Original Article

Fetal Biometry

Fetal Biometry in Correlation with Ultrasonographic Appearance and Measurement of Epiphyseal Ossification Centres of Fetal Peripheral Long Bones for Assessment of Gestation age in the Third Trimester

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ABSTRACT

Objective: To determine the correlation between fetal biometry and ultrasonographic appearance and measurement of epiphyseal ossification centres of fetal peripheral long bones for assessment of gestation age in the third trimester.
Study Design: Descriptive, Observational study.
Place and Duration of Study: This study was carried out at Department of Radiology, Dow University of Health Sciences/Civil Hospital Karachi, from February, 2009 - July 2009.
Material and Methods: 200 pregnant females were examined having gestational age of 28 or more weeks. Obstetrical ultrasound was done using 3.5MHz convex transducer on Toshiba ultrasound scanner model Nemio-17. Measurement of Biparietal Diameter, (BPD), femur Length (FL) and abdominal Circumference (AC), placental localization and assessment of liquor was done as per standard protocol. The distal femoral, proximal tibial and proximal humeral ossification centers were identified and measured.
Results: Appearance and size of distal femoral, proximal tibial and the proximal humeral epiphyseal ossification centers in correlation with fetal biometry is helpful in accurate assessment of gestational age in the third trimester.
Conclusions: Ultrasonographic visualization of the epiphyses ossification centers in correlation with fetal biometry is a useful marker of fetal gestational age in third trimester.
Key Words: Gestational Age, Biparietal Diameter, Head Circumference, Femur Length, Abdominal Circumference, Fetal Epiphyseal Ossification Centers.

INTRODUCTION

Fetal biometry with the help of Ultrasound (US) scanning provides the most reliable and important information about the fetal growth and wellbeing[1-11]. However, the accuracy of Ultrasound declines as the pregnancy advances, owing to the increasing biological variability in the size of the fetus and its parts. So much so that, in the third trimester, using the standard fetal biparietal diameter (BPD), femur length (FL) and abdominal circumference (AC) for assigning gestational age, the accuracy of Ultrasound is $\pm$2-3 weeks (Table-1) [12].

This range of $\pm$2-3 weeks creates problem for Obstetrician in deciding fetal maturity. This problem is further compounded in our local circumstances; particularly in case of illiterate women, who neither remember their last menstrual period, nor undergo for early Ultrasound examinations and present themselves either directly at the time of labor or late complications. In these situations among all the proposed Ultrasound parameters for gestational age, none is very precise, particularly when taken for the first time during the third trimester of pregnancy, leaving the obstetrician in a real quandary. The rationale of this study, therefore, is to have an additional parameter that, in correlation with fetal biometry, may help to narrow this range in third trimester gestational age. The time of appearance and size of the epiphyseal ossification centers of fetal peripheral long bones (femur tibia and humerus) is one such parameter[14-23].

MATERIALS AND METHODS

This was a case series of two hundred pregnant females with known gestational age of 28 weeks and above, attending the Department of Radiology for their routine antenatal Ultrasound examination, from February 2009 - July 2009.

The first variable i.e. gestational age as per last menstrual period was calculated. The other variables measured for data analysis were: (I) BPD (Bi-parietal diameter), (II) FL (Femur length), (III) AC (Abdominal circumference) (IV) DFE (Distal femoral epiphysis) (V) PTE (Proximal tibial epiphysis) and (VI) PHE (Proximal humeral epiphysis). The volume of each epiphysis was calculated by multiplying the three-dimensional measurements and it was taken as size of the epiphysis. The data collection tool was a pre-designed Performa. A database was created, and data analysis was carried out using SPSS 10.0 version.

Inclusion Criteria: All pregnant females having knowledge/record of LMP with menstrual age ranging 28-40 weeks and fundal height corresponded to dates.

Exclusion Criteria: Pregnant females having diabetes, hypertension, twin or multiple pregnancies, fetal anomaly, suspected IUGR (intrauterine growth restriction), suboptimal fetal position in which epiphyses could not be observed.

RESULTS

The accuracy of standard parameters of fetal biometry i.e. biparietal diameter (BPD), femur length (FL) and abdominal circumference (AC) varied from ± 2 weeks 2 days to 3 weeks and 1days (Table-2).

Table No.1: Variability in predicting gestational age.

Parameters used	Variability±2 SD	
	30-36wks	**36-40wks**
BPD	3.08	3.20
HC	2.98	2.70
AC	2.96	3.04
FL	2.96	3.04
BPD, AC	2.60	2.88
BPD, HC	2.86	2.64
BPD, FL	2.60	2.62
HC, AC	2.68	2.52
HC, FL*	2.52	2.28
AC, FL	2.66	2.60
BPD, AC, FL*	2.50	2.52
BPD, HC, FL*	2.52	2.34
HC, AC, FL*	2.52	2.34
HC, AC, BPD,	2.60	2.52
BPD, HC, AC, FL*	2.44	2.30

Table No.2: Week-wise variability range in gestational age based on BPD, FL and AC.

Gestational age in weeks	Variability range ± in weeks and days
28	2 weeks 2 days
29	2 weeks 2 days
30	2 weeks 3 days
31	2 weeks 3 days
32	2 weeks 4 days
33	2 weeks 4 days
34	2 weeks 5 days
35	2 weeks 6 days
36	2 weeks 6 days
37	2 weeks 6 days
38	3 weeks 0 days
39	3 weeks 0 days
40	3 weeks 1 days

During 28 and 29 weeks it was ± 2 weeks 2 days, during 30 and 31 weeks it was ± 2 weeks 3 days, during 32 and 33 weeks it was ± 2 weeks 4 days, during 34 weeks it was ± 2 weeks 5 days, during 35, 36 and 37 weeks it was ± 2 weeks 6 days, during 38 and 39 weeks it was ± 3 weeks 0 days, and during 40 weeks it was ± 3 weeks 1 days.

As for as epiphyses of peripheral long bones is concerned, the results show that with the increasing gestational age the proportion of fetuses in which epiphyses have appeared also increases, thus showing positive linear correlation (Table 3).

The results also show that with the increasing gestational age the mean size of the appeared epiphyses also increased (Table-4).

The mean size of DFE was 0.27cm at gestational age of 29 weeks, increasing to 1.9cm at 33 weeks, 2.4cm at 37 weeks and 4.5cm at 40 weeks.

Table No.3: Week-wise proportional appearance of epiphyses.

Gestational Week	No. of Cases	Distal Femoral Epiphysis appeared cases (%)	Proximal tibial epiphysis appeared cases (%)	Proximal humeral epiphysis appeared cases (%)
28	25	0	0	0
29	21	23.80	0	0
30	22	45.45	0	0
31	22	60.86	0	0
32	21	85	15	0
33	19	100	26.31	0
34	15	100	46.66	0
35	15	100	73.33	0
36	14	100	85.71	14.28
37	12	100	100	25
38	9	100	100	66.66
39	3	100	100	100
40	2	100	100	100

Table No.4: Week-wise mean BPD, FL, AC and mean size of DFE, PTE and proximal humeral epiphysis.

Gestational Week	Mean BPD	Mean FL	Mean AC	Mean size of DFE in mm.	Mean size of PTE in mm.	Mean size of proximal humeral epiphysis in mm.
28	69.39	56.32	226.12	0	0	0
29	68.65	60.75	263.55	2.7	0	0
30	72.82	60.61	262.54	1.68	0	0
31	77.39	62	283.72	73.3	0	0
32	80.56	62.5	289.85	93.07	3.99	0
33	82.53	64.43	297.42	118.98	6.42	0
34	85.3	66.12	306.93	136.58	7.7	0
35	86.71	67.16	321.2	122.98	22.45	0
36	88.31	68.94	333.17	199.14	82.7	5.28
37	88.32	69.48	335.58	244	91.77	4.81
38	89.01	72.24	363.55	239.22	95.98	4.7
39	90.36	73	376	386.78	312.08	107.93
40	92.4	72.95	378.5	450.87	353.95	98.09

The mean size of PTE was 0.4cm at gestational age of 32 weeks, increasing to 9.2cm at 37 weeks and 3.5cm at 40 weeks.

Similarly the mean size of proximal humeral epiphysis was 2.28mm at gestational age of 36 weeks, increasing to 98.09mm at 40 weeks.

Each of the 3 epiphyses was most useful indicator of a critical period of gestational age.

Presence of the DFE in 100% of cases at 33 weeks, PTE at 37weeks and proximal humeral epiphysis at 39weeks offered greater diagnostic accuracy for that gestational age (Table 3).

The mean gestational age for appearance of DFE was calculated as 33.81, for PTE it was 35.92 and for proximal humeral epiphysis, it was 38.00.

DISCUSSION

The results of this study indicate that correlating fetal biometry with the presence or absence as well as size of epiphyseal ossification centers of femur, tibia and humerus can enhance the accuracy of prediction of gestational age.

The accuracy of standard parameters of fetal biometry i.e. biparietal diameter (BPD), femur length (FL) and abdominal circumference (AC) varied from $\pm$ 2 weeks 2 days to 3 weeks and 1days (Table-2). It ranged from $\pm$ 2 weeks 2 days during 28 and 29 weeks gestational age to $\pm$ 3 weeks 1 days during 40 weeks of gestational age. This result is in conformity with international reseach[12]-. correlating it with the presence or absence as well as size of epiphyseal ossification centers of femur, tibia and humerus can further narrow down this variability and thus enhance accuracy.

The mean GA for appearance of DFE, PTE and PHE was 34, 36 and 38 weeks respectively. If none of the 3 EOCs is detected at US examination, there is a very good chance that the fetus has not yet reached 34 weeks' gestation. If only the DFE is observed, and particularly if it is less than 200mm in size, the fetus has very probably not yet reached 36 weeks' gestation. If both DFE and PTE have appeared the fetus has most likely completed at least 37 weeks' of gestational age. If all the three epiphyseal ossification centers are visible, the fetus has certainly completed at least 37 weeks' of gestational age.

This information is very important as the fetus showing 37 weeks of gestational age is considered as mature fetus. Similarly the visualization of PHE also implies that fetus has attained maturity. Mahony et al. showed that all fetuses with a visible PHE had a mature amniocentesis, a good indicator of fetal lung maturity based on L/S ratio and phosphatidyl glycerol in amniotic fluid.[15]

In this study DFE was not seen in any of fetus at 28 weeks' gestation. The DFE however appeared in 24% of fetuses at 29th week, 45% at 30 weeks' reaching 61% at 31 weeks, 85% at 32 weeks, and 100% at 33 weeks gestation (Table-2 & 3). Similarly PTE was not visualized before 32 weeks. It was visualized in 15% of fetuses at 32 weeks, 26% at 33 weeks, 46% at 34 weeks, 73% at 35 weeks' gestation, 85% at 36 weeks and 100% at 37 weeks' gestation (Table 2 & 3).

The only study in Pakistan reported by Ahmed T and Siddiqi I. H, the DFE was visualized in 70% of fetuses at 33 weeks, 92% at 34 weeks' and 100% at 36 weeks gestation.

The PTE was visualized in 32% of fetuses at 35 weeks, 55% at 36 weeks, and 100% at 40 weeks' gestation [22].

The most recent study in international literature reported by Donne et al, DFE appeared in 17% of fetuses at 30th week, 71% at 32 weeks' reaching to 91% at 35 weeks, and 100% at 37 weeks gestation. Similarly PTE in this study appeared in 17% of fetuses at 34 weeks, 66% at 36 weeks, 80% at 37 weeks, 97% at 39 weeks, and 100% at 40 weeks' gestation. PHE in

this study appeared in 28% at 38 weeks, 39% at 39 weeks and 55% at 40 weeks. In comparison, PHE in our study appeared 66% at 38 weeks and 100% at 39 and 40 weeks. [23]

CONCLUSION

In view of the fact that growth charts of fetal biometry show levelling off and the wider biological scattering range of all parameters currently used to determine the duration of gestation during the last (third) trimester, making use of presence or absence as well as size of epiphyseal ossification centers of femur, tibia and humerus with its double advantage - the first appearance of the epiphyseal ossification centers during the third trimester as well as the following near-linear increase in size – is helpful in accurate prediction of gestational age.

Recommendation: There is clearly ample space for further research into the possible usefulness in our region of the Ultrasound visualization of the epiphyseal ossification centers as markers of fetal development and GA, not only during normal pregnancy but also in the presence of a number of conditions known to affect fetal growth and development.

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REFERENCES

1. Kieler H, Hagloud B, Waldenstrom U, Axelssson O. [Abstract of: Routine ultrasound screening in pregnancy and the children's subsequent growth, vision and hearing. Br J Obstet Gynaecol 1997; 104:1267-72] [electronic] [cited on 2009 Jul 06]. Available from: URL: http:// www.pubmed.com.htm
2. Salaveen KA, Vatten LJ, Eik-Nes SH, Hugdhal K, Bakketeig LS. [Abstract of: Routine ultrasonography in utero and the subsequent handedness and neurological development. BMJ 1993; 307(6897): 159-64] [electronic] [cited on 2009 Jul 06]. Available from: URL: http:// www.pubmed.com.htm
3. Zaidi S. Ultrasound examination in early pregnancy. In: Zaidi S, editor. Real-time Ultrasound in Obstetrics and Gynaecology. 2nd ed. Twel Publishers: Karachi;1991.p.23.
4. Palmer PES. Obstetrics. In: Breyer B, Brugera CA, Gharbi HA, Goldberg BB, Tan FEH, Wachira MW, Weil FS, editors. Manual of diagnostic Ultrasound.1st ed. World Health Organization: France; 1995.p.227.
5. Gary S, David A, Thomas D. [Abstract of: Fetal crown-rump length and biparietal diameter in the second trimester of pregnancy. Am J Obstet Gynecol 1974;172:9-12] [electronic] [cited on 2009 Jul 06]. Available from: URL: http:// www.pubmed.com.htm
6. Drumm JE, Mac Kinza J, Coombe L. [Abstract of: The ultrasonic measurement of fetal crown-rump length as a method of assessing gestational age. Br J Obstet Gynaecol 1976;6:417-21] [electronic] [cited on 2009 Jul 06]. Available from: URL: http:// www.pubmed.com.htm
7. Hadlock FP, Shah YP, Kanon DJ, Lindsey JV. [Abstract of: Fetal crown-rump length: re-evaluation of relation to menstrual age (5-18 weeks) with high-resolution real time US. Radiology 1992; 182(2): 501-5] [electronic] [cited on 2009 Jul 06]. Available from: URL: http:// www.pubmed.com.htm
8. Bovicilli L, Orisni LF, Rizzo N, Calderoni P, Pazzaglis FL, Michelacci L. [Abstract of: Estimation of gestational age during the first trimester by real-time measurement of fetal crown-rump length and biparietal diameter. J Clin Ultrasound 1981; 9(2): 71-5] [electronic] [cited on 2009 Jul 06]. Available from: URL: http:// www.pubmed.com.htm
9. Salomon LJ, Bernard JP, Duyme M, Dorion A, Ville Y. [Abstract of: Revisiting first-trimester fetal biometry. Ultrasound Obstet Gynecol. 2003 Jul; 22(1):63-6. Ultrasound Obstet Gynecol. 2003 Jul; 22(1):63-6] [electronic] [cited on 2009 Jul 06]. Available from: URL: http:// www.pubmed.com.htm
10. Salomon LJ, Bernard JP, Nizard J, Ville Y. [Abstract of: First-trimester screening for fetal triploidy at 11 to 14 weeks: a role for fetal biometry. Prenat Diagn. 2005 Jun; 25(6):479-83] [electronic] [cited on 2009 Jul 06]. Available from: URL: http:// www.pubmed.com.htm
11. Hadlock FP, Deter RL, Harris RB, Park SK. [Abstract of: Fetal biparietal diameter: a critical re-evaluation of the relation to menstrual age by means of real–time ultrasound. J ultrasound Med 1982; 1(3): 97-104] [electronic] [cited on 2009 Jul 06]. Available from: URL: http:// www.pubmed.com.htm
12. Goldberg BB, McGahan JP. Atlas of Ultrasound Measurements. 2nd ed. Mosby-Elsivier: Philadelphia;2006.p.53.
13. Chinn DH, Bolding DB, Callen PW, Gross BH, Filly RA. Ultrasonographic identification of fetal lower extremity epiphyseal ossification centers. Radiology. [serial online] 1983 Jun [cited 2009

Jul 5]; 147(3):815-8. Available from: URL: http:// www.radiology.com.htm
14. McLeary RD, Kuhns LR. [Abstract of: Sonographic evaluation of the distal femoral epiphyseal ossification center. J Ultrasound Med 1983;2(10):437-8] [electronic] [cited on 2009 Jul 06]. Available from: URL: http:// www.pubmed.com.htm
15. Mahony BS, Callen PW, Filly RA. The distal femoral epiphyseal ossification center in the assessment of third-trimester menstrual age: sonographic identification and measurement. Radiology.; [serial online] 1985 Apr [cited 2009 Jul 5]; 155(1):201-4. Available from: URL: http:// www.radiology.com.htm
16. Gentili P, Trasimeni A, Giorlandino C. [Abstract of: Fetal ossification centers as predictors of gestational age in normal and abnormal pregnancies. J Ultrasound Med. 1984 May; 3(5):193-7] [electronic] [cited on 2009 Jul 06]. Available from: URL: http:// www.pubmed.com.htm
17. Bernaschek G. [Abstract of: Sonographic detection of fetal epiphyseal centers--an additional parameter for determining delivery date] Wien Klin Wochenschr Suppl 1985; 159:3-26] [electronic] [cited on 2009 Jul 06]. Available from: URL: http:// www.pubmed.com.htm
18. Goldstein I, Lockwood C, Belanger K, Hobbins J. [Abstract of: Ultrasonographic assessment of gestational age with the distal femoral and proximal tibial ossification centers in the third trimester. Am J Obstet Gynecol 1988; 158(1): 127-30] [electronic] [cited on 2009 Jul 06]. Available from: URL: http:// www.pubmed. com.htm
19. Mahony BS, Bowie JD, Killam AP, Kay HH, Cooper C. Epiphyseal ossification centers in the assessment of fetal maturity: sonographic correlation with the amniocentesis lung profile. Radiol [serial online] 1986 May [cited 2009 Jul 5]; 159(2):521-4. Available from: URL: http:// www.radiology.com.htm
20. Goldstein I, Lockwood CJ, Reece EA, Hobbins JC. [Abstract of: Sonographic assessment of the distal femoral and proximal tibial ossification centers in the prediction of pulmonic maturity in normal women and women with diabetes. Am J Obstet Gynecol 1988;159(1):72-6] [electronic] [cited on 2009 Jul 06]. Available from: URL: http:// www.pubmed.com.htm
21. Nazário AC, Tanaka CI, Novo NF. [Abstract of: Proximal humeral ossification center of the fetus: time of appearance and the sensitivity and specificity of this finding. J Ultrasound Med 1993;12(9):513-5] [electronic] [cited on 2009 Jul 06]. Available from: URL: http:// www.pubmed. com.htm
22. Ahmad T, Siddiqi IH. Ultrasonographic assessment of Gestational age with distal femoral and proximal tibial ossification centers. Pakistan Postgrad Med J 2001;12(4):170-2.
23. Donne HD, Faundes A, Tristao EG, de Sousa MH, Urbanetz AA. Sonographic identification and measurement of the epiphyseal ossification centers as markers of fetal gestational age. J Clin Ultrasound 2005;33(8):394-400.

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