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INNOVATE GESTATIONAL AGE ESTIMATION MODEL FOR IRAQI FETUSES BASED ON ULTRASOUND IMAGES MEASUREMENTS

Ahlam A. HUSSAIN[1], Ebtesam F. KANGER[2]

Abstract

Imaging by Ultrasound (US) is an accurate and useful modality for the assessment of gestational age (GA), estimation fetal weight, and monitoring the fetal growth during pregnancy, is a routine part of prenatal care, and that can greatly impact obstetric management. Estimation of GA is important in obstetric care, making appropriate management decisions requires accurate appraisal of GA. Accurate GA estimation may assist obstetricians in appropriately counseling women who are at risk of a preterm delivery about likely neonatal outcomes, and it is essential in the evaluation of the fetal growth and detection of intrauterine growth restriction. There are many formulas are used to estimate fetal GA in the world, but it's not specify for Iraqi population and leading to some error in GA estimation results, so the objective of this study is to innovate GA estimation model for Iraqi people. This study was performed in the department of Obstetrics and Gynecology in Al- Yarmouk Teaching Hospital and AL- Alawiya Teaching Hospital in Baghdad, Iraq, during 2019 on 200 pregnant women of singleton and normal pregnancies, fetal GA (20-40) weeks (W). The obtained dataset (fetal biometry), were utilized to create GA estimation model in Iraq using IBM SPSS Version 23 software package (IBM^® Software). The statistical analysis of proposed GA model showed, the correlation (R) of model is 0.987 it is very high value and this is a good result to obtain the best regression model. as well as the Std error of Estimation was 0.61095 this is very small value and indicate the best result. The significant of model P=0.000 That means the model, as a whole, is a significant fit to the data (because P < 0.05).

Keywords: Ultrasound, Fetal Biometry, Estimation Gestational Age, SPSS.

[1] Baghdad University, Iraq, aa0507681@gmail.com, https://orcid.org/0000-0001-9883-2806
[2] Baghdad University, Iraq, dr.efk33@yahoo.com, https://orcid.org/0000-0003-4375-602X

1. Introduction

Diagnosis by US considered the most widely used in the medical field, because it is economical, transferable, and adaptable. US imaging is used in pregnancy to monitor the development of the fetuses, estimate the gestational age (GA), determine the fetal weight. Sonography is a useful method for the GA estimation, and can greatly affect obstetric management and improve prenatal care. Accurate estimation of GA is also essential in the evaluation growth of fetuses and detection of intrauterine growth restriction. As well as, GA estimation is crucial for counseling patients regarding the option of pregnancy termination. Inaccurate estimation of GA has been associated with adverse pregnancy outcomes including low birth weight, spontaneous preterm delivery and perinatal mortality, independent of maternal characteristic. So making appropriate management decisions and delivering optimal obstetric care requires accurate appraisal of GA [1].

Estimation of GA by US imaging is done using many regression formulas, each formula depend on one fetal biometric parameter. There are many biometric parameters which are used for establishing GA these are: bi-parietal diameter (BPD), head circumference (HC), abdominal circumference (AC), femur length (FL), and others [2]. Several formulas (models) are used to estimate fetuses GA, in Iraq Hadlock regression models are commonly used, but these models still produce an errors in GA estimation, which may affect the planning and management of delivery mode and maternal health [3]. To solve this problem, Iraqi GA model is created to estimate the fetal age using the many fetal parameters are AC, BPD, and FL taken from Iraqi pregnant women.

Fetal Growth

Fetal growth defined as the time dependent changes in the body dimensions during pregnancy. Time from conception to birth is usually about nine full month, divided into three periods called trimesters. Figure (1) shown the fetal growth stage.

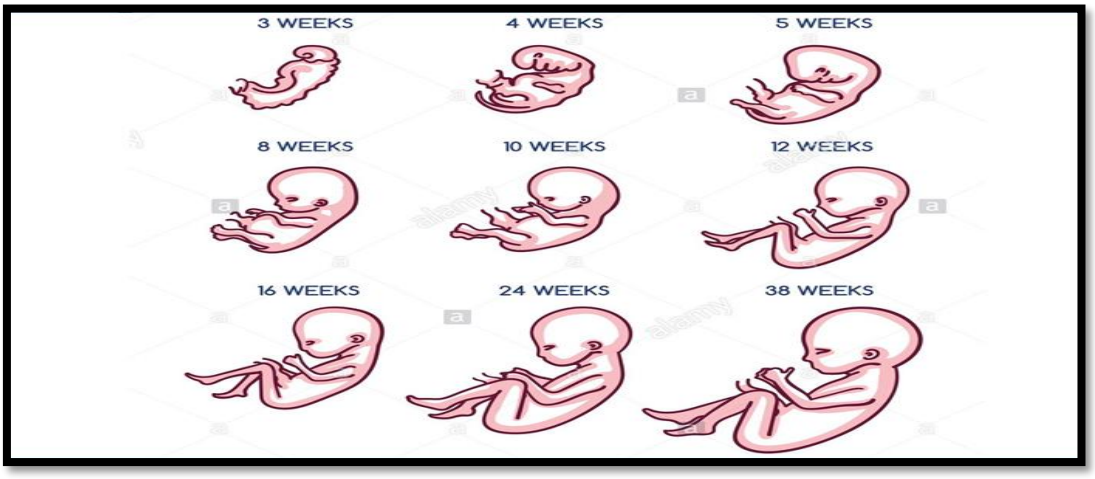


Figure (1): The fetal development stages[Internet website-https://www.alamy.com/fetal-development-vector-illustration-pregnancy-antenatal-embryo-growth-image159920638.html].

First trimester (from 0 to 14) W, in this time period the head and upper body are well developed, eyes have begun to form, and the structures that will become arms and legs (called limb buds) begin to appear, the fetal heart begins to beat, as well as, the neural tube has formed which will give rise to the brain and spinal cord. From 9 to 14 W eyelids are formed and fingernails are developing, the fetus begins small have random movements that are too slight to be felt by the mother. At the end of first trimester the fetal heartbeat can be detected electronically, and all major fetal body organs are formed, even though they are not able to function outside of the uterus [4].

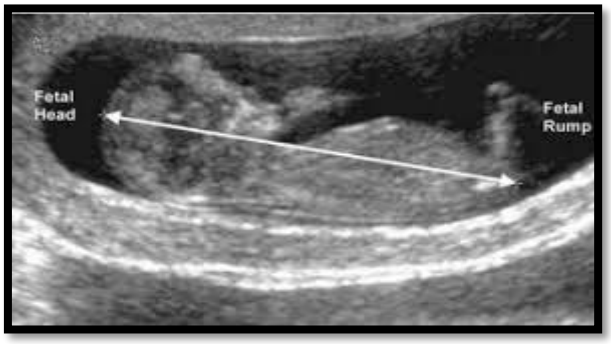
Second trimester (from 15 to 28) W, by this GA it is possible to distinguish the sex of the fetus. At 18 week, the body and facial features of the fetus are now recognizable. The fetus is able to respond to sound, nose, lips and ears can be recognized at this stage, during this period head and body hair called lanugo thickly covers the fetus, the fetus begins to gain weight steadily and it's skin is typically wrinkled and red, as well as, eyebrows and eyelashes are recognizable. At the end of second trimester, the fetus can respond to sounds

that occur both inside the mother's body and outside in the mother's surroundings. From 29 to 40 W, this period in pregnancy called third trimester, in this period the fetus continues to grow and mature. Toenails are fully formed, the muscle tone is developed and the fetus can turn and lift its head. At 38 week, the skin on the fetal face and body becomes smooth along with the head continues to be the largest body part [4].

Fetal Biometry

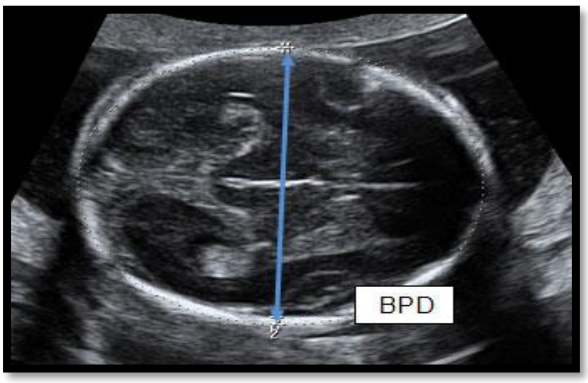
Fetal biometry means the measurement of anatomic segments of the fetuses by US. It is done by taking measurements. The most important measurements are gestational sac diameter(GSD), crown rump length (CRL), abdominal circumference (AC), femur length (FL), bi-partial diameter (BPD) and others. Ultrasonographic fetal biometry is the most common method used to establish GA, estimate fetal weight and monitor the fetal growth [3]. The brief description of the most fetal biometry is contained in this section:

(i)Crown rump length (CRL):- CRL has been described as the most reliable ultrasonic parameter for determining GA in the first trimester. Fetal CRL is measured at sitting height, mid brain to the lowest point of breech as shown in figure (2). CRL can be measured reliably form 5 to 14 W of GA, and it is important to assess fetal position as fetal flexion can cause variations of up to seven days [5].



Figure(2): CRL measurement [Internet website- https://tonygood4.wordpress.com/2013/02/03/developing-and-eye-for-ultrasound/].

(ii)Bi-parietal diameter(BPD):- It measures the maximum distance between the two parietal bones taken from the outer edge to the inner edge of the fetal skull as shown in figure(3). The BPD measurement is commonly used in fetal biometry to assess intrauterine fetal growth process and estimate the fetal GA. BPD is a relatively good predictor of measurement age between 7 to 13 W [6].



Figure(3): measurements of fetal BPD [Internet website- http://brochures.mater.org.au/brochures/mater-mothers-hospital/ultrasound-scan-fetal-growth-scan].

(iii)Head Circumference(HC):- HC fetal biometry is a parameter used in the third trimester along with other biometric to estimation GA. The HC is the circumference of the fetal skull bone as shown in figure (4), it is measured at the same level at which the BPD is taken by using the ellipsoid mode of the US machine [5].

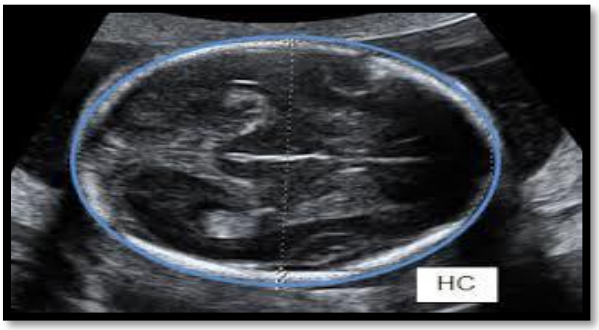


Figure (4): shows the fetal HC [Internet web-site http://brochures.mater.org.au/brochures/mater-mothers-hospital/ultrasound-scan-fetal-growth-scan].

(iv)Abdominal Circumference(AC):- AC is one of the best biometric that assesses both fetal size and growth. The measurement is taken at the level of fetal liver, which constitutes about 4% of the total fetal weight as shown in figure (5). This increases steadily with increasing GA. It is useful method for estimating fetal weight in the third trimester [6].

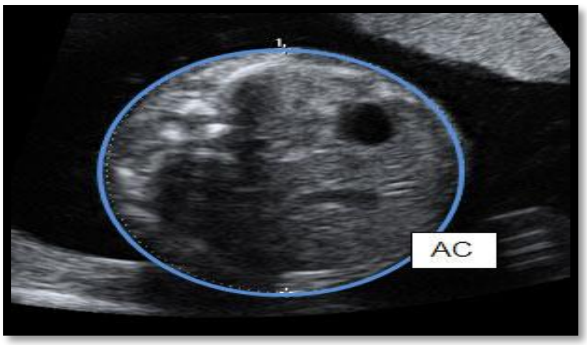
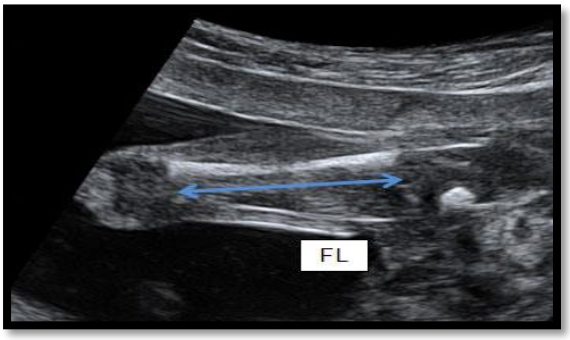


Figure (5): shows the AC measures around the fetal abdomen [Internet website-http://brochures.mater.org.au/brochures/mater-mothers-hospital/ultrasound-scan-fetal-growth-scan].

(v)Femur Length(FL):- FL is measurement of the long fetal bone as shown in figure (6), and it is a very useful biometric parameter used in the second and third trimesters of pregnancy to estimate GA as well as fetal weight estimation. It grows linear throughout and is best measured after 14 W of gestation [5].



Figure(6): measurement of FL [Internet web-site http://brochures.mater.org.au/brochures/mater-mothers-hospital/ultrasound-scan-fetal-growth-scan].

Gestational Age Estimation

Accurate estimation of GA is very important because prematurity and post maturity can result in increased risk of perinatal mortality and morbidity. Approximate duration of gestation is about 40 W which are 280 days. Initially GA was calculated from the first day of last menstrual period in a regular 28 day menstrual cycle. But this method is not reliable for those women who are unsure of date of cycle, and for women whose cycle is not regular [7], for this reason, the US imaging method is used to estimate fetal GA. Currently, the

sonographic estimation of GA is derived from calculations based on fetal biometric measurements. Over the past three decades, numerous equations regarding the relationship between fetal parameters and GA have been described. Among many methods the Hadlock regression models are commonly used to estimate fetal GA in Iraq [8]. In first trimester GA is calculated from CRL using Hadlock formula (equation 1).

$$GA = – 0.0007 (CRL)^2 + 0.1584 (CRL)+ 5.2876 \quad (1)$$

As pregnancy advances, GA can be estimated by measuring different biometrics of fetus, in the second trimester GA can be estimated using Hadlock regression formulas (equation 2 and 3), as well as the GA estimation in third trimester is estimated using of Hadlock formulas(equation 3, 4 and 5)

$$GA = 2.412 + 0.131 (BPD) \quad (2)$$

$$GA = 1.863 + 6.280 (FL) - 0.211 (FL)^2 \quad (3)$$

$$GA = 0.0001797 (HC)^2 + 0.02631 (HC) + 9.667 \quad (4)$$

$$GA = 5.956 + 0.941 (AC) \quad (5)$$

Experimental Procedure

1.Material and method

Quantitative data were collected and analyzed to develop a new GA model for Iraqi pregnant women, the study was done using retrospectively collected records of 200 pregnant women (chosen the best 80 images from a total 200 sonar images as would be displayed in Appendix), who were delivered in Al- Yarmouk Teaching Hospital and Al- Alawiya Teaching Hospital in Baghdad, Iraq, during 2019.

2. Create gestational age estimation model

Created the GA estimation model for Iraqi pregnant women based on the fetal biometry, namely AC, BPD, and FL in millimeters were used as independent variables (IVs), and fetal age were used as dependent variable (DV). The best 80 images were chosen from a total of 200 images to create GA estimation model. Where the training set (N=80) used to derive new model for GA depending on multiple linear regressions by using IBM® Software. Multiple linear regression is carried out to form the relationship between a dependent DV and IVs. The general equation of multiple linear regression given by equation(6), [9]:

$$Y=B_\circ+B_1X_{1\,i}+ B_2X_{2\,i}+B_3X_{3\,i} +.....+ B_PX_{P\,i} \quad (6)$$

Where:$(B_\circ)$ is the constant term, $(B_1$ to $B_p)$ are the coefficients relating the (p) explanatory variables to the variables of interest, (Y) is DV, and $(X_{1\,i}$ to $X_{P\,i})$ are IVs.

3. Statistical analysis

The collected data (fetal biometry) are analyzed using Statistical Package for Social Sciences (SPSS) version 23. Based on the collected dataset, a multiple linear regressions were used to create GA estimation model for Iraqi people, the obtained fetal biometry were subjected to statistical analysis using SPSS software. where fetal biometry were regarded as IVs, while the fetal age was regarded as the DV. The significant value (Sig. or P value, when P < 0.05 the model was considered statistically significant for an GA estimation), other statistics are presented in an analysis of variance (ANOVA) table, also standard deviation, correlation coefficient (R), R^2, as well as the adjusted coefficient of determination (R^2) was measured [10].

Results and Discussion

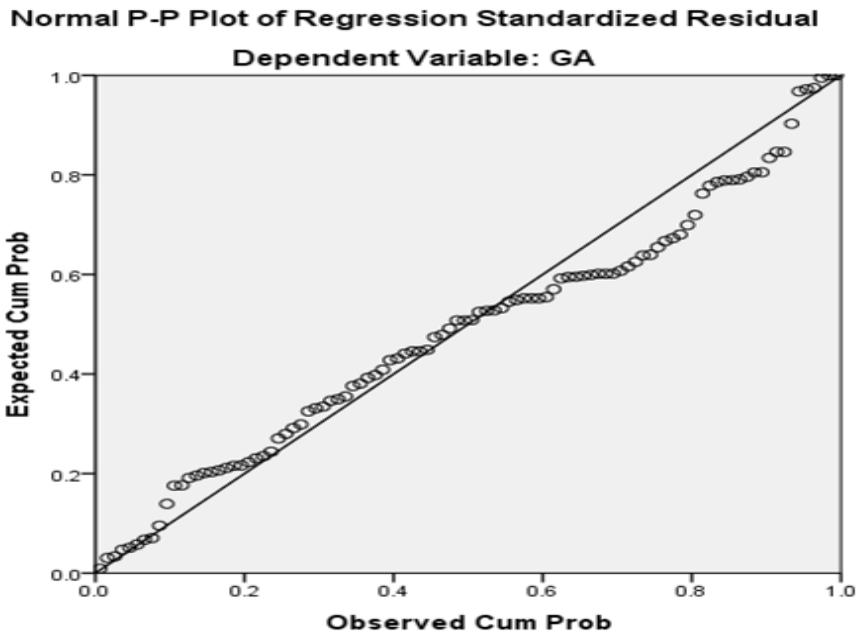
Eighty pregnant women (N=80) met the inclusion criteria for the study. The age range of the women was between (20- 42) years with a mean of 30.7 years. In SPSS software, the Enter regression method is used to create our proposed model as shown in table(1).

Table(1): Variables Entered/Removed a

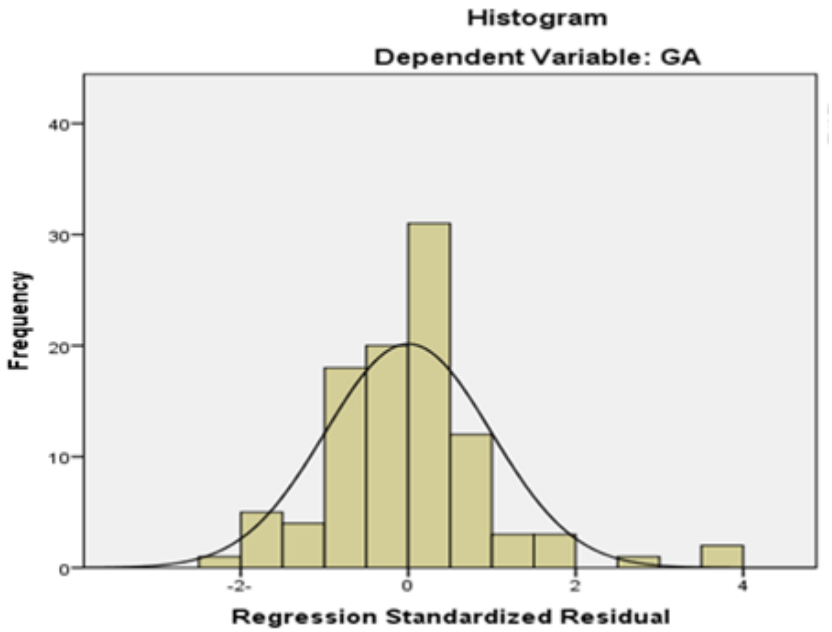
Model	Variables Entered	Variables Removed	Method
1	BPD, AC, FL b	_	Enter

a. Dependent Variable: GA
b. All requested variables entered.

Before writing down the proposed model, the data set should be satisfy the linear regression conditions. First condition: relationship between the IVs and DV should be linear. Linearity assumption can be tested by scatter plots. Second condition: multiple linear regression analysis requires the distribution of all variables should be normal. The normality can be checked best with a histogram. And the third condition is: multiple linear regression assumes that there is little or no multicollinearity in the data. Multicollinearity occurs when the IVs are not independent from each other. Figure(7), illustrate the scatter plot of variables, and figure(8): shows the histogram distribution of variable.

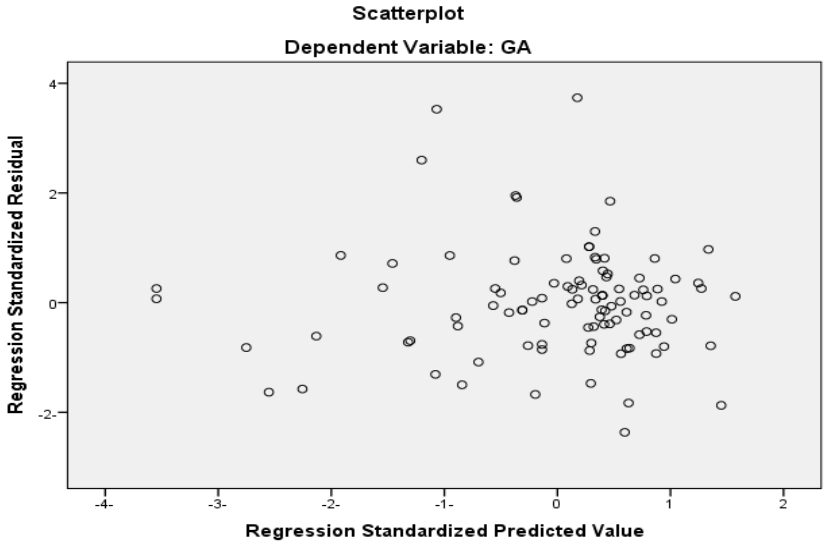


Figure(7): Shown the scatter plot of variables.



Figure(8): represent the histogram distribution of variables.

Figure(7), shown the relation between variables is linear, as well as the correlation between DV and IVs was strong and the most of variables were surrounding the regression line. From the histogram analysis of dataset figure(8), it is clear that, the variables were distributed as normal distribution, also the distribution of residuals do not taken a specific shape as shown in figure(9), all of these characteristics are satisfy the first and second conditions of linear regression.



Figure(9): The scatter plot of residuals.

To satisfy the third condition of, the Multicollinearity or correlation between IVs variable should be very low (Multicollinearity occurs when the IVs are not independent from each other). Table (2) shows the correlation coefficient between all variables.

Table (2): Coefficient Correlations a

Model			BPD	AC	FL
1	Correlations	BPD	1.000	.099	-.901
		AC	.099	1.000	-.434
		FL	-.901-	-.434-	1.000

a. Dependent Variable: GA

From results that are showed in table(2), it is obvious the relationship between IVs is weakly, and that satisfy the last condition of multiple linear regression. After satisfied all condition, now we can create GA estimation model using the regression method. The statistical analysis of correlation coefficients for proposed model will be shown in table (3).

Table (3): Model Summary b

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate
1	.987a	.972	.975	.61095

a. Predictors: (Constant), BPD,AC, FL

b. Dependent Variable: GA

Table(3) shown the correlation (R) of model is 0.987 it is very high value and this is a good result to obtain the best regression model. When the sample size (N) is large, R^2 and adjusted R^2 will usually be identical or very close, as well as the Std error of Estimation was 0.61095 this is a good result. The significant of model will show in table(4).

Table (4): ANOVA a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	334.098	3	111.366	298.357	.000 b
	Residual	8.585	76	.373		
	Total	342.683	79			

a. Dependent Variable: GA

b. Predictors: (Constant), BPD, AC, FL

The Sig. value was (P=.000) as shown in the ANOVA table. That indicates the model, as a whole, is a significant fit to the data (because P < 0.05). Finally the model can be written using the Unstandardized Coefficients from coefficients table (table (5)).

Table(5): Coefficients a

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.693	1.148		3.216	.004
	AC	.005	.004	.076	1.372	.183
	FL	.391	.059	.841	6.634	.000
	BPD	.035	.046	.089	.773	.448

a. Dependent Variable: GA

Table (5) column B, represent the important constants (slope coefficients) can be used to build our model, where constant B_0or intercept term for the line of best fit, when X= 0, is 3.693. B_1 =.005, B_2=.391, and B_3=.035, with Std. Error are 1.148,.004,.059, and.046 respectively. The standardized regression coefficient (Beta) provides a useful way of seeing what the impact of changing the IVs by one SD, as well as (t) values = slope coefficients / standard error were (3.216, 1.372, 6.634 and.773). The last column represent the Sig. value for each variable in the model. Now, by using equation (6), and B coefficients from table(5), the GA estimation model can be written as the following form:

$$GA= 3.693 +0.005\ AC +0.391\ FL + 0.035\ BPD \qquad (7)$$

Conclusion

Accurate estimation of GA has a great interesting in obstetrics. The first method of GA estimation is calculation the time from first day of last menstrual period, this method is useful for women whose regular cycle, but not for women who are unsure of dates, and whose irregular cycle. This requires using the other methods to estimate GA. In Iraq, most of Sonographers use Hadlock's and other formulas to GA estimation. But these models were not created specifically to estimate GA in Iraq. Often, 7 days are added to the values resulted from those models. Therefore, the results of GA estimation are inaccurate. To solve this problem, a mathematical model was innovated to estimate the GA in Iraq, based on the biometric of the Iraqi fetuses. The proposed model (equation 7) created by Enter method of multiple linear regression using SPSS software, after statistical analysis the results shown the high value of R and significant value was smaller than 0.005. That indicates the model, as a whole, is a significant fit to the data and give the better results of GA estimation in Iraq.

References

Azra Bano Khuwaja, Minaz Mawani, Savera Aziz Ali, Gulshan Bano, and Sumera Aziz Ali, 2016, "Estimation of Gestational Age Through Various Parameters: A Narrative Review", EC GYNAECOLOGY, Vol.3, No.4, pp. 323-330.

B.Priestly Shan and M.Madheswaran, 2010, “Revised Estimates of Ultrasonographic Markers for Gestational Age Assessment of Singleton Pregnancies among Indian Population”, International Journal of Advanced Science and Technology Vol. 17.

Füsun Varol, Ahmet Saltık, Petek Balkanlı Kaplan, Tüly kılıç, and Tugut Yardım, 2001 “Evaluation of Gestational Age Based on Ultrasound Fetal Growth Measurements”. Journal of Yonsei Medical, Vol. 42, No. 3, pp. 299-303.

Joshi BR., 2010, “Fetal transcerebellar diameter nomogram in Nepalese population”. Journal of Institute of Medicine, Vol.32, No.1, pp.19-23.

Keith L. Moore, Ph.D., F.I.A.C, F.R.S.M.; T.V.N. Persaud, M.D., Ph.D., F.R.C. Path (Lond): Cynthia Barrett, M.D.; and Kathleen A. Veness-Meehan, M.D., 1995 “fetal growth and development”, South Dakota Department of Health.

Loc Nguyen, Truong-Duyet Phan, and Thu-Hang T. Ho, 2018, "Phoebe Framework and Experimental Results for Estimating Fetal Age and Weight", http://dx.doi.org/10.5772/intechopen.74883.

Marek Lubusky, Martin Prochazka, Martina Langova, Katherine Vomackova, and Ludek Cizek, 2007, " DISCREPANCY IN ULTRASOUND BIOMETRIC PARAMETERS OF THE HEAD (HC – HEAD

CIRCUMFERENCE, BPD– BIPARIETAL DIAMETER) IN BREECH PRESENTED FETUSES", Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub., Vol.151, No.2, pp.323–326.

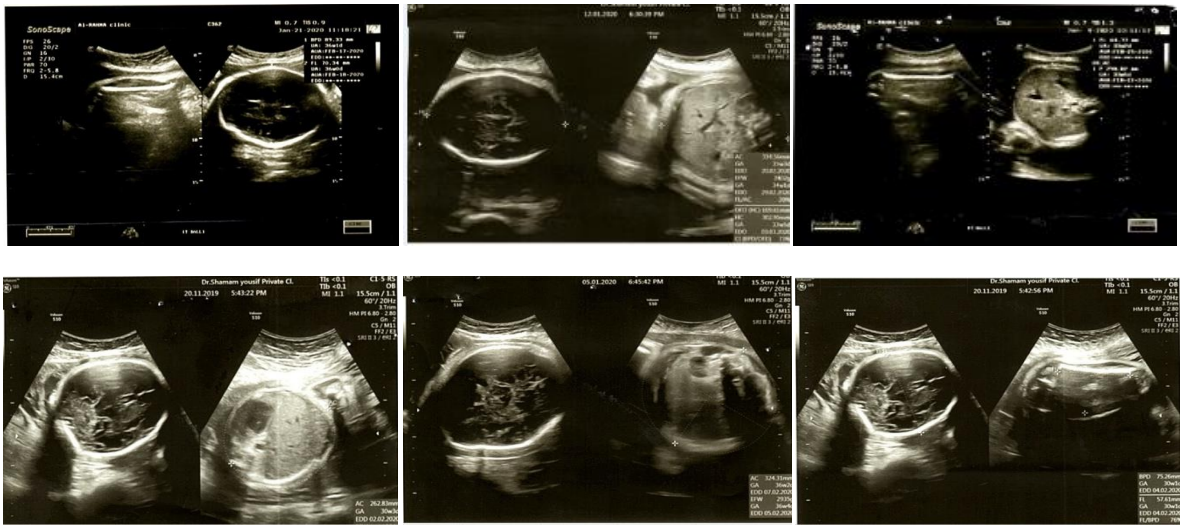
Robin B. Kalish, and Frank Chervenak, 2009, "SONOGRAPHIC DETERMINATION OF GESTATIONAL AGE", Timisoara Medical Journal TMJ, Vol. 59, No. 2, pp. 202-208.

Sujitkumar Hiwale, Hemant Misra, and Shrutin Ulman, 2019, " Fetal weight estimation by ultrasound: development of Indian population-based models", Journal of Medical Ultrasound, Vol. 38, No.1, pp.50-57.

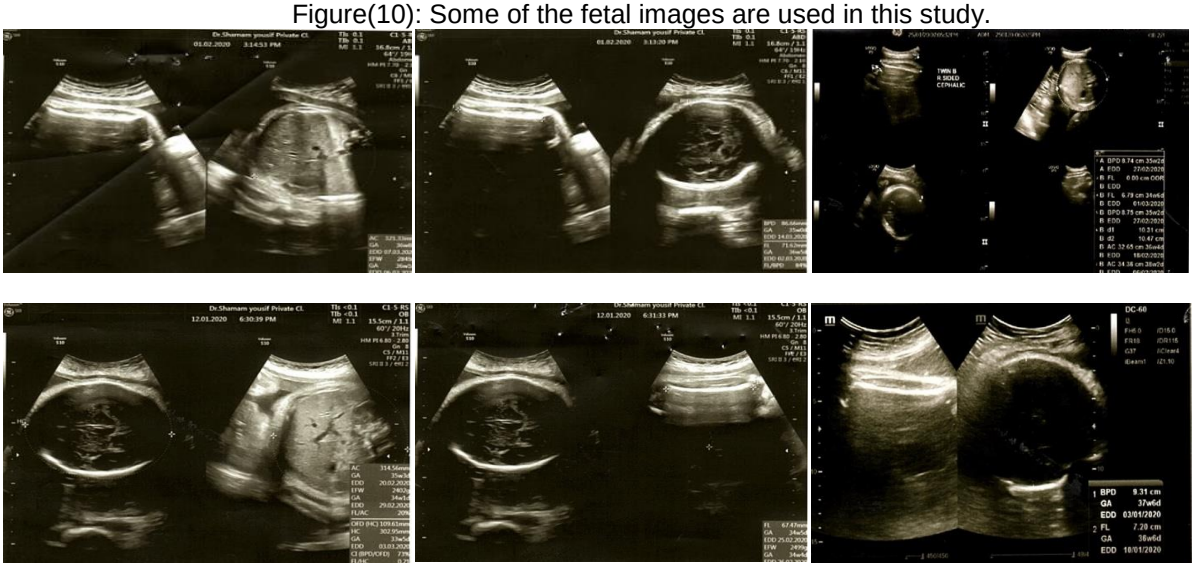
ZUNAIRA SARWAR, SYED AMIR GILANI, ROMANA LATIF, FAISAL NADEEM KHAN, and NAWAZ ANJUM, 2018, "Sonographic Estimation of Gestational Age by Umbilical Cord Diameter and its Relationship with Bi-Parietal Diameter and Femur Length in Second and Third Trimester in Lahore, Pakistan", P J M H S, Vol. 12, NO. 2, pp.514-517.

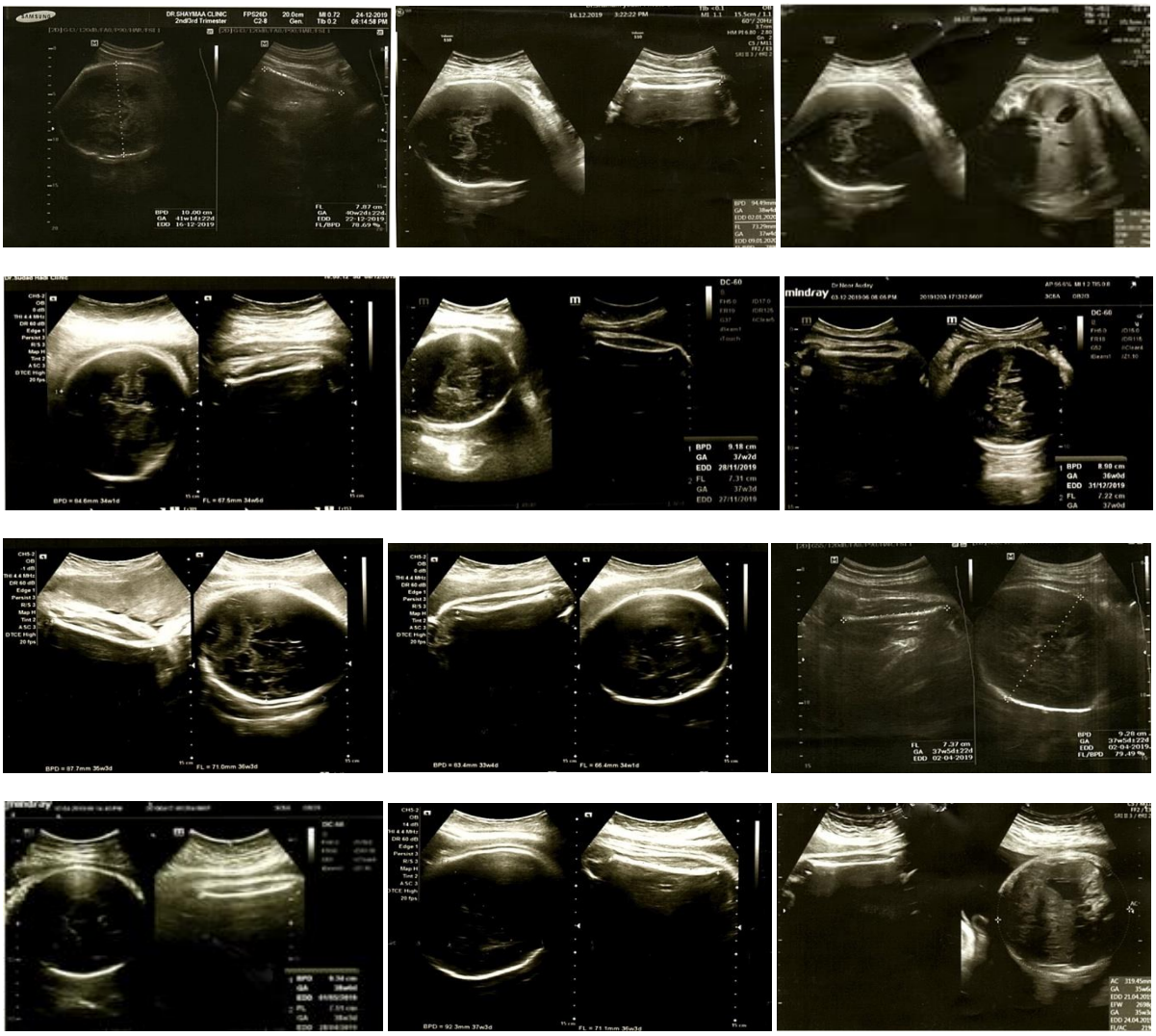
Appendix

all US fetuses images used in this work will be shown in the next figures.

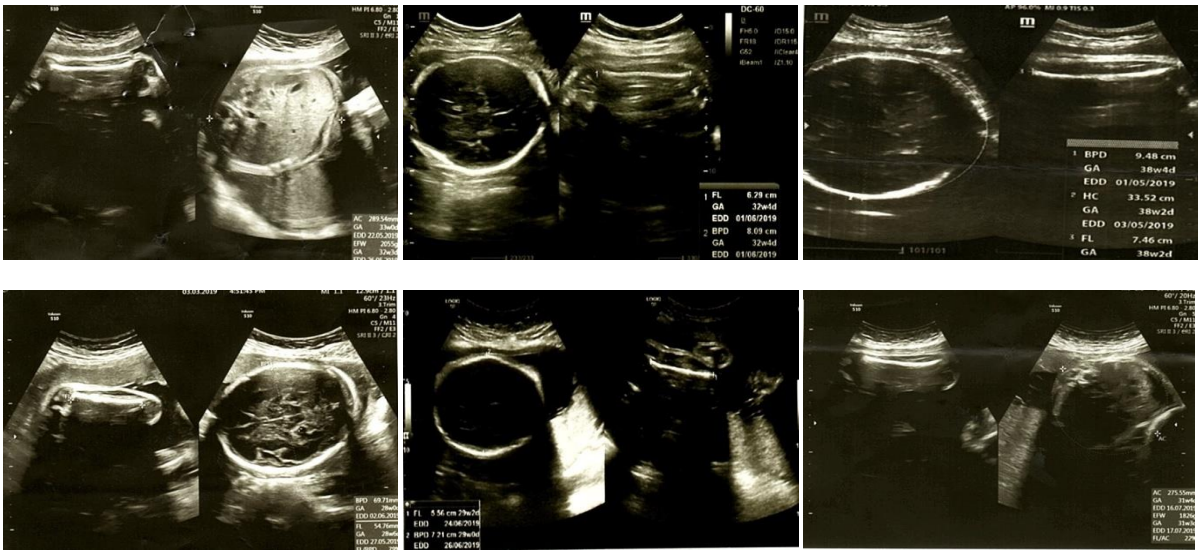


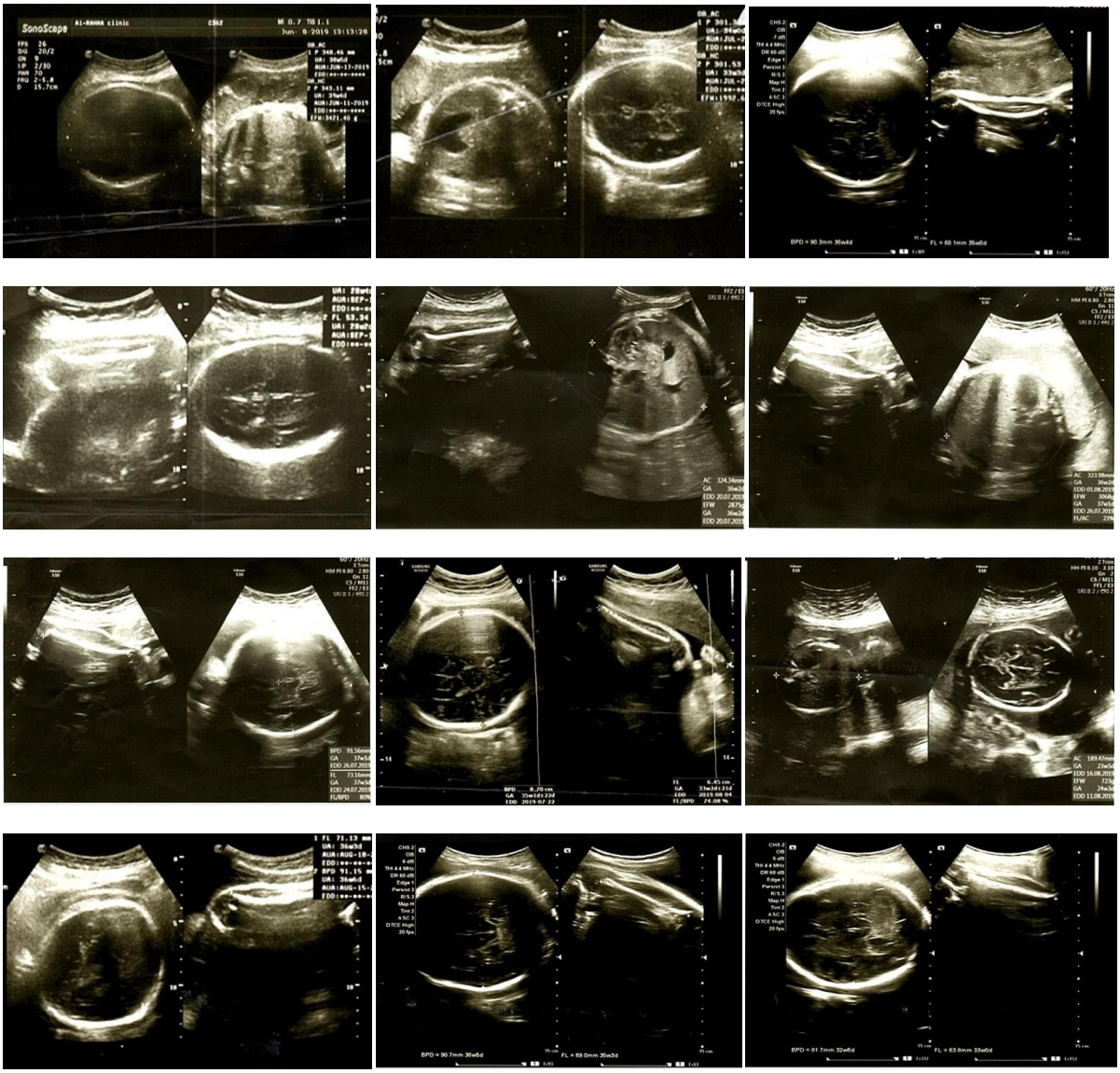
Figure(10): Some of the fetal images are used in this study.



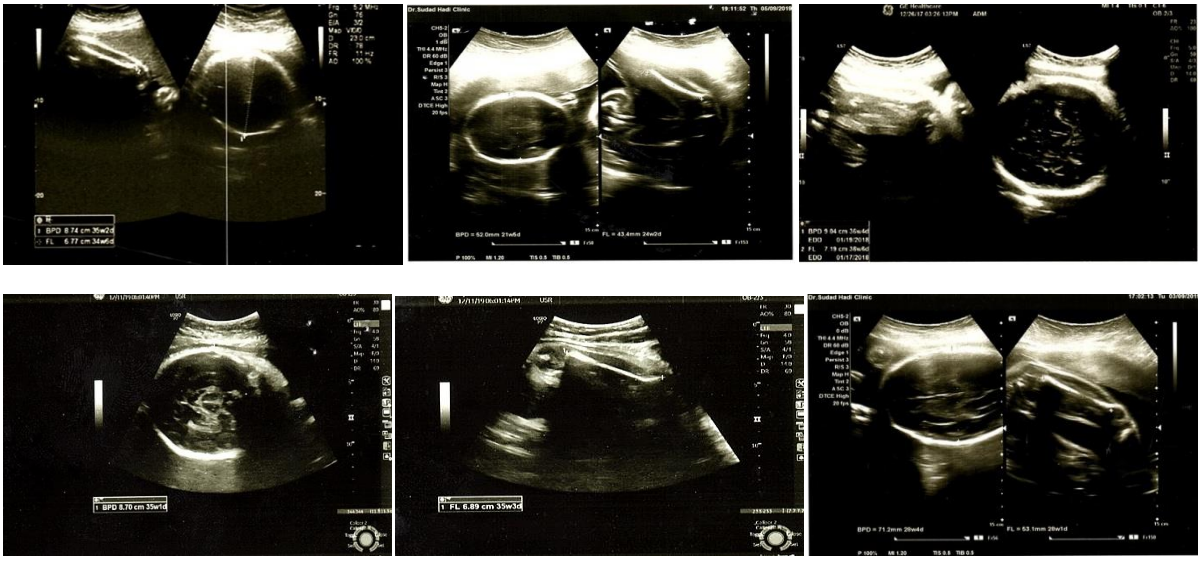


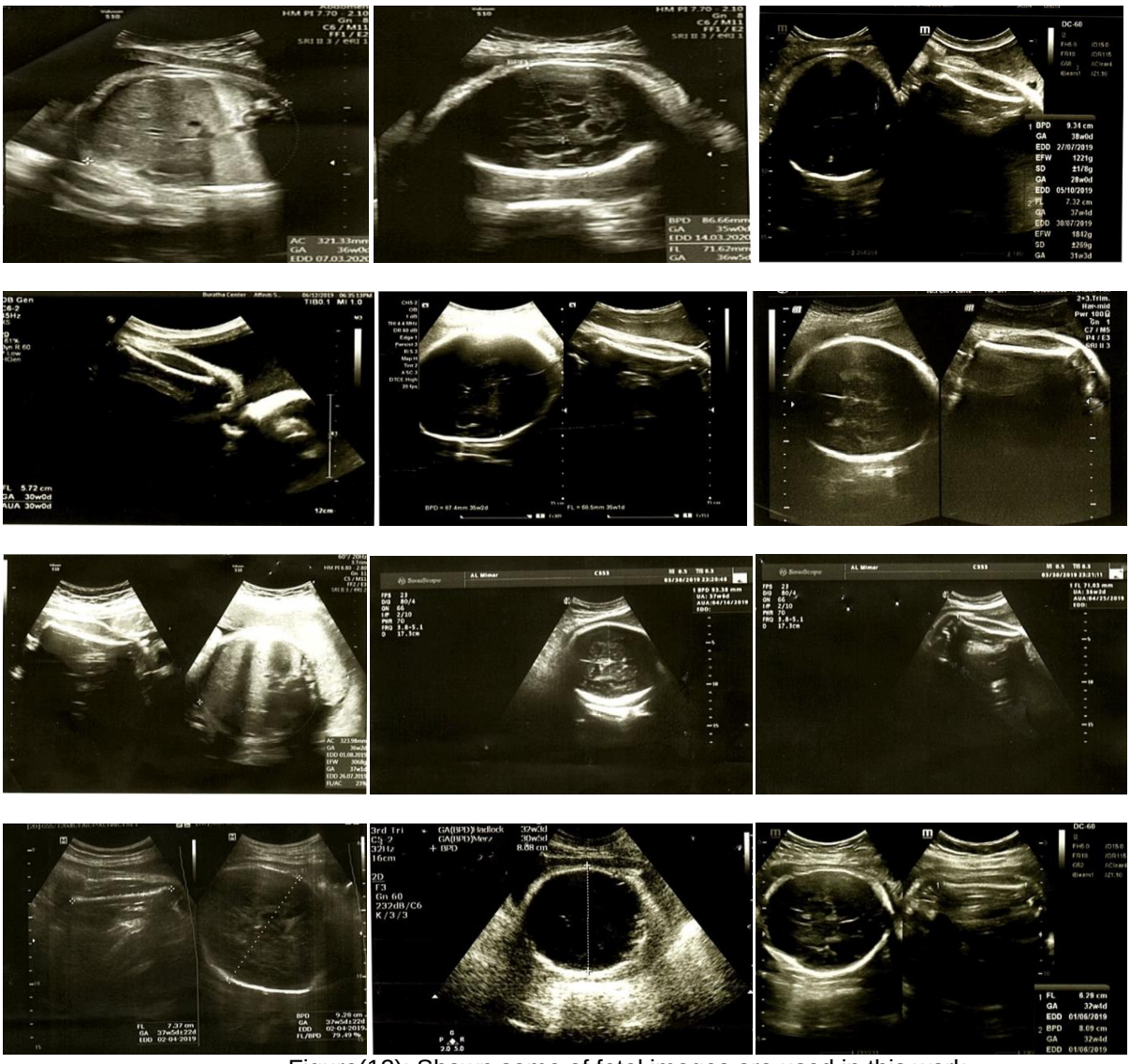
Figure(11): Part of fetuses images are used as a dataset in this study.



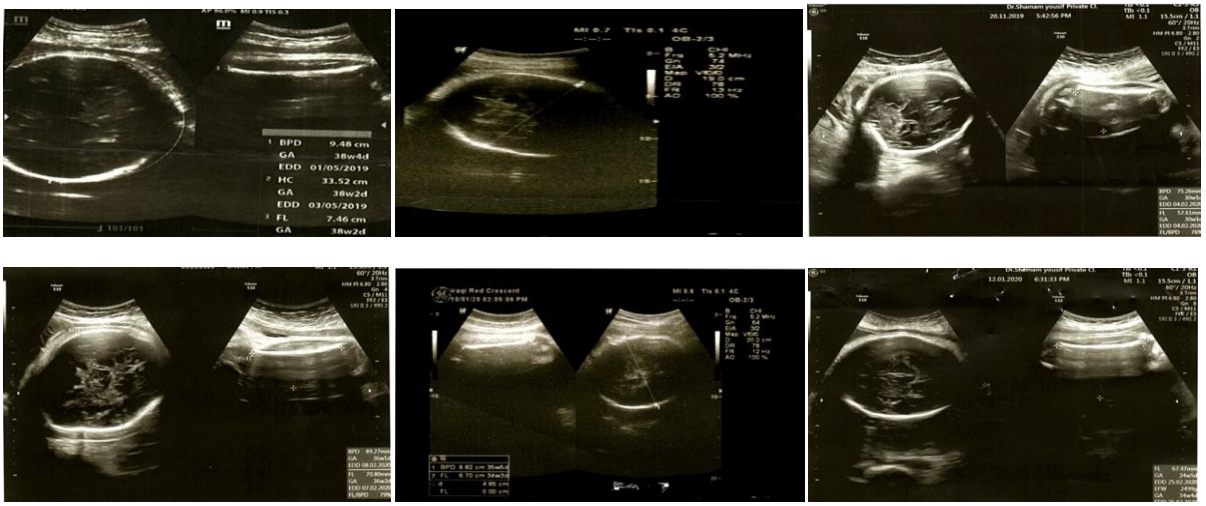


Figure(12): Shown some of US fetal images are used in this study.





Figure(13): Shown some of fetal images are used in this work.



Figure(14): Shown the final parts of US fetuses images are used in this work.