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RESEARCH ARTICLE

THE EFFICACY OF CROWN RUMP LENGTH MEASUREMENT BY ULTRASOUND IN ESTIMATING THE GESTATIONAL AGE

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ABSTRACT

Objective: This research aimed to determine the efficacy of Crown Rump Length (CRL) by ultrasound in estimating the Gestational Age (GA) compared to GA by Naegele's rule using Last menstrual period (LMP) date.

Materials and Methods: This was a prospective observational study of women with a normal spontaneously conceived viable singleton pregnancy, a regular menstrual cycles, andspontaneous onset of labor at term. The LMP was considered certain in all cases. We used ultrasound to scan 2067 fetuses (894 healthy women) and we had 500CRL measurements. Data were collected prospectively and used for statistical analysis. We used Descriptive Statistics to calculate the Mean, Standard Deviation (SD), Median and Percentiles values (3rd, 5th, 10th, 50th, 90th, 95th, and 97th) for CRL measurements on gestational age. We found a regression equation to estimate the GA using CRL measurements. The results of the current study were compared with different studies using the Paired Differences (t-test analysis). The results were represented as tables & diagrams.

Results: The best-fit equation for the estimate of GA $\hat{Y}_i$ from CRL (in mm) was: $\hat{Y}_i = 6.254 + 0.151\,(CRL)_i - 9.5*10^{-4}(CRL)_i^2 + 4.12*10^{-6}(CRL)_i^3$

The Mean Sum of Squares of regression deviations of the GA regression model using (CRL) was 1546.8and this value is significant at P <0.001. The standard error of the Estimate (Std.Error)was 0.67 and the standard deviation (SD)was (0.65, 0.71, 0.69) weeks when the GA were (≤12, 12-18, 18-22), respectively.

Conclusion: In this study, we presented diagrams and tables for the estimation of GA using CRL measurements in a group of pregnant Syrian women. These results can be useful in women who cannot recall their last menstrual period (LMP). Our criteria will provide useful references for estimating gestational age and fetal care. A larger study might be needed to include a larger sample of the population.

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INTRODUCTION

Monitoring fetal growth and assessing the growth predictors has an important role in the care of pregnant women. Accurate estimation of GA gestational age and Fetal Weight (FW) are clinically important. Ultrasound is useful as an accurate method for estimating Gestational Age (GA). Different embryonic measurements can be used to date pregnancy. Accurate estimation of GA is important in for normal and pathological pregnancies management (National Collaborating Centre for Women's and Children's Health, 2008; Wu *et al*., 2015; Ana, 2015).

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We used CRL to predict the GA in pregnant women reviewing ALZAHRAWI Hospital. Up to our Knowledge, this study is the first of its kind in Syria.

MATERIALS AND METHODS

- Study design: This study is a prospective descriptive longitudinal population study.
- Setting: ALTAWLID UniversityHospital- Damascus, Syria
- Description of populations and variables: All the participants were pregnant women representing a specific geographic region from Damascus and its suburbs, who reviewed the hospital either to confirm

pregnancy or for following up. 51% (455/894) of all participants were between 22-30 years old and most of them were housewives of a low socioeconomic status.

Inclusion criteria

- voluntary participation with informed consent.
- A correct, accurate and reliable patient's knowledge of the first day of the LMP.
- Regular menstrual cycles (at least three previous regular menses).
- Singular alive normal fetus with a gestational age between 13-41 weeks. [3].
- Spontaneous labor by full term pregnancy (259-293 days/37-41 weeks).

Exclusion criteria: Women who have one of the following

- Uncertainty of the LMP date.
- Irregular menstrual cycles.
- Multigestation or fetal demise.
- Oral contraceptive use (OCP) or any recent hormonal treatment (3-4 months) before current pregnancy.
- Pregnancy during lactation.
- History of previous abortion or recent delivery preceding the current pregnancy.
- Diagnosis of fetal malformations during examination or after birth.
- Presence of any medical or obstetric complication with known effect on fetal growth.
- Smoking or drug addiction.

Table 1. Growth chart of the CRLmeasurements (mm) showing the Percentile Values and Standard deviation (SD) between6-20 weeks of pregnancy

GA (weeks)	Standard deviation (SD)	CRL (mm) Percentiles						
		%3	%5	%10	%50	%90	%95	%97
6	2.12	3.51	4.01	4.78	7.50	10.22	10.99	11.49
7	3.23	3.77	4.53	5.71	9.85	14.00	15.17	15.94
8	4.05	6.43	7.38	8.85	14.04	19.23	20.70	21.66
9	5.41	9.35	10.63	12.59	19.52	26.44	28.41	29.68
10	6.20	17.28	18.74	20.99	28.94	36.89	39.14	40.61
11	7.15	24.42	26.11	28.70	37.86	47.02	49.62	51.31
12	7.94	36.04	37.92	40.80	50.98	61.15	64.04	65.91
13	6.96	50.95	52.59	55.12	64.04	72.95	75.48	77.12
14	8.05	59.91	61.81	64.73	75.04	85.36	88.28	90.18
15	10.91	65.07	67.65	71.61	85.60	99.59	103.55	106.13
16	9.16	80.65	82.81	86.14	97.88	109.62	112.95	115.11
17	4.77	94.03	95.15	96.89	103.00	109.11	110.85	111.97
18	9.19	103.21	105.38	108.72	120.50	132.28	135.62	137.79
19	0.35	130.59	130.67	130.80	131.25	131.70	131.83	131.91
20	2.55	130.91	131.51	132.44	135.70	138.96	139.89	140.49

Table 2: Expected GA (weeks) using the CRL measurements (mm) and the lower and upper limits of both the 95% Prediction Limits and the 95% Confidence Limits based on the regression model

95%Confidence Limits		95% Prediction Limits		$\dot{Y}_i$	X_i
Upper Limit	Lower Limit	Upper Limit	Lower Limit	GA(weeks)	CRL(mm)
7.4	7.1	8.6	5.9	7.3	7
7.5	7.3	8.7	6.1	7.4	8
7.7	7.4	8.9	6.2	7.5	9
7.8	7.6	9.0	6.3	7.7	10
7.9	7.7	9.1	6.5	7.8	11
8.0	7.8	9.3	6.6	7.9	12
8.2	8.0	9.4	6.7	8.1	13
8.3	8.1	9.5	6.9	8.2	14
8.4	8.2	9.6	7.0	8.3	15
8.5	8.4	9.8	7.1	8.4	16
8.6	8.5	9.9	7.2	8.6	17
8.8	8.6	10.0	7.4	8.7	18
8.9	8.7	10.1	7.5	8.8	19
9.0	8.8	10.3	7.6	8.9	20
9.1	9.0	10.4	7.7	9.0	21
9.2	9.1	10.5	7.8	9.2	22
9.4	9.2	10.6	7.9	9.3	23
9.5	9.3	10.7	8.1	9.4	24
9.6	9.4	10.8	8.2	9.5	25
9.7	9.5	10.9	8.3	9.6	26
9.8	9.6	11.0	8.4	9.7	27
9.9	9.7	11.2	8.5	9.8	28
10.0	9.8	11.3	8.6	9.9	29
10.1	9.9	11.4	8.7	10.0	30
10.2	10.0	11.5	8.8	10.1	31
10.3	10.1	11.6	8.9	10.2	32
10.5	10.2	11.7	9.0	10.3	33
10.6	10.3	11.8	9.1	10.4	34
10.7	10.4	11.9	9.2	10.5	35
10.8	10.5	12.0	9.3	10.6	36
10.9	10.6	12.1	9.4	10.7	37

Continue ……

11.0	10.7	12.2	9.5	10.8	38
11.0	10.8	12.3	9.6	10.9	39
11.1	10.9	12.4	9.7	11.0	40
11.2	11.0	12.5	9.8	11.1	41
11.3	11.1	12.6	9.9	11.2	42
11.4	11.2	12.6	10.0	11.3	43
11.5	11.3	12.7	10.1	11.4	44
11.6	11.4	12.8	10.2	11.5	45
11.7	11.5	12.9	10.3	11.6	46
11.8	11.6	13.0	10.3	11.7	47
11.9	11.7	13.1	10.4	11.8	48
12.0	11.7	13.2	10.5	11.9	49
12.0	11.8	13.3	10.6	11.9	50
12.1	11.9	13.4	10.7	12.0	51
12.2	12.0	13.4	10.8	12.1	52
12.3	12.1	13.5	10.9	12.2	53
12.4	12.2	13.6	10.9	12.3	54
12.5	12.3	13.7	11.0	12.4	55
12.5	12.3	13.8	11.1	12.4	56
12.6	12.4	13.9	11.2	12.5	57
12.7	12.5	13.9	11.3	12.6	58
12.8	12.6	14.0	11.4	12.7	59
12.9	12.7	14.1	11.4	12.8	60
13.0	12.8	14.2	11.5	12.9	61
13.0	12.8	14.3	11.6	12.9	62
13.1	12.9	14.4	11.7	13.0	63
13.2	13.0	14.4	11.8	13.1	64
13.3	13.1	14.5	11.9	13.2	65
13.4	13.2	14.6	11.9	13.3	66
13.4	13.2	14.7	12.0	13.3	67
13.5	13.3	14.7	12.1	13.4	68
13.6	13.4	14.8	12.2	13.5	69
13.7	13.5	14.9	12.2	13.6	70
13.8	13.6	15.0	12.3	13.7	71
13.8	13.6	15.1	12.4	13.7	72
13.9	13.7	15.1	12.5	13.8	73
14.0	13.8	15.2	12.6	13.9	74
14.1	13.9	15.3	12.6	14.0	75
14.1	13.9	15.4	12.7	14.0	76
14.2	14.0	15.5	12.8	14.1	77
14.3	14.1	15.5	12.9	14.2	78
14.4	14.2	15.6	12.9	14.3	79
14.5	14.3	15.7	13.0	14.4	80
14.5	14.3	15.8	13.1	14.4	81
14.6	14.4	15.8	13.2	14.5	82
14.7	14.5	15.9	13.3	14.6	83
14.8	14.6	16.0	13.3	14.7	84
14.9	14.6	16.1	13.4	14.8	85
14.9	14.7	16.2	13.5	14.8	86
15.0	14.8	16.2	13.6	14.9	87
15.1	14.9	16.3	13.7	15.0	88
15.2	14.9	16.4	13.7	15.1	89
15.3	15.0	16.5	13.8	15.1	90
15.4	15.1	16.6	13.9	15.2	91
15.4	15.2	16.6	14.0	15.3	92
15.5	15.3	16.7	14.1	15.4	93
15.6	15.3	16.8	14.1	15.5	94
15.7	15.4	16.9	14.2	15.6	95
15.8	15.5	17.0	14.3	15.6	96
15.8	15.6	17.1	14.4	15.7	97
15.9	15.7	17.1	14.5	15.8	98
16.0	15.8	17.2	14.6	15.9	99
16.1	15.8	17.3	14.6	16.0	100
16.2	15.9	17.4	14.7	16.1	101
16.3	16.0	17.5	14.8	16.1	102
16.4	16.1	17.6	14.9	16.2	103
16.5	16.2	17.6	15.0	16.3	104
16.5	16.3	17.7	15.1	16.4	105
16.6	16.3	17.8	15.2	16.5	106
16.7	16.4	17.9	15.2	16.6	107
16.8	16.5	18.0	15.3	16.7	108
16.9	16.6	18.1	15.4	16.8	109
17.0	16.7	18.2	15.5	16.9	110
17.1	16.8	18.3	15.6	16.9	111
17.2	16.9	18.4	15.7	17.0	112
17.3	17.0	18.5	15.8	17.1	113
17.4	17.0	18.6	15.9	17.2	114
17.5	17.1	18.7	16.0	17.3	115

Continue…….

17.6	17.2	18.8	16.1	17.4	116
17.7	17.3	18.9	16.2	17.5	117
17.8	17.4	19.0	16.3	17.6	118
17.9	17.5	19.1	16.4	17.7	119
18.0	17.6	19.2	16.5	17.8	120
18.2	17.7	19.3	16.6	17.9	121
18.3	17.8	19.4	16.7	18.0	122
18.4	17.9	19.5	16.8	18.1	123
18.5	18.0	19.6	16.9	18.2	124
18.6	18.0	19.7	17.0	18.3	125
18.7	18.1	19.8	17.1	18.4	126
18.9	18.2	19.9	17.2	18.6	127
19.0	18.3	20.0	17.3	18.7	128
19.1	18.4	20.1	17.4	18.8	129
19.3	18.5	20.3	17.5	18.9	130
19.4	18.6	20.4	17.6	19.0	131
19.5	18.7	20.5	17.7	19.1	132
19.7	18.8	20.6	17.8	19.2	133
19.8	18.9	20.7	18.0	19.3	134
19.9	19.0	20.9	18.1	19.5	135
20.1	19.1	21.0	18.2	19.6	136
20.2	19.2	21.1	18.3	19.7	137
20.4	19.3	21.3	18.4	19.8	138
20.5	19.4	21.4	18.5	20.0	139
20.7	19.5	21.5	18.6	20.1	140

- CRL measures taken after week 41 of pregnancy.
- Pregnancies that ended in abortion preterm or postterm deliveries.
- Date of delivery (vaginal or cesarean section) is inaccurate.
- Malpositioned deliveries.

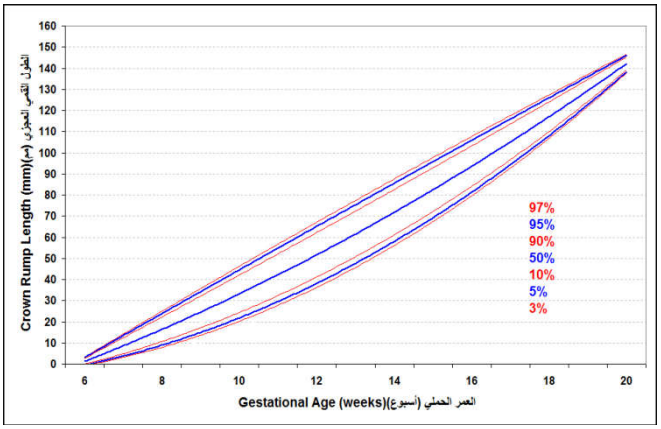

Figure 1: CRL growth chart showing the fitted Percentile Values (3^{rd},5^{th},10^{th},50^{th},90^{th},95^{th},97^{th}) of the CRL and GA

Ultrasound examination

An ultrasound examination was made for 894 pregnant women (2067 fetuses) who were selected according to the previously explained inclusion and exclusion criteria and reviewed the hospital between March2017 and November 2017 to determine gestational age by measuring different fetal parameters (in this study CRL). We had 500CRL measurements.

Statistical Analysis Methods

The regression model of the CRL was used to determine the GA and in order to choose the best regression model we used the: 1- Coefficient of Determination (r^2) and the adjusted Coefficient of Determination ($\overline{r^2}$) and chose the one with the higher value. 2- The standard error (Std.Error) of both methods and chose the one least value. 3- Durbin–Watson Test and chose the one that gives a value close to the Std. Error. 4- The significance of regression model by doing an analysis of variance. 5- The significance of the regression model constants' (parameters) using T test. 6- Estimating the SD of the GA using the CRL regression model. Paired – Samples T-TEST were done to test each method accuracy.

RESULTS

Table 3. Standard Deviation (SD) of estimated the GA (weeks)

Standard Deviation	GA (weeks)
0.65	12 ≥
0.71	18 – 12
0.69	22 – 18

Table 4 Comparison between our study and reference studies

Sig.	Correlation	N	Comparison
0.000	0.995	8	Present Study & Robinson.[6]
0.000	0.999	6	Present Study & Drumm *et al*.[8]
0.000	0.995	6	Present Study & MacGregor etal.[7,8]
0.000	0.997	6	Present Study & Robinson and Fleming.[8]
0.000	0.996	7	Present Study & Baltzer FR, *et al*.[4]
0.000	0.998	15	Present Study & Hansman.[5]

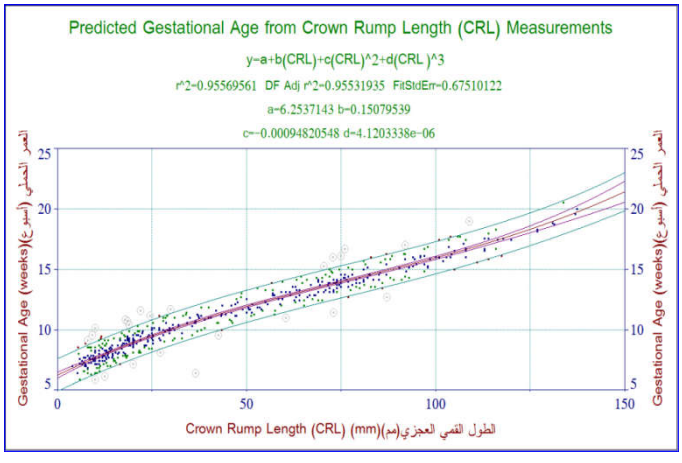

Figure 2. Predicted GA (weeks) using CRLmeasurements (mm) Each point represents one fetus result

Table 5. Comparison of Paired Differences between our study and reference studies about predicting the GA (weeks) using CRL (mm)

Statistical Significance	Sig	df	t	Paired Differences					Comparison
				95% Confidence Interval of the Difference		Std.Error Mean	Std. Deviation	Mean	
				Upper	Lower				
Yes	0.002	7	4.71	2.61-	7.87-	1.11	3.15	5.24-	Present Study & Robinson (Gestational Age Calculation).
Yes	0.001	5	6.60	2.00-	4.54-	0.50	1.21	3.27-	Present Study & Drumm *et al*. (1987)
No	0.359	5	1.01	1.19	2.73-	0.76	1.87	0.77-	Present Study & Mac Gregor *et al* (MacGregor, 2008; MacGregor, 1987)
Yes	0.009	5	4.17	1.36-	5.74-	0.85	2.09	3.55-	Present Study & Robinson and Fleming (MacGregor, 1987).
No	0.131	6	1.75	0.73	4.38-	1.04	2.76	1.82-	Present Study & Baltzer *et al*. (1983)[4]
No	0.064	14	2.01	0.12	3.63-	0.87	3.38	1.75-	Present Study & Hansman (?)

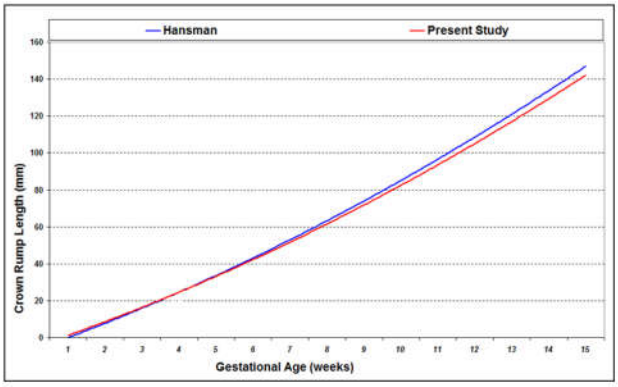

Figure 3: Comparison between GA using CRL in our study (red line) and the GA using CRL in reference study (Hansman[5]) (blue line)

DISCUSSION

The Embryonic Parameters have several applications in clinical practice such as estimating the gestational age, fetal weight, and fetal growth. In this study, we presented Growth Charts & Tables with the (3rd, 5th, 10th, 50th, 90th, 95th, and 97th) Percentile Values and the standard deviation of CRL during the concordant pregnancy periods. We set a regression model equation that can be used to estimate the expected GA using CRL measurements (mm). This equation was statistically significant (P <0.001). A strong correlation was found between the dependent variable (GA) and the independent variable (CRL). We presented charts and tables that can estimate the GA (weeks) using CRL measurements (mm). We found a third degree valuable regression equation (p<0.001) that we can use to get the expected GA from CRL measures (mm).

GA from CRL measures (mm):

$$\hat{Y}_i = 6.254 + 0.151\,(CRL)_i - 9.5\cdot10^{-4}(CRL)^2 + 4.12\cdot10^{-6}(CRL)^3$$

$\bar{r}^2$ =0.96 Std. Err =0.67 Sig=0.000

The Adjusted Coefficient of Determination $(\bar{r})^2$ of the regression model of GA (weeks) using CRL measurements (mm) was 0.96. The coefficient of determination is greater than 0.75 (75%), therefore, the correlation between the dependent variable Y line (GA) and the independent variable X line (CRL) is very strong (Figure 2).

The Mean Sum of Squares of regression deviations of the GA regression modelusing (CRL) was 1546.8and this value is significant at P <0.001. The standard error of the Estimate (Std.Error) for the GA regression model (using CRL measurements) was 0.67(Figure 2). This value represents the effect of many factors that were not included in the regression model which affect the dependent variable Y line (GA) (Figure 2). Figure 2 shows the expected GA (weeks) usingCRL measurements (mm). Based on the regression model, we also demonstrated the expected GA, the lower and upper limits of the confidence interval (Table 2). The standard deviation (SD) of estimated the GA (weeks) from the actual GA using CRL measurements (mm) was 0.65 weeks when the GA is <12 weeks, 0.71 weeks when the GA is between 12-18 years and 0.69weeks when the GA is between 18-22 years (Table 3). We compared this study to similar studies such as Robinson, Drumm *et al*, Mac Gregor *et al*, Robinson and Fleming,Baltzer FR *et al*, and Hansman. We compared the correlation coefficient, the mean, standard deviation, standard Error, lower and upper limits of the confidence interval (95% Confidence Interval of the Difference), the T value, the degree of freedom df, P value and Statistical Significance. The comparison results were: the correlation coefficients values were strong (0.995, 0.999,0.995,0.997, 0.996 and 0.998) and significant (0.000, 0.000,0.000,0.000, 0.000, 0.000) between this study and the compared studies (Robinson, Drumm *et al*, Mac Gregor *et al*, Robinson and Fleming, Baltzer FR *et al*, and Hansman), respectively (P <0.001) (Table 4). The mean difference in the CRL measurements (mm) using the Paired-Samples T-TEST between this study and the compared studies in the same order was -1.75, -1.82, -3.55, -0.77, -3.27, -5.24 mm, respectively according to GA (weeks). The negative values indicates that the values of the compared studies were higher. There is statistical significance (P <0.001) between the current study and the compared studies exceptMac Gregor *et al*,Baltzer FR *et al*, and Hansman (Table 5, Figure 3).

Conclusion

Many women do not recall their LMP and most pregnant women review the clinic in the first three months of pregnancy and the estimation of GA is important for the follow up and determining the Expected delivery date (EDD) for assessing growth during the rest of pregnancy and predicting the expected date of delivery (EDD). We presented diagrams and tables for the estimation of GA using CRL measurements in a group of pregnant Syrian women reviewing ALZAHRAWI Hospital according to the inclusion and exclusion criteria

stated before. These results can be useful in women who cannot recall their last menstrual period (LMP). Our criteria will provide useful references for estimating gestational age and fetal care. A larger study might be needed to include a larger sample of the population.We also compared our results with similar studies abroad, and we found that our results were lower than their counterparts were. These results could help in estimating the gestational age, diagnosing fetuses who are younger than their GA, and IUGR embryos. Thus, ultrasound may be more accurate and could replace LMP method.

Recommendations

- Emphasize the importance of doing a bigger more inclusive study to determine the accuracy of the fetal measurements in predicting the delivery date
- Using the CRL by ultrasound to determine the GA especially in women who cannot recall their LMP accurately.

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