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ORIGINAL PAPER

FETAL ULTRASOUND ANATOMY AND MORPHOMETRIC PARAMETERS OF THE HUMERUS IN FETUSES AT 19-22 WEEKS OF GESTATION

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Abstract

Introduction. Fetal biometrics is a method based on the measurement of certain anatomical parts of the fetus at different stages of pregnancy. Fetal growth is influenced by a complex interaction of genetic, hereditary and environmental factors. A correct assessment of fetal development requires knowledge of fetal anatomy. Measurement of the length of the long bones correlates directly with gestational age and is therefore of paramount importance.
The objective of the study was to determine the morphometric parameters of humerus length during 19-22 weeks of human ontogeny.
Materials and methods. To determine the fetal anatomy of the humerus structures, we used an imaging method such as ultrasound scanning. Fetal humerus length measurements were performed using intravital ultrasound (IVUS) during 19-22 weeks of gestation. We analyzed 44 fetal ultrasounds in women with normal pregnancies.
Results. From 19 to 22 weeks of fetal development, the length of the right humerus increased from

Résumé

Anatomie échographique fœtale et paramètres morphométriques de l'humérus chez les fœtus à 19-22 semaines de gestation

Introduction. La biométrie fœtale est une méthode basée sur la mesure de certaines parties anatomiques du fœtus à différents stades de la grossesse. La croissance du fœtus est influencée par une interaction complexe de facteurs génétiques, héréditaires et environnementaux. Une évaluation précise du développement fœtal nécessite une connaissance de l'anatomie fœtale. La mesure de la longueur des os tubulaires longs est directement corrélée à l'âge gestationnel, ce qui la rend extrêmement importante.
L'objectif de l'étude a été d'établir les paramètres morphométriques de la longueur de l'os humérus au cours des semaines 19 à 22 de l'ontogenèse humaine.
Matériels et méthodes. Pour élucider l'anatomie fœtale de la structure de l'os humérus, la méthode de visualisation utilisée était l'échographie. Les mesures fœtométriques de la longueur de l'os humérus du fœtus

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2.92±0.05 mm to 3.46±0.12 mm, while the length of the left humerus increased from 2.95±0.06 mm to 3.48±0.09 mm. Our data on fetal morphometry of humerus lengths indicate a relatively uniform growth of the right and left humeri in human fetuses during 19-22 weeks of gestation. The period of slow increase in length of humerus is 21 and 22 weeks of fetal development.

Conclusions. Ultrasound fetometry of the humerus is one of the basic studies of fetal development. During 19-22 weeks of intrauterine development the right and left humeri grow equally, without significant differences in their length. It has been established that the period of intensive growth of the length of the right and left humeri is from 20 to 21 weeks of gestation.

Keywords: fetal morphometry, ultrasound diagnostics, fetus, humerus.

ont été effectuées par échographie obstétricale pendant les semaines 19 à 22 de la grossesse. Quarante-quatre échographies ont été analysées chez des femmes enceintes avec une grossesse normale.

Résultats. De la 19e à la 22e semaine de développement intra-utérin, la longueur de l'os humérus droit augmente de 2,92±0,05 mm à 3,46±0,12 mm, tandis que la longueur de l'os humérus gauche augmente de 2,95±0,06 mm à 3,48±0,09 mm. Nos données sur la morphométrie fœtale des longueurs des os humérus indiquent une croissance relativement uniforme de la longueur des os humérus droit et gauche chez les fœtus humains de 19 à 22 semaines de gestation. Les périodes de croissance ralentie de la longueur des os humérus se situent entre la 21e et la 22e semaine de développement intra-utérin humain.

Conclusions. La fœtométrie des os humérus par échographie est une étude fondamentale du développement fœtal. De la 19e à la 22e semaine de développement intra-utérin, les os humérus droit et gauche croissent de manière égale, aucune différence significative de longueur n'a été observée. Il a été établi que la période de croissance intensive de la longueur des os humérus droit et gauche se situe entre la 20e et la 21e semaine de gestation.

Mots-clés: morphométrie fœtale, diagnostic par ultrasons, fœtus, os humérus.

Introduction

The abnormal fetal development is the leading cause of perinatal mortality in both developed and developing countries[1]. The rates of early detection of fetal anomalies remain low and vary widely between geographic regions[2].

The main method used to assess fetal health is 2D ultrasound (US) due to its low cost, wide availability, real-time capability and absence of harmful radiation. Currently, most countries offer at least one routine ultrasound scan between 18 and 22 weeks of pregnancy[2]. Ultrasound screening is the global standard for the diagnosis of fetal anomalies during pregnancy[3]. In modern clinical practice, monitoring of specific fetal anatomical structures is a screening method to assess growth and development and requires clinical experience in both obtaining and interpreting ultrasound images[4,5].

Fetal biometry is the measurement of fetal anatomical structures using ultrasound, assessment of their development and linear fetal growth[6]. Since the introduction of ultrasound in obstetrics, fetal biometry has become an important part of prenatal diagnosis. Accurate biometric measurements that can be obtained with ultrasound are important for quality obstetric care. In addition to confirming normal fetal development, ultrasound-derived measurements can be compared to standard reference charts to detect early fetal growth abnormalities. Common measurements include fetal coccygeal length (FCL), biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), femur length (FL), and humerus length (HL). These values help diagnose fetal pathology and assess severity, including congenital malformations such as macrocephaly, microcephaly, and limb anomalies, as well as intrauterine growth retardation or macrosomia[7,8].

The measurement of the length of the long tubular bones of the fetus, including the humerus, is used in fetal anatomy and to estimate the gestational age of the fetus. In addition, the assessment of the length of the long tubular bones of the skeleton is important for early detection of bone anomalies and chondroplasia[9]. Out of all pregnancies, 2% of fetuses have structural anomalies, while approximately 10-20% of fetuses have growth disorders[9-11]. Therefore, the importance of performing fetal biometry using ultrasound, which is a highly accurate method, should not be underestimated, as inaccurate biometric

Table 1. Length of humeri measured by ultrasound in fetuses at 19-22 weeks of gestation (mm).

	19 weeks		*20 weeks*		*21 weeks*		*22 weeks*	
	right	*left*	*right*	*left*	*right*	*left*	*right*	*left*
Number of fetuses	12		17		10		5	
Min	2,85	2,88	2,93	2,16	3,2	3,23	3,27	3,37
Max	3,00	3,06	3,24	3,24	3,55	3,58	3,58	3,57
M	2,92	2,95	3,13	3,18	3,34	3,77	3,46	3,48
m	0,05	0,06	0,08	0,04	0,11	0,11	0,12	0,08

measurements can lead to incorrect management decisions that can have serious consequences[11,12].

The objective of the study was to determine the morphometric parameters of humerus length during 19-22 weeks of human ontogeny.

Materials and methods

To determine the fetal anatomy of humeral structures, ultrasound scanning was used. The study was performed in accordance with the cooperation agreement with the Yuzko Medical Center (Ukraine) using an ultrasound scanner (Voluson E8, manufactured by General Electric, 2013).

The fetal humerus length was measured by ultrasound at 19-22 weeks of gestation. We analyzed 44 fetal ultrasounds in women with normal pregnancies. To measure fetal humerus size, the transducer was positioned so that the distal and proximal ends of the bone were clearly visible and the angle to the surface of the transducer was less than 45°. The humeral plane should occupy more than half of the total image area. Calipers were correctly placed at the proximal and distal ends of the humerus. Two biometric images of the humerus were collected at each examination.

Multiple pregnancies, pregnancies over 18-22 weeks, or pregnancies complicated by structural anomalies were excluded from the study.

The built-in functions of MS Excel were used for statistical calculations. The arithmetic mean and its error were calculated. Comparisons between study groups were made using the non-parametric Mann-Whitney test in Excel.

The study was conducted in accordance with the basic bioethical provisions of the Convention of the Council of Europe on Human Rights and Biomedicine (April 4, 1997), the Declaration of Helsinki of the World Medical Association on the Ethical Principles for Scientific Medical Research Involving Human Subjects (1964 – 2013), Order of the Ministry of Health of Ukraine No. 690 from 23.09.2009 and taking into account the Methodological Recommendations of the Ministry of Health of Ukraine "Procedure for removal of biological objects from deceased persons whose bodies are subject to forensic and pathological examination for scientific purposes" (2018). The Commission on biomedical ethics of the Bukovinian State Medical University (Protocol No. 3, dated 16.11.2023) did not find any violations of moral and legal norms in the conduct of research.

Results and discussion

The morphometric parameters of the length of the right and left humeri in 19-22 weeks of gestation were determined (Table 1).

From the 19th to the 22nd week of intrauterine development, the length of the right humerus increases from 2.92±0.05 mm to 3.46±0.12 mm, while the length of the left humerus increases from 2.95±0.06 mm to 3.48±0.09 mm (Table 1).

Our data on fetal morphometry of humerus lengths indicate a relatively uniform growth of the right and left humeri in human fetuses during 19-22 weeks (Fig. 1-4). Thus, both humeri grow equally during this period and no significant differences in their lengths were found. The study revealed a period of intensive growth in the length of the right and left humeri, namely from 20 to 21 weeks of gestation (Table 1). Periods of slow growth of humerus length are from 21 to 22 weeks of gestation (Table 1).

Data on the length of the long tubular bones are extremely important for determining fetal anatomy and for assessing the gestational age (GA) of the fetus in normal and pathological conditions. Shortening of long fetal bones, such as the humerus and femur, is an ultrasound indicator for screening for Down syndrome in the second trimester[13,14].

Ethnic differences in fetal biometric measurements have been reported[13,14,19]. Beigi and Zarrin Koub reported that the fetuses studied had a shorter femur length compared to European studies[14].

Fig. 1. Fetal humerus ultrasound at 19 weeks gestation.

Fig. 2. Fetal humerus ultrasound at 20 weeks gestation.

Fig. 3. Fetal humerus ultrasound at 21 weeks gestation.

Fig. 4. Fetal humerus ultrasound at 22 weeks gestation.

Accurate fetal biometry is of paramount importance to the obstetrician, who will make clinical decisions about pregnancy management based on the measurements made by the ultrasound providers. When fetal biometry is not performed accurately, it can lead to over- or underestimation of fetal development, which in turn can lead to subsequent inappropriate pregnancy management[15,16].

The femur and humerus are long, tubular bones; they can be very easily visualized and measured by ultrasound to calculate fetal weight in the second and third trimesters[17]. For the prediction of GA, it

is necessary to use the lengths of two or more bones for accuracy. In cases where measurement of biparietal diameter (BPD) is difficult, the length of the femur and humerus can reliably estimate fetal age. Very few studies have been conducted in the literature so far using humerus length (HL) to estimate GA. Therefore, it is important that fetal biometry is performed for local populations and it is important to build localized charts of normal biometry relative to the place of residence[18].

Kovac et al concluded that Asians have a shorter than expected femur length[13]. Undoubtedly, ethnic differences in fetal long bone length will affect Down syndrome screening. In some studies, positive ultrasound findings for Down syndrome screening were more common in non-white individuals due to reduced long bone length[13].

Patre et al. found that humerus length, along with femur length, accurately detected GA among all other measurements[20]. Tahmasebpour et al. examined the linear relationship between GA and the length of the femoral diaphysis and humeral diaphysis. Several biometric parameters were measured in each fetus, including biparietal diameter, femoral length, and length of the ossified part of the humerus, at different gestational ages from 13 to 28 weeks. The correlation coefficient of femoral length (r = 0.84) and biparietal size (r = 0.93) showed a high degree of linear relationship with humerus length (HL)[21,22].

Most of the parameters of standard growth curves were developed by researchers in Europe. Very few studies have been conducted on fetuses in Ukraine. According to previous studies, it is obvious that normal ranges for long tubular bones of the respective GA should be specified for different racial and ethnic groups, and each population should have its own normal growth charts[23]. In our study, we provide the normal growth range for humerus length in fetuses of 19-22 weeks of gestation of the Ukrainian population.

Conclusions

Fetometry of the humeri by ultrasound is one of the main studies of fetal development. Both humeri grow equally in the period of 19-22 weeks, no significant differences in their length were found. It has been established that the period of intensive growth of the length of the right and left humerus is from 20 to 21 weeks of fetal development.

Author Contributions:

T.V.K. is responsible for the conception, reviewing and editing the manuscript. O.A.K. is responsible for the data acquisition, anatomical investigations and data analysis, design and writing the manuscript. I.I.Z., O.V.G., and M.I.K. aided to the design, reviewing and editing the manuscript. All authors contributed equally to the present work. All authors contributed to the critical revision of the article for valuable intellectual content. All the authors have read and agreed with the final version of the article.

Compliance with Ethics Requirements:

"The authors declare no conflict of interest regarding this article"

"The authors declare that all the procedures and experiments of this study respect the ethical standards in the Helsinki Declaration of 1964, as revised in 2013, as well as the national law"

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