Original Article

Assessment of Gestation Age

Ultrasonographic Appearance and Measurement of Epiphyseal Ossification Centres of Fetal Peripheral Long Bones for Assessment of Gestation Age

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ABSTRACT

Objective: To determine the ultrasonographic appearance and size of epiphyseal ossification centers of fetal peripheral long bones for assessment of third trimester gestational age.

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 from July 2009.

Materials 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: Gestational age correlated well with appearance and size of distal femoral, proximal tibial and the proximal humeral epiphyseal ossification centers but even better with the sum of the three ossification centers.

Conclusions: Ultrasonographic visualization of the epiphyses ossification centers may be a useful marker of fetal gestational age.

Key Words: Gestational Age, Biparietal Diameter, Head Circumference, Femur Length, Abdominal Circumference, Fetal Epiphyseal Ossification Centers.

INTRODUCTION

Last menstrual period (LMP) and Ultrasound (US) play complementary roles in establishing gestational age (GA). The LMP provides a preliminary estimate, while the US findings are used to confirm or replace the GA based on the LMP r[1-11].

However, the accuracy of US 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 GA, the accuracy of US is ±3-4 weeks (Table-1). [12] This range of ±3-4weeks 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 LMP, nor undergo for early US examinations and present themselves either directly at the time of labor or late complications. In these situations among all the proposed US parameters for GA, 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 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) has been studied by researchers as an additional parameter[14-23].

During the third trimester of pregnancy the most central and oldest cells of the distal femoral, proximal tibial as well as humeral epiphyses convert from a cartilaginous model into bone. These secondary ossification centers, which are visible using US, enlarge centrifugally until the cartilaginous epiphysis becomes completely ossified after birth. Identification and measurement of secondary ossification centers, therefore, provide valuable information regarding skeletal maturation and growth during the third trimester of pregnancy.

The distal femoral epiphysis (DFE) and proximal tibial epiphysis (PTE) appears around 32 and 37 weeks respectively after the amenorrhoea begins; whereas the proximal humeral epiphysis (PHE) is visualized significantly frequently after the 38 weeks.12[3] This

information can be a useful parameter for deciding the fetal maturity in our prevalent circumstances, as shown in international as well as in local literature.

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

No epiphysis was seen in any fetus of 28 weeks' gestation. The DFE appeared in a small proportion of fetuses (5 of 21, 24%) as early as the 29th week. However this proportion increased dramatically to 45% at 30 weeks' reaching 61% at 31 weeks, 85% at 32 weeks, and 100% at 33 weeks gestation (Table-2 & 3).

The PTE appeared for the first time in three of 20 fetuses at 32 weeks and in 26% (5 of 19) at 33 weeks, 46% (7 of 15) at 34 weeks' gestation. Up to 35 weeks' gestation, the PTE was detectable in 73% (11 of 15) fetuses, increasing to 85% at 36 weeks and 100% at 37 weeks' gestation (Table 2 & 3).

The PHE was observed in a small proportion of fetuses (2 of 14, 14%) at the 36th week of GA, and this percentage increased to 25% (3 of 12) at the 37th, 66% (6 of 9) at the 38th, and 100% at the 39th (3 of 3) and 40th (2 of 2) weeks, respectively (Table 2 & 3).

It is evident from the above-mentioned results that with the increasing GA the proportion of fetuses in which epiphyses have appeared also increases, thus showing positive linear correlation.

The results also showed that with the increasing GA the mean size of the appeared epiphyses also increased (Table-4). The mean size of DFE was 0.27cm at GA of 29 weeks, increasing to 1.9cm at 33 weeks, 2.4cm at 37 weeks and 4.5cm at 40 weeks.

Table No.1: Variability in predicting gestational age.

Parameters used	Variability $\pm$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 epiphyses appearance.

Gestational week	Number of cases	DFE appeared	PTE appeared	PHE appeared
28	25	0	0	0
29	21	5	0	0
30	22	10	0	0
31	22	14	0	0
32	21	17	3	0
33	19	19	5	0
34	15	15	7	0
35	15	15	11	0
36	14	14	12	2
37	12	12	12	3
38	9	9	9	6
39	3	3	3	3
40	2	2	2	2

The mean size of PTE was 0.4cm at GA of 32 weeks, increasing to 9.2cm at 37 weeks and 3.5cm at 40 weeks. Similarly the mean size of PHE was 2.28mm at GA of 36 weeks, increasing to 98.09mm at 40 weeks.

Each of the 3 epiphyses was most useful as an indicator of a different GA (Table 3).

Presence of the DFE in 100% of cases at 33 weeks, PTE at 37weeks and PHE at 39weeks offered greater diagnostic accuracy for that GA.

The new variable, ''sum of the size of the three EOCs" also showed linear increase in its size with increasing GA.

The ''sum of the size of the three EOCs" measured 2.7mm at the GA of 29 weeks, increasing to 1.25cm at 33 weeks, 3.4cm at 37 weeks and 9.03cm at 40 weeks.

This new variable was also correlated with commonly used parameters i.e. BPD, FL and AC (Table-4) and all the parameters increased with increasing GA.

The mean GA for appearance of DFE was calculated as 33.81, for PTE it was 35.92 and for PHE 38.00.
Ability of the size of epiphyses to determine the 37-weeks GA to decide fetal maturity was also evaluated. For this mean pre-37 weeks and mean post-37weeks size of each of epiphyses as well as was ''sum of three EOCs" was also calculated.

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

Gestational Week	Number of Cases	% of DFE appeared cases	% of PTE appeared cases	% of PHE 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 sum of EOCs.

Gestational Week	Mean BPD	Mean FL	Mean AC	Sum of EOC's
28	69.39	56.32	226.12	0
29	68.65	60.75	263.55	2.7
30	72.82	60.61	262.54	1.68
31	77.39	62	283.72	73.3
32	80.56	62.5	289.85	97.06
33	82.53	64.43	297.42	125.4
34	85.3	66.12	306.93	144.8
35	86.71	67.16	321.2	145.43
36	88.31	68.94	333.17	287.12
37	88.32	69.48	335.58	340.58
38	89.01	72.24	363.55	339.9
39	90.36	73	376	806.79
40	92.4	72.95	378.5	902.91

DISCUSSION

The results of this study indicate that the presence or absence as well as size of epiphyseal ossification centers of femur, tibia and humerus can be useful in prediction of gestational age. 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 and particularly if its size is more than 300mm, the fetus has most probably reached 37 weeks gestation.

This information is very important as the fetus showing 37 weeks GA 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]
The sum of the three EOCs can also be useful in prediction of GA particularly the all-important GA of 37 weeks of fetal maturity. The mean sum of EOCs for GA of 37-38 weeks was 340mm in this study.
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

The Ultrasound appearance and size of epiphyseal ossification centres of femur, tibia and humerus can be useful in prediction of gestational age during the third trimester of pregnancy, a period in which standard fetal biometric estimates of gestational are least accurate. This technique appears to identify a GA of <33 weeks or >33 weeks based on the respective absence or presence of the DFE. The US demonstration of the PTE is a strong indicator of GA of 36 weeks or more where as appearance of PHE virtually confirms the maturity of fetus. Further evaluation is necessary to support these observations.

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