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Original Article

Effect of oligohydramnios on the accuracy of sonographic foetal weight estimation in at term pregnancies

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ABSTRACT

Objective: Ultrasound estimation of foetal weight is a very important aspect of antenatal care. The role of amniotic fluid volume as a potential factor which may impede the relevance of ultrasonographic foetal weight estimation is still questionable. The aim of our study was to evaluate the impact of isolated oligohydramnios on the accuracy of ultrasound foetal weight estimation in at term pregnancies when examination was performed within 48 h before delivery.

Materials and methods: The retrospective cohort study included 1831 women with low-risk, singleton, at term pregnancy. Estimated foetal weight (EFW) was calculated using Hadlock-4 formula. Exclusion criteria consisted of multiple pregnancies, active phase of labour, preeclampsia, foetal growth restriction, foetal anomalies, gestational diabetes mellitus and the evidence of intrauterine infection. Isolated oligohydramnios was defined as Amniotic Fluid Index (AFI) $\leq$50 mm without any other foetal anomalies. EFW and actual birth weight (ABW) were compared by calculation of: absolute error (AE), absolute percentage error (APE) and substantial error (SE) = APE >10%.

Results: Participants were divided into 2 groups: Group 1: patients with normal AFI ($50 \leq$ AFI ≤ 250 mm; $n = 1602$) and Group 2: (isolated oligohydramnios, $n = 229$). There were not observed statistically significant differences between mean ABW and mean EFW in both groups (Group 1: $p = 0.525$; Group 2: $p = 0.317$). Mean AE in Group 1 was 221.8 g and 223.1 g in Group 2 ($p = 0.919$). Mean APE was 6.54% and 6.64% in Group 1 and 2 respectively ($p = 0.816$). SE ratio was 21.9% in Group 1 and 19.2% in Group 2. Underestimation to overestimation ratio in Group 1 was 1.01 and 0.84 in Group 2.

Conclusions: Amniotic fluid volume has limited impact on ultrasound foetal weight estimation. In oligohydramnios group there might be a tendency of overestimation of neonatal ABW.

Introduction

Ultrasound estimation of foetal weight is a very important aspect of antenatal care and has become an integral part of routine practice in obstetrics. Abnormal values of estimated foetal weight (EFW) may be linked with the presence of numerous foetal, maternal and associated with labour complications and may have influence on decision-making regarding pregnancy management. On the one hand, many former studies reported that foetal macrosomia is strongly related with gestational diabetes mellitus [1] and other perinatal complications, including shoulder dystocia [2,3], birth canal trauma [4], asphyxia injuries [5], meconium aspiration [6], prolonged labour [7], humeral and clavicular fractures [8,9], brachial plexus palsies [10] or even postpartum haemorrhage [11]. On the other hand, low birth weight may be associated with foetal prematurity or intrauterine growth restriction [12].

A wide range of formulas has been created to calculate EFW. Nevertheless, it is the Hadlock-4 formula which is the most commonly used in western Europe, since it appears to be encumbered by the slightest mean percentage error compared to the others [13]. In this particular formula, EFW is calculated from sonographically measured foetal circumferences of abdomen and head, biparietal diameter and femur length [14].

Many different factors may alter the accuracy of the sonographic estimation of foetal weight. Huber et al. showed that the accuracy of sonographic prediction of actual birth weight (ABW) is related to

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sonographer's experience, equipment quality, foetus' presentation, location of the placenta, foetal sex and the time between weight estimation and delivery [15]. Nonetheless, the role of amniotic fluid volume as a potential factor which may impede the relevance of sonographic foetal weight estimation is still questionable and poorly documented [16,17].

Our study aimed at evaluating the impact of isolated oligohydramnios on the accuracy of ultrasound foetal weight estimation in at term pregnancies.

Materials and methods

The study obtained approval from the Jagiellonian University Institutional Bioethics Committee. It was a retrospective cohort study conducted in the Department of Obstetrics and Perinatology, which is a tertiary referral centre affiliated to Jagiellonian University Medical College (JUMC) in Cracow, Poland. The study included 1831 women with low-risk, singleton, at term pregnancies (gestational age from 37 + 0 to 41 + 6 weeks) who were admitted to our hospital between January 1st 2016 and December 31st 2017, who underwent sonographic estimation of foetal weight and amniotic fluid volume within 48 h before delivery. Exclusion criteria consisted of multiple pregnancies, active phase of labour, foetal presentation other than vertex, preeclampsia, foetal growth restriction, foetal anomalies, gestational diabetes mellitus and the evidence of intrauterine infection.

Ultrasound examinations were performed by experienced obstetricians who underwent the same ultrasound training course, with the use of General Electric Voluson ultrasound device with 4–8 MHz transabdominal curvilinear transducer (GE Healthcare, Chicago, IL, United States). EFW was calculated with the use of Hadlock-4 formula, namely: $\log_{10}EFW = 1.3596 - 0.00386\,(AC) \times (FL) + 0.0064\,(HC) + 0.00061\,(BPD) \times (AC) + 0.0424\,(AC) + 0.174\,(FL)$ [18]. Head circumference (HC) and biparietal diameter (BPD) were measured on an axial cross-section of the cranium at the level of the cavum septum pellucidum and the thalami. Abdominal circumference (AC) was obtained from an axial cross-section of the abdomen at the level of porto-umbilical vein complex within the liver. The linear distance between greater trochanter and the distal metaphysis of the femur was used for obtaining the femur length (FL). Amniotic fluid index (AFI) was calculated by adding up vertical measurements of amniotic fluid pockets from 4 quadrants of uterus, using linea nigra and umbilicus as landmarks [19].

Isolated oligohydramnios was defined as AFI lower than 50 mm without any other diagnosed foetal anomalies [20]. Normal value of AFI was defined as greater than or equal to 50 mm and less than or equal to 250 mm [20]. We decided to exclude from the study pregnancies with isolated polyhydramnios (AFI >250 mm) [20] because of not representative number of its cases. EFW and actual birth weight (ABW) were compared by calculation of: 1) $\Delta EFW = EFW - ABW$; 2) absolute error (AE): $AE = |EFW - ABW|$; 3) absolute percentage error (APE): $APE = \frac{|EFW-ABW|}{ABW} \times 100\%$. We also calculated the rate of substantial error (SE) defined as APE >10%, which was used in previously conducted studies as a cut-off point to delivery mode counselling and decision-making. Additionally, to compare the incidence of underestimated and overestimated EFW results, we calculated underestimation to overestimation (U/O) ratio which was a quotient of percentage of underestimated and overestimated EFW results. The case was classified as underestimated when the value of ABW was higher than EFW. On the contrary, each case with ABW lower than EFW was categorised as overestimated.

All the data, including results from ultrasound examination as well as maternal and foetal characteristics, were obtained from the Department of Obstetrics and Perinatology JUMC's database which consists details about maternal and foetal characteristics (e.g. maternal age, number of pregnancies, parity, height) collected by our staff at the moment of admission to hospital.

Statistical analysis was performed using STATISTICA 13.1 software (StatSoft Inc., Tulsa, OK, USA). Groups comparison was conducted with the use of Mann–Whitney U test, independent two-sample T-test, Fisher's exact test and chi-squared test to the appropriate data. In order to assess the connection between substantial error and AFI logistic regression was performed. We also utilized Person correlation coefficient to analyse the power of correlation between continuous variables. P value <0.05 was defined as statistically significant.

Results

1831 patients included into the study were divided into two groups: Group 1, which consisted of patients with normal AFI values ($50 \leq$ AFI ≤ 250 mm; n = 1602) and Group 2: with patients with diagnosed isolated oligohydramnios (AFI <50 mm; n = 229). There were not observed any statistically significant differences in terms of maternal characteristics including maternal age, parity, number of pregnancies, gestational age, pre-pregnancy weight, height and BMI between both groups. Mean AFI was 108.68 ± 37.14 mm in Group 1 and 22.17 ± 15.19 mm in Group 2 (p <0.001). During the analysis of foetal characteristics, we noticed that mean ABW was 3419.14 ± 436.24 g and 3356.00 ± 461.99 g in Group 1 and Group 2, respectively and the difference was statistically significant (p = 0.042). Mean EFW was not statistically significant different between both groups (Group 1: 3409.69 ± 404.21 g; Group 2: 3398.21 ± 440.44 g; p = 0.691) (Table 1).

Mean ABW and mean EFW did not differ significantly between Group 1 and Group 2 (Group 1: mean ABW = 3419.14 ± 436.24 g, mean EFW = 3409.69 ± 404.21 g; p = 0.525. Group 2: mean ABW = 3356.00 ± 461.99 g, mean EFW = 3398.00 ± 440.44 g; p = 0.317). Mean AE was 221.85 g in Group 1 and 223.15 g in Group 2 (p = 0.919). Both groups also were not statistically significant different in terms of mean APE (Group 1: APE = 6.54%; Group 2: APE = 6.64%; p = 0.816).

Persons' correlation coefficient (r) between EFW and ABW was 0.765 for Group 1 and 0.818 for Group 2. SE ratio was slightly higher in Group 1 compared to Group 2 (21.91% and 19.21%, respectively; p = 0.353). In Group 1, we noticed 49.87% of underestimated cases and 49.56% of overestimated cases, thus U/O ratio was 1.01 and it was lower in comparison to Group 2 (percentage of underestimated cases: 45.85%, percentage of overestimated cases: 54.15%, U/O ratio: 0.84) (Table 2). The odds ratio (OR) for the presence of SE in oligohydramnios group was 0.835 (95% confidence interval: 0.589–1.185).

Discussion

Only a small number of papers published in recent years describe the influence of AFI on accuracy of ultrasound estimation of foetal weight. What is more, results of these studies may be influenced by different period between ultrasound estimation of foetal weight and labour in which foetuses are still growing and increase their weight to the level achieved on the day of labour [15]. Ashwal et al. [17] and Blitz et al. [21] performed EFW measurement within a week prior to delivery, when Karahanoglu et al. [22] shortened this period to 72 h. To achieve the highest precision of foetal weight estimation we included into our study only cases in which ultrasound examination was performed within 48 h before the delivery.

Accuracy of foetal weight estimation may be also disturbed by mathematical formula used for calculation of EFW [23]. We decided to use Hadlock-4 formula which combines head and abdominal

Table 1
Maternal and foetal characteristics of Group 1 and Group 2.

Parameter	Group 1	Group 2	p value
Maternal age (years)	30.97 ± 4.62	30.35 ± 4.51	0.057
Number of pregnancies (n)	1.98 ± 1.09	1.91 ± 0.98	0.350
Parity (n)	1.66 ± 0.77	1.65 ± 0.74	0.875
Gestational age (weeks)	39.05 ± 1.00	39.11 ± 1.09	0.383
Maternal pre-pregnancy weight (kg)	61.49 ± 10.00	60.30 ± 9.35	0.089
Height (m)	1.66 ± 0.06	1.66 ± 0.06	0.504
Maternal pre-pregnancy BMI (kg/m^2)	22.28 ± 3.40	21.90 ± 2.98	0.108
ABW (g)	3419.14 ± 436.24	3356.00 ± 461.99	0.042
EFW (g)	3409.69 ± 404.21	3398.21 ± 440.44	0.691
Placental location (%)			
Anterior	31.10	30.57	0.937
Other	68.90	69.43	
AFI (mm)	108.68 ± 37.14	22.17 ± 15.19	<0.001

BMI; body mass index, ABW; actual birth weight, EFW; estimated foetal weight, AFI; amniotic fluid index.

circumferences, biparietal diameter and femur length, because it seems to be encumbered by the slightest error in our population [13] and it is routinely used in our hospital.

Moreover, the level of medical staff experience in performing ultrasound examination may also impact study results. For this reason, medical staff recruited to made ultrasound measurements in our Department was composed of specialists in gynaecology and obstetrics and undergone training course confirmed by appropriate certificate.

In our study, we did not observed any statistically significant differences between mean EFW and ABW in both oligohydramnios and normal AFI value groups. Mean AE and APE also were not statistically significant different. Above-mentioned results are quite similar to results obtained by Ashwal et al. [17] from their study which included 1096 pregnancies with AFI values within normal limits and 455 oligohydramnios cases. They reached SE ratio at the level of 8.4% for oligohydramnios group and 8.7% for normal AFI group, which are slightly lower than these achieved in our study. In general, there are two meaningful methodological aspects which may explain noticed disparity. Firstly, Ashwal et al. defined the SE as APE >15%, while we set SE threshold as APE >10%. Secondly, the interval between ultrasound examination and labour was relevantly longer than in our work (7 days versus 2 days prior delivery). As mentioned above, these factors may have crucial meaning for the accuracy of obtained results. Karahanoglu et al., Perni et Al., Blitz et al., and Meyer et al. [16,21,22,24] also confirmed that amniotic fluid volume did not affect the accuracy of foetal weight estimation. Their APEs oscillated between 6.0% and 9.7% in oligohydramnios cases. On the other hand, Ott et al. [25] published study in which they showed that the level of amniotic fluid may have significant impact on foetal weight estimation. These findings imply the necessity for conduction of new studies concentrated on this subject.

In the case of normal AFI values, our study showed similar frequency of underestimated and overestimated EFW results (U/O ratio about 1). In oligohydramnios group we noticed the tendency to overestimation (54.1%) of actual birth weight. Karahanoglu et al. and Blitz et al. [21,22] confirmed presented tendency in their studies reaching 66.3% and 68.0% of overestimated results. Tendency to overestimation of ABW may be a result of the fact that oligohydramnios is more frequent in pregnancies complicated by SGA (small for gestational age) foetuses [26]. In this case, the difference between ours and previously mentioned studies may also arise from different study populations and shorter period between ultrasound foetal weight estimation and delivery. To decrease ratio of SE and the incidence of overestimation, ultrasound measurements should be repeated several times in any single case and final value of AFI and EFW should be the average of obtained results.

Table 2
Comparison of absolute error, absolute percentage error and overestimation to overestimation ratio in Group 1 and Group 2.

Parameter	Group 1	Group 2	p value
AE (g)	221.85 ± 186.31	223.15 ± 162.16	0.919
APE (%)	6.54 ± 5.64	6.64 ± 4.86	0.816
SE, n (%)	351 (21.91)	44 (19.21)	0.353
Underestimated results, n (%)	799 (49.87)	105 (45.85)	0.255
Overestimated results, n (%)	794 (49.56)	124 (54.15)	0.194
ABW = EFW, n (%)	9 (0.57)	0 (0.00)	–
U/O ratio	1.01	0.84	0.223

AE; absolute error, APE; absolute percentage error, SE; substantial error; U/O ratio; underestimation to overestimation ratio.

Previously published studies also suggested the impact of some maternal factors on accuracy of foetal weight estimation, such as maternal age, weight, height, pre-pregnancy body mass index and parity [15]. To reduce the influence of mentioned variables on achieved results both, oligohydramnios and normal AFI value groups included to our study were not statistically significant different in terms of these factors.

Our study also had some limitations due to its retrospective design. Furthermore, our database included medical records only from single medical centre. Moreover, due to the small number of cases, we decided to exclude from statistical analysis patients with the diagnosis of isolated polyhydramnios. We believe that well-designed multicentre prospective observational studies are vital to provide indisputable proofs of the influence of amniotic fluid volume on foetal weight estimation.

Conclusions

There is no relationship between low amniotic fluid volume and the accuracy of foetal weight estimation in at term pregnancies. There is a tendency to overestimation of estimated foetal weight in oligohydramnios cases.

Conflict of interest

The authors declare that they have no conflict of interest.

Acknowledgments

None declared.

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