The effect of maternal body mass index on clinical and ultrasonic estimations of fetal weight

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Abstract

Background assessment of fetal weight (clinically or by ultrasound) has an important issue to decrease maternal and fetal complications during labour. **Objective:** To assess the effect of maternal body mass index on clinical and sonographical estimation of fetal weight. **Patients and methods:** (80) Eighty pregnant women were studied from the start of October 2007 to the end of September 2008 in Al-Kadhymia teaching hospital. These women had single, cephalic and term pregnancy. About 24 hour prior to delivery of the fetus, clinical estimation of fetal weight using Leopold's maneuver was done followed by sonographic estimation of fetal weight using Hadlock's equation. Then a comparison of clinical and sonographical estimation of fetal weight with the weight of the newborn baby was done. The accuracy of fetal weight estimation was done in obese and non obese women. **Results:** Clinical estimation of fetal weight has a better agreement with true birth weight than sonographic estimation in low and high BMI pregnant women. Both clinical and sonographic estimation of fetal weight under-estimate true birth weight in women with low and high BMI. , the agreement between clinical estimation of fetal weight and birth weight was higher than sonographical estimation, both in high and low BMI groups. Sonographical estimation of fetal weight tended to under estimate the true fetal weight in both low and high BMI groups. Clinical estimation of fetal weight tended to under estimate true fetal weight in both low and high BMI groups, but had a better correlation with true fetal weight than sonographical estimations.

Conclusion:

The accuracy of clinical estimation of fetal weight was better than sonographical estimation and was not influenced significantly by maternal BMI.

Introduction

Obstetric management is often influenced by clinical and ultrasonic estimations of fetal weight ,especially in suspected macrosomic or small for gestational age fetuses(1). The Pathophysiology of fetal macrosomia is related to the associations between maternal, placental and fetal conditions that accounts for its developments.

Maternal causes include;

1- Maternal obesity and excessive maternal weight gain during pregnancy. (2)
2-Diabetic pregnant and pregnant with impaired glucose tolerance test.(8)
3- Multiparity .(2)
4- Race and ethnicity.(2)
5- Maternal birth weight.(2)
6- Previous infant weighing more than 4000 gm .(2)

Placental causes include prolonged gestation.(5)

Fetal causes include male fetus.(2)

Maternal obesity associated with macrosomia and intermittent periods of hyper-glycaemia. Hyperglycaemia in the fetus results in stimulation of insulin, insulin like growth factor ,growth hormone and other growth factors which in turn stimulate fetal growth and deposition of fat and glycogen in fetal tissues which results in macrosomic fetus.(2) There is evidence that insulin and insulin like growth factor 1 and 2 have role in the regulation of fetal growth (3). Insulin is secreted by fetal pancreatic B-cells primarily during the second half of gestation ,and is believed to stimulate somatic growth and fat deposition (3). Another hormones which are required through late gestation to ensure appropriate growth and development include thyroid hormone ,cortisol hormone ,epidermal growth factor and prostaglandins. These growth factors ,which are structurally pro-insulin polypeptide, produced by all fetal organs and are potent stimulators of cell differentiation and division.(4) Advanced gestational age results in larger birth weight at delivery by allowing the growth process to continue in the uterus, at 38-40 weeks the incidence of fetal macrosomia is 10% and at 43 weeks it is 43%.(5) Any increase in perinatal mortality after 42nd weeks of gestation is due, in part, to the high incidence of fetal macrosomia, and these fetuses are at particular risk of complications such as shoulder dystocia. Consequences of fetal macrosomia

Fetal consequences include; 1-Shoulder dystocia.(6) 2-Birth trauma.(7) 3-Intrapartum asphyxia.(8) 4-Neonatal hypocalcaemia.(9) 5-Neonatal cardiomyopathy.(10)

Maternal consequences include;(11)(8)

1-Increase incidence of cephalopelvic disproportion. And operative vaginal delivery.

2-Increase the risk of third and fourth degree laceration of the perineum by five folds.(11) 3-Increase incidence of postpartum hemorrhage.(8)

Small for gestational age fetus ; Failure of the fetus to achieve it is genetic growth potential, or fetus below 10th centile for abdominal circumstances or estimated fetal weight.(12),10% of all pregnancies are small for gestational age. The majority of small fetuses are in fact healthy but small , and only as few as 15% of small fetuses caused by fetal growth retardation. Fetal growth retardation can affect larger fetuses, about 70% of fetuses suffering from reduced growth velocity will have a birth weight considered appropriate for gestational age.(12) Consequences of small for gestational age fetus. (12)

1-During pregnancy ,there is 40% increase risk of still birth ,which is mostly due to development of utero-placental insufficiency , oligohydramnios and cord compression.

2-During labor ,increase risk of fetal hypoxia ,acidaemia ,fetal distress , intra-partum death and incidence of caesarean section.

3-Early neonatal complications include hypoglycemia, hypocalcaemia, hyperbilirubinaemia, polycythaemia, apnea spell and the need for intubations, seizure, low Apgar score, early neonatal death, early cognitive and neurological impairment and cerebral palsy.

4-Later in life there is a risk of development of obesity, hypertension , glucose intolerance and atheromatous vascular disease.(12)

5-Increase the risk of emergency caesarean section mostly for fetal distress.

Clinical estimation of fetal weight; Tactile assessment of fetal dimensions through the maternal abdomen . This is the most intuitive technique .It is done by palpating the fetal parts directly through the maternal abdominal and uterine walls to estimate fetal weight. This method is both convenient and costless. The volume of amniotic fluid ,the size and configuration of the uterus and maternal body habits may complicate fetal size estimation.(8)

Fetal weight estimation by ultrasound; The two dimensional ultrasound maps the contents of the uterus and the pictures provided in thin slices .The advent of ultrasound has overcome many of the diagnostic limitations of x-ray and has virtually eliminates the need for fetal exposure to ionizing radiation.(37)

Fetal measures made by ultrasound in pregnancy

1-The biparietal diameter which represent the diameter between the two sides of the head , used after 13 weeks and it increases from about 2.4 cm at 13 week to about 9.5 cm at term.
2-The femoral length which measures the longest bone of the body (femur) and reflects the longitudinal growth of the fetus. It increases from about 1.5 cm at 14 weeks to about 7.8 cm at term.
3-The abdominal circumference which reflects more the fetal size and weight rather than age and it is the most important measurement to be made in late pregnancy.
4-Head circumference which is calculated by:
HC=(BPD + OFD)*1.62
HC-head circumference.
BPD-transverse plane.
OFD-antero-posterior plane. (37)

Maternal obesity

Obesity has became an epidemic disease and is now recognized as one of the most important public health problem worldwide . A generally accepted definition of obesity is a body mass index more than 30 kg\m^2(13)

Figure (1.1) Demonstrate the weight status of the population.

B M I(kg\m2)	Weight status
< 18.5	Under weight
18.5 – 24.9	Normal
25 – 29.9	Over weight
> 30	Obese

Obesity related adverse out comes in women.

Obesity can be a barrier to reproduction as there is an association between high body mass index and infertility. Obese women commonly present with higher incidence of maternal disorders and miscarriage and also sub-fertility treatment is dependent on body mass index and interventions to reduce weight would be beneficial in the treatment of sub-fertility and subsequently during pregnancy.(14)

The major maternal complications associated with obesity during pregnancy;

1-Diabetes(pregestational and gestational): Diabetes occur in approximately 1-3% of pregnant women, compared to 17% of obese women develop gestational diabetes. Thus active strategies for weight control and life style advice after delivery with regular follow up is needed for the management of women with gestational diabetes to prevent type 2 diabetes and associated morbidity and mortality.(15)(16)(17)(18)
2-Hypertensive disease: Maternal obesity is an important factor for the development of gestational hypertension. The systematic review of O'Brien et al. demonstrate a consistently strong positive association between maternal prepregnancy body mass index and the risk of pre-eclampsia , the risk of pre-eclampsia typically doubled with each 5-7 kg per m2 increase in prepregnancy body mass index .Over all pregnant women have 14- 25% incidence of pre-eclampsia.(19)
3-Thrombo-embolic complications: Venous thromboembolic complications are the leading cause of maternal mortality in the developed world. The Royal college of obstetrician and gynecologist reports on maternal deaths concluded that obesity is the most common risk factor for thrombo-embolism.(20)(21)
4-Respiratory complications: obesity has been shown to have a causal association with sleep apnoea and asthma. Sleep apnoea can lead to pulmonary hypertension , right heart failure, stroke and arrhythmia.(22)
5-Infection: Increase incidence of urinary tract infection in obese women.

6- Metabolic syndrome: Metabolic syndrome is defined as the association of obesity, insulin resistant , hypertension and dyslipidaemia. Boney et al .suggested that obese mothers who do not fulfill the clinical criteria for gestational diabetes mellitus still have metabolic factors that affect fetal growth and postnatal outcomes. This is of interest as the study of Boney et al. showed that children of obese mothers were at increased risk of developing metabolic syndrome , an complication with a bad implication for subsequent generation.(23)

Obesity related adverse outcome in labour

1-Caesarean section: Maternal obesity is an independent risk factor for caesarean section . Sebire et al .showed that caesarean section rate for obese women was over 20% compared to nearer 10% for normal weight women.(24)

2- Shoulder dystocia : Defined as delivery in which additional maneuvers are required to deliver the fetus after gentle down ward traction has failed.(25)(26)

3-Post-partum complications : Obese women who had vaginal delivery had greater than 500 ml blood loss compared to those with normal weight.(27) The reason for this may be due to the relatively large volume of distribution related to obesity and the decrease bio-availability of utero –tonic agents.

4- Lactate dysfunction : Obesity is associated with increased risk of failure to initiate lactation and decrease duration of lactation. Maternal obesity is implicated in altering the hypothalamic-pituitary-gonadal axis and fat metabolism, resulting in lactate dysfunction.(28)

5-Contraception: Oral contraceptive failure is more likely in overweight women .The mean serum medroxyprogesterone acetate concentration was lower in obese women compared to normal weight women.

The adverse effects of maternal obesity on fetal outcome;

1-Neural tube defect: Recently there has been evidence to support the association between maternal obesity and the increased risk of neural tube defect . Hendrisks et al. showed that hyperinsulinaemia is a strong risk factor for neural tube defect and may be the driving force for the observed risk in obese. Folate consumption was found to be associated with a reduced risk of neural tube defect among women with less than 70 kg ,but not among heavier women, so it is very important to encourage weight reduction in obese women before pregnancy due to the failure of the protective action of folate against neural tube defect.(28)(29)(30)

2- Small for gestational age fetus and intra-uterine death:

The study of Sebire et al. showed that obese multiparous women had increase the risk of late intra-uterine fetal death compared to normal weight women.(31)(32)(33)

3-Macrosomia:

It is thought that in early pregnancy, maternal obesity and hence increase maternal insulin resistance may be related to altered placental function, in addition to increase fetoplacental availability of glucose, free fatty acids and amino acids, however, the mechanism behind this is unknown.(34)

4-Childhood complications:

Maternal obesity results in infant at birth having an increased degree of adiposity, yet these infants are no significantly more obese compared to control.(35) However, there is evidence showing that elevated antepartum plasma levels of maternal free fatty acids, a hall markers of obesity and insulin resistance , correlates inversely with the intelligence of the off sprig at 2-5 years of age.(23)

Patients and methods This study was conducted for a period of one year, from the start of October 2007 to the end of September 2008, in the Obstetrics and

Gynaecological Department of Al-Kadhymia Teaching Hospital. The study included (80) term pregnant women, (40) pregnant women were obese and (40) pregnant women were not.These women either presented in early labour, admitted for induction of labour or for caesarean section. Women included in the study met the following criteria: Singleton pregnancy, Term, the gestational age was considered to be reliable based on sure last menstrual period and early ultrasound estimation of gestational age, Cephalic presentation.

Exclusion criteria: Preterm delivery, Multiple pregnancy, Rupture of the membrane , if the pregnant woman presented in early labour, Patient with excessive uterine contraction, Ultrasound evidence of congenital abnormalities, polyhydramnios or oligohydramnios. Detailed history was taken from each patients regarding indication of induction of labour or caesarean section , using the following questionnaire:

1-Name. 2-Age. 3-Last menstrual period and early ultrasound scan. 4-Review the antenatal care of the patient looking for any problems in the current pregnancy such as diabetes, hypertension, decrease fetal movement, watery vaginal discharge and vaginal bleeding. 5-Past obstetrical history including delivery of previous macrosomic baby. 6-Past medical history.

General examination including maternal weight and height was performed and maternal body mass index was calculated using the following equation:

Maternal BMI = maternal weight in kg / maternal height in square meter. Using maternal BMI at the time of induction rather than at booking in order to determine the effect of the current maternal BMI on fetal weight estimation . Clinical estimation of fetal weight was performed using Leopold's maneuver and fundal height measurement. Women were then referred for ultrasound study. A 3.5 MHz curvilinear abdominal transducer was used to obtain morphometrical measurements. Fetal weight estimation was done by using Had lock's formula:

[Log 10 B W=1.326 -0.00326 (AC) (FL) + 0.0107(HC) +0.438(AC) + 0.158(FL)] .

Abdominal circumference measurement was made from an axial section of the fetal trunk at the level of the liver, the main landmark is the porto- umbilical venous plexus, with the fetal stomach as a secondary landmark if the vein cannot be visualized. Femoral length measurement must include the entire shaft of the femur, the femur should be perpendicular to the ultrasound beam. Inclusion of the distal femoral epiphysis was avoided. Care should also be taken about false shortening of the femur with an tangential section or including soft tissue reflection in the measurement , particularly at the distal end of the femur. Head circumference was calculated from this equation:

HC= (BPD +OFD)* 1.62

BPD→ represent transverse plane of the head .

OFD→ represent anteroposterior plane.

Delivery whether by caesarean section or vaginal delivery was attended by senior house officer and midwife, newborn was handled by pediatrician for resuscitation and assessment of body weight. Correlation between the actual birth weight with clinical and sonographical estimation was collected independently after delivery. Statistical analysis; Data were collected , analyzed and represented in simple measures of mean, standard deviation, sensitivity, specificity , positive predictive value , negative predictive value and accuracy. Student t-test and chi-square were used for evaluation the significances of the result. P value <0.05 was considered statistically significant.

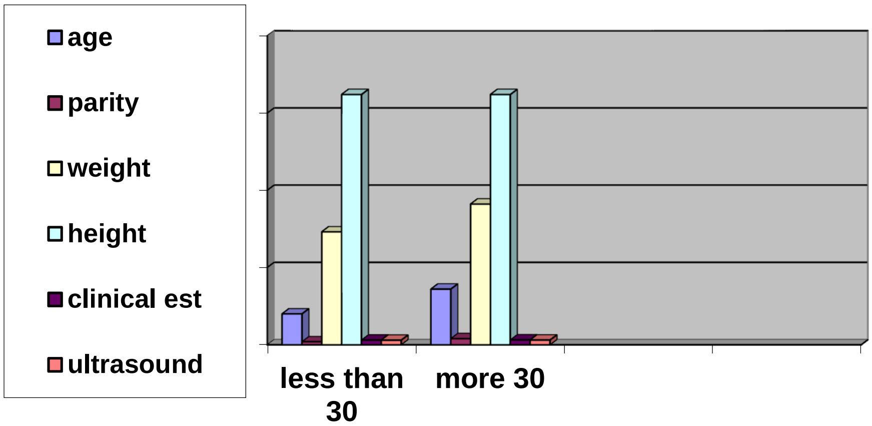
Results: 80 pregnant women were included in this analysis. Table (2.1)demonstrate the characteristics of the women and the sonographical finding of the study group.

Table (2.1) Demographic characteristics of the study group

Descriptive data	Study group (n=80) mean +-[SD]	BMI <30 (n=40) mean +-[SD]	BMI ≥ 30 (n=40) mean +_[SD]	P value
Age(years)	27.8[4.41]	27.1[4.1]	29.9[5.5]	0.506
Parity	2[1.8]	1[1.7]	3[1.3]	0.640
Weight(kg)	85.7[9.3]	77.2[6.1]	88.6[7.4]	0.431
Height(cm)	164[6.2]	166[5.4]	158.7[4.3]	0.132
HC(mm)	340[1.6]	341[1.6]	340.8[2.2]	0.240
AC(mm)	351[1.8]	350[2.3]	351[1.8]	0.324
FL(mm)	72.6[1.9]	72[2]	71.9[1.9]	0.426
AFI(cm)	7.2[0.6]	7.3[0.7]	7.5[0.6]	0.240
BMI(kg/m2)	30[1.5]	27.1[1.4]	35.4[3.2]	0.021
C/S%	30	24	38	0.026

BMI body mass index, SD standard deviation

Figure(2.1) maternal characteristic



The mean BMI for the study group was 30 +- [1.5], 50% of the cases had a BMI equal to or greater than 30 (mean 35.4 ,SD 3.2) and 50% had BMI less than 30 (mean 27.1,SD 1.4) and a part from body mass index and caesarean section rate there is no significant differences were found between the two groups in term of descriptive details. In the study we use cut point of fetal weight equal to 4 kg because fetal weight equal to or greater than 4 kg may be associated with fetal and maternal adverse out come.

Table(2.2) demonstrate the accuracy of clinical estimation of fetal weight using Leopold's maneuver, when maternal BMI was less than 30kg/m^2. The sensitivity and specificity were 66.6% and 97.2% respectively. The positive predictive value was 66.6% and the negative predictive value was 97.2%.

Table (2.2) The accuracy of clinical estimation in predicting fetal weight when maternal BMI less than 30.

Clinical estimation	True fetal weight		
	≥ 4 kg	< 4 kg	total
≥ 4 kg	2	1	3
< 4 kg	1	36	37
total	3	37	40

Sensitivity=66.6%, Specificity=97.2% , Positive predictive value=66.6%, Negative predictive value=97.2%

Table (2.3) shows the accuracy of clinical estimation in predicting fetal weight when maternal BMI equal to or more than 30kg/m^2. The sensitivity and specificity were 66.6% and 94.2% respectively. The positive predictive value was 50% and the negative predictive value was 97.2%.

Table(2.3) The accuracy of clinical estimation in predicting fetal weight when maternal BMI was equal to or greater than 30 kg/m2.

Clinical estimation	True birth weight		
	≥ 4 kg	< 4 kg	total
≥ 4 kg	2	2	4
< 4 kg	1	35	36
Total	3	37	40

Sensitivity=66.6%, Specificity=94.2%, Positive predictive value=50%, Negative predictive value=97.2%

Table(2.4) shows the accuracy of sonographic estimation of fetal weight when maternal BMI was less than 30 kg/m2,using Hadlock's formula. The sensitivity and specificity were 50% and 97.2% respectively. The positive predictive value was 66.6% and the negative predictive value was 97%.

Table (2.4) The accuracy of sonographic estimation of fetal weight when maternal BMI was less than 30 kg /m^2.

Sonographic estimation	True birth weight		
	≥ 4 kg	<4kg	total
≥4kg	2	1	3
<4kg	2	35	37
Total	4	36	40

Sensitivity=50%, Specificity=97.2%, Positive predictive value=66.6%, Negative predictive value=97%

Table (2.5) shows the accuracy of sonographic estimation of fetal weight when maternal BMI was equal to or greater than 30kg/m2. The sensitivity and specificity were 50% and 94.4% respectively. The positive predictive value was 50% and the negative predictive value was 94.4%.

Table(2.5) The accuracy of sonographic estimation of fetal weight when maternal BMI was equal to or greater than 30 kg/m^2.

Sonographic estimation	True birth weight		
	≥4kg	<4kg	total
≥4kg	2	2	4
>4kg	2	34	36
total	4	36	40

Sensitivity=50%, Specificity=94.4%, Positive predictive value=50%, Negative predictive value=94.4%

Table (2.6) shows that the accuracy of clinical estimation of fetal weight was 80% when maternal BMI was less than 30kg/m2 and 75% when maternal BMI was greater than 30kg/m2, while the accuracy of sonographic estimation of fetal weight was 72% when maternal BMI was less than 30 kg/m^2, and 68% when maternal BMI was greater than 30 kg/m^2.

Table (2.6) The accuracy of clinical and sonographical fetal weight estimation when the mother had BMI below or above 30 kg/m^2.

	Maternal BMI<30					Maternal BMI ≥30				
	sensitivity	specificity	PPV	NPP	Accuracy	sensitivity	specificity	PPV	NPP	Accuracy
Clinical estimation	66.6%	97.2%	66.6%	97.2%	80%	66.6%	94.4%	50%	97.2%	75%
Sonographic estimation	50%	97.2%	66.6%	97.2%	72%	50%	94.4%	50%	94.4%	68%

PPV positive predictive value, NPP negative predictive value

The effect of maternal BMI on clinical and sonographical estimations of fetal weight was statistically non significant, P values using unpaired t test were 0.56 (> 0.05) for clinical estimation and 0.32(>0.05) for sonographic estimation.

Table (2.7) The clinical and sonographic estimation of fetal weight using mean and standard deviation of the study group.

	Study group	Women with BMI < 30	Women with BMI ≥ 30
	Mean [SD]	Mean [SD]	Mean [SD]
Clinical estimation	3290 [295]	3100 [351]	3270 [278]
Sonographical estimation	3000 [440]	3000 [250]	3100 [270]

The difference between clinical and sonographical estimations when maternal BMI was below or above 30 was statistically significant. P value using unpaired t test < 0.001.

Table (2.8) The mean birth weight and the mean discrepancy between true birth weight and estimated weight for the study group and for the high and low BMI groups.

	Study group		Women with BMI<30		Women with BMI≥30	
	Mean birth weight	MBW-estimated weight	Mean birth weight	MBW-estimated weight	Mean birth weight	MBW-estimated weight
Clinical estimation	**3290**	**160**	**3100**	**100**	**3270**	**170**
Sonographic estimation	**3000**	**450**	**3000**	**200**	**3100**	**340**

Table (2.8) shows the mean birth weight and the mean discrepancy between clinical and sonographical estimation of birth weight with the birth weight. In general , the agreement between clinical estimation of fetal weight and birth weight was higher than sonographical estimation, both in high and low BMI groups. Sonographical estimation of fetal weight tended to under estimate the true fetal weight in both low and high BMI groups. Clinical estimation of fetal weight tended to under estimate true fetal weight in both low and high BMI groups, but had a better correlation with true fetal weight than sonographical estimations.

Discussion;

Prelabour assessment of fetal weight is very important because fetal macrosomia is associated with adverse peripartum outcomes(maternal and fetal) and modifying the plane of delivery and care of newborn. In this study estimation of fetal weight by using Leopold's maneuver has a better correlation with true birth weight than sonographic estimation both in obese and normal weight pregnant women, clinical estimation of fetal weight had sensitivity and specificity of 66.6% and 97.2% respectively when maternal BMI was less than 30 kg /m^2 and 66.6% and 94.2% respectively when maternal BMI was equal to or greater than 30 kg/m^2, while sonographic estimation of fetal weight using Hadlock's equation had sensitivity and specificity of 50%and 97% respectively when maternal BMI was less than 30kg/m^2 and 50% and 94.4% respectively when maternal BMI was more than 30kg/m^2.

The effect of maternal BMI on clinical and sonographical estimation was not significance (P value was >0.05).

Farrell et al(2002) found that sonographic estimation of fetal weight had a better correlation with true fetal weight than clinical estimation with a limit of agreement for sonographic estimation of -500 to 800 gm for those with high BMI and -200 to 600 for those with low BMI , he also found that the effect of BMI on fetal weight estimation (clinically and sonographically) was statistically non significant.(36)

Another study done by George Noumi(2005) who studied 192 pregnant women within 2 weeks of their delivery and found that the sensitivity and specificity of clinical estimation of fetal weight was 50% and 95% respectively and for sonographic estimation was 50% and 97% respectively, so the advantage of using ultrasound for estimation of fetal weight was questionable.(37)

Study done by Chauhan et al (1998) who studied 661 pregnant women and compared the accuracy of different methods for fetal weight estimation, he found that clinical estimation of fetal weight had sensitivity and specificity of 54% and 94% respectively, and when we compare this study with our study we found that clinical estimation of fetal weight had a higher sensitivity and specificity for both obese and non obese pregnant women.(38)

Predanic et al(2002) reported that a significant improvement in fetal weight estimation occurred with the introduction of training programs among doctors.(39)

In comparison with study done by O Reilly and Davin(1999) who evaluate fetal weight estimation by using ultrasound, the sensitivity and specificity of fetal weight estimation was 85% and 72%respectively, which had a higher sensitivity but lower specificity than our result, which may be due to different equation used for fetal weight estimation, different sonographical scanner machine used and may be due to inter – observer bias.(40)

Another study done by Stotland et al(2004) who studied 9000 pregnant women to detect the relation between high BMI and the mode of delivery, he found that there is an association between high BMI and caesarean section even with average fetal weight, also in our study we found that caesarean section rate was higher in pregnant women with high BMI about 38% while caesarean section rate about 24% in pregnant women with low BMI.(41)

Atalic et al (2006)found that fetal weight estimation using ultrasound tends to overestimate the weight of small fetuses and under estimate the weight of large fetuses and fetuses of diabetic mothers.(42)

Ben –Aroyo et al (2002) found that clinical estimation of fetal weight was less accurate in twin and non cephalic presentation fetuses.(43)

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