The Effect of Maternal Obesity on the Accuracy of Ultrasound Fetal Weight Estimation

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Abstract: Background: estimation of fetal weight is important for antenatal and intrapartum management of pregnant women. Ultrasound fetal weight estimation (EFW) has become a routine practice in obstetrics with a major impact on obstetrical management. It is generally a better predictor of the actual birth weight than the clinical method. **Aim of the Work:** to determine if maternal obesity affect the accuracy of ultrasound fetal weight estimation. **Patients and Methods:** to singleton pregnancies underwent sonographic (Hadlock) fetal weight estimation within 7 days of delivery. Patients were stratified into two groups based on maternal body mass index (BMI): (1) study group (more than 29, 9),2)control group (less than 29, 9). The estimated fetal weight was compared among the two BMI groups. **Results:** there was no difference in the magnitude of the absolute percent error with maternal obesity. **Conclusion:** Maternal obesity does not affect the accuracy of ultrasound fetal weight estimation. Therefore, sonographic fetal weight prediction provides accurate and valid guidelines for determining management decisions in women, regardless of body size.

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1. Introduction

Accurate estimation of fetal weight by ultrasound is important in the treatment of many complications in pregnancy. When complication occur at the limit of fetal viability knowledge of fetal weight will help to assess the likelihood of neonatal survival and hence determine whether to prolong the pregnancy with conservative treatment or to deliver the fetus **(Vasapollo et al., 2011).**

Small for gestational age (SGA) fetuses are known to be less tolerant of the stress of labor. Therefore antenatal identification of such fetuses will enable closer intrapartum monitoring, as they are more commonly delivered by cesarean for suspected fetal distress **(Owen et al., 2008).**

Estimated fetal weight is also a consideration when planning labor management and mode of delivery for very large, very small, and malpresenting fetuses **(Langer et al., 1995).**

Initial attempts to estimate fetal weight by ultrasound consisted of individual fetal measurements such as biparietal diameter (BPD) or abdominal circumference (AC). Subsequent reports showed that accuracy of estimated fetal weight is improved when multiple fetal measurements are used.

With the advent of three-dimensional ultrasound, some researchers found it useful for fetal weight estimation by using limb circumferences, upper arm volumes, and thigh volumes, fetal limb volume is related to fetal growth and nutrition **(Lee et al., 2006).**

The accuracy of three – dimensional ultrasound in volumetry has been validated in manyorgan systems, in vitro and in vivo. Hence, thigh volume assessed by three- dimensional ultrasound should effectively predict birth weight.

In other studies, fetal upper arm or thigh volume assessed by three-dimensional ultrasound achieved satisfactory results in birth weight prediction the only drawback was the long time needed to measure volumes **(Moore et al., 2010).**

Two studies confirmed that increasing maternal size impairs ultra-sonographic visualization of fetal anatomy and identified a weight threshold above which optimal fetal structural visualization deteriorated markedly. These finding strongly suggest that maternal obesity represents a major risk factor for the failure to diagnose fetal anomalies **(Wolfe et al., 1990).**

Aim of the Work

To determine if maternal obesity affect the accuracy of ultrasound estimation of fetal weight.

2. Patients and Methods

This is a retrospective case control was conducted for 6 months at Obstetric and Gynecological department of Alzahraa University Hospital. The study population was selected from patients who attended outpatient clinic for antenatal care within 7 days of delivery.

For data analysis 60 cases were divided into two groups based on maternal BMI; (weight in kg, height in M).

1) Study group (BMI >30) (30 cases)
2) Control group (BMI 18,5-29.9) (30 cases)

Their age ranged between study group (18 – 38) and control group (21 – 33) and who fulfilled all of the following criteria.

Inclusion criteria

- Gestational age 37- 39 weeks
- Cephalic presentation
- Singleton pregnancy
- Delivered within one week of fetal weight estimation by U/S
- No congenital malformation
- Sure of dating (L.M.P or first trimester u/s)
- Intact membranes

Exclusion criteria

- Multiple gestations
- Premature rupture of membranes
- Diabetic or hypertensive patient
- Heart disease with pregnancy
- Oligohydramnios
- Non – cephalic presentations
- Uterine fibroid

All patients subjected to the following detailed history;

1- Personal history; (Name, Age, Residence, Marital status, special habits, parity (having boy (s) & girl (s) and the youngest is…..).
2- Obstetric history; (delivery or CS, full term, preterm, abortion, no of living) for each delivery (n, year & place of birth, antepartum period, duration of pregnancy, onset of delivery, mode of delivery, postpartum comp, baby (alive, incubated, malformed, dead, boy or girl, weight, breast or bottle fed, puerperium).
3- Past history (Medical disease, surgical operation, Allergy, Blood transfusion).
4- Family history (Diabetes, Hypertension, Multi fetal pregnancy, Congenital anomalies)

Examination

General examination; Height, weight to calculate BMI (Weight /(Height)2)

Abdominal examination; by inspection (shape, controur of abdomen, fetal movement scar of previous operation and skin pigmentation).

Palpation: 1) superficial palpation (tenderness, rigidity or superficial masses), 2) deep palpation to palpate deep (intra-peritoneal organ), 3) special obstetric palpation of the gravide uterus to know the presentation, position of the fetus and duration of pregnancy by funal level, umbilical grip, 1st pelvic grip and 2nd pelvic grip.

Body mass index was calculated.

Ultrasound was performed using volson 730 pro /730 pro v software version 5,0x on wards CE0123 2005 machine using abdominal probe. **Procedure**

Cases in supine position, using abdominal probe.

Statistical analysis

Data were statistically described in terms of range, mean ± Standard deviation (±SD) when appropriate. Comparison of quantitive variables between the study groups was done using one way analysis of variance test with post hoc multiple 2 group comparison. Correlation between various variable was done using Pearson moment correlation equation. Aprobability value (p v) less than 0,05 was considered statistically significant.

3. Results

This table shows that there was no statistical significant difference between study group and control groups regarding height but there was highly statistical significant difference between the two groups regarding weight and BMI.

Table (1): Comparison between study group and control group regarding anthropometric measures of the studied cases

		Study group	Control group	P-value	Sig.
		No. =30	No. =30		
Height (m)	Mean±SD	1.57 ± 0.06	1.54 ± 0.08	0.104	NS
	Range	1.46 – 1.67	1.42 – 1.67		
Weight (kg)	Mean±SD	98.23 ± 12.48	67.43 ± 7.64	0.000	HS
	Range	81 – 130	55 – 80		
BMI (kg/m2)	Mean±SD	39.69 ± 4.56	27.91 ± 1.15	0.000	HS
	Range	32.42 – 49.26	25.81 – 29.90		

NS: Non significant; S: Significant; HS: Highly significant *: Chi square test; •: Independent t-test

Table (2): Comparison between study and control groups regarding BPD (cm), HC (cm), AC (cm), FL (cm), HL (cm).

		Study group	Control group	P-value	Sig.
		No. =30	**No. =30**		
BPD (cm)	Mean±SD	9.35 ± 0.28	9.16 ± 0.37	0.031	S
	Range	8.77 – 9.97	8.12 – 9.6		
HC (cm)	Mean±SD	31.99 ±0.95	31.45 ± 1.24	0.057	NS
	Range	30.34 – 34.5	29.5 – 33.9		
AC (cm)	Mean±SD	33.75 ± 2.45	31.71 ± 2.67	0.003	HS
	Range	30.2 – 38.8	26 – 38.8		
FL (cm)	Mean±SD	7.07 ± 0.35	6.88 ± 0.32	0.030	S
	Range	6.35 – 7.75	6.3 – 7.58		
HL (cm)	Mean±SD	6.50 ± 0.33	6.23 ± 0.32	0.002	HS
	Range	6 – 7.01	5.69 – 6.75		

NS: Non significant; S: Significant; HS: Highly significant *: Chi-square test; •: Independent t-test

Data shows that there was statistical significant difference between the two groups regarding all parameters (BPD, AC, FL, HL) except HC showed no statistical significant difference between two groups.

Table (3): Comparison between study and control groups regarding scapular fat thickness (cm), abdominal fat thickness (cm)

		Study group	Control group	P-value	Sig
		No. =30	**No. =30**		
Scapular fat thickness (cm)	Mean±SD	0.58 ± 0.14	0.44± 0.13	0.000	HS
	Range	0.37 – 0.88	0.3 – 0.65		
Abdominal fat thickness (cm)	Mean±SD	0.65 ± 0.13	0.57± 0.15	0.017	S
	Range	0.38 – 0.92	0.28 – 0.81		

This table shows that there was statistical significant difference between the two groups regarding scapular fat thickness and abdominal fat thickness.

Table (4): Comparison between study and control groups regarding Femur volume (cm3), Humerus volume (cm3)

		Study group	Control group	P-value	Sig
		No. =30	**No. =30**		
Femur volume (cm3)	Mean±SD	126.06 ± 24.476	105.45± 28.53	0.004	HS
	Range	100 – 191	52.3 – 183		
Humerus volume (cm3)	Mean±SD	82.75 ± 24.77	70.19± 22.69	0.045	S
	Range	50.2 – 177	36 – 160		

NS: Non significant; S: Significant; HS: Highly significant
•: Independent t-test

This table shows that there was statistical significant difference between the two groups regarding femur volume and humerus volume.

Table (5): Correlation between EFW by US and actual weight after delivery in study group with the other studied parameters

	Study group			
	EFW by US		Weight after delivery	
	r	P-value	r	P-value
Weight before delivery	-	-	0.896**	0.000
Weight after delivery	0.896**	0.000	-	-
Age (years)	0.401*	0.028	0.390*	0.033
GA (weeks)	-0.080	0.674	-0.260	0.165
	Study group			
	EFW by US		**Weight after delivery**	
	r	**P-value**	**r**	**P-value**
Height (m)	0.241	0.200	0.113	0.552
Weight (kg)	0.563**	0.001	0.548**	0.002
BPD (cm)	0.017	0.929	-0.089	0.646
HC (cm)	-0.321	0.084	-0.340	0.066
AC (cm)	0.381*	0.038	0.325	0.080
FL (cm)	0.140	0.462	0.112	0.556
HL (cm)	0.322	0.083	0.251	0.181
Scapular thickness (cm)	-0.004	0.983	0.043	0.823
Abdominal thickness (cm)	0.275	0.141	0.226	0.229
Femur volume (cm3)	0.541**	0.002	0.536**	0.002
Humerus volume (cm3)	0.658**	0.000	0.613**	0.000

	Study group			
	EFW by US		Weight after delivery	
	r	P-value	r	P-value
BMI (kg/m2)	0.491**	0.006	0.402*	0.028

This table shows that there was positive correlation between EFW by US and actual birth weight after delivery with Age, BMI. Femur volume, Humerus volume While no correlation found with other studied parameter) GA, BPD, HC, AC, FL, HL, Scapular thickness, Abdominal thickness.

Table (6): Correlation between EFW weight by U/S and actual weight after delivery in control group with the other studied parameters

	Control group			
	EFW by US		Actual Weight after delivery	
	r	P-value	r	P-value
EFW by u /s	-	-	0.985**	0.000
Weight after delivery	0.985**	0.000	-	-
Age (years)	0.211	0.264	0.287	0.124
GA (weeks)	0.307	0.098	0.261	0.164
BPD (cm)	0.308	0.098	0.386*	0.035
HC (cm)	0.421*	0.021	0.461*	0.010
AC (cm)	0.801**	0.000	0.861**	0.000
FL (cm)	0.535**	0.002	0.558**	0.001
HL (cm)	0.173	0.361	0.223	0.236
Scapular thickness (cm)	0.025	0.894	0.056	0.770
Abdominal thickness (cm)	0.471**	0.009	0.520**	0.003
Femur volume (cm3)	0.635**	0.000	0.696**	0.000
Humerus volume (cm3)	0.684**	0.000	0.777**	0.000

	Control group			
	EFW by US		Actual Weight after delivery	
	r	P-value	r	P-value
BMI (kg/m2)	0.702**	0.000	0.761**	0.000

This table shows that there was positive correlation between EFW by US and actual birth weight after delivery with HC, AC, FL, Abd thickness and femur volume, BMI, Humerus volume while no correlation was found with the other studied parameter (age, GA, BPD, HL, Scapular thickness.

4. Discussion

Estimation of fetal weight is important for antenatal and intrapartum management of pregnant women. Ultrasound fetal weight estimation (EFW) has become a routine practice in obstetrics with a major impact on obstetrical management. It is generally a better predictor of the actual birth weight than the clinical method. However, the technique had many issues related to timing of fetal weight estimation **(Stefanelli and Groom, 2014)**, multiplicity of used equations **(Eze et al., 2015)** and fetal size particularly in macrosomic infants **(Shivkumar et al., 2015).**

Moreover, maternal obesity represents a challenge in the sonographic (US) assessment of fetal weight besides being a recognized risk factor for adverse pregnancy outcome **(Cody et al., 2016).** It is though maternal obesity decreases the accuracy of sonographic fetal weight estimation and subsequently, clinicians should be aware of the limitations of sonographic fetal weight estimation, especially in obese patients **(Aksoy et al., 2015).**

So, the present study aimed to determine the influence of maternal obesity on the accuracy of ultrasonographic weight estimation. The study recruited 30 obese pregnant women (study group) in addition to 30 normal weight women who served as control group. Both groups were matched regarding age, gestational age, and parity. Similar matching was reported by the study of **Farrell et al. (2002)** who assessed matching between three methods of estimation of fetal weight (including ultrasound) and determine the influence of maternal obesity. The study assured women with low and high BMI are harmonized regarding gestational age, age and parity. Our study showed, patients in the study group had higher weight and BMI when compared with those in the control group.

Our study showed that fetal measurements in the studied groups showed that fetuses in the study group had significantly higher BPD, AC, FL and HL when compared with their counterparts in the control group. This is in accordance with the study of **Grivell et al. (2012).** In their work, they assessed fetal growth in women who are overweight or obese women during pregnancy and noted that fetal biometric growth measures (biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), femur length (FL) were significantly higher in those women when compared to normal weight mothers.

In addition, our study reported significantly higher scapular thickness and abdominal thickness in fetuses belonging to obese mothers when compared to lean ones. These data in agreement with **Buhling et al. (2012)** on estimation of fetal subcutaneous adipose tissue measurements where they found a positive correlation between these measurements (the ultrasound-estimated fetal weight and actual fetal weights). So, it is expected for babies of obese mother to have such measurements.

Moreover, the present study found that babies obese women had significantly higher femur and humeral volumes. These results are supported by the study of **Chang et al. (2003).** In their work, they tried to establish a normal reference chart of the fetal humerus volume for clinical use. Their study found a significant linear correlation between fetal humerous volume and estimated fetal weight. Furthermore, the study of **Ioannou et al. (2012)** that assessed the relation between maternal characteristics including vitamin D status and fetal bone found a linear correlation between maternal BMI and fetal femur volume.

The current study, shown that fetus of obese mothers had significantly higher weight before and after delivery. This was in agreement with the study of **Melo et al. (2008)** who evaluated the effect of maternal, socioeconomic and obstetric variables on the fetal weight estimated by ultrasound at the end of pregnancy in 137 pregnant women. The study found that the main factors associated to the fetal weight estimated at the 36th week were BMI at the pregnancy onset and weight gain in the second trimester.

Importantly, the present study found no significant differences between the studied groups regarding the absolute error of fetal weight estimation. This finding nullifies the influence of maternal obesity on ultrasound estimation of fetal weight and was in agreement with no effect of maternal weight on accuracy of ultrasound assessment of fetal weight. Moreover, no relation between maternal BMI and the accuracy of ultrasonographic weight assessment.

In addition, **Kritzer et al. (2014)** reported that increasing body mass index (BMI) doesn't influence the accuracy of sonographic estimation of fetal weight in a retrospective cohort study of singleton deliveries over a 2-year period including 1177 women. The study found that the percentage error of the EFW was similar between women of varying BMI classifications, as was the rate of substantial error and the rate of underestimation of the EFW.

Similar conclusions were derived from the study of **Ryan et al. (2014)** on twins. The authors found no relationship between BMI and the accuracy of EFW and concluded that contrary to a commonly held clinical impression, increasing maternal BMI has no significant impact on the accuracy of EFW in twin pregnancy.

Furthermore, **Cody et al. (2016)** found that the EFW determined prior to delivery was within 6% of the actual birth weight in all BMI subcategories with no statistically significant differences.

Likewise, the study of **Gonzalez et al. (2017)** on 403 pregnant women with a mean BMI was 32.62 ± 8.59 kg/m2 found that accuracy of the estimated ultrasound-derived birth weight was not predicted by the maternal BMI. Also, **Al-Obaidly et al. (2017)** in retrospective study of obese patients with recorded BMI ≥30 kg/m2, class I and II (BMI: 3039.9 kg/m2) compared with extreme obese class III (BMI ≥40 kg/m2) could not illustrate a significant difference on ultrasound accuracy across various obesity classes.

Most recently, the study of **Blitz et al. (2018)** found that even in singleton gestations with ultrasound fetal weight estimation performed at 40 to 42 weeks, there was no significant difference in absolute percentage error or rate of substantial error between BMI groups.

In contradiction to our study the study of **Aksoy et al. (2015)** investigated the possible effect of maternal obesity on the accuracy of sonographically estimated fetal weight in the third-trimester shortly before induction of labor and to compare the accuracy of the estimation between normal weight, overweight, and class I, class II and class III obese groups. Women were classified according to current body mass index (BMI) into five categories: normal, overweight, obese class I (BMI 30.0-34.9 kg/m (2)), obese class II (BMI, 35.0-39.9 kg/m (2)) and obese class III (BMI ≥ 40.0 kg/m (2)). The authors found that mean absolute percentage errors were 3.51 ± 2.76, 6.37 ± 3.91, 7.93 ± 4.81, 9.87 ± 4.32 and 14.06 ± 5.83 ($P < 0.001$). They concluded that maternal obesity decreases the accuracy of sonographic fetal weight estimation.

The study of **Aksoy et al.** explained by three factors: **first**: the different characteristics of the included mothers and in more precise words, the different range of BMI; **second**: use of different equations of fetal weight calculations which may cause minor variations among various studies but their additive effects can't be neglected; **third**: technical issues related to the convenience of the ultrasound technology used and the experience of the practicing sonographers.

Our study found that in both studied and control groups, no significant differences were found between ultrasound estimated fetal weight and actual weight after delivery (Table 6-7). Also, the present study found a significant correlation between estimated birth weight and actual weight after delivery in both groups (Table-8). This reflects the accuracy of ultrasound as a method of fetal weight estimation and accords with many previous studies.

In the study of **Ricci et al. (2011)**, the authors proposed to determine the accuracy of ultrasound in fetal weight estimation and to evaluate maternal and/or fetal factors that could interfere in the result in 106 patients. The study found a good correlation between estimated fetal weight and birth weight and concluded that ultrasound presented good accuracy in the estimation of fetal weight.

Conclusion

In general, we concluded that maternal obesity does not affect the accuracy of ultrasound fetal weight estimation. Therefore, Sonographic fetal weight prediction provide accurate and valid guideline for determining management decision in women regardless of body size. Our study has shown that obesity doesn't affect the accuracy of ultrasound fetal weight estimation.

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