REVIEW OF LITERATURE

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❖ Review of literature on use of ultrasonography:

Carol M. Rumack, Stephanie R. Wilson, *et al*, in their highly esteemed text book "Diagnostic Ultrasound" Vol. 2, Second Edition(1997), Chapter 31, Page 961, mentioned "The introduction of sonography to obstetrics by Ian Donald and his colleagues in 1958 is now regarded as one of the major milestones of modern medicine. For the first time it became possible to obtain information about the fetus and its environment directly with a noninvasive diagnostic procedure considered safe even when used repeatedly. Recent advances in technology and expertise have enhanced image quality allowed for considerable insight into fetal anatomy." [12]

Wilson Stephanie R, Carol M. Rumack, *et al*, in Diagnostic Ultrasound, Vol. 2, Second Edition(1997), Chapter 33, Page 1013, stated that by convention, pregnancies are dated beginning from the first day of the last menstrual period (LMP). In women with regular 28 day cycles, conception occurs approximately two weeks after the LMP. Gestational age, the term commonly used to date the pregnancy, is thus defined as conceptual age plus two weeks. In women with regular 28 day cycles, gestational age and menstrual age are the same. Accurate knowledge of gestational age is important for better diagnosis and management. [68]

In "Diagnostic Ultrasound", Vol. 2, Second Edition (1997), Chapter 31, Page 962, Stephanie R Wilson, Carol M. Rumack, *et al,* gives the guidelines for the first trimester ultrasound examination which includes confirmation of the location of the gestational sac, the presence or absence of fetal life, fetal number, and evaluation of the uterus and adnexae. The second and third trimester examinations include these parameters and as well as documentation of fetal presentation, amniotic fluid volume (AFV), location of the placenta, assessment of gestational age using biparietal diameter(BPD),femur length(FL) abdominal circumference(AC) and fetal anatomy.[62]

Seeds JW. *et al,* in the journal of "Obstet Gynecol", 1982 Dec; 60(6):680-5 said that ultrasonic long bone imaging is a potentially valuable index of fetal growth. Reported here are fetal limb measurements in normal pregnancies, produced with readily available ultrasound equipment and described using simple statistical techniques. Lengths of femur, humerus, tibia/fibula, and radius/ulna are related to gestational age. Femur and humerus measurements are also related to biparietal diameter. Linear correlation is high and with few exceptions these results confirm those of other investigators. Comparability between these data and previously published work is examined and the utility of these standards of growth discussed. Long bone imaging is confirmed as being reliable, reproducible, and a viable alternative to the measurement of biparietal diameter in the biophysical assessment of fetal development. [58]

In the journal of "Obstet Gynecol Surv", 1989 Jul; 44(7):544-55, Reece EA, Gabrielli S, *et al,* Department of Obstetrics and Gynecology, Yale University School of Medicine, New Haven, Connecticut - 06510, mentioned that the accurate estimation of gestational age is an essential part of pregnancy management, since the consequences of erroneous dating carry increased risks of perinatal morbidity and mortality. Ultrasonography offers a unique opportunity to objectively measure quantitative changes in growth increments of various fetal structures, as well as qualitative changes occurring near term which are indicative of fetal maturity. Therefore, dating through pregnancy is possible by the use of various parameters such as the crown-rump length, the trunk circumference, and the biparietal diameter in the first trimester; the biparietal diameter, the cerebellum, orbital distance, clavicular length, lengths of the long bones of the upper and lower extremities, and the foot length in the second and third trimesters; and the indices of maturity in the late third trimester such as fetal renal length and epiphyseal ossification centers of the long bones of the upper and lower extremities. Using a combination of fetal biometry and maturity indices permit dating through pregnancy as a measure of growing up of fetus.[51]

The American Institute of Ultrasound in Medicine (AIUM) in the journal of Ultrasound in Medicine 1991; 10:576-78, formulated a guide line for the first trimester ultrasound examination which includes confirmation of the location of the gestational sac, the presence or absence of fetal life, fetal number and evaluation of the uterus and adnexae. The fetal anatomic

assessment includes the evaluation of intracranial anatomy, heart, spine, abdomen (including kidneys, bladder and stomach) and cord insertion in their study. [3]

Society of Obstetricians and Gynecologist of Canada (SOGC) in 1993 recommended that all patients be offered a mid trimester fetal ultrasound examination. They suggested that 18 weeks is the ideal time to perform the scan that should combine an evaluation of dates, biometry, number of fetuses and assessment of fetal abnormalities and also gave specific recommended images and measurements. [61]

❖ **Review of literature on conventionally used fetal biometric parameters for assessment of gestational age:**

Stephanie R. Wilson, Carol M. Rumack, *et al,* in "Diagnostic Ultrasound", Vol. 2, Second Edition(1997), Chapter 32, Page 987, proposed that using endovaginal ultrasonography (EVS), an embryo with a crown rump length (CRL) of as small as 1 to 2 mm may be identified immediately adjacent to the yolk sac. Embryonic cardiac activity can be identified routinely by EVS when the CRL is greater than 5mm. [63]

Carol M. Rumack, Stephanie R. Wilson *et al,* in "Diagnostic Ultrasound" Vol. 2, Second Edition(1997), Chapter 32, Page 989, mentioned that using endovaginal sonography (EVS), the embryo can be visualized from the 5th menstrual week onward. A well performed crown rump length (CRL) measurement in the first trimester of pregnancy is accurate up to 5 to 7 days and is equivalent to or greater in accuracy than the biparietal diameter measured early in the second trimester. [11]

Willocks J, Donald I, *et al*, In the Journal "J Obstet Gynaecol Br Common" 1967; 74:639-647, "Intrauterine growth assessed by ultrasonic fetal cephalometry", Willocks J, Donald I, *et al*, mentioned that BPD increases steadily throughout gestation but that after about 32 weeks the rate of changes decreases and difficulty of accurate measurement increases. [67]

In "Br J Obstet Gynaecol" 1975; 82: 702-710, in a study "A critical evaluation of sonar 'crown rump length' measurements", Robinson HP, *et al*, mentioned that from 6 weeks until the end of the first trimester, gestational age correlates closely with the crown rump length (CRL) of the embryo or fetus. The term "embryo" applies up to the end of organogenesis at 10 weeks' gestation; the term "fetus" applies thereafter. The CRL is the length of the embryo or fetus from the top of its head to the bottom of its torso. It is measured as the longest dimension of the embryo, excluding the yolk sac and extremities. The CRL of the longer, more developed fetus becomes less reliable. At this later stage, the CRL is affected by the fetal position, measuring shorter in a fetus whose spine is flexed and longer in a fetus whose spine is straight. [52]

AB Kurtz, Wapner RJ, *et al*, in "J Clin Ultrasound" 1980; 8:319-326, mentioned in their study "Analysis of biparietal diameter as an accurate indicator of gestational age", that there have been 25 studies attempting to correlate biparietal diameter and gestational age; of these, 17 meet specific criteria and thus are included in this evaluation. Although all studies have shown an increase in biparietal diameter with advancing gestational age, between 17 wk and term there is a discrepancy of

approximately 3 wk. In this evaluation the charts are compared and the variations analyzed. An ideal table is constructed by combining the mean gestational age, calculated from a statistical analysis, and the variation at each millimeter point, determined by comparison of all the studies. It is hoped that this new 90% composite table, which consists of a range of gestational ages in weeks for each biparietal diameter, will not only provide more realistic indications of fetal age but also will serve as a reminder to sonographers, obstetricians, and patients of the relative accuracy and variations of biparietal diameter measurements. [1]

In "Am J Obstet Gynecol", 1981 Dec 1; 141(7):759-62, in a study "Comparison of ultrasound femur length and biparietal diameter in late pregnancy", Quetel TA, *et al,* showed a linear relationship between growth of fetal femur length (FL) and biparietal diameter (BPD) after 22 weeks' gestation is described. The normal ratio of femur length to BPD (FL/BPD ratio) was found to be 79 +/- 8%. Effective uses of the FL/BPD ratio include its use as a quality control check on femur length and BPD measurements and its use to diagnose short-limbed dwarfism, hydrocephalus, and microcephaly. Pregnancy dating by means of BPD can now be cross checked by use of femur measurements and new observations on normal and abnormal fetal growth will now be possible. [50]

In "AJR Am J Roentgenol" 1982 Aug; 139(2):367-70, Deter RL, Hadlock FP, *et al,* made a study on "Fetal abdominal circumference as a predictor of menstrual age". In their study the relation between fetal abdominal circumference and

menstrual cycle age was determined by cross-sectional analysis of 400 fetuses (15-41 weeks) examined with a linear-array real-time ultrasound scanner using specifically defined methodology. Predicted abdominal circumference values at specific points in gestation were comparable to the data reported by other investigators using static-image equipment. Predicted menstrual age values associated with a given abdominal circumference measurement were calculated and are presented in tabular form. The variability (+/- 2 SD) in predicting menstrual age from abdominal circumference measurements is broader than that observed with the fetal biparietal diameter; nonetheless, this measurement can be useful as an adjunct in predicting menstrual age in cases in which the biparietal diameter is technically inadequate or impossible to obtain due to unusual positioning.[19]

In "Br J Obstet Gynaecol", 1982 Oct; 89(10):836-8, Parker AJ, Davies P, *et al*, made a study on "Assessment of gestational age of the Asian fetus by the sonar measurement of crown-rump length and biparietal diameter". In their study two populations of pregnant Asian and European women were scanned using linear array real-time ultrasound machines. Measurements were made of fetal crown-rump length (CRL) up to 14 weeks gestational age and of biparietal diameter (BPD) up to 20 weeks gestational age. There were no significant differences between the Asian and European parameters for the CRL and BPD curves. European nomograms may be used to establish Asian fetal gestational age up to 20 weeks. [46]

Hadlock F P, Deter R L, *et al,* in "AJR Am J Roentgenol". 1982 Aug; 139(2):367-70, mentioned in the study "Fetal head circumference: relation to menstrual age" that a number of groups have produced charts of HC against gestational age and the two most often used are very similar. Both shows that changes in HC, like BPD, tend to tail off towards term but the standard deviations are much smaller. [27]

In "J Ultrasound Med" 1982; 1:281-288, in a study "Head circumference as an index of fetal age", Law RG, *et al,* showed that head circumference (HC) plays an important role in sonographic determination of fetal age. [38]

David Cosgrove, Hiltone Meire, *et al,* in "Ultrasound in Obstetrics and Gynaecology" 2nd Edition (2001); Vol.3; Chapter 10; Page 229, mentioned that the AC is undoubtedly the best index with which to assess both fetal size and growth because the measurement is taken at the level of the fetal liver, which constitute about 4% of the total fetal weight and which steadily increases in size with gestational age. [17]

Hobbins JC, Jeanty P, *et al,* in the journal "Clin Obstet Gynecol" 1983 Dec; 10(3):423-44, mentioned that reliable fetal age assessment is possible using antenatal sonography. Crown-rump length, biparietal diameter, head perimeter and femur length are the most widely used parameters, while biocular distance and humerus length are of ancillary value. Techniques of sonographic measurement and clinical applications are reviewed and nomograms relating these parameters to

gestational age are presented. Multiple sonographic parameters have been used to diagnose altered fetal growth. [31]

In "J Ultrasound Med", 1983 Apr; 2(4):147-50, Smazal SF Jr, Weisman LE, *et al,* mentioned in their study "Comparative analysis of ultrasonographic methods of gestational age assessment". That the measurement of crown-rump length (CRL) is widely accepted as the most accurate method of gestational dating. The statistical accuracy of growth-adjusted sonographic age (GASA) determinations has been demonstrated to be similar. Ninety-six patients were prospectively examined by use of serial ultrasonography, and findings were evaluated to correlate CRL with a single biparietal diameter (BPD) obtained between 20 and 24 weeks of gestation, with GASA, and with accurate maternal dates. Growth-adjusted sonographic age was shown to be not as accurate as CRL and no more accurate than a single BPD obtained between 20 and 24 weeks or reliable maternal dates.[60]

Fendel H, Giani G, *et al.* in "Zeitschrift für Geburtshilfe und Perinatologie". 1984 Jul-Aug; 188(4):161-6, in a German article "Determination of gestational age using crown-rump length and the biparietal diameter in the 1st half of pregnancy--comparison of 2 methods" stated that they made ultrasound investigations on women with known gestational age by regular menstruation or conception in the first half of pregnancy. In 221 cases of single pregnancies fetal crown rump length was measured. Biparietal cephalometry was performed in 198 single fetuses. Growth curves and the velocity of growth from biparietal diameter and from crown-rump length were

determined and compared. The accuracy of the estimation of gestational age was observed to be +/- 10 days (2 SD) with both methods. [23]

Hohler CW, *et al,* in "Clin Obstet Gynecol", 1984 Jun; 27(2):314-26 said in their study "Ultrasound estimation of gestational age" that many ultrasonologists feel that if they are unable to obtain a BPD measurement at the time of an ultrasound examination that they have somehow failed to do an adequate job. However, from the information outlined in this chapter, it can be seen that the biparietal diameter is only one measurement that can be taken of the fetus in order to estimate gestational age. Furthermore, since the recognition of variability in fetal head shape, absolute reliance on measurement of the fetal biparietal diameter for estimation of gestational age has become much less common, especially after 20 weeks of gestation. The move toward measurement of several parts of the fetal anatomy has been called fetal biometry. The purpose of this approach is to evaluate body proportion and symmetry of growth of different organ systems, in the hope of elucidating subtle patterns which might be recognized as abnormal in very early stages when some form of prenatal management might improve reproductive outcome. Simultaneously, with the implementation of this approach to estimating age, a desire to inject an element of "quality control" into the obstetric ultrasound examination has come about. It has been found that measurement of more than one fetal parameter, in a sense, prevents over reliance on any single measurement, which, by itself, might mislead the clinician. While an error of clinically

significant magnitude can be made in any measurement, it is unlikely that an error of the same magnitude, in "the same direction" of over or underestimation of the actual, would occur. Thus, there is an element of protection of the patient built into this approach which makes it appealing intuitively. However, it is uncertain that measurement of BPD, head circumference, abdominal circumference, and femur length will, in all cases, give a better estimate of gestational age than will measurement of the BPD alone. Recent data from Hadlock et al. showed that in 177 normal pregnancies, there was significant improvement in the ultrasound estimation of estimated date of delivery when two or more parameters were used to make that estimate rather than just BPD alone. Prior to 36 weeks, the optimal combination of parameters included the biparietal diameter, the abdominal circumference, and the femur length. However, after 36 weeks, the head circumference, abdominal circumference, and femur length gave the best estimate, with significant reduction in the mean errors, standard deviations, and size of maximum errors. [32]

In "J Ultrasound Med", 1984 Feb; 3(2):75-79. Jeanty PJ, Rodesch F, *et al,* in their study "Estimation of gestational age from measurements of fetal long bones", have mentioned in their study regarding sonographic measurement of fetal long bones (femur, humerus, tibia, and ulna) from 12 to 40 weeks of gestation. The combined use of the four bones allowed a good estimation of gestational age. [34]

Tse CH, *et al,* in "Aust N Z J Obstet Gynaecol", 1984 Aug; 24(3):186-8, conducted a study on "A comparison of the fetal femur length and biparietal diameter in predicting gestational age in the third trimester". In their study the accuracy of predicting gestational age, fetal femur length was compared with the biparietal diameter after 28 weeks' gestation in 50 patients. The results showed that ultrasonic fetal femur length was more accurate than the biparietal diameter in predicting gestational age in the third trimester. Ultrasonic fetal femur length provides an additional parameter in assessing gestational age in late pregnancy. [65]

In "J Reprod Med", 1984 May; 29(5):323-6, Allen G, Quinlan RW, *et al,* in a study "Clinical utility of the relationship between fetal femur length and biparietal diameter", showed the relationship between fetal femur length and biparietal diameter on ultrasound examination was evaluated in a large, unselected obstetric population of 12-40 weeks' gestational age. The derived ratio of fetal femur length to biparietal diameter was evaluated retrospectively as a tool for examining the technical reliability of fetal measurements obtained and as a screening mechanism for detecting asymmetric fetal development. The ratio of femur length to biparietal diameter is of value as an aid to the detection of fetal developmental and these should be a routine parameter considered in the performance of an obstetric ultrasound examination.[2]

Schmidt W, *et al,* in an Article of German, "Geburtshilfe und Frauenheilkunde", 1985 Feb; 45(2):91-7, "Fetal femur length in the 2nd and 3rd trimester of pregnancy", presented results of

sonographic determination of the length of femur between the 12th and 42nd week of pregnancy. The length of femoral diaphysis was determined as part of a cross-sectional study on a total of 595 patients who were not at risk, and where the gestation age was known and confirmed. The growth function of the foetal femoral length was determined via a polynomic regression equation. The foetal femoral length growth presents a characteristic appearance between the 12th and 42nd pregnancy week. In the 12th pregnancy week it is 11 mm on the average, 33 m in the 20th, 58 mm in the 30th, and 76 mm at birth. After an almost linear progression up to about the 30th week of pregnancy, the growth curve gradually begins to flatten out from that time. The mean growth rate of foetal femoral length during the entire period under observation is about 1 to 3 mm per pregnancy week. A relatively accurate estimate of the gestational age is particularly possible in the "early" range between 5 and 32 mm (corresponding to the 12th to 20th week of pregnancy), namely, +/- 9.7 to 10.3 days. [57]

Ott WJ, in the journal "Obstet Gynecol", 1985 Sep; 66(3):311-5, conducted a study "Accurate gestational dating" and calculated gestational age by four ultrasonic parameters (biparietal diameter, head circumference, abdominal circumference, and femur length). 210 normal obstetric patients divided into four gestational age groups based on time of first ultrasound examination. Accuracy of the calculations was determined by comparison of each technique and a simple arithmetic average of the four techniques to the gestational age calculated from the Dubowitz examination of the neonate after delivery. The

analysis indicated that each ultrasonic technique has certain advantages and disadvantages, but that the simple arithmetic average of the four techniques had the lowest systematic and random error. [43]

In the journal "Obstet Gynecol", 1985 May; 65(5):613-20, in the study "Routine ultrasound screening for the prediction of gestational age", Campbell S, Little D, *et al,* described that clinical dating of pregnancy is usually based on the patient's recollections of the first day of her last menstrual period and on physical examination of uterine size. Unfortunately both these methods are subject to imprecision, leading to inaccuracies in gestational age assignment. Dating by the last menstrual period may be inaccurate because of variability in length of menstrual cycles .faulty memory, or bleeding during early pregnancy. Determining gestational age from the palpated dimension of the uterus may be affected by uterine fibroids and maternal body habitus. [10]

In the journal "Obstet Gynecol", 1985 Jul; 66(1):69-75. Warda AH, *et al,* did an investigation on "Fetal femur length: a critical reevaluation of the relationship to menstrual age". This investigation had reexamined the measurement of the femur length and the use of this measurement as a growth and dating parameter. Straight-line measurements of shaft length were found to be smaller than measurements made along the bone curvature. However, the maximum difference did not exceed 2 mm. Thus, because of its simplicity, use of straight-line measurements appears justified. The variability associated with age estimates increased with femur length. These data were

used to construct new standard curves for growth assessment and dating of fetuses using femur length measurements. [66]

In the journal "J Ultrasound Med", 1986 Mar;5(3):145-49, the study "Comparison of biparietal diameter and femur length in the third trimester: effects of gestational age and variation in fetal growth", conducted by Wolfson RN, Peisner DB, *et al,* did a multiple regression-based statistical model capable of quantitatively comparing two or more sonographic parameters for the effects of gestational age, variation in fetal growth and error in sonographic measurement is presented and then used to compare the biparietal diameter and femur length as estimators of gestational age in late pregnancy. A total of 311 patients were studied between 24 and 42 weeks' gestation. Variation in fetal growth was expressed as the birth weight percentile for gestational age. Biparietal diameter and femur length correlated equally well with gestational age. However, the biparietal diameter was more than twice as sensitive as the femur length to variation in fetal growth. Femur length had a larger error associated with its measurement. These results suggest that the biparietal diameter and femur length in late pregnancy are equal estimators of gestational age; that the femur length is a more stable estimator of gestational age when fetal growth deviates from normal; and that the femur length is technically more difficult to obtain. [70]

In "Am J Perinatol", 1986 Apr; 3(2):77-9, in the study "Femur length versus biparietal diameter for estimating gestational age in the third trimester", Egley CC, Seeds JW, *et al,* established that ultrasound measurement of femur length and biparietal

diameter is comparably accurate estimators of gestational age when obtained in the first half of pregnancy. Both estimators, however, become less accurate later in pregnancy. The present study compares the relative accuracy of these estimators when obtained in the third trimester. It is concluded from linear regression analysis that the correlation between gestational age estimated from femur length and the actual gestational age is stronger than that between gestational age estimated from biparietal diameter and actual gestational age. Furthermore, gestational age calculated from femur length is significantly more likely to be within 2-3 weeks of actual gestational age than is gestational age calculated from biparietal diameter. Estimating gestational age from the mean of the gestational age based on biparietal diameter and that based on femur length is less accurate than estimating gestational age from femur length alone. [22]

In the journal published from Denmark "Acta Obstet Gynecol Scand", 1986; 65(5):481-3, in the study "The reliability of ultrasound fetometry in estimating gestational age in the second trimester", Persson PH, *et al*, evaluated biparietal diameter (BPD), occipitofrontal diameter (OFD), mean abdominal diameter (AD), and femur length (FL), each value being taken as the mean of five measurements. Of the individual variables, BPD gave the best precision, with a standard deviation (SD) from true GA of 3.2 days. Using a combination of all four variables, GA could be estimated with a SD of 2.2 days. The maximum difference between GA estimated by BPD and by FL was 7 days. Using a combination of BPD and

FL to estimate GA in the total population, the number of post-term deliveries was only marginally less than when using BPD alone. [48]

Yagel S, Adoni A, *et al,* in "Br J Obstet Gynaecol", 1986 Feb; 93(2):109-15, in the study "A statistical examination of the accuracy of combining femoral length and biparietal diameter as an index of fetal gestational age". mentioned that the use of femur length (FL) and biparietal diameter (BPD) for estimation of gestational age (GA) was investigated using 1123 ultrasound measurements between the 14th and 41st week of gestation. Femur length was found to provide a more accurate index than BPD for the entire range of gestational age considered. If an interval of approximately +/- 2.5 weeks is considered 'satisfactory', the accuracy of FL past the 31st week is not sufficient to justify its use. Combining the FL and BPD measurements provides an index of gestational age accurate to approximately +/- 2.5 weeks up to the 32nd week of gestation and accurate to approximately +/- 2.75 weeks up to the 34th week of gestation. This is the first time that combining FL and BPD in a statistically rigorous manner has been proposed as an index of gestational age, and was suggested that this combination be used as a routine tool in its assessment. [71]

In "Am J Obstet Gynecol", Harrist RB, Hadlock FP, *et al* (1987), reported that in the second and third trimesters, the mean menstrual age defined as the mean of menstrual ages predicted by the biparietal (BPD), head circumference (HC), abdominal circumference (AC) and femoral length (FL) may be used to eliminate errors caused by inaccuracy of any one parameter. [29]

Needleman L, Kurtz AB, *et al,* in "Ultrasound Obstet Gynecol", 2nd edition, Philadelphia: WB Saunders, 1988:47-64, in their study Ultrasound assessment of fetal age" mentioned that by the end of first trimester measurement of biparietal diameter (BPD) becomes more accurate than the crown rump length (CRL), which by that time reflects errors associated with fetal flexion and extension. [42]

Benson CB, *et al,* in the journal of United States "Radiology" 1988; 169(P):210, said in their study "Fetal measurements for predicting gestational age in the second and third trimesters: a reappraisal with a more reliable gold standard" that in the second trimester, biparietal diameter BPD) and head circumference (HC) measurements are the best predictors of gestational age. In the third trimester, these two head measurements, the femoral length (FL) and the composite age formulas all predict gestational age with similar accuracy. [5]

In "Asia Oceania J Obstet Gynaecol", 1989 Sep; 15(3):223-7, Dali SM, *et al,* did a study on "Biparietal diameter of nepalese foetus in different periods of gestation by ultrasonography". In their study presented an analysis of 316 primigravida with their known date of last menstruation. These cases have been attending antenatal clinic from 14 to 40 weeks of gestation. The mean BPD (Biparietal Diameter) values and percentile values were calculated. It was observed that there is a steep rise of growth up to 31 weeks and thereafter a gradual rise up to 40 weeks. The maximum BPD from 31 to 40 weeks was 90.9 mm whereas western workers like Hansmann and Campbell reported 99 mm and 98.1 mm, respectively.[15]

Miller JM Jr, Foster TA, *et al* , Department of Obstetrics and Gynecology, Louisiana State University School of Medicine, New Orleans 70112. in "J Clin Ultrasound", 1989 Mar-Apr; 17(3):193-6, mentioned in a study of 324 term pregnancies, fetal measurements (biparietal diameter, femur length, and abdominal diameter) obtained within one week of delivery correlated more strongly with relative birth weight than with menstrual age.[41]

Hadlock FP, Baylor College of Medicine, Houston, Texas, in "Radiol Clin North Am", 1990 Jan; 28(1):39-50, mentioned in their study "Sonographic estimation of fetal age and weight" that real-time ultrasound is a very effective tool in the estimation of fetal age and weight. The most accurate fetal age estimates are from crown-rump length measurements in early pregnancy. Late pregnancy age estimates are less accurate, but the use of multiple body measurements provides a composite age estimate generally accurate to within 7 per cent of actual age. Estimates of fetal weight are improved with the use of head, body, and femur measurements, and generally are accurate to within 15 per cent of actual birth weight. [28]

In "AJR. Am J Roentgenol", 1991 Dec; 157(6):1275-7, in a study "Sonographic prediction of gestational age: accuracy of second and third-trimester fetal measurements". Doubilet PM, *et al,* Department of Radiology, Harvard Medical School, Brigham and Women's Hospital, Boston, measured the accuracy of second and third-trimester sonographic predictors of gestational age against highly reliable gold standard (crown-rump length) in a group of fetuses. Using a prospectively collected computerized

data base, They selected 460 fetal sonograms obtained at 14-42 weeks of gestation in which age could be reliably established on the basis of crown-rump length in the first trimester. They used data obtained from these sonograms to compare several predictors of fetal age. The accuracy of all predictors worsened progressively as pregnancy proceeded. In the second trimester, corrected biparietal diameter and head circumference were more accurate predictors of gestational age than were biparietal diameter, femoral length, and abdominal circumference. In the third trimester, the corrected biparietal diameter, head circumference, and femoral length were the best predictors, significantly better than biparietal diameter and abdominal circumference. Prediction of gestational age that relies on a single sonographic measurement should be based on the head circumference or corrected biparietal diameter in the second trimester and on one of these two predictors or the femoral length in the third trimester. [20]

In "Am J Obstet Gynecol", Volume 168(3), March 1993, Page 903-08, in a study "Accuracy of Gestational Age Estimation by Means of Fetal Crown-Rump Length Measurement" Daya Salim MB, MSc, Department of Obstetrics and Gynaecology, McMaster University, developed a gestational age table by means of crown-rump length measurements in the first trimester in pregnancies conceived through in vitro fertilization. Ninety-four infertile women with singleton intrauterine pregnancies resulting from in vitro fertilization underwent ultrasonographic examinations in the first trimester. The relationship between gestational age (calculated with the day of

oocyte retrieval used as day 14) and the crown-rump length was explored with regression analysis. A more accurate equation for gestational age estimation with crown-rump length measurements in early pregnancy has been developed with in vitro fertilization pregnancy data.[18]

In "Clin Exp Obstet Gynecol", 1994; 21(2):108-18. Piantelli G, Sacchini C, *et al,* Department of Obstetrics and Gynecology, University of Parma, Italy, mentioned that the accurate assessment of gestational age is very important in everyday practice. By the use of multiple regression analysis, in a longitudinal study, ultrasound dating-curves were calculated for the crown-rump length, biparietal diameter, femur length, humerus length, binocular distance and transverse cerebellar diameter. All the examined parameters showed a good statistical correlation with gestational age; however, the earlier the estimation of the gestational age, the more accurate it is. The crown-rump length has been shown as the best parameter during the first trimester. Later on, the other biometric parameters become easier and more reliable. If determination of gestational age is required during the third trimester, the use of multiple parameters is recommended. [49]

In "Am J Perinatol",1994Nov;11(6):404-8, Ott WJ, Department of Obstetrics and Gynaecology, St.John's Mery Medical Center, St.Louis, Missouri 63131, in their study "Accurate gestational dating: revised", mentioned that using first trimester fetal crown-rump length (CRL) measurements as the criterion for gestational dating, rather than menstrual history or neonatal gestational age evaluation after birth, may be a more accurate

way of evaluating the accuracy of second or third trimester ultrasonic measurements for gestational age estimation. This hypothesis was tested using two study groups to evaluate the accuracy of second or third trimester ultrasound measurements for the estimation of gestational age. Three hundred twenty normal obstetric patients who had first trimester CRL measurements were evaluated in the first study. Stepwise multiple regression analysis was used to determine the best combination of multiple ultrasonic parameters for calculation of gestational age, using each patient's CRL as control. The best formula derived from the first set of patients was used in a second set of 138 high-risk patients to determine the accuracy of multiple ultrasonic parameters obtained during the second or third trimester to date gestation accurately. The analysis confirmed the accuracy of multiple ultrasonic parameters for gestational dating and indicated that the use of two parameters (head circumference and femur length) was as accurate as the traditional four-parameter technique. [44]

In "Singapore Med J", 1995 Dec; 36(6):628-36), Lai FM and Yeo GS, Department of Maternal-Foetal Medicine, Kandang Kerbau Hospital, Singapore, in their study "Reference charts of foetal biometry in Asians", constructed reference ranges for foetal biometry measurements of biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), femur length (FL), humerus length (HL) and mandible length (ML) for the Asian population in Singapore. A prospective, cross-sectional study done in the obstetric ultrasound services and the labour ward of the department of Obstetrics and

Gynaecology in Singapore General Hospital. The foetuses of 6,374 women whose delivery date was within 2 weeks of their estimated date of delivery (EDD) as calculated from the last menstrual period. A total of 6131measurements of BPD, 6117 measurements of HC, 6017 measurements of AC, 6078 measurements of FL, 2863 measurements of HL and 2029 measurements of ML were obtained and a regressed reference chart prepared for Asian Foetus from parametric analysis of cross sectional data.[37]

J. William Charboneau, Carol M. Rumack, *et al*, in "Diagnostic Ultrasound", Vol. 2, Second Edition (1997), Chapter 33, Page 1015, said that many sonographic parameters have been proposed for estimating gestational age in the second third trimesters. These include several fetal measurements: biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), femur length (FL), length of other long bones and biocular distance. Measurements of structurally abnormal fetal body parts should not be used in the assignment of gestational age.[33]

In the journal "Obstet Gynecol", 2001 Feb;97(2):189-94, Taipale P, *et al,* Department of Obstetrics and Gynecology, Jorvi Hospital, Espoo, Finland, in the study "Predicting delivery date by ultrasound and last menstrual period in early gestation", compared last menstrual period and ultrasonography in predicting delivery date. They used ultrasound to scan 17,221 nonselected singleton pregnancies at 8-16 completed weeks. The last menstrual period (LMP) was considered certain in 13,541 and uncertain in 3680 cases. The duration of pregnancy

from the scan to the day of spontaneous delivery was predicted by crown-rump length, biparietal diameter (BPD), and femur length (FL) using linear regression models and the results were compared with estimates based on LMP. At all gestational ages, ultrasound was superior to certain LMP in predicting the day of delivery by at least 1. 7 days. When deliveries before 37 weeks were excluded, crown-rump length measurement of 15-60 mm (corresponding to 8-12.5 weeks) had the lowest prediction error of 7. 3 days. After that time, BPD (at least 21 mm) showed a similar error (7. 3 days) and was more precise than crown-rump length. Femur length was slightly less accurate than crown-rump length or BPD. Regression models using a combination of any two or three ultrasonic variables did not improve accuracy of prediction. When ultrasound was used instead of certain LMP, the number of post term pregnancies decreased from 10.3% to 2.7% (P <.001). Ultrasound was more accurate than LMP in dating, and when it was used the number of post term pregnancies decreased. Crown-rump length of 15-60 mm was superior to BPD, but then BPD (at least 21 mm) was more precise. Combining more than one ultrasonic measurement did not improve dating accuracy in their study.[64]

Chowdhury SB, Jehan AH, *et al,* Deptt. of Obstrics & Gynaecology, Bangabandhu Sheikh Mujib Medical University, Dhaka, in "Bangladesh Med Res Counc Bull", 2003 Aug; 29(2):67-77, said that Infants born of small for date (SFD) fetuses have an increased risk of perinatal mortality and morbidity. Different methods have been applied to identify these fetuses including history, clinical examination and ultrasonography.

Ultrasonography has a better predictive value and majority of such fetuses can be identified. Measurements of the fetal biparietal diameter (BPD), abdominal circumference (AC) and femur length (FL) charts are widely used in dating pregnancies and follow-up of pregnant women in assessing fetal growth, identification of small for date (SFD) and growth retarded fetuses. This prospective study was performed to construct fetal chart for BPD, AC and FL at different gestational weeks from the Bangladeshi pregnant women. Seven hundred and ten women had ultrasonic measurements of fetal BPD, AC and FL between 12 to 42 weeks of pregnancy. In cases of BPD and AC, after 38th weeks of gestation showed a slower growth rate towards 42 weeks of pregnancy. This slower growth rate from 38 weeks of pregnancy was not noted in case of femur length. The new fetal measurement charts of BPD, AC and FL are unique for the Bangladeshi population and have not been found similar in the later weeks of pregnancy to those published for other Caucasian populations. These charts will help the clinicians and sonographers in dating pregnancy, identifying SFD and growth retarded fetuses.[14]

Wilson Stephanie R, Carol M. Rumack *et al,* in "Diagnostic Ultrasound", Vol. 2, Second Edition (1997), Chapter 33, Page 1017, proposed that the fetal abdominal circumference (AC) is the length of the outer parameter of the fetal abdomen, measured on the transverse scan at the level of stomach and intra-hepatic portion of the umbilical vein.[69]

Hiltone Meire, David Cosgrove, *et al*, in "Ultrasound in Obstetrics and Gynaecology" 2nd Edition; Vol.3; Chapter 10; Page 229, mentioned that femoral length(FL) is primarily a measurement for the estimation of gestational age with good accuracy from around 15 to 25 weeks. Its use in estimation of fetal growth is limited, although it has been combined with other measurements to estimate fetal size.[30]

In "West Afr J Med", 2004 Jan-Mar; 23(1):24-6, Dare FO, Smith NC, *et al*, of Ultrasound Department, Aberdeen Maternity Hospital, Corn Hill Road, Aberdeen, UK, in their study "Ultrasonic measurement of biparietal diameter and femur in foetal age determination" mentioned that their objective was to verify ultrasonic measurement of biparietal diameter and femur in foetal age determination in the second and third trimester of pregnancy. The prospective cross sectional study was carried out at the ultrasound department of Aberdeen Maternity Hospital Scotland. The study population consisted of 716 pregnant Scottish (Caucasian) women who were certain of their gestational ages and had their gestational ages confirmed in the first trimester by ultrasound. The findings revealed: (1) Linearity through out pregnancy using the femur length measurements while that of the biparietal diameter demonstrated poor correlation after 32 weeks of gestation. The results suggest that femur length measurement is a more reliable index of late third trimester gestational age prediction than biparietal diameter.[16]

❖ **Review of literature on fetal kidney length measurement for assessment of gestational age:**

Lawson TL, Foley WD, *et al,* in the journal "Radiology", 1981 Jan; 138(1):153-6, in a study "Ultrasonic evaluation of fetal kidneys" stated the fetal renal morphology, technique and frequency of reliable visualization of the kidneys, and also renal size was evaluated in 177 apparently normal fetuses. The kidneys were not reliably identified before 15 post-menstrual weeks and were seen in fewer than 50% of cases prior to 17 weeks. However, between 17 and 22 weeks (the critical time for genetic counseling) one or both kidneys were seen in 90% of cases, with both being identified in 75%. After 20 weeks, one or both kidneys were identified in approximately 95%. With high-resolution equipment, positive identification of one or both fetal kidneys should be possible in a large percentage of cases after 20 post-menstrual weeks.[39]

In "J Ultrasound Med", 1983; 2: 505-07, "The changing sonographic appearance of fetal kidneys during pregnancy", Bowie JD, Rosenberg ER *et al.* (1983) showed that with transabdominal sonography fetal kidneys can be demonstrated by 14 to 16 menstrual weeks as hypoechoic structures adjacent to the fetal spine. As the fetus matures, the kidneys become delineated because of fat deposition in the perinephric and renal sinus regions.[7]

In "J Clin Ultrasound",1983; 11:349-356, in the study "Quantitative characterization of the growth of the fetal kidney", Bertagnoli L, Lalatta F, *et at,* of Ultrasound School of Obstetrics

and Gynecology, Ospedale S. Giuseppe, Milan, Italy, mentioned that there is a time-dependent change in the antero-posterior (A-P) diameter and length (L) of fetal kidneys and this has been evaluated by means of statistical analysis of measurements made during the third trimester in a normal population. Two hundred eighty pregnant women were examined between 22 and 40 weeks of gestation. The relationships of the A-P diameter and length to menstrual age were determined in cross-sectional and longitudinal studies of kidney growth. The results obtained confirmed that there was no significant difference between right and left fetal renal length and measurements of fetal kidney can be used as an additional parameter in the routine assessment of fetal well being and to rule out kidney malformations characterized by changes in kidney size.[6]

Sato A, Yamaguchi Y, *et al,* in the journal of "Gynecol Obstet Invest", 1985; 20(1):1-5, published a study "A cross-sectional study of changes in fetal renal size with gestation in appropriate and small-for-gestational-age fetuses", presented a method for measuring the size of the fetal kidney by real-time ultrasound. They examined 241 normal pregnancies and 27 pregnancies with intrauterine growth retardation by this method. The cross-sectional area of the kidney (KA) increases linearly from 20 weeks to term whereas the relative size of the kidney to the abdomen (KA/AA ratio) remains constant during this period. Growth-retarded fetuses had significantly smaller KA values than normal fetuses but their KA/AA ratios were generally in the normal range. The results showed that the growth of the

fetal kidney correlates well with that of the abdomen and could be an additional parameter for the detection of intrauterine growth retardation.[56]

Callan NA, Otis CS, *et al,* in "J Reprod Med", 1985 Jun; 30(6):485-8, in their study "Growth of the fetal kidney. Ultrasonographic measurement of the ratio of average kidney diameter to biparietal diameter", studied Kidney size ultrasonographically in 101 normal fetuses. A ratio of average kidney diameter to biparietal diameter was established and found to be constant across gestation. Three fetuses with known urinary tract pathology were then studied and were found to have ratios significantly different from normal ones.[9]

Duval JM, Milon J, *et al,* in the journal "Anat Clin", 1985; 7(2):107- 23, said in their study "Ultrasonographic anatomy and physiology of the fetal kidney", that the aim of this work was to demonstrate the impact of ultrasonography in utero to gain a better understanding of the anatomy, growth, anatomical variations and function of the fetal kidney and urinary tract. Three main topics are discussed in this paper based on the authors' personal experience and data from the literature: 1) the technique of ultrasonography in utero, including the main difficulties encountered and limitations of this technique; 2) ultrasonographic study of the morphology, growth and anatomical variations of the fetal kidney. The length of the fetal kidney was found to be the most significant parameter for assessment of its growth. At term, the kidney measures slightly more than 4 cm in length. 3) current knowledge of the physiology of the fetal urinary apparatus especially the kidney,

the excretory function of which begins in the third month of gestation and its main role involves the regulation of the amniotic fluid.[21]

Sagi J, Vagman I, *et al,* in "Gynecol Obstet Invest", 1987; 23(1):1-4, assessed in their study "Fetal kidney size related to gestational age", fetal renal anatomy of 660 apparently normal fetuses ultrasonographically. The problems of visualization of kidneys were outlined. A correlation of fetal kidney length and gestational age was presented. The results were presented to be used as an adjunct in establishing fetal gestational age and as well as the assessment of normal renal morphology in routine obstetric ultrasound assessment.[53]

Kushnir O, Bronshtein M, *et al,* in "J Clin Ultrasound", 1990; 18: 299-301, mentioned in their study "Transvaginal sonographic measurement of fetal kidneys in the first trimester of pregnancy" that the fetal kidneys may be identified late in the first trimester as hyperechoic structures, distinguishable from the hypoechoic adrenal glands on transvaginal sonography.[36]

Bronshtein M, Kushnir O, *et al,* of Rambam Hospital, Haifa, Israel, In "J Clin Ultrasound", 1990 May; 18(4):299-301, in the study "Transvaginal sonographic measurement of fetal kidneys in the first trimester of pregnancy" measured fetal renal size late in the first trimester of pregnancy by transvaginal ultrasonography in 50 patients not at risk for congenital kidney disease and whose pregnancies resulted in a normal outcome. Both kidneys were reliably identified in all patients scanned at 12 weeks, 13 weeks, and 14 weeks, menstrual age. Kidney

diameter measurements obtained in this study are presented for reference in evaluating patients in late first trimester whose fetuses are at risk for kidney abnormalities.[8]

Pattern RM, Mack LA, *et al,* in their study "The fetal genitourinary tract" in "Radiol Clin North Am" 1990; 28(1) :115-130, mentioned that fetal kidneys may be imaged in the first trimester, but with transabdominal ultrasound are more easily seen from 14 weeks onward and reliably visualised in 90 % of cases between 17 and 22 weeks.[47]

Sampaio FJ, *et al,* Department of Anatomy, State University of Rio de Janeiro, U.E.R.J., Brazil, in the journal of "Eur Urol", 1990; 17(1):62-5, "Study of the fetal kidney length growth during the second and third trimesters of gestation" studied the fetal kidney length growth in 240 kidneys ranging from 10 to 36 weeks of gestation. Each kidney was quantitatively evaluated considering its greatest longitudinal length. The data were correlated with gestational age. Equation and growth curve of right and left kidneys and the whole sample during the second and third trimesters were presented. The study showed the practical utility in the quantitative determination of the renal anomalies and in the determination of gestational age.[55]

HL Cohen, J Cooper, *et al,* Department of Radiology, North Shore University Hospital Cornell University Medical College, Manhasset, in "AJR Am J Roentgenol" 1991 Sep; 157(3):545-8, in their study "Normal length of fetal kidneys: sonographic study in 397 obstetric patients" made a study on renal length and its correlation with gestational age. This study was done to measure normal

lengths of fetal kidneys sonographically during pregnancy. The greatest length of each kidney in fetuses between 18 and 41 weeks gestation was measured on sonograms. Gestational ages were determined by last menstrual period and biometry; Abnormal fetuses, twins, offspring of diabetic mothers, and fetuses with renal pelvic dilatation of 4 mm or greater were excluded to avoid any questionable measurements. The results show that mean lengths are greater and confidence intervals are wider than previously reported. Strong correlation exists between renal length and gestational age, determined by biparietal diameter, femoral length, and abdominal circumference, and an average of the three. No significant difference was found between right and left renal lengths in fetuses in whom both kidneys were imaged. No correlation is seen between parental height or weight and fetal renal length. Results show that fetal renal lengths are longer than previously reported.[26]

A Bulgarian Article published in "Akusherstvo i ginekologiia." 1991; 30(3):11-6, in the study "Ultrasonic biometry of the fetal kidney", by Pandurski F. *et al*, showed that there was no statistically significant difference in the biometric parameters of the right and left kidney of the fetus in their study. Renal biometry of the fetus was carried out on 1200 women when difference between renal and surrounding tissue became distinct. Three dimensions of the kidney were measured and in their study it was established that the ratio between the circumference of the kidney and the abdominal circumference was a constant, preserving itself during the whole pregnancy.[45]

In "International Society of Ultrasound in Obstetrics and Gynecology", 1996 Aug; 91(2)169-75, in a study "Human fetal kidney morphometry during gestation and the relationship between weight, kidney morphometry and plasma active renin concentration at birth" Bell SC, J. C. Konje, *et al,* Department of Obstetrics and Gynaecology, University of Leicester Medical School, Robert Kilpatrick Clinical Sciences Building, Leicester Royal Infirmary, Leicester, UK, performed a cross-sectional study aimed to determine whether there are differences in kidney size and shape in small- and appropriate-for-gestational-age fetuses at different gestations. They studied cross-sectionally at different gestational ages from 22 to 38 weeks. They found that the circumference and transverse and anterior-posterior diameters were significantly greater in the appropriate-for-gestational-age fetuses from about 28 weeks' gestation.[4]

In the journal "Australasian Radiology", Vol 41, issue:1-February 1997(1-90), in a study "Ultrasonographic study of 793 foetuses: Measurement of normal foetal kidney lengths in Bangladesh", Saha M, Paul AK, *et al,* Nuclear Medicine Centre, Khulna, Bangladesh, did an ultrasonographic study in normal pregnancies between 16 and 40 weeks of gestation. An excellent correlation was seen between gestational age, biparietal diameter, femoral length and renal length measurements. It is well known that, structurally, the people of Asia are shorter than Europeans. The size of different organs of the foetus may also vary accordingly. To assess this, 793 foetuses between 16 and 40 weeks' gestation were studied and kidneys were

measured on ultrasonograms. Only normal pregnancies were included in the study. The results show that the mean length of foetal kidneys in the present study is either slightly higher or similar to that previously reported by many authors. In this study, the average kidney length at full term is 3.95 cm. An excellent correlation was seen between gestational age, biparietal diameter, femoral length and renal length measurement.[54]

Carol M. Rumack, Stephanie R. Wilson, *et al,* in their highly esteemed text book "Diagnostic Ultrasound" Vol. 2, Second Edition(1997), Chapter 37, Page 1094, mentioned the often quoted rule of thumb is that "renal length in millimeters approximates gestational age in weeks". However, a recent study and their own experience showed that renal lengths are longer than previously reported.[13]

Gloor JM, Breckle RJ, *et al,* in an American journal "Mayo Clinic proceedings". 1997 Feb; 72(2):124-9. Division of Nephrology and Internal Medicine, Mayo Clinic Rochester, MN 55905, USA, performed prenatal ultrasonography of 100 pregnant women between 18 and 39 weeks of gestation. Fetal renal length and volume were determined by prenatal ultrasonography and compared with gestational age and obtained a reference range as a function of gestational age for renal length and renal volume which helps to identify fetal abnormalities in renal size or growth patterns.[24]

Guariglia L, *et al,* Department of Obstetrics and Gynecology, Catholic University of the Sacred Heart, Rome, Italy, in "Fetal diagnosis and therapy". 1998 May-Jun; 13(3):154-6, made a study on "Transvaginal sonographic fetal biparietal diameter/kidney length ratio in early pregnancy as a screening tool for renal malformations". In this prospective cross-sectional study, a transvaginal high-resolution sonography was performed between 11 and 16 weeks' gestation in 807 pregnant women with a history of regular cycles, singleton pregnancies and absence of fetal malformations. Measurements of kidney length and biparietal diameter were obtained in all cases and biparietal diameter/kidney length ratio was plotted against gestational age. The values of biparietal diameter/kidney length ratio were found to be fairly constant throughout the period evaluated.[25]

Lotan.D, Zalel Y, *et al,* Department of Obstetric and Gynaecology in the journal "Prenatal Diagnosis", 2002 Nov; 22(11):962-5. The Chaim Sheba Medical Center Tel- Hashomer, Sackler School of Medicine, Tel Aviv University, Israel, in their study "The early development of the fetal kidney an in uteri sonographic evaluation between 13 and 22 weeks' gestation" presented a data which established normogram for kidney length from early stages of gestation, which will help to assess the correct gestational age of fetal development. The study was a prospective evaluation of 275 fetuses between 13 and 22 weeks in normal singletone pregnancies. Measurements of fetal kidney length were performed by high resolution transvaginal sonography between 14 and 17weeks gestation and by

transabdominal sonography beyond 18 weeks of gestation. Kidney length as a function of gestational age was expressed by equation. The normal mean and the 90% prediction limits were defined and the data offered a normal range of fetal kidney length from early stage of gestation that may allow intrauterine assessment of its development.[40]

Konje J C, Abrams KR. *et al,* of Robert Kilpatrick Clinical Sciences Building, Leicester, UK, in "Ultrasound in obstetrics & gynecology" volume 19, Page 592-7, June 2002, in their study "Determination of gestational age after the 24th week of gestation from fetal kidney length measurements", reported the measurement of fetal kidney length by ultrasonography between 24 & 38 weeks' gestation to be very useful and recommended its incorporation into the model for dating pregnancies after 24 weeks of gestation, in particular when measurement of the bi-parietal diameter and head circumference are difficult. Kidney length is a more accurate method of determining gestational age than the fetal biometric indices of biparietal diameter, head circumference, femur length and abdominal circumference between 24 and 38 weeks' gestation. When combined with biparietal diameter, head circumference and femur length, the precision of dating is improved by 2 days. This measurement is easy to make and could therefore be easily incorporated into the model for dating pregnancies after 24 weeks of gestation, in particular when measurements of the biparietal diameter and head circumference are difficult.[35]

Slobodan Vlajkoviç, *et al*, Department of Anatomy, Faculty of Medicine, University of Niš, Niš, Serbia and Montenegro in the journal "Cells Tissues Organs" 2006;182:193-200 2006; Vol. 182, No. 3-4, 2006, in their study "Age-Related Changes of the Human Fetal Kidney Size" evaluated normal fetal anatomy ultrasonographically. This study was also created to estimate the changes in kidney size during gestation in fetuses and concluded that the period from the 14th to 16th week of intrauterine life is the fastest period of kidney growth during fetal development. Measurements of kidney dimensions (length, width, thickness) were performed in 110 fetuses. The importance of this study lies in determining the average fetal kidney dimensions, which could be used as standard values in obstetrics.[59]