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Chart for Sudanese Fetal Age Assessment using Sonographic Fetal Limb Bones Measurements

Authors
Dalia B. A., Mona Ahmed, Ahmed Abukonna*
Sudan University of Science and Technology, College of Medical Radiologic Science, Khartoum, Sudan
Corresponding Author
Ahmed Abukonna
Email: *konaa17@hotmail.com*

Abstract
A study conducted on140pregnant women referred routinely for routine scan of 14 – 40 weeks' gestation at ultrasound department of Oma-algora specialize hospital (Aljazeera-Sudan) during the period from June 2016 to February 2017. Sonographic examination was obtained for all participants (140 pregnant ladies) in supine position using ultrasound machine (LOGIQ 100 PRO) with 3.5 MHz convex transducer. Women were selected on the basis of certain last menstrual period, history of regular cycle and at least one ultrasound scan before 16 weeks to confirm gestational age. All long bones (radius, ulna, humerus, tibia, fibula and femur) were measured in a plane such that the bone was as close as possible to a right angle to the ultrasound beam. The values were expressed as means ± 2 standard deviations for each week of gestation. The growth of the fetal limb bones was linear from 14 through 38 weeks' gestation, but the various bones appeared to grow at different rates. The result of the study revealed that growth pattern of long bone length, early fetal development is characterized by accelerated growth of the upper and lower limbs from 14 to 30 weeks followed by a decrease in weekly increment rate. Furthermore the growth of the upper limbs accelerated compared with the lower limbs. All of the limb bone lengths correlate with gestational age and may serve as indicators of skeletal dysplasia.
Keywords: *Radius, Ulna,Fibula, Tibia, Gestational age.*

Introduction

Fetal growth is a result of complex interactions between several maternal, fetal and placental mechanisms. A final classification of neonatal growth outcome depends on how this development is defined. Most obstetricians rely on uterine fundal height, fetal abdominal circumference (AC) measurement and/or a sonographic estimate of fetal weight for the detection of intrauterine growth restriction (IUGR).Fractional limbvolume can be used for fetal growth assessment and weight estimation using three-dimensional ultrasonography (3DUS) (Lee et al., 2009).

Fetal size charts are used to compare the size of a fetus (of known gestational age) with reference data and to compare it on two or more different circumstances. This can be performed using look-up tables or charts, but, as it is easier to identify any deviation from normal by plotting measurements on charts, the use of charts is recommended and the clinical evidence supports

their efficacy (Tinelli et al., 2014).Fetal growth charts are compared to statistical data (i.e., reference charts with fetal growth curves, showing average values of biometric parameters as a function of the gestational age) so that clinicians may detect fetal growth associated to fetal intrauterine anomalies (Chitty and Altman, 2002).

Measurement of fetal limbs can be used to date pregnancies as well as forming an important part of the assessment of fetal anatomy. The femur length is the most commonly used limb measurement and is usually included as a routine part of any fetal anomaly scan. However, when signs indicating the possibility of a skeletal dysplasia (short femur, small chest, hypo mineralization, etc.) are found, more extensive evaluation of all long bones is needed to aid diagnosis (Chitty and Altman, 2002). Recently, there has been a growing interest in adjusting fetal size charts for genetic influence: this has resulted in a renewed body of publications regarding race-adjusted and/or customized fetal size charts (Paladini et al., 2005).

The aim of this study was to establish the growth patterns of fetal limbs in Sudanese population, data on the normal growth of femur, humerus, tibia, fibula, radius and ulna were measured and related to gestational age.

Material and method

A total of 140 Sudanese singleton pregnant women were investigated in cross-sectional study, their age from 18 to 36 years old. They were referred routinely for routine scan of 14 – 40 weeks' gestation at ultrasound department of Oma-algora specialize hospital (Aljazeera-Sudan) during the period from June 2016 to February 2017.Verbal consent was firstly obtained from all potential participants. Maternal disease or medication which was likely to affect the growth of the fetus(diabetes mellitus, renal disease, hypertension requiring treatment, etc), multiple pregnancies, the presence of a fetal malformation were excluded.

Sonographic examination was obtained for all participants (140 pregnant ladies) in supine position using ultrasound machine (LOGIQ 100 PRO) with 3.5 MHz convex transducer. Women were selected on the basis of certain last menstrual period, history of regular cycle and at least one ultrasound scan before 16 weeks to confirm gestational age. All long bones (radius, ulna, humerus, tibia, fibula and femur) were measured ina plane such that the bone was as close as possible to a right angle to the ultrasound beam.

To locate ulna and radius firstly identify the humerus. By tracing the humerus to the elbow, the ulna and radius are imaged in transverse sections, two bones which are seen as echogenic dots. Then, with a probe rotation of 90 degrees, a sagittal plane is obtained and the long axis of each bone is identified. The radius and ulna can be well differentiated and measured when the arm is in a supine position because the two bones are lying exactly parallel, three or more measurements are taken in each examination to obtain the accurate mean measurement. To locate fetal tibia and fibula firstly identify the femur. After that moving the transducer inferior to the femur until two echogenic dots comes into view (transverse section), then rotate the probe until the long axis of two parallel bones can be identified.

Standard numerical techniques included computing descriptive statistics such as mean ± SD, minimum, median and maximum to assess the symmetry of data distribution and the validity of the assumption of normality. A scatter plot matrix of all continuous variables, including the pair wise correlations, was computed to assess the presence of significant interrelations among the different parameters. *P*-values less than 0.05 were considered statistically significant. Statistical analysis was performed using SPSS System version 20 for Windows (IBM, USA).

Results

Table (1) shows mean, standard deviation, minimum, and maximum length of Radius in different gestational age

		N	Mean	Std. Deviation	Minimum	Maximum
Radius	14 Weeks	20	1.0360	.03817	1.00	1.11
	18 Weeks	20	2.0610	.08540	1.85	2.20
	22 Weeks	20	3.1380	.04561	3.10	3.25
	26 Weeks	20	4.0220	.16551	3.55	4.12
	30 Weeks	20	4.4920	.12923	4.30	4.65
	34 Weeks	20	4.8130	.13581	4.67	5.18
	38 Weeks	20	5.4910	.19210	5.22	5.93
	Total	140	3.5790	1.48308	1.00	5.93

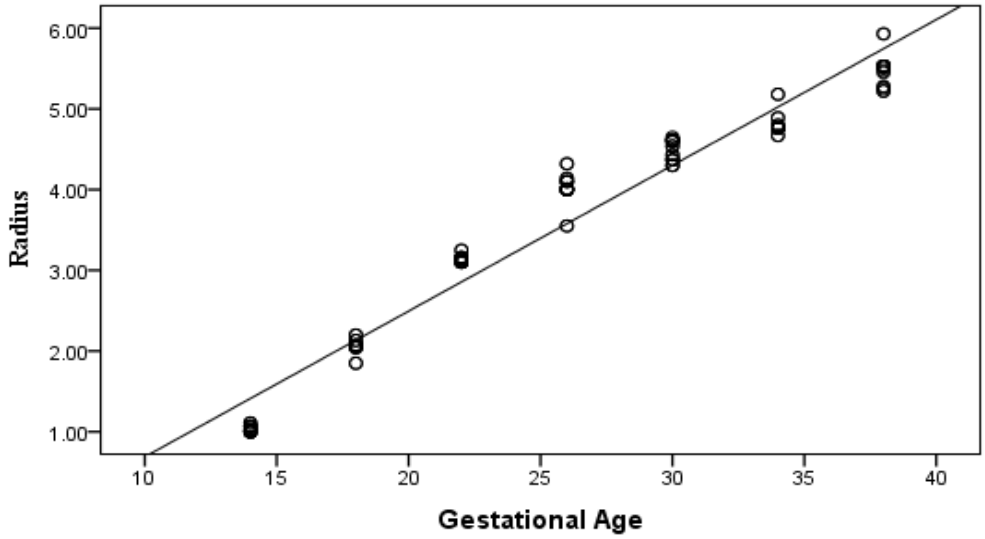

Figure (1): scatter plot diagram shows the significant positive correlation between gestational age and radius measurement.

Table (2) shows mean, standard deviation, minimum and maximum length of ulna

		N	Mean	Std. Deviation	Minimum	Maximum
Ulna	14 Weeks	20	1.2260	.04358	1.15	1.31
	18 Weeks	20	2.2600	.08547	2.05	2.40
	22 Weeks	20	3.3580	.05483	3.30	3.45
	26 Weeks	20	4.3340	.44346	3.75	5.54
	30 Weeks	20	4.9905	.18326	4.71	5.28
	34 Weeks	20	5.5680	.05483	5.50	5.66
	38 Weeks	20	6.3190	.33395	5.15	6.53
	Total	140	4.0079	1.71337	1.15	6.53

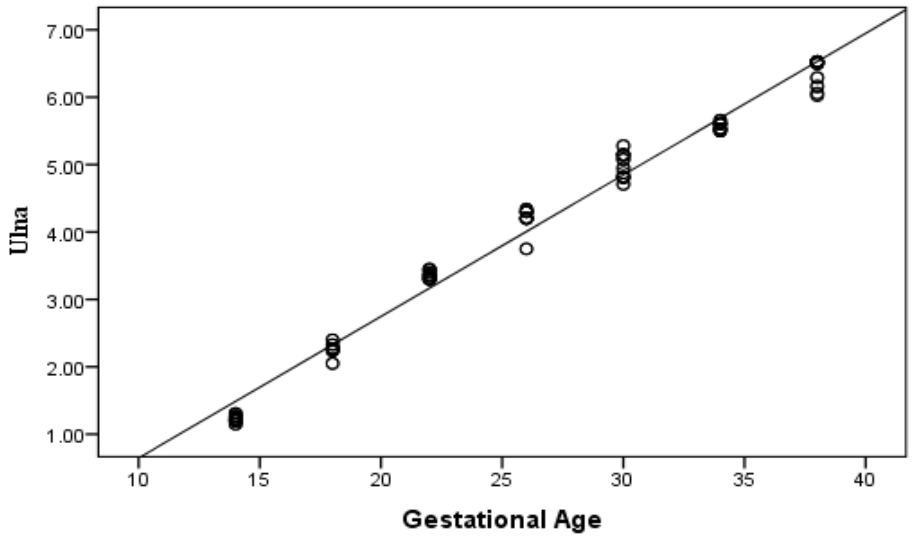

Figure (2): scatter plot diagram shows the significant positive correlation between gestational age and measured ulna.

Table (3) shows mean, standard deviation, minimum, and maximum length of Fibula

		N	Mean	Std. Deviation	Minimum	Maximum
Fibula	14 Weeks	20	1.1210	.07100	1.04	1.30
	18 Weeks	20	2.1310	.08577	1.97	2.30
	22 Weeks	20	3.2700	.08932	3.20	3.44
	26 Weeks	20	4.2120	.12138	4.02	4.52
	30 Weeks	20	4.8900	.16815	4.59	5.11
	34 Weeks	20	5.5160	.07950	5.35	5.64
	38 Weeks	20	6.0715	.59034	5.81	6.48
	Total	140	3.8874	1.69848	1.04	6.48

Figure (3): scatter plot diagram shows the significant positive correlation between gestational age and measured Fibula.

Table (4) shows mean, standard deviation, minimum and maximum length of tibia

		N	Mean	Std. Deviation	Minimum	Maximum
Tibia	14 Weeks	20	1.2950	.05790	1.15	1.38
	18 Weeks	20	2.3310	.08577	2.17	2.50
	22 Weeks	20	3.4600	.07455	3.40	3.64
	26 Weeks	20	4.4090	.12416	4.22	4.72
	30 Weeks	20	5.0955	.16732	4.79	5.31
	34 Weeks	20	5.7170	.08027	5.55	5.84
	38 Weeks	20	6.4755	.23189	6.04	6.68
	Total	140	4.0980	1.73447	1.15	6.68

Figure (4): scatter plot diagram shows the significant positive correlation between gestational and measured Tibia.

Discussion

This is a descriptive study aimed to measure fetal radius, ulna, fibula, and tibia by ultrasound at 14 - 38 weeks of gestation and related them to gestational age. This study conducted in 140 normal singleton pregnant Sudanese women (each twenty pregnant women at 14, 18, 22, 26, 30, 34, and 38 weeks of gestational age); this interval based on the fact that the increment in limb bone growth to be detected, it should be taken at least after 2 weeks from previous measurement (Exacoustos et al., 1991).

Most studies reporting on the length of fetal limb bones in the first trimester of pregnancy were performed by trans vaginal ultrasound, often including a relatively low number of fetuses enrolled from a selected population, we were able to obtain measurements of the fetal radius, ulna, femur and tibia by trans abdominal ultrasound between 14 and 38 weeks of gestation. In order to reduce the error due to inter observer variability, all our measurements were performed by a single observer. The indices describing intra observer variability indicated a good repeatability of the measurements. Despite this, a rather large variability of the data was observed, This variability is not to be attributed to a lower accuracy of the trans abdominal technique, as similar results were observed in studies using trans vaginal Sonography (Zorzoli et al., 1994, Mills, 1992, Gabrielli et al., 1999).

The result of the study revealed that growth pattern of long bone length, early fetal development is characterized by accelerated growth of the upper and lower limbs from 14 to 30 weeks followed by a decrease in weekly increment rate. Furthermore the growth of the upper limbs accelerated compared with the lower

limbs; this result was in line with previous studies (Chitty and Altman, 2002). It is difficult to explain the differences observed in growth rates among long bone measurements. Since all bones are subjected to similar intra-uterine environmental factors, differences in the rate of bone growth are probably genetically determined in order to provide each bone with the specific shape appropriate for its postnatal function (Rodríguez et al., 1992).

A significant positive correlation between gestational age (GA) and lengths of long bone was observed($r \geq 0.99$);this result was agreed with the previous studies (Exacoustos et al., 1991); therefore they can be used as additional parameter in monitoring fetal growth and for diagnosing of bone dysplasia.

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