Original Article

DOI: 10.17354/ijss/2015/448

Ultrasonographic Evaluation of Fetal Humerus Length for Assessment of Gestational Age and Its Comparison with Other Conventional Parameters

Vivek Patre[1], Abhay Kumar Aryan[2], Preeti Sahu[3], Vibha Patre[4]

[1]Associate Professor, Department of Radio-Diagnosis, Pt. Jawahar Lal Nehru Memorial Medical College, Raipur, Chhattisgarh, India, [2]Registrar, Department of Radio Diagnosis, Mahatma Gandhi Memorial Medical College, Indore, Madhya Pradesh, India, [3]Registrar, Department of Obstetrics and Gynecology, Mahatma Gandhi Memorial Medical College, Indore, Madhya Pradesh, India, [4]Registrar, Department of Radio Diagnosis, Pt. Jawahar Lal Nehru Memorial Medical College, Raipur, Chhattisgarh, India

Abstract

Introduction: Ultrasonography is proved to be an ideal imaging method, as it is safe for the mother and fetus. It being a painless, non-invasive, non-ionizing, and relatively inexpensive technique used to evaluate fetal growth parameter many times during pregnancy.

Purpose: To estimate the gestational age (GA) with humerus length (HL) and establish the accuracy of it as a reliable indicator for prediction of GA in comparison with other routine parameters.

Materials and Methods: Prospective study was performed on 100 normal singleton pregnancies at second and third trimesters. The study was conducted on a gray scale real-time ultrasound scanner using linear and sector transducers to measure the fetal biometrics. After visualizing the heart, the transducer is moved to image the scapular spine located on the dorsal surface to the head of the humerus. A straight measurement was made from the one end of the diaphysis to the other.

Results: Biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL) were compared with standard charts and scatter graphs were plotted. Coefficient of correlation were calculated which were 0.9620, 0.8632, 0.8208, 0.9853 for BPD, HC, AC, and FL, respectively, proving them reliable indicators except for AC. HL measured in the present study was compared with standard nomogram. A statistically significant curvilinear correlation was found between the HL and GA indicating it to be a reliable indicator of GA. Significant coefficient of correlation (0.9704) was observed between HL and GA indicating it to be a reliable parameter.

Conclusion: The HL was most accurate parameter next to FL in assessing GA. The study also indicates that combination of BPD, HC, AC, FL, HL is more accurate in predicting GA than any single parameter, particularly in the third trimester of pregnancy. HL would contribute to maximum accuracy next to FL amongst all the parameters.

Key words: Femur, Fetal biometry, Gestational age, Humerus, Ultrasonography

INTRODUCTION

Ultrasound is a safe, non-invasive, non-ionizing, and relatively inexpensive technique for the assessment of obstetric patients.[1,2] Accurate prediction of the gestational age (GA) is very important in the management of obstetric patients for planning a timely and uneventful outcome. Many antenatal assessment parameters have been studied to predict the correct GA. Biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC) and femur length (FL) are considered reliable predictors and are used as routine parameters. These parameters are helpful in the estimation of fetal age in patients whose fundal height on abdominal examination does not corresponding to the last menstrual period (LMP).[3,4] In cases where the BPD measurement is not reliable femoral length and humeral length allow reliable estimation of fetal age. The purpose of this study is to determine the GA using sonographic

Access this article online

www.ijss-sn.com

Month of Submission : 08-2015
Month of Peer Review : 09-2015
Month of Acceptance : 10-2015
Month of Publishing : 10-2015

Corresponding Author: Dr. Vivek Patre, Department of Radio Diagnosis, Pt. Jawahar Lal Nehru Memorial Medical College and Dr. B R Ambedkar Hospital, Raipur - 492 001, Chhattisgarh, India. Phone: +91-7712889161. Fax: +91-7712523919. E-mail: vivek_patre@yahoo.com

measurement of the fetal humerus length (HL) and to confirm that it is reliable and essential method in estimation of GA compared with other routine parameters.

MATERIALS AND METHODS

A prospective study was conducted in the Department of Radio-Diagnosis, MGM Medical College, Indore, Madhya Pradesh, India. The patients were selected from the antenatal clinics, as well as maternity wards. The study was performed on gray scale real time scanner Shimadzu 500 SDU and Shimadzu - Aspire with a 3.5 MHz linear and 3.5 MHz sector transducers. Electronic calipers were used to take measurements. The study envisaged the recording of various routine fetal biometric parameters, as well as fetal HL.

The inclusion criteria included: A history of amenorrhea, confirm date of the 1st day of the last normal menstrual period and regular menstrual cycles.

The exclusion criteria were a GA that could not confirmed by early ultrasonography, a discrepancy of more than 10 days between GA by LMP and ultrasound parameter and any malformation.

The patients were between 18 and 35 years of age. 36 out of these were primigravida, and 64 were multigravida; 38 were uniparous, and 23 were multiparous. No patient with a bad obstetric history (i.e., fetal loss more than two in the past) was included in the study.

Sonographic Procedure

The patients were examined in the supine position exposed from the xiphisternum to the pubic symphysis. The transducer was then placed over the abdomen, and fetal head was identified to ascertain the lie of the fetus, confirm viability and rule out multiple pregnancies.

Humerus Scanning Technique

After visualizing the heart, the transducer is moved to image the scapular spine which is dorsal to the humerus head. The full length of the humerus was then obtained in a plane as close as possible to right angles of the ultrasound beam. A straight measurement was made from the center of one end of the diaphysis to the other, disregarding any curvature.

Routine Parameter Scanning

After ascertaining the fetal head position, serial scans were made in a plane transverse to the fetal head. The BPD was measured in a scan that shows the widest diameter at the level of midline echo complex; two lateral ventricle, thalami, and cavum septum pellucidum. Three measurements were made using freeze frames with electronic calipers. The reference point for BPD is the measurement from the inner margin of distal skull interface to the outer margin of proximal skull interface. The fetal spine was traced from the skull downward till a large anechoic area (fetal bladder) identified anterior to the sacral spine. The transducer was then placed at right angle to mid of heart and bladder to get to the level of AC which was completely circular and included the liver, horizontal portion of portal sinus, as well as the stomach bubble and the fetal spine. The AC was measured with maximum diameter using outer to outer technique. For measuring the FL, the transducer was placed at right angles to the fetal spine and passed down the fetus maintaining this angle to the caudal end. Since the distal femur is usually flexed, the transducer was rotated from this position through 30-45 degrees toward the abdomen until the full length of the femur was visualized. An attempt was made to define both ends of the calcified portion of the femur which was measured when the maximum length was obtained. The HC measurements were taken after obtaining a horizontal section of the fetal head which included both the BPD (corona plane) and the occipitofrontal diameter (sagittal plane). Measurements were taken when the head appeared as an ovoid and echoes from the third ventricle were detected in the midline.

After noting BPD, HC, AC, HL, and FL, the complete information was recorded as in the proforma.

Each parameter was compared with its respective standard chart. The graph was plotted between GA and individual parameters and the accuracy of each parameter evaluated and compared amongst each other.

RESULTS

A total of 100 pregnant women who were clinically considered to be undergoing an uneventful pregnancy were examined ultrasonographically. In all cases taken up for this study, patients were very sure of the data of their LMP. The GA was calculated from the LMP up to the day of examination with ultrasound, and this was taken as known or standard menstrual age.

The various parameters (BPD, HC, AC, FL, and HL) were meticulously noted.

Each parameter is then compared with its standard chart (western nomograms) and the accurate parameters are noted for that known GA:

- BPD was compared with Sabbagha and Hugheys chart

- HC, AC, and FL were compared with their respective Hadlocks chart
- HL was compared with Jeanty (Western chart).

Fetal maturity was assessed ultrasonographically considering following four conventional parameters:

1. BPD
2. HC
3. AC
4. FL.

Each one of these parameters was independently correlated to GA using standard charts:

- Bi-Parietal diameter (BPD): BPD recorded in the present study was compared with standard nomogram (Sabbagha and Hughey, 1978) (Table 1). It was found that between GA of 16-30 weeks BPD was a good indicator of maturity, except in breech presentation and in dolichocephaly where BPD was not a very good indicator nor it was easily measurable. In the later period of gestation (30-40 weeks), the accuracy of predicting GA by BPD decreases (4-5 mm difference). The maximum error in predicting GA was 4.1 weeks with a mean error of 0.8 weeks. Scatter graph was plotted between BPD and GA, and their correlation was calculated. The overall correlation coefficient between the two was found to be equal to 0.9620.
- HC: HC recorded in the present study was compared with standard nomogram (Table 2). With GA between 16 and 30 weeks, HC was also found to be a good predictor age. Beyond 30 weeks on an average (5-6 mm difference was found between standard and present study data). It was a good parameter when BPD was difficult to detect in cases where the head was in transverse lie or dolichocephaly. The scattered graph was plotted between HC and GA, and their correlation was calculated. Coefficient of correlation was found to be equal to 0.8632 indicating it to be a good parameter for assessing GA. The maximum error in predicting GA was 3.5 weeks with a mean error of 0.93 weeks.
- AC: AC was compared with standard Hadlock chart (Table 3). It was found to be a good predicator of GA in early second trimester, however, in late second trimester and third trimester was found to be an unreliable indictor with maximum error in predicting GA up to 5 weeks and mean error 1.62 week. Nonetheless, it can be used as a predictor of GA in the case in which BPD is technically impossible or in cases in which molding of head can significantly alter the accuracy of BPD. Coefficient of correlation was found to be equal to 0.8208.
- FL: FL correlated well with the standard nomogram (Table 4). Beyond 32 weeks, the FL was 2-3 mm less than standard value. The maximum error in predicting menstrual age was found to be 3 weeks and mean error 0.6 weeks. A highly significant coefficient of

Table 1: Comparison of mean BPD in the present study with standard BPD chart

Gestational age (in weeks)	Standard nomogram (Sabbagha and Hughey) 1978	Mean BPD in present study (in mm)
16	36	36
17	39	40
18	42	40
19	45	44
20	48	47
21	51	51
22	54	53
23	58	56
24	61	60
25	64	62
26	67	67
27	70	69
28	72	70
29	75	74
30	78	76
31	80	78
32	82	80
33	85	81
34	87	83
35	88	85
36	90	86
37	92	88
38	93	89
39	94	90
40	95	90

BPD: Bi-parietal diameter

Table 2: Comparison of mean HC in the present study with standard HC chart

Gestational age (weeks)	Standard nomogram (Hadlock *et al*., 1982)	Mean HC in present study (mm)
16	122	120
17	134	129
18	148	146
19	160	160
20	177	176
21	182	192
22	193	207
23	208	207
24	221	220
25	239	231
26	241	240
27	256	248
28	271	261
29	273	272
30	276	273
31	281	280
32	292	290
33	302	297
34	308	303
35	317	311
36	322	322
37	328	325
38	334	328
39	340	335
40	345	339

HC: Head circumference

Table 3: Comparison of mean AC in the present study with standard AC chart

Gestational age (weeks)	Standard nomogram (Hadlock *et al*., 1982)	Mean AC in present study (mm)
16	105	101
17	117	112
18	129	122
19	141	140
20	152	145
21	164	157
22	175	157
23	186	169
24	197	185
25	208	194
26	219	209
27	229	219
28	240	229
29	250	235
30	260	245
31	270	254
32	280	267
33	290	273
34	300	276
35	309	283
36	318	305
37	327	306
38	336	307
39	345	310
40	354	315

AC: Abdominal circumference

Table 4: Comparison of mean FL in the present study with standard FL chart

Gestational age (weeks)	Standard nomogram (Hadlock *et al*.)	Mean FL in present study (mm)
16	23	23
17	26	25
18	28	28
19	30	30
20	33	33
21	35	34
22	38	37
23	40	40
24	42	42
25	45	45
26	47	47
27	49	49
28	52	51
29	54	55
30	57	56
31	59	58
32	61	60
33	64	62
34	66	65
35	69	66
36	71	69
37	73	72
38	76	73
39	78	74
40	80	75

FL: Femur length

correlation (0.9853) between FL and GA was observed indicating it to be a reliable predictor.

GA Assessment by HL

HL measured in the present study was compared with standard nomogram suggested by Jeanty (Table 5). The observation showed that present study data correlates well with the standard nomogram throughout gestation. A statistically significant curvilinear correlation was found between the HL and GA indicating it to be a reliable indicator of GA. The sonographic evaluation of humeral length reveals a linear relationship during the second trimester, thus the GA in weeks during this period. However, later in the gestation the growth curve of humerus tends to flatten. The maximum error in predicting GA by HL was found to be 2.3 weeks and mean error 0.71 week. In the majority cases (34%), the HL value were between 50 and 60 mm; corresponding to period of gestation ranging from 30 to 36 weeks (Table 6).

A maximum mean error was found with AC, 1.62 week and least with FL 0.6 week and next to this is HL 0.71 week, indicating it to be reliable predictor of GA (Table 7).

In the majority of cases, the error between humeral age and known menstrual age was between 0 and 1 weeks (Table 8).

Significant coefficient of correlation was observed between HL and GA indicating it to be a reliable parameter (Table 9).

Above observations shows that the HL can be taken as a reliable parameter for recording GA (accuracy 82%) only superseded by FL (accuracy 86%) (Table 10).

DISCUSSION

Our observations are self-explanatory, and they are fulfilling almost all the aims and objective for which this study was undertaken. Ultrasonography is a useful means of detecting GA and to monitor fetal growth and development accurately. GA must be reliably established so that needless interference and perinatal mortality rates can be decreased. A total of 100 singleton pregnant women between 16 and 40 weeks of gestational were included in the study. No fetuses with evidence of intrauterine growth retardation, high-risk factors, bad obstetric history were included. The GA was confirmed by clinical examination of the pregnant women at the time of their selection and also if possible from their interrogation on their first visit in an antenatal clinic in early pregnancy. The routing bimanual pelvic examination in the first trimester is a fairly acceptable method of estimating the GA within a range of the 2 weeks.[2]

Patients were excluded if:

1. Their GA, as predicted by the LMP, could not be confirmed by early clinical or ultrasonography examination

Table 5: Comparison of mean HL in the present study with standard HL chart

Gestational age (weeks)	Standard nomogram	Mean HL in present study (mm)
16	21	20
17	24	24
18	27	26
19	29	27
20	32	30
21	34	33
22	36	34
23	38	36
24	41	39
25	43	40
26	45	43
27	46	46
28	48	45
29	50	51
30	52	50
31	53	50
32	55	53
33	56	54
34	57	56
35	58	57
36	60	58
37	61	59
38	61	59
39	62	60
40	63	61

Table 6: Distribution of fetal HL

Serial number	HL (mm)	Gestational age (weeks)	No of cases	Percentage of cases
1	20-30	16-20	13	13
2	30-40	20-25	18	18
3	40-50	25-30	25	25
4	50-60	30-36	34	34
5	60-70	36-40	10	10
Total			100	100

HL: Humerus length

Table 7: The error in predicting gestational age with various parameters

Serial number	Parameters	Maximum error (weeks)	Mean error (weeks)
1	BPD	4.1	0.8
2	HC	3.5	0.93
3	AC	5	1.62
4	FL	3	0.6
5	HL	2.3	0.71

BPD: Bi-parietal diameter, HL: Humerus length, HC: Head circumference, AC: Abdominal circumference FL: Femur length

2. A discrepancy of more than 10 days between the GA predicated by the LMP and that estimated by the ultrasound measurement
3. Impaired fetal growth and malformation existed
4. The patient had any medical complication of pregnancy.

Table 8: Distribution of error of period of gestation (in weeks) between HL and known menstrual age

Serial number	Error of gestational age in weeks	Number of cases
1	0-1	93
2	1-2	6
3	2-3	1

HL: Humerus length

Table 9: Coefficient of correlation between various parameters and GA

Serial number	Independent variable (x)	Dependent variable (y)	Coefficient of correlation
1	Gestational age	BPD	0.9620
2	Gestational age	HC	0.8632
3	Gestational age	AC	0.8208
4	Gestational age	FL	0.9853
5	Gestational age	HL	0.9704

BPD: Bi-parietal diameter, HL: Humerus length, HC: Head circumference, AC: Abdominal circumference FL: Femur length, GA: Gestational age

Table 10: Percentage of accuracy of various study parameters in the present study

Serial number	Parameters	Percentage of accuracy (%)
1	BPD	80
2	HC	75
3	AC	70
4	FL	86
5	HL	82

BPD: Bi-parietal diameter, HL: Humerus length, HC: Head circumference, AC: Abdominal circumference FL: Femur length

Ultrasound is a non-invasive, non-ionizing, inexpensive and safe method of evaluating GA in obstetrical cases. It has been born since 1960s and shall continue to be the same years and ahead. The ultrasound observable parameters currently available are BPD, FL, HC, and AC.

The relationship between the BPD and GA has been studied by various workers.[3,5-7] BPD is a fairly accurate method of estimating the GA.[8] In the present study, the correlation coefficient between GA and BPD is equal to 0.9620, indicating that BPD is highly correlated to GA. However, the natural variations in the growth patterns of the head size in different individuals make the prediction by BPD inaccurate in the third trimester. BPD is also less reliable in breech head, dolichocephaly, uterine anomalies, and multiple gestation. BPD is also difficult to record when the head gets engaged in the late third trimester.

Fetal FL is a relatively easy measurement to obtain. It is especially useful where it is difficult or impossible to obtain a reliable BPD for example, where position or engagement of the head makes visualization difficult or in cases of

hydrocephalus, anencephaly, dolichocephaly where FL can be better relied upon. The FL has a linear relationship with the GA, similar to BPD, but the growth appears to be slow in the third trimester. Fetal FL has been widely used for prediction of GA.[9-12] It has been observed that there is a high degree of positive correlation between GA and FL ($r = 0.987$). In the present study, the correlation coefficient for FL on GA is 0.9853, which is significant. In our study, FL turned out to be a better indicator of GA the BPD, HC, AC, and HL, with percentage accuracy of 86%.

The AC has relationship to GA similar to that of the BPD.[13-16] Because a reproducible AC is more difficult to obtain than a reproducible BPD or FL, this limits its value as a sole estimator of GA. However, these parameters help if other parameters cannot be obtained. The evolution of the variability in predicting menstrual age from AC indicates that it is actually a poor predictor of menstrual age than the BPD except during 36-40 weeks of pregnancy.[15] In the present study, the coefficient of correlation with GA has been found to be 0.8208, indicating 75% of the total variability. The reasons accepted are that the abdomen shape is not constant and is affected by various factors including fetal breathing; in addition certain technical factors may contribute to the fluctuations in the evolution of gestation age by AC. It is a well-documented and established fact that Indian fetal growth does not match with western fetal growth standard due to various socio-economic and environmental factors. In majority of our cases abdominal girth readings were falling short of western standard by 2 SD, but the outcome of fetus after delivery was found to be normal with lower birth weight in comparison with western Hadlock's charts. Hence, they cannot be labeled as case of IUGR in our set up.[17]

HC measurements are acceptable parameters not only for evaluating GA but also in intrauterine growth retardation cases. In situations where the head shape is significantly altered, such as breech presentation or transverse lie, HC measurement offers better correlation than BPD.[16,18-20] HC measurement in our series proves to be a reliable predictor of GA with coefficient of correlation 0.8632. HC correlated well with Hadlock's nomogram up to 30 weeks; after 30 weeks on an average 5-6 mm difference was found between standard western nomograms and present study data. The above observation suggest that a combination of BPD, HC, AC and FL is more accurate in predicting GA than any single parameter particularly in the last trimester of the pregnancy. These conventional parameters were used to confirm the GA of the 100 patients in the present study, to be certain of the GA according to the LMP.

Sonographic measurement of the ossified shaft of fetal humerus is possible after the 12th week of gestation. Humerus is difficult to define accurately, because of its proximity to the chest wall and its apparent continuity with the scapula and clavicle. The relationship between HL and GA has been studied by only few workers. They have stated that HL is also a useful parameter for assessing GA.[21-23] We undertook this study in order to correlate ultrasonographic HL with GA. Various workers have compared linear regression of HL versus GA and demonstrated a strong correlation with "r = value." In our present study, the coefficient of correlation was found to be (0.9704) which is highly significant and shows that with increase in GA and HL also increases. Hence, it can be used to assess GA. HL recorded in present study correlated well with the nomograms suggested by Jeanty (1983)[21] with difference of only 2-3 mm in late third trimester. The maximum error in predicting GA with HL was 2.3 weeks, and percentage accuracy of humeral length for assessing GA was 82% which was second most highest than all other conventional parameters. We found that it is a reliable indicator of GA in conjunction with FL, when other parameters do not accurately predict GA. In the management of the patient with premature labor, to accurately predict GA HL can be used in conjunction with BPD and FL. Hence, the present study demonstrates that the ultrasonography measurement of HL is a reliable indicator of GA.

CONCLUSION

This is a study to assess the HL with ultrasonography in the evaluation of fetal growth and development. The period of gestation was calculated from LMP and clinical examination. With each patient, several biometric parameters were obtained including BPD, HC, AC, FL, and HL.

The mean measurement of these parameters thus obtained for each GA group were compared independently with western nomograms and their accuracy in predicting gest age were determined. The coefficient of correlation of BPD ($r = 0.9620$), FL ($r = 0.9853$), HC($r = 0.8632$), AC ($r = 0.8208$), and HL ($r = 0.9704$) observed in present study showed a high degree of linear relationship with GA. In our study, AC was found to be an unreliable indicator of GA. It fell short of western standards by –2SD in the third trimester of pregnancy. This may be because of difference in socio-economic and environmental factors. Therefore, it would be unwise to compare Indian fetal abdominal growth with western standards. A statistical significant positive correlation was found between HL and GA ($r = 0.9704$) indicating it to be reliable predictor of GA. Mean error in predicting GA with HL was only 0.71 week indicating it to be a very accurate parameter. The accuracy of HL was

found to be 82% in predicting GA. Hence, it is a reliable indicator of GA.

The accuracy of various parameters was compared:

- BPD - 80%
- HC - 75%
- FL - 86%
- HL - 82%

It was found that HL was most accurate parameter next to FL in assessing GA.

In condition that may alter shape of fetal skull as well as when abnormality of the BPD and HC is suspected, such as hydrocephalous, anencephaly, breech presentation, multiple gestations, and uterine anomalies. HL can be used as a reliable alternative parameter for estimating GA. In case of preterm labor, in which assessment of several growth parameters help to better approximate GA more accurately, the addition of fetal humerus single length measurement may aid in crucial management decisions. The study also indicates that combination of BPD, HC, AC, FL, HL is more accurate in predicting GA than any single parameter, particularly in the third trimester of pregnancy. HL would contribute to maximum accuracy next to FL amongst all the parameters. It is hoped that sonologists would take up HL also in practice as a parameter for assessing GA in future.

REFERENCES

1. Andersen HF, Johnson TR Jr, Barclay ML, Flora JD Jr. Gestational age assessment. I. analysis of individual clinical observations. Am J Obstet Gynecol 1981;139:173-7.
2. Beazley JM, Underhill RA. Fallacy of the fundal height. Br Med J 1970;4:404-6.
3. Buckshee K, Arora V, Hingorani V. Evaluation of fetal development by real time sonar cephalometry in Indian pregnant women. India J Obstet Gynaecol 1983;33:284.
4. Campbell S. An improved method of fetal cephalometry by ultrasound. J Obstet Gynaecol Br Commonw 1968;75:568-76.
5. Campbell S. The prediction of fetal maturity by ultrasonic measurement of the biparietal diameter. J Obstet Gynaecol Br Commonw 1969;76:603-9.
6. Sabbagha RE, Turner JH, Rockette H, Mazer J, Orgill J. Sonar BPD and fetal age. Definition of the relationship. Obstet Gynecol 1974;43:7-14.
7. Kurtz AB, Wapner RJ, Kurtz RJ, Dershaw DD, Rubin CS, Cole-Beuglet C, *et al.* Analysis of biparietal diameter as an accurate indicator of gestational age. J Clin Ultrasound 1980;8:319-26.
8. Sabbagha RE, Hughey M. Standardization of sonar cephalometry and gestational age. Obstet Gynecol 1978;52:402-6.
9. O'Brien GD, Queenan JT. Growth of the ultrasound fetal femur length during normal pregnancy. Part I. Am J Obstet Gynecol 1981;141:833-7.
10. Hohler CW, Quetel TA. Fetal femur length: Equations for computer calculation of gestational age from ultrasound measurements. Am J Obstet Gynecol 1982;143:479-81.
11. Yeh MN, Bracero L, Reilly KB, Murtha L, Aboulafia M, Barron BA. Ultrasonic measurement of the femur length as an index of fetal gestational age. Am J Obstet Gynecol 1982;144:519-22.
12. Hadlock FP, Harrist RB, Deter RL, Park SK. Fetal femur length as a predictor of menstrual age: Sonographically measured. AJR Am J Roentgenol 1982;138:875-8.
13. Tamura RK, Sabbagha RE. Percentile ranks of sonar fetal abdominal circumference measurements. Am J Obstet Gynecol 1980;138:475-9.
14. Deter RL, Harrist RB, Hadlock FP, Carpenter RJ. The use of ultrasound in the assessment of normal fetal growth: A review. J Clin Ultrasound 1981;9:481-93.
15. Hadlock FP, Deter RL, Harrist RB, Park SK. Fetal abdominal circumference as a predictor of menstrual age. AJR Am J Roentgenol 1982;139:367-70.
16. Hoffbauer H, Pachaly J, Arabin B, Baumann ML. Control of fetal development with multiple ultrasonic body measures. Contrib Gynecol Obstet 1979;6:147-56.
17. Meire HB, Farrant P. Ultrasound demonstration of an unusual fetal growth pattern in indians. Br J Obstet Gynaecol 1981;88:260-3.
18. Hadlock FP, Deter RL, Carpenter RJ, Park SK. Estimating fetal age: Effect of head shape on BPD. AJR Am J Roentgenol 1981;137:83-5.
19. Ott WJ. The use of ultrasonic fetal head circumference for predicting expected date of confinement. J Clin Ultrasound 1984;12:411-5.
20. Deter RL, Harrist RB, Hadlock FP, Carpenter RJ. Fetal head and abdominal circumferences: II. A critical re-evaluation of the relationship to menstrual age. J Clin Ultrasound 1982;10:365-72.
21. Jeanty P. Fetal limb biometry. Radiology 1983;147:601-2.
22. Tahmasebpour AR, Pirjani R, Rahimi-Foroushani A, Ghaffari SR, Rahimi-Sharbaf F, Masrour FF Normal ranges for fetal femur and humerus diaphysis length during the second trimester in an Iranian population. J Ultrasound Med 2012;31:991-5.
23. Zelop CM, Borgida AF, Egan JF. Variation of fetal humeral length in second-trimester fetuses according to race and ethnicity. J Ultrasound Med 2003;22:691-3.

How to cite this article: Patre V, Aryan AK, Sahu P, Patre V. Ultrasonographic Evaluation of Fetal Humerus Length for Assessment of Gestational Age and Its Comparison with Other Conventional Parameters. Int J Sci Stud 2015;3(7):58-64.

Source of Support: Nil, **Conflict of Interest:** None declared.