Comparison of the Accuracy of Ultrasonic Fetal Weight Estimation by Using the Various Equations

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Abstract

Objective : To compare the accuracy of ultrasonic fetal weight estimation using the Hadlock's, Shepard's, Tongsong's and Hansmann's equations.

Material and Method : The analytical-cross sectional study was conducted on 102 pregnant women who were admitted for delivery in the Labor Room at Srinagarind Hospital, Faculty of Medicine, Khon Kaen University between January 1, 1999 and June 30, 1999. The fetal parameters, including biparietal diameter, abdominal circumference, transverse trunk diameter and femur length, were measured by ultrasound. The estimated fetal weight was calculated by those four equations. The mean absolute error was calculated from the absolute of the difference between the estimated fetal weight and the actual birth weight.

Results : The mean absolute error and standard deviation of the estimated fetal weight by the Hadlock's, Shepard's, Tongsong's and Hansmann's equations were 8.09 $\pm$ 4.18, 7.94 $\pm$ 4.63, 7.77 $\pm$ 3.70 and 7.83 $\pm$ 4.35 per cent respectively and there were no statistically significant differences at 95 per cent confidence interval ($p>0.05$).

Conclusion : Apart from having comparable accuracy in the estimation of fetal weight to those of Hadlock, Shepard and Tongsong, Hansmann's equation employed at Srinagarind Hospital was more convenient to use than the others.

Key word : Fetal Weight Estimation, Ultrasound, Hansmann's Equation

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Accurate assessment of fetal weight is an important part in the management of a pregnant woman with complications, since perinatal mortality and morbidity rates correlate with the birth weight (BW)(1,2).

Estimating fetal weight from bimanual palpation or symphysis-fundus height are crude and inaccurate(3,4). Nowadays, fetal weight estimation by ultrasound measuring fetal parameter(s) is well-known. In the beginning, only a single fetal parameter was used (5,6) and then it was found that more than one parameter improved the accuracy of fetal weight estimation(7). Increasing attention is being paid to the accuracy of using various equations from multiple parameters, biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL), in estimating weight.

Hadlock's equation(8) and Shepard's equation(9) are well known in Thailand. The errors in fetal weight estimation were reported to range from 5-20 per cent and depended on the parameters and the equations used(10).

The equation II of Tongsong et al developed from the local Thai population and has comparable accuracy to Shepard's equation(11).

Hansmann's equation has been used to estimate fetal weight at Srinagarind Hospital for 8 years. The authors have found that it is convenient because only two parameters account for estimation and nomogram is available(12). However, there has been no research to compare the accuracy between these equations: Hansman's, Hadlock's, Shepard's equation and equation II of Tongsong. Therefore, the present study attempted to compare the accuracy of these equations in the estimation of fetal weight.

MATERIAL AND METHOD

Study population

The authors recruited 102 singleton pregnant women who were admitted for delivery in the Labor Room at Srinagarind Hospital, Faculty of Medicine, Khon Kaen University between January 1, 1999 and June 30, 1999 and met the inclusion criteria; 1) were delivered within 24 hours after ultrasonic measurement, 2) measuring birth weight within 30 minutes of delivery and 3) gave consent to participate in the study. The exclusion criteria were 1) a dead fetus *in utero* or stillbirth, 2) congenital anomalies e.g. anencephaly, ascites, hydrocephalus, 3) abnormal fetal head e.g. dolichocephaly, brachycephaly, 4) unable to measure all ultrasonic parameters accurately and 5) active phase of labor. The study protocol was approved by the Ethics Committee of the Faculty of Medicine, Khon Kaen University.

Study measurement

Demographic data of the pregnant women were obtained by structured questionnaires. Sonographic measurement of the biparietal diameter (BPD), fronto-occipital diameter (FOD), abdominal circumference (AC), femur length (FL) and transverse trunk diameter (TTD) were done with the Aloka ultrasound machine, model SSD-620 (5 MHz probe) by one of the authors who had no information regarding the pregnant women and neonatal outcomes. Each parameter was measured twice and then substitution of the average of each parameter into the following equations was employed for estimated fetal weight (EFW).

Hadlock's equation(8) : $\log_{10}EFW = 1.335-0.0034(AC \times FL)+0.0316(BPD)+0.0457(AC)+0.1623(FL)$

Shepard's equation(9) : $\log_{10}EFW = -1.7492+0.166(BPD)+0.046(AC)-2.646(AC \times BPD)/1{,}000$

Tongsong's equation(11) : $\log_{10}EFW = 2.24784+0.09122(FL)+0.002798(BPD \times AC)-0.0010112(AC \times FL)$

Hansmann's equation(12) : $EFW = -1.05775(BPD)+0.649145(TTD)+0.0930707(BPD^2)-0.020562(TTD^2)+0.515263$

Statistical analyses

The mean and standard deviation (SD) were calculated for continuous variables and percentage for categorical variables. After tests of normality of subjects using one-sample Kolmogorov-Smirnov test, one-way ANOVA was performed to compare the mean absolute errors of various equations. Absolute error was calculated by (EFW-BW)/BW x100. P< 0.05 was considered statistically significant.

Table 1. Mean absolute error of the four equations.

Equation	Mean absolute error ± standard deviation (%)	95% confidence interval
Hadlock	8.09 ± 4.18	7.27-8.91
Shepard	7.94 ± 4.63	7.03-8.85
Tongsong	7.77 ± 3.70	7.04-8.50
Hansmann	7.83 ± 4.35	6.98-8.69

RESULTS

The mean age (± SD) of the pregnant women was 25.9 ± 5.4 years and ranged from 17 to 39 years. Most of the subjects (44.1%) were primigravidas. The mean gestational age (± SD) was 38.5 ± 2.1 weeks and most were between 37-39 weeks. The majority (52.9%) of fetal sex was male. The mean birth weight (± SD) was 3,039.2 ± 485.8 grams and ranged from 1,200-4,090 grams. The mean fetal parameters, including BPD, AC, TTD and FL were 8.9 ± 0.4 cm, 32.4 ± 2.2 cm, 10.2 ± 0.8 cm, 7.0 ± 0.4 cm, respectively. The mean absolute errors of the four equations are shown in Table 1.

The authors classified the birth weight into three groups as follows: 1) less than 2,500 grams: 11 cases, mean ± SD = 2,203.6 ± 358.3, range 1,200-2,490, 2) 2,500-3,500 grams: 72 cases, mean ± SD = 2,990.8 ± 285.0 grams, range 2,500-3,500 grams and 3) more than 3,500 grams:19 cases, mean ± SD = 3,706.3 ± 162.6 grams, range 3,520-4,090 grams.

One-sample Kolmogorov-Smirnov test showed normal distribution of birth weight. There was no statistically significant difference in overall mean absolute errors, both mean absolute error and 95 per cent confidence intervals, of the four equations in estimating the fetal weight tested by one-way ANOVA (Table 1).

When the birth weight was classified into three groups, the accuracy of the four equations is shown in Table 2. It was noted that in the group of birth weight less than 2,500 grams, Hansmann's equation had the highest mean absolute errors (mean ± SD and 95% CI) among the four equations ($p<0.05$). In the group of birth weight between 2,500-3,500 grams, Hansmann's equation had the least mean absolute error among the four equations; it, however, had statistically significant difference between Hansmann's and Tongsong's. In the group of birth weight more than 3,500 grams, Tongsong's equation had the least mean absolute error (mean ± SD and 95% CI) among the four equations ($p<0.05$).

DISCUSSION

This study was conducted to compare the mean absolute error in estimating the fetal weight based on the four different equations. The results showed that there was no statistically significant difference in the overall mean absolute errors of the four equations in the fetal weight estimation. However, the subgroup analysis demonstrated that Hansmann's equation provided the most accurate estimation for the fetus weighing between 2,500-3,500 grams but it provided the least accurate estimation for the fetus weighing below 2,500 grams.

Table 2. Mean absolute error classified by birth weight.

Equation	Mean absolute error ± SD (%) (95% confidence interval)		
	<2,500 grams (n=11)	2,500-3,500 grams (n=72)	>3,500 grams (n=19)
Hadlock	4.92 ± 3.39 (2.63-7.20)	7.95 ± 3.98 (7.01-8.88)	10.49 ± 4.10 (8.51-12.47)
Shepard	5.66 ± 5.15 (2.20-9.12)	7.64 ± 4.58 (6.57-8.72)	10.39 ± 3.65 (8.63-12.15)
Tongsong	5.68 ± 3.22 (3.51-7.84)	8.24 ± 3.83 (7.34-9.15)	7.20 ± 3.08 (5.71-8.68)
Hansmann	9.82 ± 5.11 (6.39-13.26)	6.72 ± 3.94 (5.79-7.65)	10.91 ± 3.61 (9.17-12.65)

The mean absolute errors in this study were lower than those in the study of Hadlock[8] and Tongsong[11]. The difference might be from the variation of the study population, the inclusion and exclusion criteria and the measurement method.

BPD and FL represent the size of the skeletal structure, whereas AC or TTD reflect the body mass (13). Theoretically, three parameters used for calculation might achieve the most accurate estimation as that reported by the study of Hadlock et al[14]. However, many researches, including this study, have found both two and three parameters had comparable fetal weight estimation[15,16]. Moreover, FL was found to be unnecessary for calculation[15,16].

When using two parameters by the equation of Shepard and Hansmann, the accuracy in estimating the fetal weight was comparable. Practically, TTD, the parameter in Hansmann's equation, could be more expedient in measurement than AC, the parameter in Shepard's equation.

In 1982, Shepard et al reported the range of difference in grams between actual and estimated fetal weight that were -489.0 to 463.24, -1,048.22 to 620.73 and -1,098.75 to 614.03 in the low birth weight group (<2,500 grams), normal birth weight (2,500-3,500 grams) and large fetus group (birth weight >3,500 grams), respectively[9]. In 1985, Hadlock et al also reported the mean deviation $\pm$ SD in various birth weight groups that were -5.3 $\pm$ 9.0, 2.2 $\pm$ 7.0, 3.2 $\pm$ 7.6, 1.3 $\pm$ 7.7, 0.1 $\pm$ 6.0, 1.4 $\pm$ 7.1 and 4.8 $\pm$ 5.1 in birth weight <1,500 grams, 1,500-2,000 grams, 2,000-2,500 grams, 2,500-3,000 grams, 3,000-3,500 grams, 3,500-4,000 grams and >4,000 grams, respectively[8]. Since there were differences in measurement outcome and the range of birth weight in each subgroup, therefore, the results of those studies could not be compared to the result of the present study.

Regarding Hansmann's equation, it is reasonable to employ this equation for estimating fetal weight in the group of 2,500-3,500 grams, which is the normal birth weight because it had the best accuracy among the four equations.

The factors providing reliability of this study included 1) sonographic parameters measured with single ultrasound machine by only one expert, 2) the operator performing ultrasonography was blinded to the information of the pregnant women and neonatal outcomes, 3) the factors, dolichocephaly or brachecephaly and abnormal fetal head, which could affect the reliability of BPD measurement were excluded, and 4) the average values of two measurements in each parameter might be more accurate than those of single measurement.

The limitations of the study included 1) the troublesome measurement in cases of obesity and 2) there was a small sample size of birth weight below 2,500 grams group and birth weight more than 3,500 grams group, therefore, the results of these subgroups were rather imprecise.

Hansmann's equation for estimating fetal weight had comparable accuracy to the equation of Shepard, Hadlock and Tongsong. The advantage of Hansmann's equation is its convenience in estimation because only two parameters, BPD and TTD, are required for calculation and TTD measurement is more expedient than that of AC. The authors, therefore, advocate that Hansmann's equation might be the promising and practical method for estimating fetal weight.

Regarding the small number of subjects in the low birth weight (birth weight <2,500 grams) and large fetus group (birth weight >3,500 grams) further study about fetal weight estimation should be focussed on low birth weight and large fetuses who are the high risk groups for perinatal mortality and morbidity.

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การเปรียบเทียบความแม่นยำของการคาดคะเนน้ำหนักทารกในครรภ์ ด้วยคลื่นเสียงความถี่สูง โดยการใช้สมการต่าง ๆ

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วัตถุประสงค์ : เปรียบเทียบความแม่นยำของการคาดคะเนน้ำหนักทารกในครรภ์ด้วยคลื่นเสียงความถี่สูง โดยใช้สมการของ Hadlock, Shepard, Tongsong และ Hansmann

วิธีการศึกษา : เป็นการวิจัยเชิงวิเคราะห์แบบตัดขวาง ในสตรีตั้งครรภ์จำนวน 102 ราย ที่มาคลอดบุตรที่ห้องคลอด โรงพยาบาลศรีนครินทร์ คณะแพทยศาสตร์ มหาวิทยาลัยขอนแก่น ระหว่างวันที่ 1 มกราคม 2542 ถึง 30 มิถุนายน 2542 โดยได้รับการตรวจด้วยเครื่องตรวจคลื่นเสียงความถี่สูงเพื่อวัดส่วนต่าง ๆ ของทารกในครรภ์ได้แก่ biparietal diameter, abdominal circumference, transverse trunk diameter และ femur length และนำไปแทนค่าใน 4 สมการข้างต้น นำค่าคาดคะเนน้ำหนักทารกที่ได้เปรียบเทียบกับน้ำหนักทารกแรกเกิดจริง เพื่อคำนวณหาค่าความคลาดเคลื่อนสัมบูรณ์เฉลี่ย

ผลการวิจัย : ค่าความคลาดเคลื่อนสัมบูรณ์เฉลี่ย และค่าเบี่ยงเบนมาตรฐานจาการคาดคะเนน้ำหนักทารกในครรภ์โดยใช้สมการของ Hadlock, Shepard, Tongsong และ Hansmann เท่ากับร้อยละ 8.09 $\pm$ 4.18, 7.94 $\pm$ 4.63, 7.77 $\pm$ 3.70 และ 7.83 $\pm$ 4.35 ตามลำดับ และไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติที่ระดับความเชื่อมั่นร้อยละ 95 ($p>0.05$)

สรุป : การคาดคะเนน้ำหนักทารกในครรภ์โดยใช้สมการของ Hansmann ซึ่งใช้ที่โรงพยาบาลศรีนครินทร์มีความแม่นยำไม่แตกต่างอย่างมีนัยสำคัญทางสถิติกับสมการของ Hadlock, Shepard และ Tongsong แต่สมการของ Hansmann มีความสะดวกในการใช้มากกว่าสมการอื่น ๆ

คำสำคัญ : การคาดคะเนน้ำหนักทารกในครรภ์, คลื่นเสียงความถี่สูง, สมการของฮันสมานน์

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