The Accuracy of Estimating Fetal Weight using Ultrasound in Women with High Body Mass Index

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Abstract

Objective: To determine the effect of maternal obesity on estimated fetal weight.
Design: Prospective cohort study.
Setting: Tertiary care hospital in Amman Al-Bashir Hospital.
Subjects: 326 women admitted for elective delivery between November 2015 and January 2016
Intervention: Participants were divided into their weight parameters: normal, overweight, obese, and extremely obese according to WHO obesity standards. A pre-delivery ultrasound exam was performed, and estimated fetal weight was calculated. Actual fetal weight was measured 30 minutes after delivery. The difference between actual and estimated fetal body weight was calculated.
Main outcome measures: Estimated fetal weight and measured postpartum fetal weight are equal.
Results: There was a significant difference between the estimated fetal weight and the actual fetal weight. This difference was measured to be higher in extremely obese mothers when compared to mothers with a lower BMI. The difference between estimated fetal weight and actual fetal weight was 222 grams for the normal weight population, 240 grams for the overweight population, 287 grams for the obese population and 466 grams for the extremely obese population ($P < 0.01$).
Conclusion: Fetal weight assessment becomes increasingly less accurate with increasing maternal BMI. Obstetricians need to take this into consideration when managing obese patients with complications.

Keywords: Obstetric Ultrasound, Fetal Body Weight (FBW), Body Mass Index (BMI), Obesity.

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Introduction

Ultrasound is currently the cornerstone of obstetric imaging. Most patients have at least one routine ultrasound scan during pregnancy. Estimating fetal weight, specifically in the third trimester, is one of the primary applications of ultrasound in obstetrics and helps in assessing the neonatal survival rate by aiding obstetricians in making clinical decisions on delivery.

Fetal weight estimation is based on fetal biometric measurements and is calculated using formulas in clinical practice with a systemic error of 10% or less relative to the actual weight of the fetus [(1)]. Sarris *et al.* found that the accuracy of fetal biometric measurement varies depending on the position of the fetus, the

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activity of the fetus, maternal obesity and the operator performing the ultrasound [2 & 3].

Obesity in pregnancy creates new challenges for adequate delivery and maintaining the health of the fetus and the mother. Obese women are at a higher risk for obstetric complications, such as shoulder dystocia, caesarean section, gestational diabetes and preeclampsia. Higher perinatal mortality and morbidity is associated with higher maternal BMI[4] and difficulty in visualizing fetal anatomy[5]. Thus, fetal weight estimation in obese women must be accurate to assist obstetricians in making appropriate delivery decisions.

Different studies have evaluated the effect of obesity on estimated fetal weight with various results, including no effect on the accuracy of fetal weight estimation[6], discrepancies in gestational age estimation in the second trimester[7] and a decrease in the accuracy of sonographic fetal weight estimation [8].

The World Health Organization (WHO) defines obesity as a state of excessive fat accumulation that leads to impaired health and an increase in mortality[9]. Maternal obesity is especially considered an epidemic that has a significant influence on maternal and fetal health. Obesity is measured by dividing the weight of a person in kilograms (kg) by the square of their height in meters (kg/m^2) to yield the body mass index (BMI). The obesity threshold according to WHO parameters is generally identified as a BMI $\geq$30 kg/m^2 [9]. The purpose of this study is to investigate the relationship between maternal obesity and fetal body weight which gives us the ability to make recommendations that allow clinicians to take appropriate action to ensure maternal and fetal well-being.

SUBJECTS AND METHODS

This paper was a prospective study that was carried out at Al Bashir Hospital in Jordan. The Hashemite University and the Ministry of Health's Institutional Review Board gave ethical approval. Pregnant women who were admitted to the hospital for planned delivery either by an elective caesarean section or induction of labor between October 2016 and February 2017 were considered candidates for the study. Women were approached and provided a leaflet about the study and upon agreement to participate were asked to sign a consent form. Participants were surveyed on age, parity and gestational age. Height and weight were measured and recorded.

Inclusion criteria:

Singleton, delivery date measured by Last Menstrual Period (LMP) with a first-trimester ultrasound, 37-42 weeks Gestational Age (GA) with cephalic presentation.

Exclusion criteria:

Multiple pregnancies, abnormal presentation, oligohydramnios, placental abnormalities (i.e. placenta previa, placental attachment abnormalities), congenital fetal anomalies, hydrops fetalis, intrauterine fetal death and active stage of labor.

All ultrasound exams were performed using the same machine, Samsung Medison R5, with a curvilinear abdominal transducer. Estimated fetal weight was calculated based on biparietal diameter, abdominal circumference and femur length. The equation used was the Hadlock equation:

(log10weight = 1.335 - 0.00034 AC × FL + 0.00316 BPD + 0.00457 AC + 0.01623 FL) [1]

Head measurements were taken in the trans-thalamic plane measuring on the outer border of the skull using an Eclipse. Abdominal measurements were taken with the umbilical vein in the anterior third of a transverse section of the fetal abdomen at the level of the portal sinus, with the stomach bubble visible measuring the outer

border of the abdomen using Eclipse. The femur closest to the probe was measured for femur length with its long axis as horizontal as possible. Fetal ultrasound weight measurements were performed 30 minutes prior to delivery. Calipers were placed on the outer borders of the diaphysis of the femoral bone (‘outer to outer') and did not include the trochanter. Actual fetal weight was recorded 30 minutes after delivery by a midwife. The estimated fetal weight was compared with the actual birth weight, and the difference between the two was recorded in grams.

Statistical Analysis:

PSW Statistics was used for all statistical analysis. Shapiro-Wilk test was used as a test of normality. Mann-Whitney U-test was used to compare two groups where data is not normally distributed and t-test was used where the distribution is normal.

RESULTS

Four hundred and eighty (480) pregnant women admitted to Al Bashir hospital for elective delivery between November 2016 and January 2017 were evaluated for recruitment in this study. 102 participants were excluded due to failure of meeting the inclusion criteria or for lack of consent. Obtaining all needed measurements was not possible for 52 participants. A complete assessment was performed for 362 participants. The BMI of participating women ranged from 17 to 44. 118 participants had a BMI between 17 – 24.9, 102 participants had a BMI between 25 – 29.9, 74 participants had a BMI between 30 – 34.9, and 32 participants had a BMI above 35 as seen in Table 1. There was no statistically significant difference between the groups in age, parity or gestational age of delivery as seen in Table 2 ($p>0.05$).

A comparison between the estimated fetal weight and actual weight for normal weight (BMI 20-24.9), overweight (BMI 25-29.9), obesity class I (BMI 30-34.9) and obesity class II and III (BMI 35- 39.9 and BMI above 40) shows that there is no significant difference in the first two groups and a significant difference in the third and fourth groups with a P value of 0.043 and 00.30 respectively (Table 3). Obesity classes I, II and III are regularly measured to be significantly less than their estimated fetal weight. Comparing the estimated fetal weight and actual weight for all patients also shows a significant difference ($P<0.001$). There was also a significant difference between the estimated weight and actual weight between the different BMI groups ($P <0.01$) as seen in Table 4 where the difference between normal weight groups ad Obesity classes II and III was more than 244 g with a standard deviation of 184 g.

DISCUSSION

This study looked at the effect of maternal obesity on the accuracy of sonographic fetal weight estimation. The accuracy of fetal weight assessment impotence is due to the clinical decisions that are made based on the weight estimation.

It was shown in the study that the accuracy of fetal weight assessment decreases with increasing maternal obesity. Overestimation of fetal weight may lead to an unnecessary caesarean section due to an incorrect diagnosis of macrosomia which is associated with higher maternal morbidity especially for women with high BMI. Overestimation may also lead to underdiagnosis of IUGR (Intrauterine growth restriction) which can negatively affect the fetus. Underestimation of fetal weight will lead to decreased diagnosis of macrosomia and over diagnosing IUGR which may lead to inappropriate or untimely interventions and

perinatal compromise.

Ultrasound images are the products of the reflection of sound waves against different tissue borders. In women with high BMI, the sound waves have to travel longer to the target organ which means that the sound wave becomes weaker due to attenuation (loss of signal strength as it propagates through tissue). This explains the impairment of fetal anatomy visualization in women with high BMI reported by Wolfe et al 1990[10].The authors of that study reported 15% loss of visualization when the BMI was above the 90%. Dashe et al in 2009 also showed that increasing maternal BMI limits the visualization of the fetal anatomic structures during a second-trimester fetal anomaly scan[11]. Only a few studies have evaluated the effects of increased maternal BMI on sonographic fetal measurements. Paterson et al 1985 was the first study that looked at estimated fetal weight in obese women and concluded that obesity affects the accuracy of fetal weight estimation[12]. Conversely, Field et al and Farrell et al found that the accuracy of fetal biometric measurements is not affected by increasing maternal obesity . Field et al evaluated almost 1000 patients over one year with a variable gestational age between 26-43 weeks. The authors of this study concluded that estimated fetal weight assessment is accurate regardless of body size. 96 randomly selected women who visited the hospital for induction of labor were analyzed and the accuracy of estimated fetal weight was not affected by maternal BMI[6].

Estimated fetal weight measurement is based on fetal biometric measurements of bony landmarks. Bone is a strong reflector of ultrasound waves which produces a strong echo. This might explain why fetal anatomy visualization is impaired while fetal measurement is not. Aksoy et al 2015 investigated fetal biometric measurements of almost 200 patients between 36-42 weeks and concluded that maternal obesity decreases the accuracy of sonographic fetal weight estimation[8]. The discrepancy in findings between studies may be due to differences in sample size and gestational age.

The accuracy of fetal weight estimation using ultrasound may therefore decrease in term-pregnant women with a BMI above 35. The Hadlock equation which uses abdominal circumference, biparietal diameter and femur length in estimating fetal weight was used in both studies. Using other formulas that have less dependence on soft tissue markers like abdominal circumference might improve accuracy.

The limitation of this study include multi-operator tests which may cause inter-observer variability. The formula used in calculating fetal weight is also a traditional formula and may be outdated. A newer formula with more accurate fetal weight estimation has been developed[14] and may prove to be more reliable.

Strengths of this study include strict protocol, using the same machine for all scans, limiting the gestational age and the prospective nature of the study.

CONCLUSION

This study shows that fetal weight assessment is less accurate in obese women. More studies are needed to confirm this finding. Advancement of ultrasound technology and using different formulas in estimating fetal weight may improve the accuracy of fetal weight assessment in women with a high BMI. With obesity becoming an epidemic, obstetricians need to take this into consideration when managing obese patients with complications.

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Table 1: Number of participants distributed across different groups of body mass index

BMI	Number of participants
Normal weight (17-24.9)	118
Over weight (25-29.9)	102
Obesity class I (30-34.9)	74
Obesity class II & III (35-48)	32

Table 2: Participants in different weight groups distributed by their mean values for age, BMI, parity, and gestational age

Participants	Age (mean)	BMI (mean)	Parity (mean)	Gestational age(mean)
All women	31.1 years	32 Kg/m^2	2.4	38.4 weeks
Normal weight	30.2 years	24 kg/m^2	2.6	38.36 weeks
Over weight	31.2 years	28.4 kg/m^2	2.3	38.37 weeks
Obesity class I	31.7 years	32.8 kg/m^2	2.5	38.67 weeks
Obesity class II &III	33.2 years	39 kg/m^2	2.5	38.24 weeks
P Value	0.286	0.01	0.324	0.421

Table 3: The estimated fetal weight vs. the actual weight

Participants	Actual fetal weight (Mean +/- SD)	Estimated fetal weight (Mean +/- SD)	P Value
All women	3192 g +/- 485 g	3024 g+/- 442	0.001 *
Normal weight (BMI 20-24,9)	3028 g +/- 360 g	2930 g +/- 352	0.134 **
Over weight (BMI 25-29.9)	3207 g +/- 457	3075 g +/- 401	0.126 **
Obesity class I (BMI 30-34,9)	3326 g +/- 419	3112 g +/- 474	0.043 **
Obesity class II,III (BMI > 35)	2875 g +/- 579	3145 g +/- 555	0.030**

* Mann Whitney U test; ** Independent T-Test

Table 4: The difference between EFW and AFW across the different BMI groups

Participant weight group	The difference mean +/- SD
Normal weight (BMI 20-24.9)	222.3 gm +/- 168
Over weight (BMI 25-29.9)	239.6 gm +/- 243
Obesity class I (BMI 30-34.9)	286.6 gm +/- 148
Obesity class II,III (BMI > 35)	466.8 gm +/- 184

تأثير السمنة الأمومية على تقدير وزن الجنين

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الملخص

الأهداف: تهدف الدراسة لمعرفة تأثير السمنة الأمومية على وزن الجنين التقديري.

الطريقة: شملت الدراسة 326 امرأة تم إدخالهن مستشفى البشير لإتمام عملية الولادة الطبيعية ما بين نوفمبر 2015 ويناير 2016 ومن ثم توزيع العينة حسب معايير الوزن الخاصة بهن: وزن طبيعي، زيادة الوزن فوق العادة، السمنة، والسمنة المفرطة وفقا لمعايير منظمة الصحة العالمية للسمنة. ثم أجري فحص الموجات فوق الصوتية قبل الولادة لتقدير وزن الجنين وقياس وزن الجنين الفعلي بعد 30 دقيقة من الولادة وحساب الفرق بين وزن الجنين الفعلي والتقديري.

النتائج: وجد فرق كبير بين وزن الجنين التقديري ووزن الجنين الفعلي. لوحظ أن هذا الفرق أعلى ما بين الأمهات اللواتي يعانين من السمنة المفرطة بالمقارنة مع الأمهات ذوي معدلات أقل بمؤشر كتلة الجسم . كان الفرق بين الوزن التقديري للجنين ووزن الجنين الفعلي 222 جرامًا في عينة الأمهات ذوي كتلة جسم طبيعية ، و240 جرامًا من الأمهات اللاتي يعانين من زيادة وزن فوق العادة ، و 287 جرامًا من الأمهات اللاتي يعانين من السمنة، و 466 جرامًا من الأمهات اللاتي يعانين من السمنة المفرطة.($P < 0.01$)

الخلاصة: يصبح تقييم وزن الجنين أقل دقة بشكل متزايد مع زيادة مؤشر كتلة الجسم في الأم. يحتاج أطباء التوليد إلى أخذ ذلك في الاعتبار عند علاج مرضى السمنة الذين يعانون من مضاعفات.

الكلمات الدّالّة: فحص الموجات فوق الصوتية للولادة ، وزن الجنين (FBW) ، مؤشر كتلة الجسم (BMI) ، السمنة.