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Length Measurement of Fetal Long Bone and Fetal Anomaly Detection

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Abstract

Fetal long bone estimation is a pivotal estimation for abnormal fetus development and fetus weight. Moreover, estimation of limb length becomes an important indicator for osteochondrodysplasia and chromosomal abnormalities. Especially, femur length is the most commonly estimated limb length that must be measured to monitor fetal malformation. In fetal length measurement, femur length measurement is the only long bone that is commonly estimated in fetus. Femur length not only helps estimating accurate gestational age, but also becomes an invaluable hint of abnormality in fetal skeletal system. Despite difficulty of accurate diagnosis, detection rate of fatal skeletal abnormality with ultrasonography is as high as 94-96%. Although prenatal ultrasonography plays the most important role in detecting skeletal abnormality, the authors believe that genetics test at molecular level should be employed at needs to confirm chromosomal mutation and help improving accuracy of prenatal diagnosis.

Introduction

Fetal skeleton grows and develops the fastest during the first trimester of pregnancy. By 10weeks of pregnancy, the fetus displays similar features as an adult and its features are readily observed from the early stages of pregnancy. It has been known that vertebrae develop by 6th weeks, cranial bone by 7th weeks, clavicle and lower jaw by 8th weeks of pregnancy. Long bone such as femur, tibia, fibula, humerus, radius and ulna are developed during 7th weeks to 12th weeks, whereas bones in hands and feet are developed during 11th and 13th week.[1,2] There is cartilage in ossification that constitutes flat bones like clavicle and lower jaw. Ossification center which is the key in ossification can be classified into two types: primary ossification center that exists in diaphysis of long bone and secondary ossification center that appears in epiphysis. The primary ossification center develops during 7th and 12th weeks of pregnancy while secondary ossification center is developed during the third trimester and short after the delivery.[3] In general, if epiphyseal ossification center is observed in femur, we can estimate 35 weeks of pregnancy at the least. Also, when ossification point appears at proximal tibia, it implies at least 35 weeks of pregnancy. Fetal long bone estimation is a pivotal estimation for abnormal fetus development and fetus weight. Moreover, estimation of limb length becomes an important indicator for osteochondrodysplasia and chromosomal abnormalities. Especially, femur length is the most commonly estimated limb length that must be measured to monitor fetal malformation.[4] As ossification of fetal physique can be monitored early and at consistent basis, detailed ultrasonography on fetus in suspicion of abnormal skeletal system must be conducted with consideration of chromosomal examination.

Fetal abnormality in skeletal system can be divided into two forms. The first is a generalized aplastic musculoskeletal system that affects the whole fetal musculoskeletal system. The second form of malformation is abnormality that occurs to a specific part of musculoskeletal system that displays eccentric size or count. Prognoses for such kind of malformation are diverse. In general, prognosis for delayed diagnosis and mild abnormality in ultrasonography results are not as ugly as those that accompany other abnormalities in different organ or chromosome.[5] Thus, this research attempts to provide a direction for quick detection of fetal abnormality before delivery by examining measures for accurate estimation of fetal long bone.

Review

Length measurement of fetal long bone

Ultrasonography on diaphysis of long bone in fetus can be conducted after 12 weeks of pregnancy, and ossification of epiphysis can be found near the end of pregnancy. Ultrasonography on musculoskeletal system begins with accurate measurement of femur length. Long bone estimation like that of femur is evaluated on diaphysis except distal epiphysis. Length of femur must be estimated within 14 weeks of gestational age as it is the most important factor that reflects fetal growth in length. Femur length is estimated from major trochanter to the end of femur's primary ossification center of epiphysis (Fig.1).[6]

When femur length implies abnormalities, estimation on other long bone parts of arm and leg must be conducted as well.[7] Classifying tibia from fibula based on ultrasonography results is difficult as two have similar lengths and similar epiphysial and proximal points. The tibia is the thicker component located in the inner region (Fig.2).[8] In classification of radius and ulna, even though radius and ulna end at the same point when observed from vertical plane, ulna stretches more toward the elbow (Fig.3). Precautionary for accurate estimation of limb lengths is that the length of bone must be estimated along the longitudinal axis. If measured at slanted axis, the measured length may be shorter than the real one. Also, when overlapped with other ossification centers, the length may appear longer.

Fetal anomaly detection

During the second and third trimester of antenatal care, lengths of fetal body parts are measured through ultrasonography to estimate gestational age with accuracy and to examine fetal growth status. In fetal length measurement, femur length measurement is the only long bone that is commonly estimated in fetus. Femur length not only helps estimating accurate gestational age, but also becomes an invaluable hint of abnormality in fetal skeletal system. Prenatal diagnosis of fetal musculoskeletal system begins with accurate length measurement of femur and humerus. If the estimated gestational age based on the femur and humerus lengths is shorter for more than 2 weeks than other biometry (biparietal diameter [BPD], head circumference [HC] and abdominal circumference [AC]) or shorter for less than 2 standard deviation than normal gestational length, chromosomal anomaly or bone dysplasia must be suspected. However, fetal biometry is known to differ according to its ethnicity. For instance, although BPD and AC of Asian fetuses are similar to those of Western, it is reported that their femur length is shorter.[9-11] Especially, as femur length greatly varies according to one's ethnicity and habitude, length measurement may vary as well with the study subject. In this light, in order to understand a shortening of long bone within Korean population, research on Korean samples is necessary to suit characteristic of Asian habitudes. Unfortunately, however, standard length of Korean fetus has not been established yet.[12,13] In case of shorter femur length relative to its gestational age, it is important to notice how much it got shortened in terms of standard deviation (SD) from the gestational average. If an estimation of femur length from the known gestational age is within the 2SD from the average, it is considered to be in the normal range. On the other hand, if it deviates from 2SD range, then the possibility of chromosomal anomaly or bone dysplasia may be questioned. However, as intrauterine growth restriction (IUGR) and familial tendency are the common explanations for the short long bone, such factors must be excluded from consideration. Also, as limb lengths of a male fetus get shorter relative to his head size, compared to those of female fetus, fetal sex must be taken into consideration during short long bone diagnosis.[14] In IUGR case, as shortening of limb lengths appears from the late second trimester yet not during the early second trimester, a follow-up test is required. In general, when femur length is less than 4SD range, skeletal system abnormality is often diagnosed. As for diagnosis of abnormal skeletal system, a differential diagnosis based on measured limb lengths is necessary. When skeletal system displays an abnormality, observation must be made on severity and spread of limb shortening, fracture or bowing, size of thoracic cavity, extent of ossification, skull shape, spine shape, curvature, polydactyly or syndactyly, and contracture in limb. As accurate differential diagnosis on musculoskeletal system cannot be done with antenatal ultrasonography, classification according to prognosis is more meaningful.[15,16] A particular bone dysplasia shows greater deviation from average along with gestational age. Thus, in absence of accurate diagnosis in the first examination, conducting follow-up tests at regular time basis is crucial.[17] For relatively common skeletal system diseases, there are thanatophoric dysplasia, acondrogenesis, osteogenesis imperfect, homozygous achondroplasia. Among them, thanatophoric dysplasia is the most common type of skeletal dysplasia with occurrence frequency of 1 neonate out of 10,000, and during which most of these neonates decease due to postpartum pulmonary hypoplasia. Thanatophoric dysplasia which displays shorter femur and humeral lengths than gestational age can be classified to type I and type II. Type I is more frequently observed and shows narrow thoracic cavity, projecting forehead and eye, telephone receiver and cloverleaf skull.[18,19] Achondroplasia occurs at frequency of 1 per 40,000 neonates and is the second most commonly observed fatal skeletal disease. It is the most frequent factor for acromicria with short limbs that display protruding forehead, low nose bridge, big sized head with a wide low jaw and trident hand in prenatal ultrasonography.[20,21] For osteogenesis imperfect, it appears at the rate of 1 per 25,000 people. It is a type of collagenous disease with bone weakness as the major pathologic feature and recently has been classified into 7 different types. Among the 7 types, the II form is the fatal form.[22,23] Features shown at

ultrasonography are severe macrodactyly, multiple fracture, low mineral deposition and often pulmonary hypoplasia is fatal cause.[24,25] As for achondroplasia, it only appears when both of parents have dyschondroplasia. The femur length does not shorten until third trimester of pregnancy and gets shortened during the late stage of pregnancy.[26] Although it shows features of atypical dyschondroplasia, it is more severe version with big sized head with protruding forehead and small and narrow thoracic cavity. Such kind of musculoskeletal system disease is rarely detected during prenatal diagnosis, so differentiating them with fatality only can be meaningful. Even if musculoskeletal system abnormality is diagnosed, not all prenatal diagnoses are complete. Some may require additional tests after delivery, and if unfortunate, a part may have fatal prognosis which highlights the importance of obstetric care.

Conclusions

Despite difficulty of accurate diagnosis, detection rate of fatal skeletal abnormality with ultrasonography is as high as 94-96%. With the advancement in technology of three-dimensional ultrasonography, abnormality in face, relative proportion of limbs, hands and feet are observed with more accuracy.[27] However, although prenatal ultrasonography plays the most important role in detecting skeletal abnormality, the authors believe that genetics test at molecular level should be employed at needs to confirm chromosomal mutation and help improving accuracy of prenatal diagnosis.

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Illustrations

Illustration 1

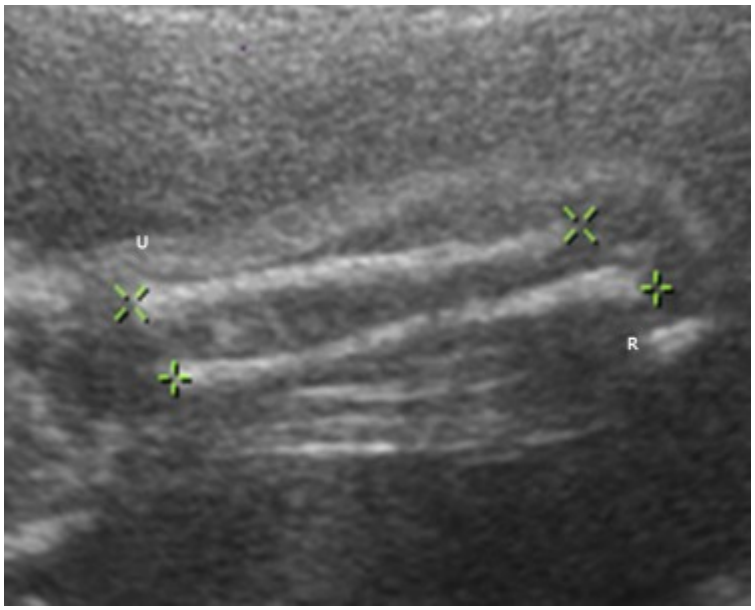
Figure 1. Femur length measurement, Femur length is estimated from major trochanter to the end of femur's primary ossification center of epiphysis.

Illustration 2

Figure 2. Tibia and fibula measurement. The tibia is the thicker component located in the inner region

Illustration 3

Figure 3. Ulna and radius measurement. Radius and ulna end at the same point when observed from vertical plane. Ulna stretches more toward the elbow



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