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Accuracy of Intrapartum Fetal Weight Estimation Using Dare's Formula and Transabdominal Ultrasonography in Pregnant Women with Normal and High Prepregnant BMI at Maharat Nakhon Ratchasima Hospital

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ABSTRACT

Objectives: To compare the accuracy of clinical fetal weight estimation using Dare's formula and sonographic estimation using Hadlock's formula in pregnant women with normal and high prepregnant BMI.

Materials and Methods: This prospective cohort study was conducted at Maharat Nakhon Ratchasima Hospital, Thailand between July 2019 to November 2019. Term singleton pregnant women whose prepregnant body mass index (BMI) was 18.5 kg/m^2 or greater were included. Maternal BMI was divided into normal BMI (18.5 - 23.0 kg/m^2) and high BMI (≥ 23.0 kg/m^2) for Asian population. Symphysis-fundal height and abdominal circumference was measured, followed by performing sonographic estimation using Hadlock's formula by second-year residents. The primary outcome was the accuracy rate defined by the absolute percentage error of estimated fetal weight < 10 percent.

Results: 205 pregnant women were recruited. Overall accuracy of clinical estimation and sonographic estimation was 52.7% and 80.0% ($p < 0.001$). In normal BMI group, the accuracy was similar between two methods ($p = 0.143$). In high BMI group, sonographic estimation was more accurate than clinical estimation (77.8% vs 36.8%, $p < 0.001$).

Conclusion: Sonographic estimation can be used to estimate fetal weight in pregnant women with normal and high prepregnant BMI group with acceptable accuracy. However, clinical estimation may reliably substitute sonographic estimation among pregnant women with normal BMI group in the condition that transabdominal ultrasonography is not accessible.

Keywords: fetal weight estimation, Dare's formula, Hadlock's formula, overweight, obesity

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ความแม่นยำของการคาดคะเนน้ำหนักทารกในครรภ์ด้วยวิธีการตรวจร่างกายโดยใช้การวัดผลลัพธ์จากการคูณระหว่างระดับความสูงยอดมดลูกกับระยะรอบเอวเปรียบเทียบกับการใช้คลื่นเสียงความถี่สูงในสตรีที่มีภาวะน้ำหนักเกินและภาวะอ้วนที่มาคลอดบุตร

วรัญญู เลิศรัตน์, สิรยา กิติโยดม

บทคัดย่อ

วัตถุประสงค์: *เพื่อเปรียบเทียบความแม่นยำของการคาดคะเนน้ำหนักทารกในครรภ์ด้วยวิธีการตรวจร่างกายตามสมการของ Dare เปรียบเทียบกับการใช้คลื่นเสียงความถี่สูงตามสมการของ Hadlock ในสตรีที่มีภาวะน้ำหนักเกินและภาวะอ้วน*

วัสดุและวิธีการ: *ทำการศึกษาเชิงพรรณาแบบไปข้างหน้าในโรงพยาบาลมหาราชนครราชสีมา ประเทศไทย ตั้งแต่เดือนกรกฎาคมถึงเดือนพฤจิกายน 2562 โดยทำในสตรีตั้งครรภ์เดี่ยว อายุครรภ์ครบกำหนด และมีดัชนีมวลกายในวันที่มาคลอดบุตรมากกว่าหรือเท่ากับ 23 กิโลกรัมต่อตารางเมตร สตรีตั้งครรภ์จะถูกแบ่งออกเป็นสองกลุ่มตามดัชนีมวลกายที่อ้างอิงตามประชากรในทวีปเอเชีย คือ กลุ่มที่มีภาวะน้ำหนักเกิน (23.0-27.5 กิโลกรัมต่อตารางเมตร) และภาวะอ้วน (> 27.5 กิโลกรัมต่อตารางเมตร) แพทย์ประจำบ้านชั้นปีที่ 2 ทำการวัดระดับความสูงยอดมดลูก ระยะรอบเอว และตามด้วยการใช้คลื่นเสียงความถี่สูง ผลลัพธ์หลักคืออัตราความแม่นยำที่คิดจากการคาดคะเนน้ำหนักทารกอยู่ในช่วงไม่เกินมากกว่าหรือน้อยกว่าร้อยละ 10 ของน้ำหนักจริงของทารกแรกเกิด*

ผลการศึกษา: *มีสตรีตั้งครรภ์จำนวน 205 คน เข้าร่วมในการศึกษานี้ พบว่าค่าความแม่นยำในการคาดคะเนน้ำหนักทารกในครรภ์ด้วยวิธีการตรวจร่างกายและการใช้คลื่นเสียงความถี่สูงอยู่ที่ร้อยละ 52.68 และร้อยละ 80.00 ตามลำดับ ($p < 0.005$) โดยการคาดคะเนน้ำหนักทารกในครรภ์ระหว่างแพทย์ประจำบ้านแต่ละคนไม่แตกต่างกัน*

สรุป: *การคาดคะเนน้ำหนักทารกในครรภ์ด้วยการใช้คลื่นเสียงความถี่สูงมีความแม่นยำมากกว่าการคาดคะเนด้วยวิธีการตรวจร่างกายโดยใช้สมการของ Dare ในสตรีตั้งครรภ์ที่มีภาวะน้ำหนักเกินและภาวะอ้วนอย่างมีนัยสำคัญทางสถิติ*

คำสำคัญ: *การคาดคะเนน้ำหนักทากในครรภ์, สมการของ Dare, สมการของ Hadlock, ภาวะน้ำหนักเกิน, ภาวะอ้วน*

Introduction

Overweight and obesity are one of international health issue which has been rising and has many impacts on morbidity, mortality, as well as financial health burden for every country[1-3]. Accordingly, the prevalence of overweight and obesity in pregnancy also has increased over the last several decades[4,5]. This condition is associated with many poor pregnancy outcomes of both mother and fetus such as increased rates of preeclampsia, gestational diabetes, cesarean delivery, and stillbirth[6,7]. Another concern is that overweight and obesity may limit the accuracy of fetal weight estimation. However, the results from many studies are conflicting[8-12].

Intrapartum fetal weight estimation has a significant role in predicting an actual birth weight of neonates. Methods of fetal weight estimation can be broadly classified into maternal self-estimation, clinical estimation, and sonographic estimation. For clinical estimation, symphysis fundal height, abdominal circumference, fetal station, and other parameters may be used to create various predicting formulas such as Dare's formula, Dawn's formula, and Johnson's formula[13,14]. For estimating by sonographic measurement, there are plenty of formulas such as Hadlock's formula, Shepard's formula, Merz's formula, and Warsof's formula[15]. Accurate estimation of fetal weight can guide appropriate obstetric management and intervention, especially for fetus with estimated fetal weight significantly below or above the normal range. It has been known that growth-restricted fetus and macrosomic fetus are associated with a variety of adverse perinatal outcomes[16,17].

The aim of this study was to compare the accuracy of intrapartum fetal weight estimation using clinical estimation by Dare's formula and sonographic estimation by Hadlock's formula in pregnant women with normal weight group (normal body mass index (BMI)) and overweight and obese group (high BMI group).

Materials and Methods

This prospective cohort study was conducted in pregnant women who admitted for delivery at Maharat Nakhon Ratchasima Hospital, Thailand between July 2019 to November 2019. It was approved by Maharat Nakhon Ratchasima Hospital Institute Review Board in Human Research.

Pregnant women aged 18 years or greater with prepregnant BMI 18.5 kg/m^2 or greater, who had a vertex, singleton pregnancy with intact amniotic membranes between $37^{0/7}$ to $41^{6/7}$ weeks of gestation as well as anticipation to deliver within 48 hours after admission were included. Exclusion criteria were intrauterine death, congenital fetal anomalies, oligohydramnios, polyhydramnios, placental previa, placental abruption, pelvic mass either uterine or adnexal mass, and patients who had unstable vital signs or had emergent obstetric conditions such as antepartum hemorrhage, eclampsia, or fetal distress. BMI was calculated by maternal prepregnant weight (in kilograms) divided by the square of height in meters. According to World Health Organization (WHO) suggested criteria for Asian population[18], normal weight was defined as BMI 18.5 - 23.0 kg/m^2, overweight was defined as BMI 23.0 - 27.5 kg/m^2, and obesity was defined as BMI ≥ 27.5 kg/m^2. In this study, the pregnant women were divided into 2 groups which were normal BMI group (BMI < 23.0 kg/m^2) and overweight as well as obese group named as high BMI group (BMI ≥ 23 kg/m^2)

The selected pregnant women were informed and informed consent was obtained. Second-year residents with one-year experience in basic ultrasound and fetal estimation performed history taking, review of antenatal care history, and physical examination. Patients' data were collected such as maternal age, gestational age on admission, parity, height, weight, total weight gain, and underlying diseases. Clinical estimation of fetal weight was calculated based on Dare's formula which was the result of symphysis-fundal height multiplied by abdominal circumference. Reverse-side up, non-elastic tape was used to measure symphysis-fundal height from the midpoint of the upper border of symphysis pubis to the highest edge of uterine

fundus in the condition that pregnant woman was in a supine position, with emptying her bladder, and without any uterine contraction at the time of measurement. Abdominal circumference was measured at the level of umbilicus in the same condition. Sonographic estimation was calculated by using Hadlock formula consisting of biparietal diameter, head circumference, abdominal circumference, and femur length. The same ultrasound machine equipped with 3.5-MHz abdominal transducer was used by all residents. Each pregnant woman was performed clinical estimation of fetal weight, followed by sonographic estimation by only one resident. Infants were weighed in grams within 30 minutes after delivery by using a digital scale.

Statistical analysis

All statistical analysis was performed using STATA software version 11.1. Demographic characteristics in continuous variables were demonstrated as mean ± standard deviation (SD). The primary outcome of the study was the accuracy rate. Estimated fetal weight by either clinical estimation or sonographic estimation was defined accurate when the absolute percentage error was less than 10 percent. The absolute percentage error was calculated as followed.

$$\text{Absolute percentage error} = \frac{|\text{estimated fetal weight} - \text{actual birth weight}|}{\text{Actual birth weight}} \times 100$$

The accuracy rate between clinical estimation and sonographic estimation was determined by McNemar's test. The Spearman correlation was used to demonstrate the correlation between clinical estimated fetal weight and the actual birth weight as well as the correlation between sonographic estimated fetal weight and the actual birth weight stratified by normal and high BMI group. A p value < 0.05 was considered statistically significant.

Results

There were 2,060 pregnant women who admitted for delivery at Maharat Nakhon Ratchasima Hospital from July 2019 to November 2019. A total of 891 pregnant women were eligible for this study. 686 pregnant women were excluded in accordance with the aforementioned criteria, leaving 205 pregnant women included in the study. (Fig. 1.)

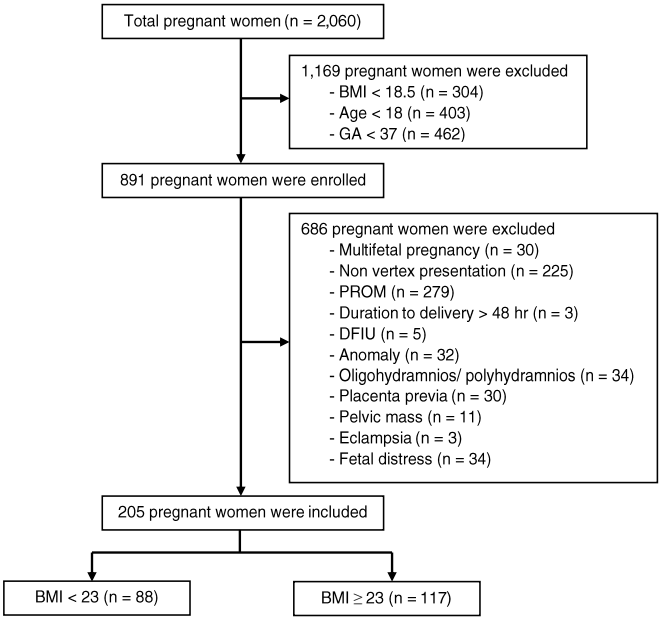

Fig. 1. Flowchart of recruitment of the participants.

Maternal and neonatal demographic characteristics stratified by maternal normal BMI and high BMI group were shown in Table 1. There were 88 pregnant women with normal BMI (42.93%) and 117 pregnant women with high BMI (57.07%). Pregnant women with high prepregnant BMI tended to be older, of high parity, and associated with higher rate of chronic hypertension, gestational diabetes mellitus, and cesarean delivery.

Table 1. Maternal and neonatal demographic characteristics.

Characteristics	BMI < 23 (n=88)	BMI ≥ 23 (n=117)	p value
Maternal characteristics			
Age (years)	26.15 ± 6.02	29.57 ± 6.13	< 0.001
Gestational age (weeks)	38.8 ± 1.2	38.5 ± 1.06	0.067
Parity :			
- nulliparous	43 (48.9%)	35 (29.9%)	0.006
- multiparous	45 (51.1%)	82 (70.1%)	0.003
Height (centimeters)	159.28 ± 6.36	158.09 ± 6.55	0.194
Pre-pregnancy weight (kilograms)	51.4 ± 5.78	74.39 ± 14.88	< 0.001
Weight on admission (kilograms)	67.77 ± 8.27	86.21 ± 15.72	< 0.001
Total weight gain (kilograms)	16.37 ± 5.4	11.81 ± 6.3	< 0.001
Pre-pregnancy BMI (kg/m^2)	20.23 ± 1.29	29.69 ± 5.29	< 0.001
BMI on admission (kg/m^2)	26.67 ± 2.39	34.44 ± 5.68	< 0.001
Maternal underlying diseases :			
- Chronic hypertension	0 (0%)	10 (8.5%)	0.005
- Overt diabetes mellitus	0 (0%)	4 (3.4%)	0.080
- Heart disease	1 (1.1%)	2 (1.7%)	0.735
- Hypothyroid disease	2 (2.3%)	1 (0.9%)	0.403
Pregnancy-related complications :			
- Gestational hypertension	1 (1.1%)	5 (4.3%)	0.187
- Preeclampsia	4 (4.5%)	5 (4.3%)	0.925
- Gestational diabetes mellitus	5 (5.7%)	23 (19.7%)	0.004
Route of delivery :			
- spontaneous vertex delivery	69 (78.4%)	67 (57.3%)	0.002
- vacuum extraction	4 (4.5%)	5 (4.3%)	0.925
- cesarean delivery	15 (17%)	45 (38.5%)	0.001
Neonatal characteristics			
Sex :			
- male	43 (48.9%)	67 (57.3%)	0.233
- Female	45 (51.1%)	50 (42.7%)	0.233
Birth weight (grams)	3,104.83 ± 363.12	3,252.9 ± 406.94	0.008

Data are presented as number (percentage) or mean ± standard deviation.
BMI: body mass index

In overall, the accuracy rate of clinical estimation using Dare's formula was 52.7% and the accuracy rate of sonographic estimation using Hadlock's formula was 80.0% with statistical significance (Table 2). The Spearman correlation between clinical estimated fetal weight by Dare's formula and the actual birth weight as well as the correlation between sonographic estimated fetal weight and the actual birth weight stratified by prepregnant BMI were illustrated in Fig. 2 and Fig. 3, respectively.

In pregnant women with normal BMI, the accuracy rate of clinical estimation using Dare's formula was 73.9%, compared with 83.0% of sonographic estimation without statistical significance. However, in pregnant women with high BMI, the accuracy rate of clinical estimation was 36.8%, compared with 77.8% of sonographic estimation with statistical significance.

Subgroup analysis to determine accuracy between two fetal weight estimation methods in high BMI group was performed. The accuracy of sonographic estimation was superior to clinical estimation in pregnant women with both overweight group (86.9% vs 54.9%, $p < 0.001$) and obese group (71.2% vs 22.7%, $p < 0.001$) as demonstrated in Table 3.

Table 2. Accuracy rate between fetal weight estimation methods.

Group	Accuracy rate of Dare's formula [95% CI]	Accuracy rate of Hadlock formula [95% CI]	p value
Overall (n=205)	52.7% [45.6 to 59.7]	80% [73.9 to 85.2]	< 0.001
BMI < 23 kg/m^2 (n=88)	73.9% [63.4 to 82.7]	83% [73.4 to 90.1]	0.143
BMI ≥ 23 kg/m^2 (n=117)	36.8% [28 to 46.2]	77.8% [69.2 to 84.9]	< 0.001

BMI: body mass index, CI: confidence interval.

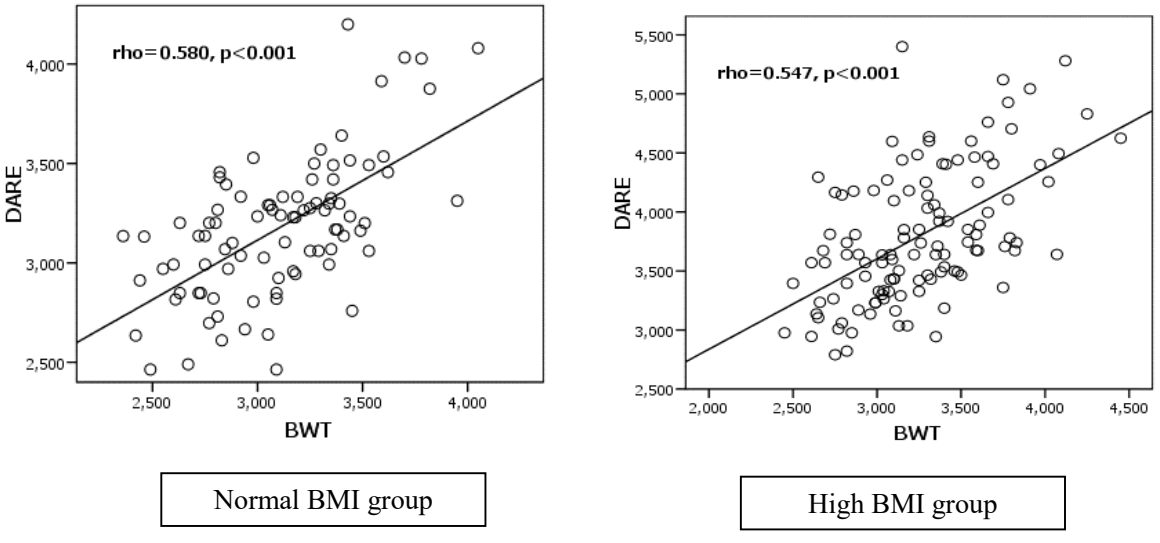

Fig. 2. The Spearman correlation of clinical estimated fetal weight and the actual birth weight stratified by body mass index.

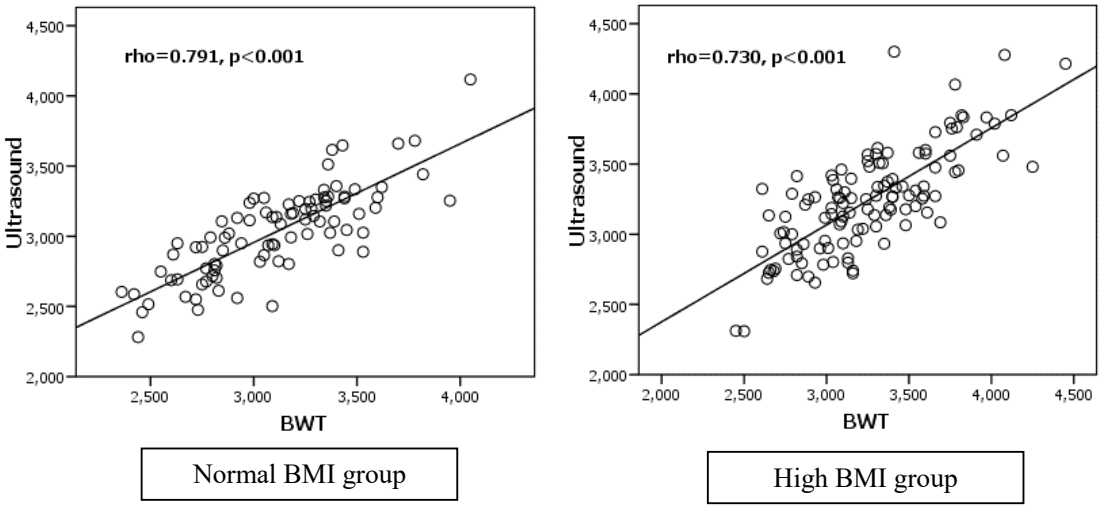

Fig. 3. The Spearman correlation of sonographic estimated fetal weight and the actual birth weight stratified by body mass index

Table 3. Subgroup analysis of accuracy rate between fetal weight estimation methods.

Group	Accuracy rate of Dare's formula [95% CI]	Accuracy rate of Hadlock formula [95% CI]	p value
BMI 23-27.5 kg/m^2 (n=51)	54.9% [40.3 to 68.8]	86.3% [73.7 to 94.3]	< 0.001
BMI ≥ 27.5 kg/m^2 (n=66)	22.7% [13.3 to 34.7]	71.2% [58.7 to 81.7]	< 0.001

BMI: body mass index, CI: confidence interval.

Discussion

Our primary outcome focused on comparing the accuracy between clinical estimation and sonographic estimation of Asian pregnant women with normal weight group (normal BMI) and with overweight as well as obese group (high BMI group) because the prevalence of obesity has risen since the last decades and there are limited studies regarding fetal estimation in these overweight and obese pregnant women, especially in Asian population. We found that sonographic estimation using Hadlock's formula was more accurate than clinical estimation calculated by Dare's formula in overweight and obese pregnant women with statistical significance. Clinical estimation by Dare's formula was chosen for this study because this formula was one of the simplest formulas with acceptable accuracy and could be performed by all labor attendants.

In pregnant women with normal weight group, the data demonstrated that there was no statistical difference between the accuracy of clinical estimation and sonographic estimation. It suggested that clinical estimation may be appropriately used for fetal weight estimation in normal weight group. However, in overweight and obese pregnant women, the accuracy of clinical estimation was dropped from 73.9% to 36.8% but the accuracy of sonographic estimation was still constant (83.0% to 77.8%). The result of clinical estimation was consistent with the study conducted by Nathan et al[10]. They studied 400 term pregnant women in the United States and found that increasing body mass index at delivery was significantly associated with decreased accuracy of clinical estimation despite using

different method for fetal estimation which used abdominal palpation. Furthermore, the result of sonographic estimation was also correlated with the finding from Sara et al[12], indicating that the accuracy of sonographic estimation was not affected by maternal BMI. However, Nancy et al[9] who studied 998 singleton pregnant women between 26 - 43 gestational weeks in the United State demonstrated that increasing maternal BMI did not alter the accuracy of clinical estimation and sonographic estimation. This discrepancy of the results may be related to differences in criteria of BMI classification. In the study of Nancy et al, overweight was defined as BMI 26.1 - 29.0 kg/m^2 and obesity was defined as BMI > 29.0 kg/m^2.

Therefore, sonographic estimation using Hadlock's formula can be used to estimate fetal weight in pregnant women with normal, overweight, and obese group with acceptable accuracy (80% accuracy). Of clinical estimation using Dare's formula, it is more preferable in pregnant women with normal weight group than those with overweight and obese group.

The major strength of this study was that we focused mainly on specific population which was overweight and obese pregnant women according to BMI classification suggested for Asian population. Our limitation was that all fetal weight estimation either by clinical or sonographic estimation was performed by second-year residents with only one-year experience in basic ultrasound and fetal estimation. Comparison of the accuracy between residents and more experienced obstetric physicians such as senior obstetrician or maternal-fetal-medicine specialist may be further required. In addition, due to the process of clinical estimation followed by sonographic estimation by the same resident, it was not possible to blind the resident from the estimated clinical measurement and it may contribute to expected value bias in sonographic estimation.

Conclusion

In overweight and obese pregnant women (high BMI group), sonographic estimation using Hadlock's formula was more accurate than clinical estimation using Dare's formula in predicting fetal weight. However, clinical estimation may reliably substitute sonographic estimation among pregnant women with normal weight group (normal BMI group) in the condition that transabdominal ultrasonography is not accessible.

Potential conflicts of interest

The authors declare no conflicts of interest.

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