarawy

Department of Obstetrics and Gynecology, Faculty of Medicine, Zagazig University, Egypt
*Corresponding author: Dalia Zakareya Hussein,
E-mail: daliazakareya9@gmail.com
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Abstract

Accurate gestational age estimation is one of the most important factors needed for optimum obstetrical management. Neonatal respiratory distress syndrome is the most leading cause for neonatal mortality and morbidity. The lake of accurate gestational age estimation, particularly in some geographical regions at greatest risk of these conditions, means that preterm delivery and small for gestational age rates are mere approximations in many parts of the world**.**

Introduction:

Gestational age (GA) is used to describe the age of pregnancy, It is the time that the baby has been in the mother's belly; measured in weeks from the 1st day of regular sure last menstrual period (LMP) to the current date. According to this method , a pregnancy that has just been conceived approximately 2 weeks after the last cycle is already 2 weeks old age in GA. Gestation is the time between conception date and birth in weeks. Anywhere pregnancies last from 38 to 42 weeks' gestation (around 280 days). Born babies before completed 37 weeks are consider prematures**. (1)**

Fetal age:

The actual age of the growing fetus.

Due date: the expected date of delivery (EDD), which can be calculated by (2):-

I. Last menstrual period (LMP).
II. Clinical examination:-
    a. Fundal level.
    b. Fetal heart auscultation.
III. Ultrasound.

I-Gestational Age Calculation Based on LMP:

1-Naegele's rule (1812):-

It is the most popular methods for calculation of GA by1st day of LMP add 7 days, then count 3 monthes back and add 1 year. **(1).**

- LMP + 280 days.
- It's based on regular menstrual cycle, (28 days), ovulation occurring on 14th day of cycle.
- Due date will be later if menstrual cycle is longer but if menstrual cycle is shorter due date will be earlier. **(3).**

2-Mittendorf-williams rule (1993):-

- LMP-3 monthes +15 days. This is for 1st pregnancies.
- LMP-3 monthes+10 days. This is for subsequent pregnancies.
- Mittendorf-Williams rule is more recent than Naegle's rule due to more accurate results. **(4).**

3-Parikh's rule (1966):-

- LMP +280 days -21 days + the length of average previous 3 cycles.
- Parikh's rule is a modification of naegele's rule. Used for irregular cycles**. (5).**

4-Wood's rule:-

- LMP + 12 monthes – (2 monthes and 14 days) = EDD for1st pregnancies.
- LMP + 12 monthes – (2 monthes and 18 days) = EDD for subsequent pregnancies.
- EDD + (actual length of cycle – 28 days) = EDD for cycles longer than 28 days.
- EDD – (28 days – actual length of cycle) = EDD for cycles shorter than 28 days.
- Wood's rule consider number of pregnancies for each female and individual length of the menstrual cycle.**(3).**

5-Adding 266 days to the date of conception.

- **Strengthness:**
  - Dating by certain menstrual history is inexpensive and readily available.
- **Weakness:-**
  - Sperms can live in the female body for up to 5 days.
  - The egg can live for 24 hours after it's released from the ovary.
  - Conception can occur several days after unprotected intercourse. **(3).**
  - Women with irregular menstrual cycles.
  - Women on hormonal contraceptions.
  - Women have lactational amenorrhea prior to conception.
  - Women have uncertain of their last menstrual period.
  - This method lakes to assess fetal wellbeing which based on LMP.**(6).**

II-Gestational Age calculation Based on clinical examination

a-The fundal level, or the size of the uterus:-

- Assessed through pelvic or abdominal examination, can be roughly correlated with GA.
- The uterus is approximately the size of a grapefruit at 10th to 12th weeks.
- The fundus reaches the umbilicus equal to 24th weeks' gestation.
- The symphysio - fundal height measurement in centimetres using a non elastic tape; can be used after the 20th weeks to 34th weeks' gestation and correlated with the week of gestation**. (6).**

- **Strengthness:-**

  - Accurate measurement of symphysio-fundal height is a reliable method of GA assessment in the second half of pregnancy.
  - The symphysio-fundal height measurement is more accurate than the reported LMP as a tool for assessing GA when the ultrasound scan used as a reference.
  - This method can be particularly useful in rural area where ultrasound equipment and the needed expertise are not readily available. **(6).**

- **Weakness:-**

The symphysio-fundal height has own limitation in dating pregnancy in women with:

- Multiple pregnancy.
- Co-existing fibroid and pregnancy.
- Polyhydramnious and oligohydramnious.
- Fetal transverse lie. **(6).**

b-Fetal heart sounds:

Audible at 11^{th} to 12^{th} weeks' gestation with electronic Doppler device, and this audipility can also assist in the clinical assignment of GA. **(2).**

III- Ultrasound:

(A) 1st trimester GA measurement based on ultrasound

TVS enables visualization and evaluation of intra- uterine pregnancy (IUP) earlier than was previously thought possible.

1- Thickening of the decidua:

- The earliest sonographic finding of an intrauterine pregnancy is thickening of the decidua, Sonographically this appears as an echogenic thick filling of the fundal region of the endometrial cavity that occurring at approximately 3 -4 weeks after LMP. This sign is nonspecific and of limited diagnostic value. **(7).**

2- Gestational Sac:

- At 4 weeks of menstrual age; a small hypoechoic area appears in the fundus or mid portion of the uterus as the double decidual sac sign. The sac embeds surrounded by an echogenic rim within the choriodecidual tissue, and known as the chorionic or gestational sac **(8).**
- An intradecidual gestational sac should be eccentrically located within the endometrium. **(7).**
- It is important to ensure that the sac abuts the endometrium canal to distinguish an intra-uterine gestational sac from a decidual cyst. The double-decidual sign is described as a method for distinguishing between an early IUP and an endometrial fluid collection of other origin. A vague or absent double decidual sign should be considered non diagnostic because it doesn't reliably exclude an IUP. **(7).**

Mean sac diameter (MSD):

- The 1st parameter that can be used to determine gestational age (GA) is measurement of the mean gestational sac diameter.

Measurement:

1- **GSD= <u>(length + height + width)</u>** = GA in days.

2- The rate of growth of normal gestational sac is 1.1 mm/ day.

3- Between 28th and 35th days' gestation; MSD is 2.6mm.**(9).**

4- At 5th weeks after LMP; the average of the 3 perpendicular internal diameters of the gestational sac calculated as the mean of the antero-posterior diameter; the transverse diameter; and the longitudinal diameter can provide an adequate assessment of gestational age.

5- When The mean gestational sac diameter exceed 16 mm; an embryo with definite cardiac activity should be well visualized with TVS, this usually occurs by 6th weeks' gestation.

6- A gestational sac should be seen within the uterine cavity when the beta – human chorionic gonadotropin (B-HCG) is 1000-2000 mlU/ml, [normal range is 217-8,245 mIU/ml], [second international standard]; this becomes especially important when evaluating a pregnancy for ectopic pregnancy. **(8).**

- **Human Chorionic Gonadotropin (B-HCG)** is often called the pregnancy hormone because it is made by cells formed in the placenta, which nourishes the egg after it has been fertilized and becomes attached to the uterine wall. Levels can first be detected by a blood test about **11 days after conception** and about **12-14 days after conception** by a urine test.
- The B-HCG levels will double every 72 hours. The level will reach its peak in the first **8-11 weeks of pregnancy** and then will decline and level off to the end of the pregnancy.
- The B-HCG level gets higher, the time it takes to double can increase to about every 96 hours.
- Caution must be used in making too much of B-HCG numbers. A normal pregnancy may have low B-HCG levels and result in a perfectly healthy baby. The results from an ultrasound **after 5 -6 weeks gestation** are much more accurate than using B-HCG numbers.
- A B-HCG level of **less than 5 mIU/mL** is considered negative for pregnancy, and anything **above 25 mIU/mL** is considered positive for pregnancy.
- A B-HCG level **between 6 and 24 mIU/mL** is considered a grey area, and a pregnant woman likely needs to be retested to see if her levels rise to confirm a pregnancy.
- TheB-HCG hormone is measured in milli-international units per milliliter (mIU/mL).
- A transvaginal ultrasound should be able to show at least a gestational sac once the hCG levels have reached between **1,000 – 2,000 mIU/mL**. Because levels can differentiate so much and conception dating can be wrong, a diagnosis should not be made by ultrasound findings until the B-HCG level has reached **at least 2,000 mIU/mL**.
- A single reading is not enough information for most diagnoses. When there is a question regarding the health of the pregnancy, multiple testings of hCG done a couple of days apart give a more accurate assessment of the situation.
- The B-HCG levels should not be used to date a pregnancy since these numbers can vary so widely.

There are two common types of B-HCG tests:-

- A qualitative test detects if B-HCG is present in the blood.
- A quantitative test (or beta) measures the amount of B-HCG actually present in the blood **(10).**

7- Gestational sac grows rapidly in the 1st 10 weeks' gestation; with an average increase of 1mm/ day. **(8).**

- When the gestational sac exceeds 8mm in its mean internal diameter; a yolk sac can be seen; a small spherical structure with an echoic center within the gestational sac, which provides early transfer of nutrients from the trophoblast to the embryo, aids in the early formation of the primitive gut and vitelline arteries and veins; and in the production of the primordial germ cells. It's size hasn't been correlated with gestational age It can be visible from 5th weeks' gestation and increases in size to a maximum mean diameter 5mm at 10th weeks' gestation. The majority of yolk sacs decrease in size before disappearing at around 12th weeks' gestation, and should be less than 5.5 mm allover, if greater than 5.6mm or solid echogenic, it has been associated with poor pregnancy outcome.
    - The developing embryo appears as an echogenic line of about 5mm tangentially touching and closely attached to the yolk sac. The fetal heart beat should be demonstrated from 6th weeks' gestation and the heart rate is approximately 120 beats /minute. The amniotic sac is seen surrounding the developing fetus and the yolk sac lies outside the amniotic sac within the extra embryonic coelom **(11).**

3-Crown rump length (CRL):

Criteria for an accurate crown rump length (CRL):

a- Magnification:

The fetus fills the majority of the image space available.

b-Mid sagittal view:

Fetal spine mid-sagittal profile; spine; and rump are visible.

c-Neutral position:

The spine is in line with the head and fluid is visible between the fetal chin and chest.

d- Measurement:

Angle of insonation perpendicular to fetus. Fetus horizontal on image. Calipers are placed on the outer border of the skin at crown and rumb. **(7).**

- The CRL is the longest length of the embryo or fetus measurable excluding the limbs and yolk sac. The embryo becomes a fetus after 10th weeks' gestation [71 completed days based on the LMP].The accuracy of the CRL in dating the pregnancy depends on a good correlation between this measurement and fetal age in a period when growth is rapid and minimally influenced by fetal pathology, it predicts fetal age with an error of 3 days

from 7th to 10th weeks' gestation; and 5 days from 10th to 14th weeks' gestation. The CRL grows approximately 10 mm/week. From 8th to 12th weeks' gestation a simple rule to obtain:-

GA (weeks) = CRL (cm)+ 6.5. (12).

- 6th -12th weeks' gestation; the measurement of the CRL of the fetus is most accurate one for dating. There are no significance differences with measurements made by the trans-abdominal route or the trans-vaginal route **(13).**

1-Bi-Parietal Diameter (BPD):

BPD is one of the basic biometric parameters used to assess fetal size; BPD together with head circumference (HC); abdominal circumference (AC) and femur length (FL) are computed to produce assessed fetal weight. In the 2nd trimester; BPD can be extrapolated to an assessed GA and an assessed due date (EDD). **(14).**

Technique:

- The BPD demonstrates linear growth of 3 mm/week from 14th – 28th weeks' gestation ; and 2mm / week to term.

The plane of measurement:

- The BPD should be measured on an axial plane that traverses the thalami and cavum septum pellucidum.

Intracerebral land marks:

- The frontal horns of the lateral ventricle.
- Cavum septum pellucidum anteriorly.
- The thalami and 3rd ventricle centrally.
- The occipital horns of the cerebral ventricle ; cisterna venae magnae cerebri ; and insula posteriorly.

Measurement:

- The transducer should be perpendicular to the central axis of the head; and thus the hemispheres and calvaria should appear symmetric.
- The calipers should be placed at the outer edge of the near calverial wall; inner edge of the far calvarial wall the cerebellar hemisphere must not be in the plane of the image **(14).**
- The occipito frontal diameter (OFD) is assessed in the same plane as the BPD, the calipers placed on the outer skull table.

Precaution:

- Based on **Joseph Woo (2020),** the BPD remains the standard against which other parameters of GA measurement compared while a wrong assessment plane can produce an error up to 20 mm. A leadind edge to leading edge measurement, and a middle to middle measurement are both acceptable.

- BPD can be smaller than is expected in fetuses with flatter heads. If the head really looks flat on the scan; chech the HC and record the findings; if the value is within the normal range; then most likely the discrepancy is due to a flat head. The cephalic index will also be useful if the value is below 74**. (12).**

Strengthness:

- The BPD has been shown to be accurate in predicting GA from 14th to 20th weeks' gestation.

Weakness:

- The variability increases after 20th weeks' gestation.
- The BPD may be influenced by factors such as; abnormalities of head shape; breech presentation; and/ or multiple gestation **(14).**
- Occipito frontal diameter (OFD) can be used to calculate the HC and cephalic index (CI) Fetal head shape variations [dolichocephaly; brachycephaly] and fetal position can affect the diagnostic accuracy of BPD. CI defined is as the ratio of the BPD divided by OFD [normal 0.75 -0.85] in abnormal CI the HC could be used instead of BPD to avoid this pitfall.
- The BPD isn't accurate in measuring true GA; in fetuses with premature rupture of membranes, breech presentation, and multiple pregnancy **(12).**

2-Head circumference (HC):

The length going around the fetuse's head. The HC is usually after 13th weeks' gestation**(15).**

HC assessment can be used to assess GA in similar manner to BPD estimation. tracing of the outer perimeter of the head by trachball on ultrasound equipment or by digitizer is the most reliable means of assessing HC ; the following formula using BPD and OFD may be used to calculate HC with a maximum error 6%:- **(16)**.

HC = $\frac{(D1+ D2)}{}$ ×3.14.

D1=BPD, and D2=OFD.

Technique:

- HC is assessed on the same plane as BPD ; on an axial plane that traverses the thalami and cavum septum pellucidum.
- Transducer should be perpendicular to the central axis of the head ; and thus the hemispheres; and calvaria should appear symmetric .
- Cerebellar hemispheres shouldn't be in the plane of the image or the probe is too caudal giving an inaccurate size of the fetal head.

Measurement:-

- If the available ultrasound equipment allows for the assessment of an ellipse this can be drawn around the outside of the calvarian.
- HC can be calculated from BPD and OFD:- **(14).**

HC = 1.62 ×(BPD + OFD) .

Strengthness:

- The accuracy of GA estimation by HC measurement is comparable with that of BPD assessment. In fetus with abnormal head shape as; brachycephaly [short headed] or dolicocephaly [long headed] ; HC can be more accurate predictor of GA than BPD **(16)**
- The direct method systematically over estimates HC by less than 1.5%. HC grows approximately 14 mm/week between 14^{th} -17^{th} weeks' gestation 5mm/week near term.

Weakness:-

- Head measurement is a poor screening method in some fetal abnormalities as it's generally spared until late; as in symmetrical growth restriction and microcephaly **(12).**

3-Abdominal circumference (AC):

- AC is one of the basic biometric parameters used to assess fetal size. AC, BPD, HC, and FL are computed to assess fetal weight. In 2^{nd} and 3^{rd} trimester; AC can be used to assess GA and EDD but with less accuracy than other parameters. **(14).**
- AC is a measurement taken during a pregnancy ultrasound in order to encircle the circumference of the fetal abdomen; AC is an indication for normal fetal growth intrauterine (size and weight). It can show how the baby is growing and detect abnormalities**. (17).**

Importance:

- AC is the single most important measurement to make in late pregnancy. It reflects a more clear picture of the fetal size and weight rather than age serial measurements are useful in monitoring growth of the fetus. AC measurement shouldn't be used for dating a fetus but rather for estimating the fetal size and weight**. (17).**

Technique:

- Transverse section through the upper abdomen ; which should demonstrate the following:

    1) Fetal stomach.
    2) Portal sinus.
    3) Umbilical vein.

- AC can be assessed in a transverse plane at the level of the liver , at the umbilical vein branches in the left portal sinus.
- In this plane, the umbilical vein and the portal vein form a J shape.
- The stomach bubble can be seen at this level on the left side of the fetal abdomen.
- The abdomen should be more circular than oval, because an oval shape indicates an oblique cut resulting in a false estimation of AC.
- Both fetal kidneys can't be seen when the proper plane is imaged. **(8)**
- AC is assessed and calculated by similar tools used in assessment of HC.

- The calipers is placed along the external perimeter of the fetal abdomen to include subcutaneous soft tissue.**(8)**

Precaution:

- AC assessment can't be taken on a curved or indented abdomen and the calipers should be on the skin surface "skin surface should be visible".
- The kidneys and cord insertion shouldn't be visible; the umbilical vein shouldn't be seen up to the skin line, the gallbladder can sometimes be seen**. (14).**

Measurement (7):

- AC is the length of the outer perimeter of the fetal abdomen; measured on transverse view at the level of the intrahepatic portion of the umbilical vein.
- AC is assessed by placing the ellipse along the outer skin surface.
- AC can be calculated from 2 orthogonal abdominal diameter (AD1; AD2); one antero-posterior and the other transverse measured on the same image:

AC = 1.57 × (AD1 + AD2).

Strengthness:

- AC is very useful in monitoring normal fetal growth and detecting fetal growth abnormalities; as intrauterine growth restriction; and macrosomia. It is more useful as a growth parameter than estimated due date.

Weakness:

- AC may change shape with fetal breathing activity; transducer compression; and intrauterine crowding; such as; multiple pregnancies and oligohydramnious and secondary to fetal position like breech presentation.
- When discrepancies occur with AC measurements; the average of multiple measurements can be taken to ensure accuracy; also done for other fetal parameters. **(8).**

4-Femur length (FL):-

1) All the fetal long bones can be assessed and measured by ultrasound.
2) The fetal femur is the largest of the long bones; least moveable and easiest to image.
3) The femur can be visualized from 13 weeks' gestation till delivery **(16).**

Technique:

- The femur is measured along the long axis of the bone.
- Straight measurement of the osseous portion is taken from one end to the other; disregarding bone curvature.
- The femoral neck and both proximal and distal epiphyseal cartilages are excluded from the measurement.
- The fetal femur length measurements can be used to accurately predict GA between 13 weeks' gestation to term.
- Most observers consider the accuracy of the FL and BPD measurements to be similar in the 3rd trimester.
- The accuracy of GA estimation based on FL is greatest in the 2nd trimester and least near term.

Precaution:-

- Several technical factors are potential sources of error in the assessment of the femur.

1) The femur is in the far field or lateral margins of the image.
2) Linear-array ultrasound images provides more accurate measurements of FL.
3) FL measurements obtained in the axial plane [parallel to the ultrasonic beam] have less mean absolute error than those obtained in the lateral plane, perpendicular to ultrasonic beam.
4) Tangential section of the femur failing to viualize the entire length of the shaft; lead to underestimation of FL then GA.
5) Factual bowing of the femur can occur on ultrasound imaging and lead to a shortened FL measurement (1.7 mm vs 3.7 mm respectively).
6) The distal femoral epiphysis becomes echogenic in the 3rd trimester and is separated from the distal end of the diaphysis; the osseous portion of the shaft; inclusion of the distal epiphysis is falsely overestimating FL +/- 5 days. **(16).**

The ultrasonic measurement of FL is a sensitive and specific variable for estimation of fetal growth and development. The data demonstrated that the femur growth curve is non linear beyond 13 weeks' gestation:

FL(cm) = GA(wk)

- The absolute percentage error ranged from 4.52% to 16.75**%** (**18).**
- FL assess the longest bone in the body and reflects the longitudinal growth of the fetus FL increases from about 1.5 cm at 14 weeks' gestation to about 7.8 cm at term similar to the BPD; dating using the femur length should be done as early as possible.
- Biologic variation can lead to inaccuracy of FL measurements in a manner similar to the other fetal parameters.

Weakness:

- Biologic variation can lead to inaccuracy of FL measurements in a manner similar to the other fetal parameters.

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