Accuracy of Sonographic Fetal Weight Estimation within 14 Days of Delivery in a Jordanian Population Using Hadlock Formula 1

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Key Words

Sonography • Fetal weight estimation • Hadlock formula 1

Abstract

Objectives: To assess the accuracy of sonographic fetal weight estimation within 14 days of delivery in a Jordanian population using Hadlock formula 1 in the third trimester.

Materials and Methods: Estimated fetal weights and actual fetal weights data were collected from the medical records of pregnant women who had undergone sonographic fetal weight estimation within 14 days of delivery over the period of March 2008 to June 2010. The analysis included 409 Jordanian women; 6 of them had twins, so the study involved estimation of 415 fetal weights, and these were compared to the actual recorded neonatal weights. Using Hadlock formula 1, we compared the estimations with the infants' actual birth weights. The data were analyzed in 2 groups: within 7 days and 8–14 days. **Results:** The mean estimated fetal weight was $3,133 \pm 475$ g (range 1,343–4,420 g). The mean actual birth weight was $3,179 \pm 450$ g (range 1,300–4,450 g). The mean absolute percentage of error of ultrasound fetal weight estimation for all infants was 6.5%; however, it was 6.1 and 8.2% if the fetus was delivered within 7 days or 8–14 days of sonography, respectively. Overall, 78.8% of fetal weight estimations were within 10% of actual birth weight;

however it was 81.3 and 69.9% if the fetus was delivered within 7 days or from 8–14 days of sonography, respectively.

Conclusion: The use of Hadlock formula 1 for sonographic fetal weight estimations in Jordanian women showed acceptable results relative to the actual neonatal weight at birth. However, fetal weight estimation was more reliable when performed within 7 days of delivery.

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Introduction

Neonatal weight is an important predictive parameter of neonatal outcome, and its estimation is valuable in planning the mode of delivery and obstetric management of labor [1]. Also, when dealing with anticipated preterm delivery, perinatal counseling on likelihood of survival, the intervention undertaken to postpone preterm delivery, optimal route of delivery, or the hospital where delivery should occur may be based wholly or in part on the estimation of expected birth weight [2, 3].

The estimation of fetal weight by ultrasound uses a regression formula to derive the birth weight after the measurement of various fetal structures [4, 5]. Over the past 30 years, there have been many such published formulas that included Hadlock et al. [6] in the USA, a

group in Germany [7], and Campbell and Wilkin [5] and Shepard et al. [8] in Great Britain. In other countries, various formulas are used depending on the center involved. The accuracy of predicting birth weight by a variety of different formulas, incorporating different ultrasonic measurements, has been studied extensively [9]. It has been reported that the highest correlation coefficient (0.914, 0.921) and the most stable results between estimated fetal weight and birth weight in all widely accepted formulas for fetal weight estimation was generated with Hadlock formulas 1 and 2, respectively [7]. Hoopmann et al. [10] tested weight formulas, specifically designed for very small fetuses, and concluded that the use of Hadlock formulas is good. Venkat et al. [11] also tested the Hadlock formula in a south-east Asian population and concluded that even though this formula was originally derived from an American Caucasian population, it was equally useful for other ethnic groups. However, this formula has not been validated in Jordan. Therefore, the aim of this study was to assess the accuracy of Hadlock formula 1 in sonographic fetal weight estimation during the third trimester, and the accuracy of sonographic fetal weight estimation within 14 days of delivery in a Jordanian population using Hadlock formula 1.

Materials and Methods

Estimated fetal weight and actual neonatal weight were collected from the medical records from March 1st 2008 to June 30th 2010. The study consisted of fetuses in the third trimester who had undergone an ultrasound estimation of fetal weight during a routine visit to the Obstetric Clinic at Jordan University Hospital and who delivered within 14 days of the measurement. The analysis included 409 Jordanian women; 6 women had twin gestation (each fetus was considered independently). A total of 415 fetuses were examined, and they were divided into two groups, those who delivered within 7 days (332) and those who delivered after 7, but within 14 days of the estimation (83). 30 g were added per day to the estimated fetal weight to cover the interval between estimation and delivery.

All stillbirths and fetuses with congenital abnormalities and hydrops were not included in the 415. Data were collected from the medical records in which maternal and infant information were present. All ultrasound measurements were performed by a single obstetric physician (A.B.) with fetomaternal sub-specialty training. Ultrasound measurement was carried out with a curvilinear abdominal transducer (3.5–5.0 MHz) using Philips HD-11 equipment. Estimation of fetal weight was determined using measurements of fetal head circumference, fetal abdominal circumference and fetal femur length. The fetal head measurements were made in the axial plane at the level where the continuous midline echo is broken by the cavum septum pellucidum in the anterior

third. The head circumference was measured around the perimeter using an electronic ellipse as described by Campbell and Thoms [12, 13]. The abdominal circumference was measured in the transverse axial view of the fetal abdomen at the level of the liver, identifying the spine and descending aorta posteriorly, the umbilical vein in the anterior third and the stomach bubble in the same plane; just above the level of the cord insertion measurements were taken around the perimeter as described by Campbell et al. [7, 8]. The fetal femur length was measured in a view where the full femoral diaphysis was seen in a plane as close as possible to a right angle to the ultrasound beam; measurements were taken from one end of the diaphysis to the other, not including the distal femoral epiphysis [14]. Measurements were made with calibrated caliper on the machine on frozen images using the mapping method. Using Hadlock formula 1 and the measured head circumference (HC), abdominal circumference (AC) and fetal femur length (FL), the estimated fetal weight (EFW) was calculated using the formula shown below:

$$\log_{10} \text{ EFW} = 1.326 - 0.00326 (\text{AC}) (\text{FL}) \\ + 0.0107 (\text{HC}) + 0.0438 (\text{AC}) + 0.158 (\text{FL}).$$

Neonatal weights were recorded soon after birth by the on duty staff nurses at the delivery room following neonatal resuscitation (if required). The weights were rounded to the nearest 50 g using regular baby scale (Misaki).

Statistical Analysis

All statistical analyses were carried out with SPSS statistical software, version 17 (SPSS Inc., Chicago, Ill., USA). The difference between the estimated fetal weight and the actual neonatal weight (simple error) was recorded as error in grams. The percentage error was calculated using the following equation: percentage error = (estimated weight – neonatal weight) × 100/neonatal weight.

Negative values for percentage error indicated that the estimated fetal weight was underestimated, and positive values indicated that it was overestimated. The absolute percentage error was defined as absolute value.

In addition, the Bland and Altman method was used for evaluating agreement between the two measurements (estimated and actual weights). Linear regression analysis for parametric data was used and statistical significance was stated at the 5% level. Data are presented as mean ± SD.

Results

The mean estimated fetal weight was $3,133 \pm 475$ g (range 1,343–4,420). The mean actual birth weight was $3,179 \pm 450$ g (range 1,300–4,450). The mean time interval between ultrasound estimation of fetal weight and delivery was 4.1 ± 3.9 days ($n = 415$), and it was 2.4 ± 2.2 for time interval less than 7 days and 10.6 ± 2 for 8–14 days of estimation. The average gestational age on estimation was 37.8 (29–41) weeks and the average neonatal gestational age on delivery was 38.5 (29–42) weeks.

Fig. 1. Bland and Altman plot of 332 paired women on estimated birth weight and neonatal weight within 7 days between estimation and birth. $R = 0.0116$ ($p < 0.01$), slope = -0.198 ($p = 0.05$), intercept = $3,175$ ($p = 0.05$).

Fig. 2. Bland and Altman plot of 83 women with estimated birth weight and neonatal weight within 8–14 days between estimation and birth. $R = 0.659$ ($p < 0.01$), slope = -0.835 ($p < 0.01$), intercept = $1,641$ ($p = 0.00$).

Table 1. Analysis of ultrasound fetal weight compared to neonatal weight at variable time intervals between estimation and birth

Parameters	Within 7 days (n = 332)	Within 8–14 days (n = 83)
GA on estimation, weeks	38.1 ± 1.5	36.8 ± 1.5
Estimated fetal weight, g	$3,163 \pm 482$	$3,014 \pm 426$
GA at birth, weeks	38.5 ± 1.5	38.4 ± 1.5
Neonatal birth weight, g	$3,180 \pm 456$	$3,173 \pm 427$
Absolute difference, g	193 ± 154	264 ± 174
Weight difference, %	6.2 ± 5.3	9.0 ± 6.3
Actual percentage error	-0.4 ± 7.7	-4.7 ± 8.5
Absolute percentage error	6.1 ± 4.7	8.2 ± 5.2

GA = Gestational age.

The mean absolute error for sonographic fetal weight estimations made ≤ 7 days prior to delivery was 6.1 ± 4.7 (n = 332); however, these tended to result in a slight underestimation of fetal weight if they were carried out 8–14 days prior to delivery, the mean absolute error was 8.2 ± 5.2 (n = 83) (table 1).

The sonographic fetal weight estimation correlated significantly with actual birth weight for all infants who delivered within 7 days of estimation ($R = 0.0116$, $p < 0.01$) (fig. 1). Of these fetal weight estimations, 81.3% were within 10% of the actual birth weight. However, the sonographic estimation of fetal weight correlated to a lesser

degree with the actual birth weight for all infants who were delivered between 8–14 days of estimation ($R = 0.659$, $p < 0.01$) (fig. 2). Of all fetal weight estimations, 69.9% were within 10% of actual birth weight.

Discussion

The problem with reliance on ultrasound estimates of fetal weight is that it has inherent inaccuracies, with large intra- and interobserver variability [7, 15]. The absolute percentage errors of 6.1% of delivery within 7 days and 8.2% within 8–14 days are comparable to other studies [2, 6, 16–19]. Equally, the 81.3% of neonatal weight estimations that were within 10% of actual neonatal weight if the fetus delivered within 7 days of estimation, and 69.9% after 8–14 days are also comparable to other studies [2, 6, 16–19]. In an extensive systematic review, Dudley [15] stated that the method of Hadlock et al. [6] generally provided more consistent mean systematic errors.

Our study confirmed the previous reports of Chauhan et al. [9] and Peregrine et al. [19] that the accuracy of prediction is significantly higher when the fetal weight estimation was performed within 7 days of delivery. The high yield of correlation coefficients in this study, when delivery was within 7 days of fetal weight estimation, and acceptable yield when the fetus was delivered between 8 and 14 days of estimation, confirmed those of other studies [20, 21] and is explained by con-

tinuous fetal growth as time elapses between sonography and delivery.

The major limitations of this study were its retrospective nature. All the data were not available; hence a table of the baseline characteristics such as parity, maternal BMI, medical conditions such as diabetes and chronic hypertension could not be included. The other limitation was that the predictive value for small or large weight for gestational age was not calculated as this predictive value is more important clinically.

Conclusion

The use of Hadlock formula 1 to estimate sonographic fetal weight in Jordanian women within 14 days of delivery showed acceptable results relative to the actual neonatal weight. However, fetal weight estimation gave better results when it was performed within 7 days of delivery.

Disclosure Statement

The authors declare that they have no conflict of interest.

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