Accuracy of Fetal Weight Estimation in Women with Diet Controlled Gestational Diabetes

Wie genau ist die fetale Gewichtsschätzung beim diätkontrollierten Gestationsdiabetes?

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Key words
- ultrasound
- estimated fetal weight
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Schlüsselwörter
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- Gewichtsschätzung

Abstract

Purpose: To evaluate whether ultrasound accuracy of estimated fetal weight (EFW) differs in women with diet controlled gestational diabetes mellitus (GDM) compared to nondiabetic pregnant women.

Material and Methods: We included 363 patients, 121 patients with diet controlled GDM and 242 patients with a normal oral glucose tolerance test (oGTT). Each case of diet controlled GDM was matched with 2 unaffected controls. All patients were screened/diagnosed for GDM by means of an oGTT. Both groups received ultrasound examination including fetal biometry, using Hadlock's Formula, within 7 days to delivery. After birth, gestational age, birthweight and Apgar scores were collected from each newborn.

Results: There was a good correlation between EFW and birth weight (coefficient = 0.747, $p < 0.001$ by Pearson correlation, even after adjustment for glucose status). Regression analyses, including noGDM/GDM, maternal age, maternal body mass index, birth weight and time interval between ultrasound and delivery revealed that only fetal birth weight significantly influences weight difference between ultrasound EFW and actual birth weight at term.

Conclusion: Our data suggests that ultrasound accuracy of EFW using Hadlock's Formula at term does not differ in women with diet controlled GDM compared to women with normal glucose tolerance.

Zusammenfassung

Fragestellung: Zu überprüfen, ob die fetale Gewichtsschätzung, im Rahmen des diätkontrollierten Gestationsdiabetes, weniger genau ist als bei Schwangeren ohne Gestationsdiabetes.

Material und Methodik: Es wurden insgesamt 363 Patienten eingeschlossen, davon 121 Schwangere mit diätkontrolliertem Gestationsdiabetes und 242 Schwangere ohne Glukosetoleranzstörung. Jeder Schwangeren mit Gestationsdiabetes wurden 2 Schwangere ohne Gestationsdiabetes gegenübergestellt. Bei allen Schwangeren wurde ein Screening für das Vorliegen eines Gestationsdiabetes mittels eines oralen Glukosetoleranztests durchgeführt. Bei beiden Gruppen wurde eine fetale Gewichtsschätzung mit der Hadlock-Formel, maximal 7 Tage vor der Geburt, durchgeführt. Nach der Geburt wurden das Gestationsalter, das Geburtsgewicht und der Apgar des jeweiligen Neugeborenen notiert, und das tatsächliche Geburtsgewicht wurde mit der Gewichtsschätzung verglichen.

Ergebnisse: Insgesamt stimmen das tatsächliche Geburtsgewicht und die Gewichtsschätzung gut miteinander überein (Koeffizient = 0,747, $p < 0{,}001$ nach Pearson-Korrelation, auch nach Abgleichung mit dem Glukosestatus). Die Regressionsanalyse, welche die Parameter Gestationsdiabetes/kein Gestationsdiabetes, mütterliches Alter, mütterlicher Body-Mass-Index, Geburtsgewicht und Zeitintervall zwischen dem Zeitpunkt der Gewichtsschätzung und der Geburt beinhaltet, zeigt, dass nur das Geburtsgewicht einen Einfluss auf die Genauigkeit der Gewichtsschätzung hat.

Folgerung: Anhand dieser Daten scheint die Gewichtsschätzung im Rahmen des diätkontrollierten Gestationsdiabetes nicht weniger genau zu sein als bei Schwangeren ohne Gestationsdiabetes.

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Introduction

Diabetes in pregnancy is one of the most common pregnancy complications, with a prevalence of 5 to 10% and a major cause of maternal and fetal morbidity [1]. Gestational diabetes mellitus (GDM), which represents approximately 90% of cases in which pregnancy is complicated by impaired glucose metabolism [2], is defined as development of glucose intolerance during pregnancy or glucose intolerance that is first detected during pregnancy [3]. Women with GDM appear to be at increased risk for fetal macrosomia and perinatal complications if treatment is not provided [4]. The exact pathogenesis of GDM is not completely understood; however, increased insulin resistance is a well-demonstrated mechanism [5]. GDM can be classified according to White's classification. White's classification A1 comprehends cases of GDM where glucose metabolism is diet controlled only, whereas in White's classification A2 glucose levels must be controlled with insulin treatment [6].

Fetal macrosomia can be defined in several ways. One commonly used weight threshold is fetal birth weight greater 4500 grams, as supported by the American College of Obstetricians and Gynecologists [7].

There is evidence for a strong continuous association between maternal glucose concentrations and increasing birth weight, cord-blood serum C-peptide levels, and other markers of perinatal complications [4,8]. A study comparing fetal outcome of mothers with diet controlled and insulin controlled GDM described a significantly higher incidence of fetal macrosomia in the group of GDM that was insulin controlled [9]. Consequently it can be hypothesized that GDM requiring insulin treatment is a more severe form of glucose intolerance during pregnancy than diet controlled GDM, causing more complications linked to maternal hyperglycaemia.

There are controversial reports concerning ultrasound accuracy of EFW in diabetic mothers. Some authors suggest that EFW is less accurate in infants of diabetic mothers, due to different allocation of soft tissue [10]. Macrosomic infants of diabetic mothers have increased soft tissue mass around the trunk and limbs [11, 12]. Therefore, Wong et al. and other authors conclude that EFW measurement in fetuses of diabetic mothers is rather underestimating the actual birth weight since standard formulas for fetal weight estimation are not taking these anthropometric changes into account [9,13].

Other studies report similar or better accuracy of EFW in diabetic compared to nondiabetic pregnant women [14,15]. A review on the detection and treatment of the macrosomic fetus suggested that EFW and detection of fetal macrosomia is more accurate in diabetic and postdate pregnancies. However the authors concluded that better accuracy of EFW is due to a higher prevalence of macrosomia in these two groups and not due to better ultrasound accuracy of EFW [16].

None of these studies are distinguishing between diet controlled and insulin treated GDM or preexisting diabetes. This might be a reason for varying study results.

The objective of this study is to evaluate whether the ultrasound accuracy of EFW differs in women with diet controlled GDM (White's classification A1) compared to nondiabetic pregnant women.

Materials and Methods

The study was conducted between 2007 and 2009 at the Department of Obstetrics and Gynaecology at the Landeskrankenhaus Klagenfurt, Austria, a tertiary care centre serving high-risk pregnancies with different pregnancy-associated complications. Clinical investigations were conducted in accordance with the Declaration of Helsinki. All women were Caucasian. Patients younger than 18 years, with multiple pregnancies, preexisting diabetes, gestational diabetes that required insulin treatment (White's classification A2), fetal anomalies, patients taking corticosteroids and patients with chronic diseases were excluded from the study. We included 363 women in our study, 121 women with diet controlled GDM (White's classification A1) and 242 women with a normal oral glucose tolerance test. Each case of GDM was matched with 2 unaffected controls. All women were diagnosed having GDM by means of an oral glucose tolerance test (oGTT). Patient characteristics, including body mass index (BMI) value, are routinely collected during the first visit at our institution. The oGTT was conducted between 24 and 28 weeks of gestation. We used a standardized 75-g glucose solution (Glucodrink®, Unipack, Wr. Neustadt, Austria). The test was performed in the morning after a fasting period of a minimum of 8 hours. Blood was drawn in the fasting state and 1 hour and 2 hours after glucose drink intake. The guidelines of the German and the Austrian Society for Diabetes (modified Carpenter Coustan criteria) were implemented for evaluation of the OGTT [17]. The upper normal limit for fasting, one hour, and two hour serum glucose was 90 mg/dL (5,0 mmol/L), 180 mg/dL (10,0 mmol/L) and 155 mg/dL (8,6 mmol/L), respectively. If at least one value was exceeded, GDM was diagnosed, and glucose monitoring and dietary instructions were started. As control group we took women with a physiological oGTT. Women diagnosed with GDM obtained dietary counselling by a trained dietary assistant and were instructed to measure capillary glucose levels on a daily basis during fasting state and 1 hour after meal. Glucose levels were rated as normal if fasting glucose did not exceed 90 mg/dL (5,0 mmol/L) and 130 mg/dL (7,2 mmol/L) one hour postprandially. If these limits were exceeded 5 times or more within the first week, insulin therapy was initiated in close collaboration with the department of internal medicine at our hospital. These women requiring insulin treatment were excluded from our study.

Women were monitored on a weekly or two weekly basis, depending on their metabolic situation and fetal biometrical data. At each visit mean glucose values were calculated for the last two week period. Labour was induced using vaginal prostaglandin application at term in all women with diet controlled GDM, unless it occurred spontaneously. The control group received medical induction of labour 10 days past term.

Both groups received an ultrasound examination including fetal biometry and EFW measurement within seven days to delivery. Women without ultrasound examination within seven days of delivery were excluded. In order to minimize inaccuracy due to worse visualization, we matched both groups according to BMI values. A Voluson E8 expert (GE Healthcare-Product Technology, Fairfield, USA), was used. Head circumference (HC), biparietal diameter (BPD), abdomen circumference (AC) and femur length (FL) were measured in a standard fashion [18]. The estimated fetal weight (EFW) was calculated using Hadlock's formula [19]. We used Hadlock's Formula because it has been described that Hadlock's Formula and Shepard's Formula are the most accurate formulas for EFW measurement at term [20].

After birth, gestational age, birth weight and Apgar scores were collected from each included newborn.

Statistical analyses were performed with SPSS software (version 15.0; SPSS, Chicago, IL). Continuous variables are summarized as means (± standard deviation), and categorical data as percentages. χ^2 test, t-test, Pearson correlation, and linear and logistic multiple regression analysis were used accordingly. For the logistic regression analysis the backward selection with likelihood ratio test was used. The goodness quality of fit of models was assessed using the Hosmer and Lemeshow test. Independent variables entered into the regression models were noGDM/GDM, maternal age, maternal body mass index, birth weight and time interval between ultrasound and delivery. P values of < 0.05 were considered significant.

Results

Overall 363 pregnant women were included in the study. 121 women had diet controlled GDM and 242 women had normal glucose tolerance. Patient characteristics are shown in **Table 1**. Patients with GDM were significantly older (32.6 ± 6.0 years, 32.1 ± 6.0 years; p < 0.001 by t-test) and had a significantly lower gestational age at delivery (39.4 ± 1.7 weeks, 40.6 ± 0.9 weeks; p < 0.001 by t-test) than pregnant women with normal glucose tolerance. Data on maternal glucose levels were 83,82 mg/dL (range 73–92) in the fasting state, 119,16 mg/dL (range 97–133) one hour after breakfast, 120,35 mg/dL (range 98–133) one hour after lunch and 121,38 mg/dL (range 97–133) one hour after dinner indicating that target glycemic thresholds were achieved. Patients had an average of six prenatal visits. As expected there was a good correlation between EFW and birth weight (coefficient = 0.747, p < 0.001 by Pearson correlation, even after adjustment for glucose status).

Regression analyses, including no GDM/GDM, maternal age, maternal body mass index, birth weight and time interval between ultrasound and delivery revealed that only fetal birth weight significantly influences weight difference between ultrasound EFW and actual birth weight at term (**Table 2**).

Using Hadlock's formula we compared the EFW measured within 1 week prior to delivery with fetal birth weight in women with diet controlled GDM and women with normal glucose tolerance. There was no statistically significant difference between these two groups (6.9 ± 6.1%, 8.0 ± 7.3%; p = 0.17 by t-test). Furthermore we have stratified the subjects in 5 different groups based on fetal birth weight. In none of the birth weight classes a significant difference in percent error could be observed. The highest percentages were observed in fetuses below 3000 g and fetuses above 4000 g (11.3 and 10%), but this difference did not reach significance (**Table 3**).

Table 1 Patient characteristics (n = 363).

	Controls	GDM	P value*
Patients (n)	242	121	
Age (years)	29.3 ± 5.5	32.1 ± 6.0	< 0.001
Primipara (%)	52.7	52.1	0.91
Body mass index (kg/m^2)	27.7 ± 4.5	28.0 ± 5.7	0.52
Gestational age at delivery (weeks)	40.6 ± 0.8	39.4 ± 1.7	< 0.001
Birth weight (g)	3 509 ± 446	3 475 ± 593	0.73
Estimated birth weight (g)	3 493 ± 391	3 554 ± 559	0.91
Ultrasound before delivery (days)	3.5 ± 2.2	3.42 ± 2.1	0.81
Weight difference (g)	271.4 ± 210.5	248.5 ± 226.8	0.24
Weight difference (%)	8.0 ± 7.3	6.9 ± 6.1	0.16
Apgar 5 minutes	9.8 ± 1.0	9.8 ± 0.6	0.90
Apgar 10 minutes	9.8 ± 1.3	9.9 ± 0.3	0.22

GDM = gestational diabetes mellitus, * t-test or χ^2, values are given as mean ± SD or percentages

Table 2 Predictors of weight difference at time of delivery between ultrasound estimated weight and birth weight in women delivered at term.

Model		Coefficient	Std. Error	Beta	p-value
1	(Constant)	− 114.084	118.597		0.337
	Body mass index	1.544	2.704	0.032	0.569
	Time interval ultrasound and delivery	− 1.871	5.894	− 0.017	0.751
	nonGDM/GDM	− 42.949	27.843	− 0.083	0.124
	Birth weight	0.090	0.027	0.185	0.001
	Age	1.490	2.175	0.037	0.244
2	(Constant)	− 118.658	117.564		0.314
	Body mass index	1.520	2.700	0.031	0.574
	nonGDM/GDM	− 42.916	27.807	− 0.083	0.124
	Birth weight	0.089	0.027	0.184	0.001
	Age	1.500	2.172	0.037	0.490
3	(Constant)	− 94.922	109.634		0.387
	nonGDM/GDM	− 42.863	27.779	− 0.083	0.124
	Birth weight	0.093	0.026	0.192	< 0.001
	Age	1.647	2.154	0.041	0.445
4	(Constant)	− 48.421	91.161		0.596
	nonGDM/GDM	− 38.855	27.263	− 0.075	0.155
	Birth weight	0.094	0.026	0.193	< 0.001
5	(Constant)	− 57.605	91.068		0.527
	Birth weight	0.093	0.026	0.192	< 0.001

Dependent variable: Difference between estimated birth weight and birth weight

Discussion

In most departments EFW measurement at term is performed. The majority of American College of Obstetrics and Gynecology fellows are using ultrasound for fetal weight estimation at term and 84% are recommending a cesarean section if EFW is greater than 4500 g [21]. Birth weight represents the most important risk indicator for neonatal and infant mortality and morbidity [22]. An accurate EFW is valuable information for planning the mode of delivery and management of labor, especially in diabetic pregnancies with a higher incidence of fetal macrosomia, since fetal macrosomia is associated with shoulder dystocia, brachial plexus injury, clavicular fracture, maternal birth trauma and cesarean section [23–25]. Since EFW measurement at term is frequently performed and influences birth mode [21], we believe that knowledge about the accuracy of EFW and consequently reliability of this diagnostic tool in different clinical situations is important.

Data on ultrasound accuracy of EFW measurement in diabetic pregnancies is controversial. There are studies reporting better, less and equal ultrasound accuracy of EFW [9, 12–14].

Table 3 Mean absolute percent difference for ultrasound estimated birth weight and birth weight in fetuses of women with GDM and normal glucose tolerance.

Birth weight	GDM		Controls		P*
	Number	% Difference	Number	% Difference	
< 3 000 g	19	6.8 (6.7)	32	11.3 (11.0)	0.15
3 000–3 500 g	44	6.8 (6.2)	93	7.1 (5.1)	0.76
3 500–4 000 g	38	6.1 (4.8)	83	7.2 (6.5)	0.39
4 000–4 500 g	11	9.2 (7.3)	30	10.0 (7.7)	0.74
> 4 500 g	9	8.8 (7.4)	4	8.7 (7.4)	0.45
Total	**121**	**6.9 (6.1)**	**242**	**8.0 (7.3)**	**0.17**

Values given as absolute numbers or mean (SD), GDM = gestational diabetes mellitus, * by t-test

However, most studies are not discriminating different forms of diabetes in pregnancy. Women with diet controlled GDM, insulin controlled GDM, preexisting diabetes mellitus type I and preexisting diabetes mellitus type II are often rated as "diabetic pregnancies". This might be a reason for varying study results.

Differences in EFW accuracy are ascribed to different allocation of fetal soft tissue in fetuses of women with GDM. In poorly controlled diabetic pregnancies, newborn have different anthropometric features showing more soft tissue around the trunk and limbs compared to newborn of women with regular glucose metabolism [10,11]. Higher maternal serum glucose levels result in higher insulin concentration in the amniotic fluid and thereby affect fetal abdominal growth [26].

A novelty of our study is that the study population consists only of women with diet controlled GDM (White's classification A1), the mildest form of diabetes in pregnancy. If adequate glucose levels were not achieved with diet control, mothers were treated with insulin and excluded from the study. Furthermore we matched our groups according to BMI value, in order to minimize inaccuracy caused by worse visualization of the fetus during ultrasound examination. We deliberately decided to include only pregnancies with diet controlled GDM (White's classification A1) because we believe that, as described above, pooling of different types of diabetes in pregnancy might be one reason for divergent results of previous studies comparing ultrasound accuracy of EFW in pregnancies complicated by diabetes and pregnancies with normal glucose tolerance.

Our results show no difference concerning ultrasound accuracy of EFW at term in pregnant women with diet controlled GDM compared to women with normal glucose tolerance. We only found fetal birth weight to influence the accuracy of EFW measurements.

Conclusions

The accuracy of ultrasound to estimate fetal weight at term in women with diet controlled GDM (White's classification A1) seems to be as reliable as EFW in unaffected pregnancies. The highest weight differences in percent error were observed in fetuses below 3000 g and fetuses above 4000 g (11.3% and 10%), which is in concordance with other studies [27].

Conflict of Interest

There is no conflict of interest to be disclosed. The authors alone are responsible for the content and writing of the paper.

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