RESEARCH ARTICLE

PARAMETERS FOR GESTATIONAL AGE ESTIMATION

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ARTICLE INFO	ABSTRACT
	Accurate age estimation of these fetuses can be very important to medico-legal authorities, particularly as it is sometimes necessary to determine if these fetuses are those of a full-term or a pre-term fetus. Age estimation is usually the primary characteristic for identification and is often the only means of identification for fetuses since they do not usually have any other type of identification with them. Age estimation can also play an important role in the prosecution of forensic cases. In this article, we discussed the different methods of age estimations and their medico-legal importances.

INTRODUCTION

In the process of development the sequential changes occur as embryogenesis and organogenesis. Although the embryogenesis has been extensively explored, the literature relating to the organogenesis appears relatively deprived of adequate scientific attention. Embryologists calculate age from the time of fertilization (postovulation), which takes place approximately two weeks after the first day of the last menstrual period and anatomical prenatal age averages 266 days (9.5 lunar months). This can vary with the interval between ovulation and fertilization and it is extremely rare to know the actual age of an embryo. Unfortunately, in the forensic context there are cases involving fetuses. Accurate age estimation of these fetuses can be very important to medico legal authorities, particularly as it is sometimes necessary to determine if these fetuses are those of a full-term or a pre-term fetus. Age estimation is usually the primary characteristic for identification and is often the only means of identification for fetuses since they do not usually have any other type of identification with them. Age estimation can also play an important role in the prosecution of forensic cases. According to Schueur (2002) determination of fetal age, specifically if the fetus reached full-term, can have legal importance in forensic cases.

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Whether the individual was liveborn or stillborn as well as whether it is viable or not is significant to a forensic pathologist. In cases of criminal abortion or infanticide, the age of the fetus is integral to the prosecution (Fazekas and Kosa, 1978). In the law, crime and its punishment is entirely based on criminal responsibility which in turn is dependent on the age of a person.

Age estimation of foetus can be done with the help of various parameters such as:-

- Ossification centres
- Biparietal Diameter (BPD)
- Abdominal Circumference
- Head Circumference
- Length of the Kidneys
- Crown Rump Length (CRL)
- Length of the Long Bones

In the literature all the above mentioned parameters were used for gestational age estimation using Ultrasonography (USG) and radiography. In majority of the forensic analysis there may be large variability in the emergence and development of the various analytical characteristics. Multiple criteria are more accurate than a single criterion and a narrow age tolerance is required if fetuses are to be accurately aged.

Article 6 of the Universal declaration of Human Rights states that everyone has the right for recognition everywhere as a person before the law (Mathiharan, 2009). Sothe personal identification is one of the important aspects of Forensic Medicine investigation. The question of personal identity arises both in criminal cases as accused of assault, sexual assault, murder, mix up of new born babies etc and in civil cases as in Insurance claims, unlawful possession of property etc.

Estimation of age in the foetus and newborn infants

The approach to fetal or perinatal autopsy is very different from the approach to adult autopsy. Fetal development is, in part, dependent on maternal health and intrauterine environment. The major objectives of the fetal or perinatal autopsy are to determine gestational age, document growth and development, detect congenital abnormalities, analyze clinical diagnosis and treatment, and determine the cause of death. In addition, the diseases and conditions considered in the fetus are not the same as in adults. Genetic syndromes must be identified if present.

MEASUREMENTS OF VARIOUS PARAMETERS FOR GESTATIONAL AGE ASSESSMENT

Reliable gestational age assessment of the fetus is usually done by ultrasonography. The various parameters which have been used for gestational age measurements are:

- Crown rump length (CRL)
- Biparietal diameter (BPD)
- Head circumference
- Abdominal circumference
- Femur length
- Hand and Foot length
- Time of appearance of ossification centers of bones.

In the context of forensics the crown heel length carries more importance than the above mentioned parameters. According to Hasse Rule (1895), the length of the fetus up to 5th month (20th week) of gestation represents the square of its age in months. Beyond 5th month, the length of the fetus measured in centimeters divided by 5 gives the age in months (Morrison Rule, 1964) (Vij, 2011).

CROWN RUMP LENGTH

Once the embryo is formed, the measurement of choice for estimating gestational age becomes the crown rump length between 6 – 12 weeks. Introduction of the concept of determining the menstrual age of fitness with static image sonographic measurement was first done by Robinson in 1973 (Goldstein, 1983). Crown rump length estimates gestational age between 8 and 12 weeks with range of 3 – 5 days at the 95% confidence levels. Between 8 and 12 weeks gestation the fetus grows at approximately 10mm/week. There is excellent correlation between fetal age and length in early pregnancy. The crown rump length is the longest length of the embryo and is defined as the distance between the top of the head to the upper part of the rump. Crown rump length should not be used after 12 weeks gestation as flexion of fetal spine renders the measurement less accurate. The crown rump length is useful only before 12 weeks and by 10 – 11 weeks the biparietal diameter measurement should be correlated with crown rump length for greater accuracy (Mazie *et al*., 1983).

Scammon.R.E. (1939), Gary, S.B. *et al* (1975) and Bartolucci, L. (1975) have reported linear correlation between occipito-frontal circumference, distance between Glabella and external occipital protuberance, bi-parietal diameter and crown-rump length and fetal age. Similarly Felts, W.J. (1954), Gardner, E and Gray, D.J. (1970), Mehta, L. and Singh, H.M. (1972), and Vare A.M. and Bansal, P.C. (1977) have shown a linear correlation between the diaphyseal lengths of fetal long bones and crown rump length and fetal age. Kharkar, A.R. and Fakhruddin, S. (1986) have shown a definite linear correlation between the external surface area of foetal parietal bone and crown-rump length. Kharkar A.R. (1993) similarly studied the correlation between external surface area of foetal frontal bone and crown-rump length (Kulkarni, 2006). The recommended equation for calculation of gestational age from crown rump length is (Loughna, 2009):

Gestational Age = 8.052 x (CRL x 1.037)$^{1/2}$ +23.73

BIPARIETAL DIAMETER

After the 12th week, biparietal diameter is the most widely accepted means of measuring the fetal head. After the 26th weeks the correlation of biparietal diameter with gestational age decreases because of increased biological variability. The growth of fetal skull slows down from 3mm/week in second trimester to 1-8mm/week in third trimester (Aantaa, 1980). The head should not be rounded (Brachycephaly) as this can lead to over estimation of gestational age just as a compressed head (Dolicocephaly) can lead to under estimation of gestational age (Aantaa, 1980).

Femur length and biparietal diameter have more value prior to 36 weeks but after 36 weeks head circumference and femur length has more value (Hohler, 1984). Length of femur is also better parameter as compared to BPD for determination of age of fetus in the third trimester. Bi-parietal diameter measurement is in less common use after 20 weeks of gestation. Measurements of bi-parietal diameter also help in determination of age of fetus. The bi-parietal diameter and femur length correlated equally well with gestational age. However, the bi-parietal diameter was more than twice as sensitive as the femur length to variation in fetal growth (Wolfson *et al*., 1986). Femur length had a larger error associated with its measurement. It is well established that ultrasound measurement of femur length and bi-parietal diameter are comparably accurate estimators of gestational age when obtained in the first half of pregnancy. Both estimators, however, become less accurate later in pregnancy (Egley *et al*., 1986).

HEAD CIRCUMFERENCE

Head circumference is less affected by the compression of the head. (Hadlock *et al*., 1982) whenever an abnormality in the shape of the head is suspected, biparietal diameter should not be used to determine gestational age. Head circumference or Femur length is more useful. The cephalic index (CI) is the ratio between the size of biparietal diameter and the size of the occipito-frontal diameter (OFD) multiplied by 100. It has been found that the cephalic index is constant throughout the pregnancy (Hohler, 1984).

Head circumference can be calculated by the formula:

Head Circumference = (BPD +OFD) x $\pi/2$.

ABDOMINAL CIRCUMFERENCE

Campbell and Wilkin in 1975 first described the use of the fetal abdominal circumference (AC) for use in the prediction of fetal weight. The abdominal circumference is very useful in monitoring normal fetal growth and in detection of Intra uterine growth retardation (IUGR), macrosomia and isoimmunization. (Mahony *et al.*, 1986) It is more useful as a growth parameter than it is in predicting gestational age. Use of the abdominal circumference in estimation of gestational age is proper only when no clinically apparent maternal conditions or fetal conditions are present that would modify liver growth. Fetal macrosmia and accelerated storage of liver glycogen or severe Intra uterine growth retardation with liver glycogen depletion as well as hepato-splenomegaly in the fetus due congenital infections such as Cytomegalovirus or Rh sensitization can lead to erroneous estimation of age based on liver size when the abdominal circumference is measured. If these complicating factors are ruled out in a given case then abdominal circumference has been found to be reliable method of estimating gestational age even in the third trimester. If these complicating factors are present then it would be better to not use abdominal circumference for estimation of age, but rather look to other parameters such as biparietal diameter, Head circumference, and/or femur length (Hohler, 1984).

FEMUR LENGTH

Femur lies at 30 – 70 degrees to the long axis of the body. It is as accurate as biparietal diameter in determination of gestational age (Stuart, 1984). Average growth of the femur is < 2mm/week (Hohler, 1984). A study was done in the year 2002 by Zuylan and Murshid (2003), to evaluate the relationships between the crown rump length (CRL) and fetal femur growth parameters and the gestational age during the second and third trimesters. Significant relationship was found between the studied fetal growth parameters and the gestational age. In the study done in 30 fetuses, 15 male and 15 female, from analysis of the data, it appeared that fetal crown rump length and femur growth parameters are accurate for the calculation of gestational age.

HAND AND FOOT LENGTH

Bardale and Sonar (2008) did a prospective study on 123 dead fetuses to determine the accuracy of fetal hand and foot length in estimating gestational age. Their study revealed high correlation of fetal hand and foot length with gestational age.

OSSIFICATION CENTRE (Reddy, 2011; Parikh, 2011)

The bones of human skeleton develop from separate ossification centres. These ossification centres are classified as

- Primary ossification centres and;
- Secondary ossification centres.

From these centres ossification progresses till the bone is completely formed. In the foetus the changes in the appearance of ossification centres can be done either by dissection of the bones or by radiological examination to ascertain the age till the ossification is complete. The following chronology of ossification data provides the principle points for determination of age of the foetus:

5th month of intra- uterine life: Appearance of epiphysis of manubrium and 1st segment of body of sternum, Appearance of epiphysis in calcaneum of foot.

7th month of intra- uterine life: Appearance of epiphysis of 2nd and 3rd segments of body of sternum, Appearance of epiphysis of talus of foot.

9th month of intra- uterine life: Appearance of epiphysis of cuboid of foot, Appearance of epiphysis of lower end of femur. 10th month of intra- uterine life: Appearance of epiphysis of 4th segment of body of sternum (Reddy, 2011).

At birth: Appearance of epiphysis of upper end of tibia.

While the time of ossification gives a good indication of age it should be remembered that:

- There are variations due to dietetic, geographic, hereditary and other factors.
- The union of epiphysis in cartilaginous bones takes place earlier in the female by about two years than in the male.
- Ossification is observed earlier under tropical conditions than in temperate areas (Parikh, 2011).

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