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Clinical and Ultrasound Estimation of Fetal Weight at Term and Its Correlation with Birth Weight

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Abstract

Objective:*To evaluate fetal weight by clinical and ultrasound methods and its correlation to actual birth weight.****Methods:****This study was cross sectional study of fetal weight estimation in Antenatal women with term gestation (37-42) weeks of gestation with vertex presentation,who hadgestational age confirmed by dates and ultrasound scanning of< 22 weeks admitted in antenatal clinics and maternitywards prepared for elective caesarean section within 24 hours. from September 2018 to march 2019. Included 84 women with singleton pregnancy, full term whowereadmittedinlabour room ofObstetrics and Gynecology department in Zagazig University Hospital.****Results:****comparisonbetween clinical and ultrasound methods at different gestational ages, the mean fetalweight was significantly higher in the clinical method at 37 and 38 weeks, while not reach significant level at 39 and 40 weeks. Both the methodshad moresensitivity inbirth weightrange 2500-4000gm than <2500gand >4000g. The Hadlocks formula is more accurate than Johnson's formula the Sensitivity of ultrasound is 82.0 % higher than clinical 76.7 %.****Conclusions:****Antenatal fetal weight can be estimated with reasonable accuracy, by ultrasounography using Hadlocks formula and clinically using Johnson's formula.Hadlocks formula is more accurate, reliable and showed better sensitivity and specificity in detecting fetal weight than Johnson's formula.*

Key words:*Foetal Birth-Weight, Pregnancy, Ultrasonography*

I. INTRODUCTION

Birth weight is a single most important factor that determines the neonatal outcome and survival[1]. Fetal and Neonatal life are affected by many factors including genetic, socio economic and environmental factor[2]. Both low birth weight and excessive fetal weight at time of delivery are associated with increased risk of newborn complications during labor and the puerperium[3].

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Two main methods for predicting birth-weight in current obstetrics were used: (a) Clinical techniques based on abdominal palpation of fetal parts and calculations based on fundal height and (b) Sonographic measures of skeletal fetal parts which are then inserted into regression equations to derive estimated fetal weight[4].

Ultrasound estimation of fetal weight, while being accurate to a degree, is associated with error ranging from ±6 to 11% depending on parameters measured and the equation used for estimation[5].

Evaluation of uterine size externally with use of a physician's hands is characterized by being simple, easy and cheap; also it is characterized by being standard clinical method as an alternative to ultrasonography (USG), which is expensive and not always easy to access, especially in countries with limited financial resources for health. But the clinical method has many drawbacks such as it is the oldest method and there have been doubts about its use because it is not objective[6].As birth weight is a single most important factor that determine the neonatal outcome and survival, this study will done conducted to evaluate clinical and ultrasonographic methods for detection of fetal birth weight and correlate the results with actual birth weight.

II. METHODS:

After obtaining approval of the ethics committee, a cross-sectional study was carried out in Zagazig University Maternity Hospital during the period from May 2017 till November 2018. Included 84 pregnant women scheduled for delivery from ante-natal care clinic were prepared for elective caesarean section within 24 hours. Congenital fetal anomalies, Oligohydramnios, Polyhydramnios, Intrauterine gross restriction (IUGR), Rupture membranes, Medical disorders with pregnancy (diabetes, heart disease, and pregnancy induced hypertension) are excluded from the study. Written informed consent was obtained from all participants.

Full history was taken (personal, menstrual, obstetric, past and family history) then general and abdominal examination was done, followed by obstetric palpation (Leopold's manoeuver) to evaluated fundal level, fundal and umbilical grip andfirst pelvic grip by the right hand to grasp the presenting part (head). Local examination was done to evaluate cervical dilatation if present and degree of descent of the fetal head into pelvis and the fetal station:

- Station -1 (the presenting part lies 1cm above the ischial spines).
- Station 0 (the presenting part is even with the ischial spines).
- Station +1(the presenting part lies 1cm blow the ischial spines).

After examination, measurement of symphyseal-fundal height (McDonald's measurement) and assessment level of engagement fetal weight was calculated by Johnson's Formula.

After clinical estimation of fetal weight, we used ultrasound for evaluation of the fetus by measuring biparietal diameter (BPD), abdominal circumference (AC) and femur length (FL) in centimeters; the sonographic machine calculated fetal weight automatically by the equipment according to hadlock's formula.

The biparietal diameter (BPD) was measured at right angles to the longitudinal axis of the elliptical skull at a level at which a clear midline echo and easily discernable lateral ventricle can be visualized. At this

level, the transvers scan also should show cavum septum pellucidum and the thalamus. Biparietal diameter (BPD) was measured from the outer table of anterior skull to the inner table of the posterior skull (Figure 1).

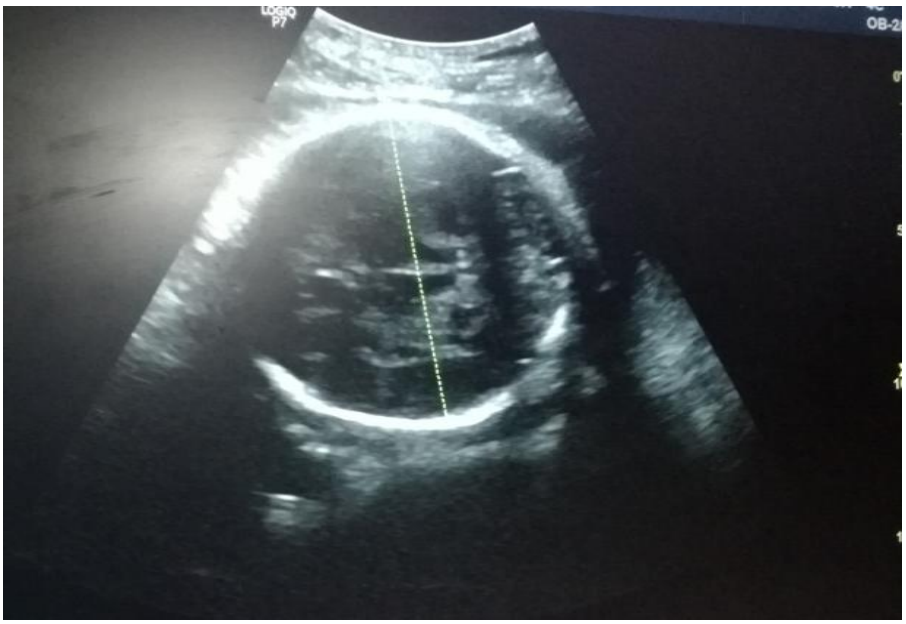

Figure 1.Biparietal diameter (BPD) Measureme

The measurement of the fetal abdominal circumference (AC) was made from a transverse axial image of the fetal abdomen at the level of the liver. The major landmark in this section is the umbilical portion of the left portal vein deep in the liver, with the fetal stomach representing a secondary landmark (**Figure** 2).

Figure 2.Abdominal circumference (AC) Measurement.

Femur length (FL) measurement was obtained from the greater trochanter to the lateral condyle. The head of the femur and the distal femoral epiphysis, when present, was not included in the measurement. The measured ends of the bone were blunt and not pointed (**Figure 3**).

Figure 3: Femur length (FL) measurement

After elective C.S the newborn babies were weighted within 30 minute of delivery by electronic children scale and their weight were recorded. Predicted estimated fetal weight by each method was compared with neonatal actual birth weight.

Statistical Analysis:

Data were analyzed using IBM SPSS 23.0 for windows (SPSS Inc., Chicago, IL, USA) and NCSS 11 for windows (NCSS LCC., Kaysville, UT, USA).

III. RESULTS:

Table (1): Obstetric data of the studied group

Variables	N = 84	
Age (years)	**Range**	20 - 37
	Mean ± SD	28.2 ± 4.63
Weight (Kg)	**Range**	55 – 90
	Mean ± SD	74.9 ± 7.92

Height (m)	**Range**	1.5 - 1.85
	Mean ± SD	1.65 ± 0.08
BMI (Kg/m^2)	**Range**	20.8 - 31.2
	Mean ± SD	26.9 ± 2.61
Gestational age (days)	**Range**	259 – 280
	Mean ± SD	267.6 ± 5.89
Gestational age	**N**	%
37 weeks	**29**	34.5
38 weeks	**40**	47.6
39 weeks	**10**	11.9
40 weeks	**5**	5.9
BMI classification		
Normal	**20**	23.8
Over weight	**58**	69.1
Obese	**6**	7.2
	Range	0 – 4
	Mean ± SD	1.5 ± 0.9
Parity	**N**	%
0	**6**	7.1
1	**45**	53.6
2	**20**	23.8
3	**11**	13.1
4	**2**	2.4
	Range	1 – 7

	Mean ± SD	2.95 ± 1.3
	N	%

Table (1) showed that basic data of the included women in the study.

Table (2): Ultrasound and clinical parameters were used to estimate fetal weights among the studied group.

Ultrasound and clinical parameters		**Studied group (n=84)**	
		Range	**Mean ± SD**
Ultrasound parameters	Bi-parietal diameter (cm)	7.55 - 10.0	9.2 ± 0.48
	Bi-parietal diameter (days)	212 - 281	258.3 ± 12.9
	Abdominal circumference (cm)	6.4 - 43.1	32.8 ± 4.9
	Abdominal circumference (days)	225 - 287	260.7 ± 13.8
	Femur length (cm)	6.4 - 8.1	7.5 ± 0.38
	Femur length (days)	232 - 291	265.2 ± 13.4
Clinical parameters	SFH (cm)	28 – 40	33.9 ± 2.6

Table (2) showed that ranges of parameters used for ultrasonic FWT estimates.

Table (3): Comparison between clinically, sonographically estimated fetal weights and actual birth weight

		Clinical	**Ultrasound**	**Actual**	**F test**	**P value**
Fetal weight	**Range**	**2325 – 4285**	**2070 – 4056**	**2125- 4025**	**3.38**	**0.04S**
	Mean± SD	**3353.7 ± 424.8**	**3199.8 ± 418.4**	**3223.8 ± 394.5**		

S: P-value<0.05 is significant

Table (3) showed that statistical significant difference among clinical, ultrasound fetal weight estimates and the actual birth weight. In which the difference revealed that clinical estimates was the higher, while ultrasonographic was the lower in relation to the actual birth weight**.**

Table (4): Multiple comparisons between clinically estimated, sonographically estimated fetal weights and actual birth weight.

Mean I	Mean II	Mean Difference (I-II)	P value
Actual weight	US weight	23.95	0.707 (NS)
	Clinical weight	-129.98*	0.04 (S)
Ultrasound weight	Clinical weight	-153.9*	0.02 (S)

NS:P-value>0.05 is not significant

S: P-value<0.05 is significant

Mean I: actual weight / ultrasound

Mean II: comparison between them

Table (4) showed that on applying multiple comparisons between fetal weight estimates and the actual birth weight in which the comparison revealed that clinical estimate is significantly higher than both actual fetal weight and ultrasound estimate.

Table (5): Paired analysis between actual fetal weight and ultra-sonographic estimates.

	Paired Differences				t	P value
	Mean	SD	S. error	95% CI		
Actual FWT – US FWT	23.95	111.1	12.1	(-0.17 - 48.1)	1.975	0.05 NS
Actual FWT – clinical FWT	-129.9	218.4	23.8	(-177.4, -87.8)	5.45	<0.001 HS
US FWT – clinical FWT	-153.9	226.3	24.7	-203.1, -104.8)	6.23	<0.001 HS

NS:P-value >0.05 is not significant

HS: P-value <0.001 is high significant

Table (5) showed that a high statistically significant mean error differences between clinical FWT with both US FWT estimates andactual FWT, while there was no statistical significant difference between US FWT estimates and actual FWT.

Table (6): Comparison between clinical and ultrasound weight estimates at different gestational ages

	Ultrasound	Clinical	t-test	P
37 weeks (n=29) **Mean ± SD**	3205.8 ± 422.3	3413.4 ± 511.7	4.36	<0.001 (HS)
38 weeks (n=40) **Mean± SD**	3164.8 ± 445.8	3292.6 ± 398.8	3.9	<0.001 (HS)
39 weeks (n=10) **Mean± SD**	3328 ± 396.6	3391 ± 333.1	1.97	0.08 (NS)
40 weeks (n=5) **Mean± SD**	3188.4 ± 196.6	3422 ± 192.2	1.62	0.128 (NS)

NS: P-value>0.05 is not significant

HS: P-value<0.001 is high significant

Table (6) showed that on comparison between clinical and ultrasound methods at different gestational ages, the mean fetal weight was significantly higher in the clinical method at 37 and 38 weeks, while not reach significant level at 39 and 40 weeks.

Table7: differencebetweenultrasoundand clinical methods as regard actual weight.

Actual BW	US FWT	Clinical method	Z test	P value
Overall				
Mean absolute error (gm)	**298.2301.3**	**469.6310.5**	**4.6**	**<0.001**
Mean error percentage (%)	**9.210.3**	**15.6 10.5**	**4.9**	**<0.001**
Actual BW<2500 gm (n=4)				
Mean absolute error (gm)	**110.3 111.2**	**120 110.3**	**1.12**	**0.08**
Mean error percentage (%)	**5.3 10.5**	**9.3 11.3**	**0.934**	**0.61**

Actual BW 2500-4000 gm (n=78)				
Mean absolute error (gm)	**107.6 100.5**	**320.3 210.3**	**5.7**	**<0.001**
Mean error percentage (%)	**6.2 5.5**	**17.2 11.6**	**3.5**	**0.001**
Actual BW >4000 gm (n=2)				
Mean absolute error (gm)	**99.3 79.4**	**100.5 89.2**	**1.1**	**0.985**
Mean error percentage (%)	**8.2 5.3**	**9.3 12.1**	**1.22**	**0.654**

In<2500g birthweightgroup,meanabsolute errorwashigherinclinicalmethod thanUltrasoundtoestimate birthweightbutdifferencewas***statisticallynot significant (p>0.05). Mean error percentage was much*** lowerinultrasoundmethodthanclinicaltoestimate birth weightbutthedifferencewasstatistically notsignificant (p>0.05).In2500-4000gm birthweightgroup,comparing clinical and ultrasound methods showed significantly higher mean absolute error and mean error percentages in the clinical methodTable (7).

Figure (4) showed the cut-off value of clinical and ultrasound FWT estimates in predicting actual fetal weight > 3500gm, Ultrasound FWT had higher AUC and better sensitivity.

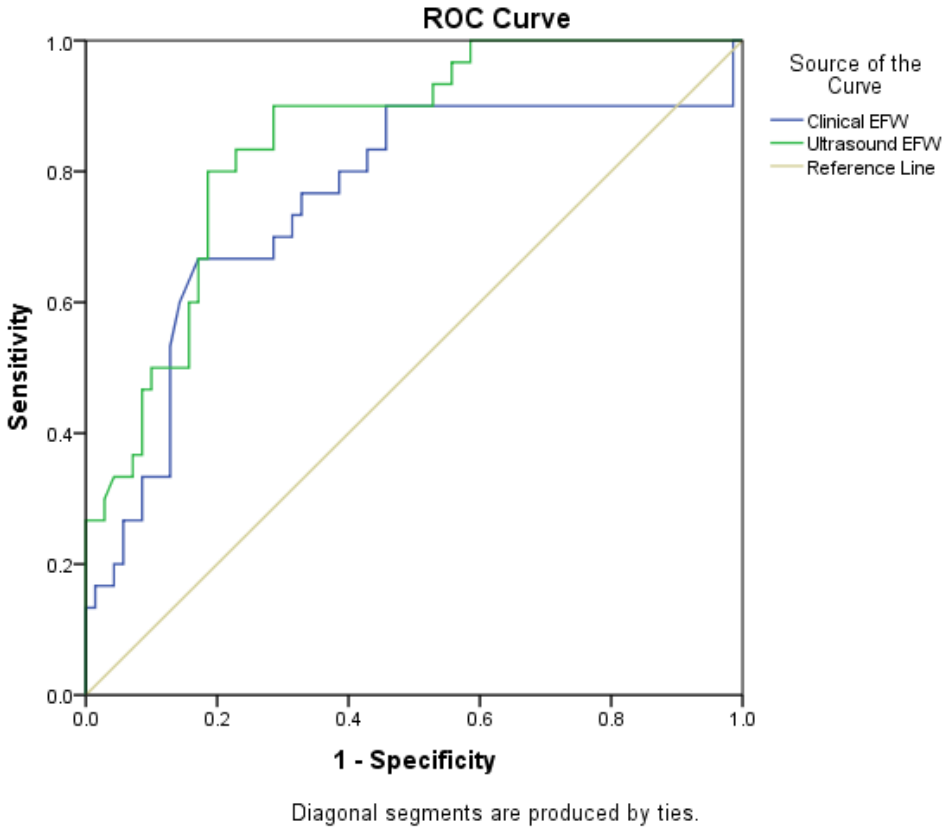

Figure (4) ROC analysis for predicting actual fetal weight > 3500 gm by clinical and ultrasound methods

IV. DISCUSSION

In the present study, the mean maternal age was 28.2, with minimum age being 20 years and maximum being 37 years. The mean gestational age was 38.1, with a minimum gestational age being 37 weeks and maximum being 42 weeks. There were some studies that were in agreement with our study, for example a study carried by **Joshi et al.** [7]in which they compared between clinical versus ultrasound in estimation of fetal weight and they found that the mean maternal age was 24.78, with minimum age being 16 years and maximum being 40 years. The mean gestational age was 39.59, with a minimum gestational age being 37 weeks and maximum being 42 weeks. Furthermore**Ingale et al.** [8]reported that mean gestational age was 37.5weeks with 1.52 weeks SD in which estimation of fetal weight was done by clinical method and ultrasonography. Then the birth weight after delivery was recorded in grams by electronic weighing machine.

Additionally, our results are in agreement with results reported by a study of **Basumatary et al.** [9]in which they calculated fetal weight by using Johnson's formula and was compared with the expected US fetal weight, Accuracy was determined bycomparing both with the actual birth weight, and found that the mean age of pregnant women was 28.08 years. The minimum age was 21years, and maximum age was 40years.

In the present study, the mean height of the study population was 165 cm and, the range was150 cm-185 cm. Our results are in agreement with results reported by a study carried by **Basumatary et al.**[9], in which theyfound that the mean height of the study population was 149.59 cm and, the range was140 cm-162 cm.

In the present study, the weight of the study population was between 55 kg - 90 kg with a mean of 74.9 kg. Also, a study carried by**Njoku et al.** [10]found that the weight of the study population used to determine accuracy of fetal weight usingultrasound and clinical fetal weight estimations was between 53 kg - 109 kg with a mean of 72.48 kg.

The result of our study was 6 women (7.1%) nulliparous and 78 (92.9%)were multiparous women.itwas similar with a study reportedby**Basumatary et al.** [9]in which there were 7 primigravida and 93 multigravida patients. Different results were reported by a study carried by **Ingale et al.**[8]in which they estimated of fetal weightby clinical method and ultrasonography and found thatout of 100 women59% were multigravida and 41% were primigravida. Also, **Bajaj et al.**[11]in their study found that out of 200 women 34.5% were primigravida and 65.5% multigravidas in which they compared the accuracy of clinical and ultrasonographic estimation of fetal weight at term with actual birth weight.

In the current study, mean birth weight by clinical examination was 3353.7 ± 424.8 gm., mean sonographically estimated fetal weight was 3199.8 ± 418.4 and the mean actual birth weight was 3223.8 ± 394.5 gm. The estimated mean birth weight by clinical method was significantly different from actual birth weight (p= 0.04) while the estimated mean birth weight by ultrasonographic method was not statistically different from actual birth weight (p=0.7). And when applying multiple comparisons between fetal weight estimates and the actual birth weight, it revealed that clinical estimate is significantly higher than actual fetal weight while ultrasound assessment was significantly lower than actual weight.

In agreement with our study,**Njoku et al.,** [10]found that the mean actual birth weight was 3,242±508 g, while the mean estimated fetal weights by clinical and ultrasound methods were 3,541±633 g and 3,141±441g, respectively. And when theycompared the accuracy of clinical and sonographic methods of predicting fetal

weights at term, they found that the clinical fetal weight estimation was significantly higher than actual weight while ultrasound assessment was significantly lower than actual weight.

Also, there was a study similar to ours study reported by **Joshi et al.** [7]in which the mean ultrasound estimated fetal weight was 3230.02±407.22gm, the mean clinical estimated fetal weight was 3492.75±393.16gm and The mean actual birth weight was3236.32±472.87gm.They found that the mean ultrasound estimated fetal weight was lower than mean actual birth weight while clinical fetal weight estimation was significantly higher than actual weight. The estimated mean birth weight by clinical method was significantly different from actual birth weight ($p<0.001$) while the estimated mean birth weight by ultrasonographic method was not statistically different from actual birth weight ($p=0.872$). Thus demonstrating ultrasound estimate to be more reliable than clinical method.

In the present study clinical estimates was higher than the actual birth weight, while ultra-sonographic was lower than actual birth weight. This came in agreement with **Ugwuet al.** [12]who found that the clinical method significantly overestimated actual birth weight, while the ultrasonic method underestimated it.

Different results were reported by **Ingale et al.** [8]in which theyfound that mean birth weight by clinical examination was 2916.6±399.15, mean sonographically estimated fetal weight was 3203.66±497.05 and the mean actual birth weight was 2831.79±515.79 gm. And there was statistically significant difference between mean birth weight estimated by clinical examination, ultrasonography and mean actual birth weight ($p<0.05$), which revealed that clinical and ultra-sonographic estimates were higher than the actual birth weight.

Alsoa study carried by**Yadav et al.** [13]and reported results against our study, theyfound that the mean actual birth weight was 3100 ± 455.8 grams. The mean estimated birth weight by US was 3240±389.7 grams while the mean estimated birth weight by Johnson's formula was 2911±364 grams (P value < 0.01).

The reason for the discrepancy between different studies may be due to several factors affecting birth weight such as regional and socioeconomic factors. And also may be attributed to different body mass indexes of the studied women. The study of **Aksoy et al.** [14]highlighted the value of BMI in modulating the sonographically assessed fetal weight where increased BMI was associated with increased estimates of ultrasound fetal weight assessment.

In the present study, the mean absolute error in estimating birth weight by ultrasonography was 23.95±111.1gmat 95% Confidence Interval with no significant difference while mean absolute error in estimating birth weight by clinical method was 129.9±218.4 gm.at 95% Confidence Interval with highly significant difference. In agreement with our study,**Ugwu et al.**[12]compared the accuracy of clinical and ultrasound methods of fetal weight estimation in 200 consecutive term pregnancies. They noted that ultrasound assessment had significantly lower absolute errors and error percentages as compared to clinical methods.

While different results were reported by **Joshi et al.**[7]in which theyperformed a cross sectional study over a period of 6 months. All singleton term mothers with cephalic presentation and intact membranes with ultrasound examination done within a week were included in the study. The study found that the net mean error in clinical weight estimation was 415.65± 283.54 gm. and that by ultrasonograhic method was 312.40±252.15gm. The mean clinical weight estimation showed significantly higher error than ultrasonograhic weight estimation.

Also,**Njoku et al.** [10]found that the mean absolute error in estimating birth weight by ultrasonography and clinical method was 293 ± 313 g and 362 ± 307 g respectively. The clinical method significantly overestimated actual birth weight, while the ultrasonic method underestimated it.The difference in mean absolute error between three studies was due to a difference of sample size and inclusion criteria. But all similar inthe mean clinical weight estimation showed significantly higher error than ultrasonograhic weight estimation.

In the present study, there was no significant correlation between gestational age and estimated fetel weight by clinical method and by ultrasonographic method. Our result was against to results reported by **Joshi et al.** [7]that found the error of estimation of weight by clinical method showed significant negative correlation (r= -0.24; p=0.01) with gestational age, thus making clinical method better as the gestational age advanced. However, ultrasonographic method did not show significant correlation (r= +0.045; p=0.64) demonstrating reliability of ultrasound in wide range gestational ages.

Also, In contrary of our results a study carried by**Ugwu et al.,** [12]in which theyshowed significantly direct correlation between Clinical EFW and gestational age, ultrasound EFW and actual BW likewise.

The variation in error in ultrasound and clinical estimation of birth weight is a factor of large intra- and inter observer variability. This variability must be minimized if estimated birth weight is to be made clinically useful. Averaging of multiple repetitive measurements, equipment calibration, improvement of image quality and careful design and refinement of measurement method can help reduce the variability to certain extent.

In the present study, at the cut-off value of clinical and ultrasound FWT estimates in predicting actual fetal weight > 3500 gm, the sensitivity was 76.7 % and 82.0% respectively and the specificity was 82.9% and 81.4% respectively. Ultrasound FWT had higher AUC and better sensitivity.

In agreement with results of the present study the reliable sensitivity of ultrasound fetal weight estimation was also reported by the study of **Ashrafganjooei et al,** [15]who compared the accuracy of ultrasound, clinical estimates of fetal weight in 246 parous women with singleton, term pregnancies. The cut-off value of clinical and ultrasound FWT estimates in predicting actual fetal weight > 3500 gm, the sensitivity was 76.1 % and 81.7% respectively and the specificity was 75.0% and 62.5% respectively. Ultrasound FWT had higher AUC and better sensitivity.

In disagreement with our study, **Joshi et al.** [7]found that the sensitivity and specificity of clinical method and ultrasonographic method for identifying fetal birth weight above 3500gm was 69.23; 65.67% and 46.15; 80.60% respectively. Larger babies were slightly better identified by clinical method (AUC- 0.732 CI- 0.64-0.84) than ultrasonograhic method (0.712 CI-0.61-0.81) as determined by area under the curve ROC method. This represents the fact that clinical method may be more useful to use as a screening tool to identify patient at risk of labour dystocia.

Moreover, the study carried by **Lanowski et al.**[16]in which they compared the accuracy of abdominal palpation with that of ultrasound performed by different examiners to estimate fetal weight. The authors showed that ultrasound notably dominated the clinical methods in the accurate assessment of fetal weight.

Other studies have also identified the superiority of ultrasound over clinical method for estimation of fetal weight especially in low birth weight babies, with no added advantage over clinical method in normal or macrosomic babies **[17].** In our study <2500g birth weight group, mean absolute error was higher in clinical method than Ultrasound to estimate birth weight but difference was statistically not significant (p>0.05). Mean error percentage was

much lower in ultrasound method than clinical to estimate birth weight but the difference was statistically not significant ($p>0.05$). In 2500-4000gm birth weight group, comparing clinical and ultrasound methods showed significantly higher mean absolute error and mean error percentages in the clinical method.

In our study ultrasound estimation was more accurate than clinical method in estimation of fetal weight. This result was similar to results of a study carried by**Ugwu et al. [12]** in which they found that the ultrasound estimation was significantly more accurate than clinical prediction.

Different result was reported by **Bajaj et al. [11]**in which theyfound that clinical estimation of fetal weight is as accurate as the ultrasonographic method of estimation within the normal birth weight range. Although, while the clinical method overestimated fetal weight, the ultrasonic method underestimated it.

The relationship between birth weight and the direction of the estimation error was not due to a bias in the time interval between ultrasound and delivery as there was no significant relationship between infant birth weight and the time interval between ultrasound and delivery here. In this study, the ultrasound estimations were performed at most within 24 hours prior to delivery. In a different study, **Akinola et al., [18]** studying reliability of ultrasound estimation of fetal weight performed up to 14 days prior to delivery. Others have restricted their data to estimations performed within 7 days for example **Nzeh et al. [19].**

V. CONCLUSIONS

Antenatal fetal weight can be estimated with reasonable accuracy, by ultrasounography using Hadlocks formula and clinically using Johnson's formula.Hadlocks formula is more accurate, reliable and showed better sensitivity and specificity in detecting fetal weight than Johnson’s formula.

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