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Correlation between the Fetal Anthropometry and Gestational Age of the Aborted Fetuses at Different Weeks of Gestation

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ABSTRACT

Background: Determination of correct Gestational age (GA) is a fundamental to obstetric care and is important at autopsy as well as for clinical assessment of growth of the fetus. Various fetal parameters like fetal anthropometry used for calculation of GA. The aim of the present study was to study correlation between the fetal anthropometric measurements like Crown-Rump length (CRL), Femur length (FL), Head Circumference (HC), Bi-Parietal diameter (BPD) and Abdominal Circumference (AC) and Gestational age to derive regression equations for the same.

Methods: This cross-sectional hospital based observational study conducted at KAMS&RC, Hyderabad; TS involved 77 aborted fetuses without congenital anomalies, aged between 12 to 40 weeks of gestational age. As per the standard protocol, the fetal measurements documented. Regression equations are derived for the anthropometric measurements.

Results: I the present study the correlation coefficients of the equation are 0.937,0.984,0.982,0.987,0.991 and 0992 respectively for birth weight, HC,CRL,BPD,FL and AC. Gestation exhibits a very strong positive correlation with all other parameters, with correlation values ranging from 0.94 to 0.99, all of which are statistically significant at $p<0.001$.

Conclusion: In conclusion, all the fetal parameters are positively correlated with gestational age. Among them, FL and AC have the highest correlation, making them the most predictive for gestational age.

Key words: Gestational age (GA), Crown-Rump length (CRL), Foot length (FL), Head Circumference (HC), Bi-parietal diameter (BPD) and Abdominal Circumference (AC).

INTRODUCTION:

Anthropometry' is quantitative assessments of human body size and are used to assess the nutritional status of humans (WHO)[1].Fetal anthropometry is a simple and non-invasive approach to evaluate and monitor fetal development and assess the nutritional state of a developing fetus[2].

The gestational age of the fetus can be calculated by using women`s last menstrual period, ultrasonography and fetal anthropometric parameters .The knowledge of gestational age and calculating an accurate expected date of delivery (EDD) is crucial for planning proper antenatal care and to improve the overall outcome[3]. GA estimation is also a prime requisite at fetal autopsy specially, in situations of criminal abortion, alleged infanticide, and in medical termination of pregnancy (MTP).

Various fetal anthropometric parameters are used to calculate the GA. The commonly used parameters for the estimation of GA are head circumference (HC), abdominal circumference (AC), crown-rump length (CRL), femur length (FL) and head circumference (HC) and Bi-parietal diameter(BPD)[4,5,6].

By using fetal anthropometric measurements, most obstetricians estimate of foetal well-being and used it for the early identification and clinical management of intra-uterine growth restriction (IUGR)[7]. In this study, we have assessed the accuracy of fetal measurements like HC, AC, CRL, BPD and FL of the aborted fetuses at different weeks of gestation.

AIM OF THE STUDY:

To study the Correlation between fetal anthropometric measurements and gestational age of the aborted fetuses at different weeks of gestation

OBJECTIVES

1. To measure the fetal anthropometric measurements like fetal weight, Crown-Rump length (CRL), , Head Circumference (HC), Bi-parietal diameter (BPD),Femur length (FL) and Abdominal Circumference (AC) for calculation of GA

2. To assess the accuracy of fetal measurements for estimation of GA
3. To derive regression equations for the same.

MATERIALS & METHODS

Study Design & Duration of Study

This observational hospital based cross-sectional study conducted at Kamineni Academy of Medical Sciences & Research Centre (KAMS&RC), Hyderabad, TS. Ethical clearance was obtained from the institutional ethics committee to perform autopsies and to conduct additional studies. The study was carried out over a period of three years, from 2020 to 2022.

Sample size

This study involved 77 aborted fetuses aged between 12 to 40 weeks of gestational age. The fetuses were obtained from the department of Obstetrics & Gynecology (OBG) after experiencing inevitable abortion,spontaneous miscarriage, stillbirth, or medical termination of pregnancy (MTP) for contraception failure/unwanted pregnancy. Prior to participation, informed consent was obtained from the parents and/or legal guardians.

Inclusion Criteria

- The study included aborted normal fetuses with a gestational age (GA) between 12 to 40 weeks.

Exclusion Criteria

- Fetuses with gross congenital anomaly.
- Macerated fetuses.
- Maternal history of infections such as TORCH, HIV.
- Mothers below 18 years of age.

Methodology

The study samples were categorized into seven groups according to their gestational and fetuses of each age group were studied, as shown in table-1.Fetuses were collected in 10% formalin immediately after still birth or abortion or medical termination of pregnancy. The demographic parameters of fetuses like as gender, weight and gestational age were recorded. Weight in grams was recorded with the help of electronic weighing machine.

Morphometric measurements of fetuses were measured by nylon thread as per autopsy protocol as illustrated in table-2

By placing the fetus in supine position, distance between the crown of the head to highest point on the trunk corresponds to crown rump length (CRL).Head circumference (HC) is measured from glabella to the most prominent point posteriorly; abdominal circumference (AC) was recorded at the level of umbilicus.

All the parameters and their means were calculated and recorded in centimeters to the nearest 0.1 decimal as per the standard protocol. All the statistical analysis is done in Python 3.11.4 version and for simple and multiple linear regression scikit-learn version 1.3.0 are used.

RESULTS

The present study compromised of seventy seven (77) aborted normal fetuses, ranging in gestational age from 12 to 40 weeks.Even though our sample size is less, we had representation from all the fetal ages except 13, 15, 24, 30 and 37 weeks. The fetuses were grouped based on both gestational age and gender. Out of the 77 fetuses, 43 were male, and 34 were female (Table-1). The highest number of study samples was observed in fetuses with a gestational age of 21 and 23 weeks, with 5 cases each. On the otherhand, there was only one case each in gestational ages 19, 25, 35, and 39 weeks.

Table -1: Distribution of Fetuses as per Gestational Age and gender

Groups	GA in weeks	No of Fetuses	Lung Specimens Male:	Lung Specimens Female:
I	12-16	8	05	03
II	17-20	13	08	05
III	21-24	13	08	05
IV	25-28	13	07	06
V	29-32	09	05	04
VI	33-36	14	06	08

VII	37-40	7	4	3
Total 7		77	43	34

According to data collected from the department of obstetrics and gynecology in the present study, we observed following comorbidities. Abruption placenta in 2 cases ,hyperemesis gravidarum in 3 cases ,septate or bi-cornuate uterus in one case ,scar rupture in 4 cases, severe anemia in 8 cases, anhydramnios in 5 cases, gestational DM in 6 cases, hypothyroidism in 3 cases, pre-eclampsia in 4 cases and one case of polyhydramnios.

The distribution of maternal age in the sample ranged from 20 to 36 years, with a mean age of 26.753 years. Most mothers were 26 years old, with a slight positive skewness indicating a distribution leaning towards younger mothers. Gestation period varied between 12 and 40 weeks, with a mean of 26.169 weeks and a median of 26 weeks. The mode for gestation stood out at 21 weeks, and the distribution was nearly symmetric with a slight negative kurtosis.

The range of fetal weight in the study extended from a mere 22.0 grams to 3750.0 grams, with an average weight of 1208.455 grams. The data for fetal weight showcased a positive skewness, indicating a higher frequency of lower weights in the sample. Head circumference (HC) measurements ranged from 66.0 to 350.0 mm, with an average of 235.094 mm. The mode, at 329 mm, suggests a relatively frequent larger head circumference, and the distribution showed a mild negative skewness.

Crown-rump length (CRL) varied from 52.0 to 438.0 mm across the sample, averaging at 226.421 mm. The distribution for CRL showed a slight positive skewness. BPD (Bi-parietal diameter) measurements ranged between 18.0 and 96.5 mm, with the average being 63.245 mm. Both FL (Femur length) and BPD distributions demonstrated a negative skewness and kurtosis, indicating a peakier and left-leaning distribution. The former ranged from 11.0 to 74.0 mm with an average of 46.161 mm, and the latter, as mentioned earlier.

Lastly, the abdominal circumference of the fetuses in the study varied between 48.0 and 378.0 mm, with a mean measurement of 215.89 mm. The distribution for abdominal circumference was the most symmetric among all variables, with minimal skewness and kurtosis close to that of a normal distribution.

Table 2: Showing the range of fetal anthropometric measurements and their mean as per GA

GA in Weeks	No of Fetuses	Range of Birth Wt.	Range of CRL in mm	Range of HC in mm	Range of BPD in mm	Range of FL	Range of AC
12	3	22-61.5	52-58.5	66-69.5	18-21.5	11-12	48-64
14	3	105-118	74-76	102-110	28-29.5	15-17	88-92
16	2	120-145	96-105	129-132	32-34	19-21	105-109
17	4	160.5-190	94-124	130-136	32-38	21-24	111-121
18	4	240-265.5	127-130	152-155	39.5-41.5	27-29	130-138
19	1	250	124	150	39.5	27	128
20	4	255-370	140.5-149.5	162-188	44-50	29.5-34	153-161
21	5	250-445	144-164	187-195	50-52.5	34-38	152-173
22	3	315-590	172-196.5	194-210	52.5-55	37.5-40	169-187
23	5	330-650	158-195	194-222	52.5-58	38-42	172-194
25	1	414	191	186.2	54	41	185
26	4	680-810	197.5-210	250.5-253.5	68-70	47-49	217-229
27	4	710-1050	201-222	245.5-261	66-71	46-52	213-228
28	4	840-1210	220-258	260-271	67-72	49-52.5	224-238
29	4	1050-1400	258-268.2	275-281	73.5-75	50-54	232-254
31	2	1750-1815	293-295	290-292	78-79	59	271-273

32	3	1250-2250	284.5-315	289.5-302	78.482.2	58-54.4	266-299
33	2	1950-2350	315-321	290-310	80.5-85	61-65.5	275-302
34	4	2050-2450	317-325	292-320	82-86	65-67.5	294-310
35	1	2230-2720	361-366	320-326.5	86-89	65-68	298-320
36	4	2950-3100	280-379	327-330	88-91	67-70	309-328
38	4	2240-3750	385-415	329-344	87-91	68-74	311-340
39	1	2500	380	330	89	69	323
40	2	3550-3750	421-438	347-350	94.596.5	73-74	365-378

Linear Regression Analysis for Various Parameters:

In the evaluation of the relationship between various fetal parameters and gestational age, a simple linear regression analysis was conducted. The results have been summarized in the table-3 below:

Table-3: showing the Simple Linear Regression Summary

Parameter	**Coefficient**	**Intercept**	**R**	**R^2**	**SEE**
Fetal Weight	0.007	18.008	0.937	0.877	2.718
HC	0.098	3.117	0.984	0.968	1.381
CRL	0.074	9.335	0.982	0.964	1.471
BPD	0.36	3.398	0.987	0.974	1.24
FL	0.426	6.496	0.991	0.982	1.037
AC	0.093	6.104	0.992	0.984	0.967

The parameters showcased in the table above are significant predictors of gestational age. Here's a brief overview:

1. **Fetal Weight:** For every unit increase in fetal weight, the gestational age increases by 0.007 weeks, with a starting intercept of 18.008 weeks. The correlation coefficient *R* is 0.937, indicating a strong positive relationship. The R^2 value of 0.877 suggests that 87.7% of the variability in gestational age can be explained by fetal weight. The standard error of estimate (SEE) for this parameter is 2.718.

2. **HC (Head Circumference):** The HC showed a strong positive correlation with gestational age, with an *R* value of 0.984. The R^2 value of 0.968 means that approximately 96.8% of the variation in gestational age can be attributed to changes in HC.

3. **CRL (Crown-Rump Length):** The CRL also has a high correlation with gestational age, as indicated by its *R* value of 0.982. Approximately 96.4% of the variation in gestational age can be explained by CRL.

4. **BPD (Biparietal Diameter):** BPD exhibits a strong correlation with gestational age, with an *R* value of 0.987, indicating that about 97.4% of the variation in gestational age can be attributed to BPD.

5. **FL (Femur Length):** FL has the highest correlation coefficient (*R* value of 0.991) among the parameters, implying that it has a very strong association with gestational age.

6. **AC (Abdominal Circumference):** AC also displays a high correlation with gestational age, with an *R* value of 0.992. This suggests that AC is a significant predictor of gestational age.

In conclusion, all the fetal parameters are positively correlated with gestational age. Among them, FL and AC have the highest correlation, making them the most predictive for GA.

Correlation Analysis among Fetal Parameters and Gestation Age:

Correlation analysis was performed to determine the strength and direction of the linear relationships between fetal parameters and gestation age. The results are summarized in the provided table, which displays the Pearson correlation coefficients and their significance levels.(table:4)

Table -4 :Showing the Correlation Analysis among Fetal Parameters and GA

	Gestation	**Fetal Weight**	**HC**	**CRL**	**BPD**	**FL**	**AC**
Gestation	1	0.94	0.98	0.98	0.99	0.99	0.99
		(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)
	0.94	1	0.9	0.95	0.91	0.92	0.94

Fetal Weight	(<0.001)		(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)
HC	0.98	0.9	1	0.96	1	0.99	0.99
	(<0.001)	(<0.001)		(<0.001)	(<0.001)	(<0.001)	(<0.001)
CRL	0.98	0.95	0.96	1	0.96	0.97	0.98
	(<0.001)	(<0.001)	(<0.001)		(<0.001)	(<0.001)	(<0.001)
BPD	0.99	0.91	1	0.96	1	1	0.99
	(<0.001)	(<0.001)	(<0.001)	(<0.001)		(<0.001)	(<0.001)
FL	0.99	0.92	0.99	0.97	1	1	1
	(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)		(<0.001)
AC	0.99	0.94	0.99	0.98	0.99	1	1
	(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)	

DISCUSSION

GA estimation is an essential step for management of pregnancy .In the present study, we have analyzed the accuracy six parameters like head circumference (HC), Bi-parietal diameter (BPD), fetal weight, crown-rump length (CRL), abdominal circumference (AC)and femur length (FL) for calculation of GA. Regression formulas for all the six were also given and our findings are in conclusion with the literature[8].

Gestation exhibits a very strong positive correlation with all other parameters, with correlation values ranging from 0.94 to 0.99, all of which are statistically significant at $p<0.001$. This indicates that as gestation progresses, all other fetal parameters tend to increase proportionally.

Fetal Weight highly correlated with gestation (0.94) and all other parameters, with values ranging from 0.9 to 0.95, all statistically significant. HC (Head Circumference) presents an extremely high correlation with gestation (0.98) and other parameters, especially BPD and FL, where it shows a perfect correlation of 1.0. Similar findings were noted in a study by hadlock FPet al[9] and doubilet PM et al[10] .

CRL (Crown-Rump Length) is strongly correlated with gestation (0.98) and has high correlation values with all other parameters, ranging from 0.95 to 0.98. BPD (Bi-parietal Diameter) shows an almost perfect correlation with gestation (0.99) and exhibits a perfect correlation of 1.0 with HC and FL, indicating that these parameters increase in a fixed proportion to each other. Similar findings seen by Sahota DS[11]. FL (Femur Length) has a very

high correlation with gestation (0.99) and shows a perfect correlation of 1.0 with HC, BPD, and AC, implying a direct proportionality in their rates of increase, which correlated with O Brien[12]. AC (Abdominal Circumference) demonstrates an extremely high correlation with gestation (0.99) and a perfect correlation of 1.0 with FL, indicating a consistent linear relationship between them similar to Hadlock FP et al[13].

For calculating the gestational age and predicting EDD during the first trimester of pregnancy, Crown-rump length (CRL) is considered ideal[14]. Hadlock et al[6] concluded that CRL is the better marker for GA. However, with advancing gestational age due to excessive curvature of the fetus and the variable position of the fetus, its accuracy drops owing to the difficulty in measuring the complete length of the fetus. In the second and third trimesters, remaining fetal measurements have been commonly used to assess the gestational age[15].

Measuring estimated fetal weight (EFW) can be more helpful when compared to above-mentioned parameters for the assessment of adequate fetal growth[16]. We observed that when measured separately FL and AC have the highest correlation, making them the most reliable predictive for the assessment of fetal growth.

The present study further revealed that low maternal hemoglobin levels during pregnancy were associated with low birth weight and other parameters were less in the anemic group, which correlated with midekso ento et al and berrin telatar et al[17]. We also noticed that maternal hypothyroidism before and during the pregnancy were associated with low anthropometric parameter measurements, which correlated with Maria Teresa murillo-llorentr et al and tripti saxena et al[18].

CONCLUSION

Fetal anthropometric measurements can play an important role in the calculation of fetal age anthropometric measurements can play an important role. Better results are possible if more than one parameters are used for estimation of GA.

In summary, the correlation table reveals strong positive relationships between gestational age and all fetal parameters. Particularly, HC, BPD, FL, and AC exhibit near-perfect correlations with each other, suggesting that they increase in tandem as gestation progresses. In this study crown rump length directly correlates with the gestational age in first trimester of pregnancy.

FL and AC have the highest correlation, making them the most predictive for gestational age in second and third trimester.

In the present study maternal comorbidities like severe anemia, hypothyroidism and gestational-HTN during pregnancy negatively affected the anthropometric parameters of the fetuses except gestational-DM. By correcting maternal anemia and early identification of pregnancies at risk for preeclampsia, we can reduce the number of SGA births. Fetal anomaly scans can be used for early recognition and interventions in pregnancies with anemia, hypothyroidism, hypertensive and GDM-

Limitations

More studies can be done on various other external fetal measurements on a large number of sample size

Author's contribution

Conceptualization, design of the study & supervision: Dr. N. Vishali and Dr. L. Peter.
Dr. Himabindhu: Methodology for autopsy & fetal anthropometry and writing-original draft:
S.Savitha: conducted research, collected the data and analyzed the data
Dr.B.Swapna Kumari: interpreted the data, Writing-review, editing and approval of final manuscript by all authors.

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Conflict of interests: None

Future Recommendation

We have also planned to look into the immunohistochemistry (expression of FGF-10; the factor for onset of branching morphogenesis) and special stains (Masson's Trichrome staining) in the above aborted fetal lung specimens.

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