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Review Article

Estimation of Gestational Age Through Various Parameters: A Narrative Review

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Abstract

Introduction

Estimating gestational age is essential to ensure proper progress of labor and growth of the fetus. It is also important to identify growth restriction in fetus and do early interventions to avoid complications. Use of sonographic parameters is hence an important component of the management of pregnancy. This review aims to highlight parameters that can estimate gestational age during intra-uterine life.

Methods

Published literature in English was retrieved through searches of PubMed or MEDLINE, CINAHL, and the Cochrane Library in 2010 using appropriate controlled vocabulary through key words (Ultrasound, Head circumference, Abdominal circumference, Bi-parietal diameter, Transcerebellar diameter).

Findings

Fetal biometry came into existence in 1980s and during this only a few parameters were considered as standard measurements which include crown-rump length, bi-parietal diameter, head circumference, femur length and abdominal circumference. Lastly, fetal transverse cerebellar diameter (TCD) came into being and is the most widely accepted and used parameter for fetal growth due to its reliability. This method is especially of benefit when intrauterine growth restriction is suspected. It has a statistically significant relationship with gestational age and has a sensitivity and specificity of more than 90%.

Conclusion

Accurate measurement of fetal growth is essential to monitor the health of fetus and identify problems in early phase and intervene. Multiple parameters have been identified to estimate the gestational age including, biparietal diameter, head circumference, abdominal circumference, crow-lump length and fetal transverse cerebellar diameter (TCD).

Keywords: Ultrasound; Parameters; Gestational age

Introduction

Estimation gestational age is very important in clinical practice to ensure appropriate management of labor and newborns. It is also very important to differentiate between normal and growth restricted fetuses [1]. Prediction of gestational age based on sonographic parameters is perhaps the cornerstone in modern obstetrics and continues to remain an important component in the management of pregnancies with fetuses who have growth disturbances. There are many parameters which are used for establishing gestational age for example biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), femur length (FL), and transcerebellar diameter (TCD). The measurement of the fetal transverse cerebellar diameter has been used for assessment of gestational age and fetal growth since it presents advantages over other biometric parameters [2].

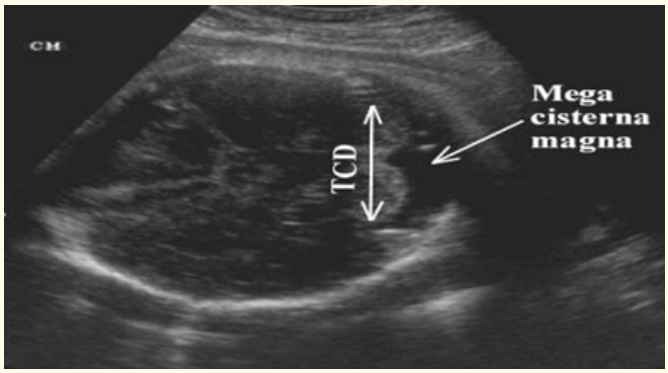

Figure 1: *Fetal Ultrasound showing transcerebellar diameter.*

Transcerebellar diameter is the distance between lateral aspects of the cerebellum and incorporates the width of cerebellar vermis; cerebellum grows progressively along with gestational age at any trimester. Transcerebellar diameter is most reliable parameter for estimating the gestational age, as there is an association between the dimension of fetal cerebellum, especially the transverse cerebellar diameter and gestational age. Furthermore, this association is not influenced by alterations in the growth of the fetus such as macrosomia or restricted intrauterine growth [3]. Majority of the data suggests that the transcerebellar diameter is extremely valuable when gestational age is unknown or Intrauterine growth restriction is suspected [4].

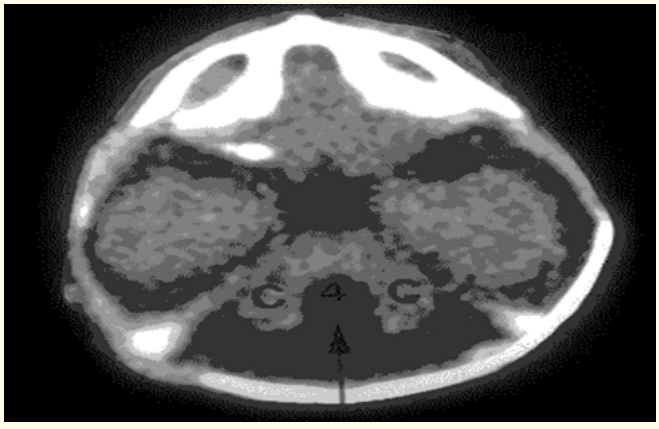

Figure 2: *Landmarks for the Trans cerebellar diameter: Normal Trans cerebellar diameter.*

The review was thus aimed to search various parameters which can estimate the gestational age during intrauterine life.

Methods

Published literature in English was retrieved through searches of PubMed or MEDLINE, CINAHL, and the Cochrane Library in 2010 using appropriate controlled vocabulary through keywords (Ultrasound, Head circumference, Abdominal circumference, Bi-parietal diameter, Transcerebellar diameter).

Findings of the review

History of Ultrasound

The history of ultrasound dates back to 1882. The term sonar refers to sound navigation and ranging. As early as 1822 Daniel Colladen, Swiss physicist, had used an underwater bell in an attempt to calculate the speed of sound in the water of lake [5]. Geneva lord ray Leigh

in England published in 1877 the famous treatise "The theory of sound" in which the fundamental physics of sound vibrations (waves), transmission and refraction were clearly delineated [6]. The breakthrough in echo sounding techniques came when the Ptezo - elective effect in certain crystals was discovered by Pierre Curii and his brother Chekus Curii in France in 1880. Apart from its use in under water navigation and metal flaw detection the early use of ultrasound was largely confirmed to its application in the therapy rather than diagnosis. It was in 1940 that ultrasound had started to be employed as diagnostic tool in the medicines [6]. In 1969 the first "world congress on ultrasonic diagnosis in medicine "was held in Vienna after which major breakthrough came in ultrasound use as diagnostic and therapeutic use. The problem of safety of diagnostic ultrasound has not escaped security since its implication particularly when high powered ultrasound has been used in 1940 for destructive and therapeutic purposes [7].

A and B mode scanning:

A mode scan has been used for placental localization in Europe and Britain in late 1950 and early 1960 [8]. Denver group in United States and Donald group in 1967 successfully reported placenta graphy in 1960 [9]. Games Willock described measurement of BPD using B mode in 1962 [10].

Real time scanning:

After A and B mode scanners real time innovations completely changed practice of ultrasound scanning in 1965, the scanning frequency was 2.25 Mhz. James Griffin and Walter Henry produced much improved mechanical oscillations real time transducers in 1973 [11]. Worth of inventions in early 1980s was an attempt to miniaturize scanner so that they could be portable. The introduction of 2-D U/S helped in the assessment of fetal growth restriction and early assessment of utero placental arterial compromise so that timely therapeutic interventions can be done. While the diagnostic U/S was progressively being introduced into clinical medicine, initially a correlation was made between fetal BPD as measured by U/S and fetal birth weight. The technique was then revised by Cambell [12].

Unidimentional measurement:

Fetal biometry is done by taking measurements. They rely on dimension taken in one plane. The most important unidimensional measurements are: bi parietal diameter, femur length and crown rump length, described by James Willocks in 1962 [13]. In 1971 Cambell published normograms for biparietal diameter from 13th week of gestation and has made cephalometry a standard tool for assessment of fetal growth in maturity [14].

Bi -Dimensional measurement:

In bi-dimensional diameter two measurements are taken in orthogonal plane and then area or circumference is calculated in certain machines. The measurements are computer fed and can be taken directly. The most commonly used measurements of this category are used in the diagnosis and monitoring of intrauterine growth restriction, those include:

Head circumferences: Thomos and Campbell have used measurements of fetal head circumferences along with bi parietal diameter in assessing fetal growth in 1977 [15].

Abdominal circumferences: Measurements of fetal abdominal diameter and circumferences were first used to estimate the fetal weight by Campbell and Willkan in 1975, since then abdominal circumferences has become the main fetal parameter used to estimate fetal weight before birth [16].

Tridimensional measurements: The tri dimensions taken into account three linear measurements and are volume or weight measurements. However, the type of measurements used varies with age of conceptus.

Advent of tissue imaging in the last four years of 1990s greatly increase spatial and contrast resolution, background noise reduction and near and far field visualization.

Fetal Biometry for assessment of fetal growth: Ultra sound has contributed greatly to our ability to diagnose and evaluate fetuses with IUGR [17]. Brief description of methodology for parameters used in the study population is reviewed as follows.

Fetal biometry developed and flourished in 1980s as accurate fetal measurements do not require the prerequisite of very high resolution equipment [18]. At least two dozen measurements were invented to assess gestational age and fetal size, each claimed their unique usefulness. Never the less by mid 1980s only a few parameters were considered as standard measurements and ones that had" stood the test of time ". These include crown-rump length (CRL), the bi parietal diameter, the head circumference, the femur length (FL), and abdominal circumference (AC) [19]. Many of the measurements were considered useful only in situations where fetal dysmorphology was in question [19].

Bi-parietal Diameter

Donald & Brown in1961 were the first to describe the use of ultrasound for measurement of fetal bi parietal diameter (BPD). Later Willocks (1963) conducted study that defines basic methodology. At one time one dimensional A-mode was the only mode utilized for BPD measurements. Campbell (1968) introduced A&B scan method of fetal cephalometry. Hoffman & Hollander (1968) were the first to report results of fetal cephalometry with real time equipment. The BPD is commonest measurement in fetal biometry to assess intrauterine fetal growth process. BPD is a relatively good predictor of measurement age between 7 to 13 weeks. Many methods have been devised to measure the BPD [20]. BPD is best done with a 3.5 or MHz transducer [21]. Lie of the fetus is determined & is longitudinal axis is confirmed by sliding the transducer over maternal abdomen until the fetal head is visualized. Transducer is the rotated at right angle until a transverse section of head is visualized. The correct section is ovoid ball appearance and shows the following.

1. Oval shaped head.
2. A short mid line echo in the anterior two thirds of the head.
3. Septum cavum pallucidum.
4. The basal cisterns.

Fetal head growth may be plotted from serial measurements and a trend of growth velocity is determined when two values are obtained 7 to 10 days apart.

The BPD is calculated by keeping the velocity of transducer in mind. If the velocity is 1600 m/sec then BPD is measured from outer edge of parietal eminence closer to the transducer to the inner edge of the parietal bone only from the transducer. If however, the speed of transducer is 1540 m/sec outer to outer edge of parietal bone are measured. The gain setting of the transducer should be such that the thickness of parietal bone is approximately 3 mm. The fetal head should be imaged in an axial section preferably with the fetus in a direct occipito-transverse position [22]. If the fetus is in breech or transverse position the fetus does not obtain the rounded shape but assumes a dolicephalic shape [23]. The BPD growth curves in a nonlinear pattern and scatter between 50^{th} & 90^{th} centile widens after 30 weeks of pregnancy therefore certainty about abdominal delay in growth of fetal head falls [24].

Femur Length

Like BPD, femur length is highly reproducible because of precisely defined points. Measurement of femur length between 12-22 weeks varies only by ± 6 to 7 days. The femur growth curve is nonlinear similar to the BPD growth curve. Fetal femur length can be used as adjunct in estimating menstrual age [25]. Fetal femur length can be measured from proximal diaphysis to distal metaphysis. The femur is intensely echogenic and due to posterior shadowing only a small width can be assessed [26]. When measuring femur length the ends of the bone should be blunt. It is a good practice to obtain measurements from different images of femur, these should be taken that femur is at 45^0 to the beam of transducer because if it is at 90^0 the femur may be lengthened by side lobe artifacts, when measuring femur length the ends of the bone should be blunt. As sharp edges indicate all images have not been cut off. It is a good practice to obtain measurements from different images of femur. These all measurements should be within 1μm of each other [27].

Head Circumference

Measurements of head circumference are used in assessing fetal growth and abnormalities [28]. Many investigators have made charts of these fetal head dimensions and their measurements are widely used in obstetric U/S examination [29].

Fetal head circumference is measured by two methods in the same axial plane as for bi parietal diameter [28].

1. By an on screen method taking the tracing around the perimeter of the head.

2. By measuring the BPD and occipito-frontal diameter and calculating it indirectly by the standard formula with individual's cd1+ cd2 where d1 and d2 are the two diameters.

Abdominal Circumference

The abdominal circumference is one of the best parameter that assesses both fetal size and growth. The measurement is taken at the level of fetal liver, which constitutes about 4% of the total fetal weight [30]. This increases steadily with increasing gestational age. It is useful method for estimating fetal weight. Campbell and William in 1975 have described the method used to obtain a transverse section of the fetal abdomen at the level of the intra-abdominal portion of the umbilical vein [16].

A longitudinal view of the fetal spine and hence of the longitudinal axis of the aorta is obtained. The transducer is rotated through 90^0 and is moved upward and downwards until the umbilical vein is seen traversing the fetal liver in its anterior third. The image should pass through the maximum width of liver. The image should be as round as possible and should not be inclined side to side or front to back. Excessive pressure by the transducer causing distortion of the fetal abdomen should be avoided. The abdominal circumference like head circumference can be calculated by two methods.

The longest axis and the shortest axis of the images are measured, summed up and multiplied by 1.57. It can also be measured with the help of a dectorine digitizer. The directly measured circumference is consistently greater than those derived from the measurement of abdominal diameter by about 35%.

However whatever the method of measurement is used it gives the good estimate of gestational age and is superior to other means of assessing intrauterine growth restriction. Shorter the time interval between scan, higher is the chance for false positive result [31].

Transverse Cerebellar Diameter

Cerebellar measurement is recently being evaluated for its accuracy in brain sparing type of fetal growth restriction. Statistically significant relationship between transverse cerebellar diameter and gestational age was found [32].

The normal transverse cerebellar diameter exhibited a more than two fold increase in size during and half of the pregnancy linear growth pattern has been observed [33]. In the cerebellar growth pattern different tables of the cerebellar diameter are available for the assessment of fetal growth for the given gestational age [34].

Figure 3: *Transverse cerebellar measurement (image courtesy of Wayne Persutte, PhD).*

An angle view is necessary for the adequate visualization of the cerebellum. The estimated variability of the fetal transverse diameter associated with determining gestational age is best until 26 weeks of gestational age with variability of ± 0.9 weeks. Afterwards due to cerebral growth spurt, the variability starts decreasing so that at term it reaches up to ± 1-6 weeks [35].

The transverse cerebellar diameter should be measured in an axial view, placing the calipers on the outer, lateral edges of the cerebellar hemisphere [36].

It has been proven by various studies that transcerebellar diameter shows linear growth throughout the gestation [37]. The cerebellum is well protected in the fetal head and it is the last organ to be affected by a decrease in blood flow [2]. Also in the presence of acute asphyxia cerebellar blood flow remains unchanged as a consequence of redistribution of cardiac output. Moreover, the internal organs of the cranium, particularly trans cerebellar diameter, are less affected in the fetuses with restricted growth due to placental insufficiency, thereby suggesting a cerebellar growth preservation mechanism in relation to other encephalic areas. Therefore, ultrasound assessment of the transcerebellar diameter has been considered as more indicated method because of its precision in determining gestational age and fetal growth [2].

Transcerebellar diameter (TCD) is especially advantageous when IUGR is suspected as in most cases of fetal growth restriction the transcerebellar diameter appears to be spared and can be used as an unbiased measure of gestational age. "Transcerebellar diameter in millimeters is equal to gestational age in weeks." Fetal transcerebellar diameter is one such parameter that has remained superior in predicting gestational age not only in singleton but also in twin gestations. Statistically significant relationship between transverse cerebellar diameter and gestational age is also found with specificity and sensitivity of more than 90% in some studies [34,38,39].

Conclusion

Multiple parameters have been identified to estimate the gestational age including, biparietal diameter, head circumference, abdominal circumference, crow-lump length and fetal transverse cerebellar diameter (TCD). Accurate and easily reproducible ultrasound fetal biometry parameter for gestational dating is clinically important for the management of pregnancies, especially in determining time of variety of gestational test assessing adequacy of growth and timing of delivery.

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