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CLINICAL STUDY

Analysis of factors influencing ultrasound-based fetal weight estimation

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ABSTRACT

OBJECTIVES: Determining the mean deviation between estimated fetal weight (EFW) measured by ultrasound biometry and the real final birth weight and defining the factors influencing the accuracy of weight estimation.

BACKGROUND: Estimated weight of the fetus before birth is valuable information for obstetricians particularly in choosing the method, management, and timing of delivery.

METHODS: The retrospective study analyzed 331 medical records of induced labor between January and June 2021. Fetal weight estimation was calculated using Hadlock formulas. The anamnestic data were obtained from medical records, namely: maternal age, maternal BMI, parity, date of the last ultrasonography (USG) before delivery, fetal presentation, placental location, EFW (including the physician's name performing the measurement, and time of the measurement), gestational age of the fetus, date of birth, fetal gender, neonatal weight and length. The correlations between the weight deviation and other factors were expressed using the Pearson and Phik (Φk) correlation coefficients. The Bland Altman method was used to visualize the correspondence between the two variables. The hypotheses were based on the acquired knowledge and then tested by Mann-Whitney U, Kruskal-Wallis, and ANOVA statistical tests, as required by the hypotheses and input data.

RESULTS: The mean EFW in the studied group was 3,459 ± 435 g, and the mean actual birth weight was 3,508 ± 508 g. The mean absolute deviation between monitored weight parameters was 260.27 g. The mean real birth weight was higher compared to EFW by 4.873 g. A significant effect on EFW was observed for the following factors: time interval between sonographic weight estimation and delivery (less than 7 days), high maternal BMI (> 30 kg/m^2), maternal age, and neonatal weight and length. The factors of fetal presentation, placental location, amniotic fluid volume, fetal gender, gestational age, parity, or those of examiner did not seem to impact EFW accuracy in our study.

CONCLUSION: The time interval between sonographic weight estimation and delivery (shorter than 7 days), maternal BMI over 30 kg/m^2, maternal age, neonatal weight and length are all factors significantly associated with the accuracy of ultrasound-based fetal weight estimation *(Tab. 2, Ref. 13)*. Text in PDF *www.elis.sk*

KEY WORDS: ultrasound, biometry, fetal weight estimation.

Introduction

Estimated fetal weight (EFW) is one of the main components of prenatal care. It can influence the intensity of monitoring a pregnant patient within prenatal care and the timing and management of the delivery method (7). Birth weight is an important parameter influencing neonatal and maternal morbidity and mortality. An inaccurate estimate of fetal weight can result in unnecessary surgery and associated risks in a mother who has undergone a cesarean section due to overestimating her baby's weight. On the contrary, it can pose an increased risk of birth complications for the fetus, namely shoulder dystocia and birth trauma in an infant whose weight had been underestimated. Several factors can influence the precision of EFW, particularly the time interval between sonographic estimation and childbirth, experience of the examining physician, selection of a formula to calculate estimated weight, maternal BMI, maternal parity, placental location, fetal gender, fetal presentation, or gestational age (2). Our paper is focused on the factors that can influence the estimation of fetal weight. In their study conducted in 2008 (7), Heer et al found that the most crucial determinant that had negatively affected fetal weight prediction accuracy was the time interval of more than 7 days between USG estimation and delivery (7). Several formulas can be used to calculate the estimated birth weight. They differ in using individual biometric parameters. Hadlock formulas (1985) are considered the most frequently used and often being most reliable (6). Hadlock-1 formula includes the biometric parameters HC, AC, and FL. Hadlock-2 formula uses only AC and FL pa-

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rameters, for which it may be less accurate. Hadlock-3 formula uses BPD, HC, AC, and FL.

Materials and methods

A retrospective study focused on induced deliveries of full-term gestations at the 2nd Department of Gynecology and Obstetrics of the Faculty of Medicine, Comenius University, and the University Hospital in Bratislava over the period of January to June 2021. Induced deliveries were selected because all patients had undergone USG measurements before delivery. The following anamnestic data were obtained: maternal age, maternal BMI, maternal parity, date of the last USG before delivery, description of fetal presentation and placental location, estimated fetal weight, physician's name who performed the last USG, the time when the last USG was performed, fetal gestational age, date of delivery, and gender, weight, and length of the infant. In our paper, we evaluated 11 factors that influence the accuracy of prenatal weight estimation (Tab. 1). The estimation of fetal weight was determined based on the size of BPD, AC, HC, and FL according to Hadlock-3 formula. We expressed the difference between the actual and estimated weight as absolute deviation regardless of the ± sign, and real deviation including the ± sign. Microsoft Excel was the primary setting; more complex statistics were generated in the Python and R programming languages. The Bland Altman method was one of the ways in which data were displayed. Depending on nature of the variables, the Pearson's correlation coefficient or Phik (Φk) correlation coefficient was used to determine the relationship between two variables. The non-parametric statistical tests, namely Mann-Whitney U (two-sample) and Kruskal-Wallis (n-sample, n > 2) were used to verify the hypotheses. The significance was set at the level $\alpha = 0.05$. The statistical analysis of variance (ANOVA) was used to verify one hypothesis regarding the infant gender.

Tab. 1. Influencing factors and the subgroups.

Number	Influencing factor	Subgroups
1	Time interval between estimation and delivery	≤7 days vs >7 days
		≤1 day vs >1 day
2	Maternal BMI	<30 vs ≥30 kg/m^2
		<25 vs ≥25 and <30 kg/m^2
3	Amniotic fluid volume	normal vs other
		normal vs oligohydramnion vs polyhydramnion
4	Location of the placenta	anterior wall vs posterior wall vs fundus
5	Presentation of fetus	cephalic vs breech
6	Fetal gender	male vs female
7	Neonatal weight	<2500 vs 2500–4500 vs >4500 g
8	Neonatal length	<48 vs 48–52 vs>52 cm
		<48 vs 48–52 cm
		<48 vs >52 cm
		48–52 vs >52 cm
9	Time of ultrasound measurement	until 11:00 vs after 11:00
10	Parity	1 vs >1
11	Maternal age	≤33 vs >33 years

Results

Our study included 331 medical records of individual fetuses. The mean estimated weight of infants was 3,459 ± 435 g (range 2,150–4,726 g), and the mean actual birth weight was 3,508 ± 508 g (range 2,080–5,060 g). The mean absolute deviation between the given weights was 260.27 g, i.e., on average, the predicted weight deviated by 260.27 g. The real average deviation was 48.73 g, i.e., the newborns' actual weight was higher than the estimated weight by 48.73 g.

Based on the results of statistical tests, it was possible to prove that the number of days between USG weight estimation and delivery influences the accuracy of fetal weight estimation. Our data show that the weight deviation is lower if the last USG is performed within 7 days before delivery. We proved that the weight deviation is lower even if the last USG is performed 1 day before delivery. Furthermore, we found that if the mother's BMI is above (including) 30 kg/m^2, the accuracy of fetal weight prediction decreases. The BMI of mothers in the range of 25–30 kg/m^2 in our study did not influence the magnitude of the deviation as compared to mothers with lower BMI. We could not prove the impact of fetal presentation, placental location in the uterus, and amount of the amniotic fluid on the accuracy of fetal weight estimation.

Our tests failed to show a significant difference in measurements based on gender of the infants. However, using the ANOVA statistical test, we could prove that the deviation of the measurement, considering its direction, is significantly influenced by gender of the newborn. In boys, the birth weight was on average 110 g higher than the predicted weight. On the contrary, it was 12.9 g lower in girls. Therefore, in our group of boys, the predicted weight was underestimated, while in girls, it was overestimated.

The birth weight and length of the infant influence the size of weight deviation, and we have shown that the deviation increases in newborns with higher weight and longer length. Unfortunately, these factors can only be assessed retrospectively. Maternal parity, USG time, and a physician performing USG did not play a significant role in our data in relation to the accuracy of fetal weight prediction. Using the Mann-Whitney U test, we were able to prove that in our data set, women over the age of 33 had a more significant measurement deviation. From our data, we can thus conclude that the increasing age of the mother affects the size of weight deviation (Tab. 2).

Discussion

In this paper, we investigated the influence of selected factors on the deviation of estimated fetal weight. We were inspired by studies in which the individual factors had already been discussed and verified our proposed hypotheses. In their studies, Bardin et al (2019), Basha et al (2012), and Dakwar et al (2019,) state that the time interval between the sonographic estimation and childbirth is the most essential factor in influencing the accuracy of estimated fetal weight is (2, 4, 6). We likewise verified this fact on our data, and based on them, we can state that in cases when the last USG examination was performed within 7 days before delivery (including), the weight deviation was lower as compared to cases when the USG measurements were performed sooner than 7 days before delivery. We also found out that in cases when the last USG examination was performed within one day before delivery (including), the weight deviation was also lower as compared to cases when the USG examination was performed sooner than 1 day before delivery. Our data show that the mother's BMI over 30 kg/m^2 predicts a higher weight deviation. Our results are consistent with the results of the study by Manzanares et al (10). We sought to verify whether the mother's BMI with values of 25–30 kg/m^2 also influenced the accuracy of weight estimation. We were unable to confirm this hypothesis. The study by Perni et al (2004) (12) showed that from the 38th gestational week onward, there was a relationship between estimated fetal weight and the amount of amniotic fluid. On the contrary, in the study of Ashwal et al (2015) (1), the effect of the amount of amniotic fluid on estimated fetal weight was not confirmed. Our data set failed to prove the impact of the amount of amniotic fluid on estimated fetal weight. The study by Krispin et al (2020) (9) showed that the placenta location changed the architecture of the uterine cavity to such an extent that the USG measurement might be modified. Obviously, this also influences the estimation of fetal weight. In our set of data, divided into three groups based on placenta position (anterior, posterior, or fundal), we failed to prove that the placenta position in the uterus impacted the size of the weight deviation. In distinction to the study of Krispin et al (9), we explain this fact by a smaller amount of data in our set. We also failed to confirm the hypothesis when examining the effect of fetal position on weight estimation. The same result was obtained in the study of McNamara et al (11), in which they worked with a percentage distribution of groups similar to that in our study. Our tests failed to show a significant difference in measurements based on the gender of infants. However, in our group, the predicted weight was underestimated in boys while overestimated in girls. Barel et

Tab. 2. Factors influencing the precision of estimation.

Influencing factor	Subgroups	n	SE	Mann-Whitney U test – significant difference (p<0.05)	Kruskal-Wallis test – significant difference (p<0.05)
Time interval between estimation and delivery	≤7 days	306	12.24	Yes: p=0.021	Yes: p=0.0433
	>7 days	25	60.28		
	≤1 day	145	19.80	Yes: p=0.044	No: p=0.1133
	>1 day	186	15.51		
Maternal BMI	<30 kg/m^2	262	13.11	Yes: p=0.042	No: p=0.0839
	≥30 kg/m^2	45	28.14		
	<25 kg/m^2	197	14.95	No: p=0.614	No: p=0.848
	≥25 and <30 kg/m^2	65	27.38		
Amniotic fluid volume	normal	296	13.13	No: p=0.14	No: p=0.2802
	other	35	34.73		
	normal	296	13.13	–	No: p=0.4146
	oligohydramnion	21	43.54		
	polyhydramnion	12	62.27		
Location of the placenta	anterior wall	174	18.94	–	No: p=0.8459
	posterior wall	107	18.88		
	fundus	14	47.11		
Presentation of fetus	cephalic	321	12.61	No: p=0.0847	No: p=0.1689
	breech	8	25.96		
Fetal gender	male	165	18.36	No: p=0.1	No: p=0.2013
	female	166	16.37		
Neonatal weight	<2500 g	13	61.27	–	Yes: p=0.00004
	2500–4500 g	308	11.42		
	>4500 g	10	135.9		
Neonatal length	<48 cm	25	38.10	–	Yes: p=0.0005
	48–52 cm	263	13.44		
	>52 cm	43	37.12		
	<48 cm	25	38.10	No: p=0.0545	–
	48–52 cm	263	13.44		
	<48 cm	25	38.10	Yes: p=0.0004	–
	>52 cm	43	37.12		
	48–52 cm	263	13.44	Yes: p=0.0003	–
	>52 cm	43	37.12		
Time of ultrasound measurement	until 11:00	169	16.70	No: p=0.316	No: p=0.6818
	after 11:00	162	18.16		
Parity	1	175	15.80	No: p=0.365	No: p=0.7303
	>1	156	19.20		
Maternal age	≤33 years	197	14.46	Yes: p=0.021	Yes: p=0.0425
	>33 years	134	21.49		

al (3) found that in their cohort, the weight was overestimated in both boys and girls and more significantly in girls. Broere-Brown et al (5) had the same results as in our study, and thus the predicted weight was underestimated in boys and overestimated in girls. Concerning these findings, it appears that the birth weight of girls is usually lower than predicted. Using our tests, it was impossible to prove the effect of USG examination time on the size of the weight deviation. In the future, further analysis could divide the cohort into groups based on different time data. The division into more than two groups could also be beneficial for a larger data set. Based on our data, the effect of maternal parity on the magnitude of weight deviation has not been confirmed, making the results consistent with those of Johnsen et al (8) of 2006. A study by Woodward et al (2016) (13) states that the accuracy of estimated fetal weight is 50 % in infants over 4,500 g. Thus, in 50 % of cases, the weight deviation was greater than 500 g. In our group, the accuracy of estimated weight in infants with birth weight > 4500 g was only 40 %. Therefore, in 60 % of cases, the weight deviation was larger than 500 g. Our data analysis shows that in a newborn with a longer length, the measurement deviation increases. We could not find a study examining the effect of newborn length on the size of the weight deviation. which is why, unfortunately, we could not compare our results to others. We consider this hypothesis to be the author's. However, the infant length factor cannot be applied to clinical practice when estimating fetal weight, as these data can only be obtained after delivery. The inspiration to observe another factor was derived from the study of Heer et al (2008) (7), which examined the influence of individual physicians on the accuracy of predicted fetal weight. In this study, experienced physicians were compared with less experienced physicians in the field of USG. Our study could not compare physicians according to their experience because this parameter is not specified in our hospital information system and is considered a subjective factor. Our data set failed to demonstrate the physician's influence on the size of the weight deviation. A study by Barel et al (3) of 2013 points out that maternal age is an independent parameter in terms of its effect on fetal weight estimation. By using Combs' formula for estimating fetal weight, they found that fetal weight tended to be underestimated with the mother's advanced age. Conversely, the estimated fetal weight was overestimated when using the Hadlock formula due to increasing maternal age. In our data set, the estimated weight was overestimated in women both under and over 33 and more significantly in those over 33.

We consider the incompleteness of information on the mother or infant in the hospital system, which reduced our file from 364 to 331 records, to be a limitation of our study. In the future, it could be beneficial to expand the data set or create a study of a prospective nature. It would be interesting to obtain more representative samples when verifying the influence of certain factors (fetal position, amount of amniotic fluid, placenta location). Obtaining data on race could also bring new insights. We hold that the benefit of our study lies in the determination of the average absolute deviation of weight in infants born at the 2nd Department of Gynecology and Obstetrics of the Faculty of Medicine Comenius University and the University Hospital in Bratislava over the period from January to June 2021. Accordingly, we managed to clearly define the factors that influence the weight deviation. We have not found any study in the available world literature dealing with verifying the influence of the infant's length on the weight deviation. Therefore, we consider the hypothesis to be put forward by the author. Our results could serve as a stimulus for gynecologists and obstetricians for highlighting the factors where accuracy needs to be especially focused on when estimating fetal weight.

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