Clinical risk score to recognize macrosomia at the time of delivery

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Summary

Objective: To develop a clinical risk score to help in recognizing macrosomia at the time of delivery. *Methods:* A case-control data analysis was conducted at a university-affiliated general hospital in Lamphun, Thailand. Macrosomic cases were 67 women who delivered babies weighing at least 4,000 g. Controls were 779 women with babies weighing between 2,500 g. and < 4,000 g. The best predictors were selected by multivariable logistic regression and transformed into clinical risk scores. *Result:* The best combination of predictors included parity, gestational age at delivery, weight at delivery and symphysis-fundal height. The scores predicted macrosomia correctly with an AuROC of 94.1% (95% CI; 92.3, 95.6). The likelihood ratio of positive for macrosomia was 0 in the low risk category and 10.68 (95% CI; 7.76, 14.68) in the high risk. *Conclusion:* A simple clinical risk score may help obstetricians suspect macrosomia at the time of delivery in areas where antenatal care services are inadequate.

Key words: Macrosomia; Large for gestational age; Birth weight; Risk factors; High risk pregnancy; Clinical prediction rule.

Introduction

Macrosomia, defined as birth weight 4,000 g or more at the time of delivery, is one of the most recognized obstetric problems in many parts of the world. The prevalence varies roughly form 5% to 20% [1]. A postulated upward trend in some developing countries may be explained partly by adoption of westernized lifestyles, which brought to elevated direct risks of macrosomia [1, 2].

Macrosomia increases morbidity and mortality of both the mothers and newborns. In mothers, the rate of cesarean delivery increases, and in those with vaginal deliveries, pelvic floor injury, perineum laceration and postpartum hemorrhage may occur. In newborns, protracted labor, shoulder dystocia, birth trauma, brachial plexus injury, Bell's palsy, hypoglycemia, polycythemia and jaundice are well documented [3-5].

Although macrosomia is highly associated with gestational diabetes mellitus (GDM), non-diabetic macrosomia is still an obstetric dilemma, as there is no clear consensus regarding its antepartum prediction and management [6]. A high proportion of macrosomic infants are born to non-GDM mothers. While screening and treatment may prevent macrosomia in GDM mothers, a high proportion of mothers carrying macrosomic infants are either not screened or screened as negative for GDM. Among all macrosomic newborns, 10% were undetected, leaving 90% unsuspected prenatally [7]. Many efforts to detect macrosomia earlier in the course of pregnancy for preventive intervention have been attempted by disclosing macrosomia risk factors and its prediction. Nevertheless, there was no evidence that macrosomic cases were centralized to larger, better equipped, maternity units, nor that planned cesarean delivery was scheduled for such cases [5].

Estimating birth weight with ultrasound has been reported in many studies [8], both using standard infant biometry and more sophisticated measurements [9]. Successful prediction by its combination with clinical characteristics was also reported [10-12].

In remote areas of many developing countries, ultrasound is not available. Ignorance of and incomplete antenatal care makes it more difficult to detect a relatively large-sized baby early in the course of pregnancy and it is not uncommon that women appear in labor rooms just before the time of delivery [13]. Precautious detection of macrosomia at the time of delivery in such women may still be important to help obstetricians in remote areas to centralize delivery to better equipped maternity units, or to translate such risk to pregnant women.

Patients and Methods

Study design and setting

A case-control study was designed from retrospective data at a university-affiliated hospital in Lamphun, Thailand, located in the northern part of Thailand, from 2007-2010.

Selection of cases

Macrosomic cases were all women who delivered babies weighing 4,000 g. or more.

Selection of controls

Controls were all women who delivered babies weighing between 2,500 g. and < 4,000 g on the same day as the index cases. In cases and controls, twin pregnancies were excluded. Pregnancies complicated with hypertensive disorders were also excluded because of routine obstetric intervention for weight control and/or early delivery.

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Table 1. — *Clinical characteristics of cases vs controls, evidence of difference (p value), area under receiver operating curve (AuROC) and 95% confidence interval (CI).*

Characteristics	Cases (n = 67) mean	± SD	Controls (n = 779) mean	± SD	*p* value	AuROC (95% CI)
Age (year)	28.9	± 5.6	26.4	± 5.3	< 0.001	0.63 (0.60, 0.67)
Gravidity	2.0	± 0.9	1.6	± 0.8	< 0.001	0.65 (0.61, 0.68)
Parity	0.8	± 0.7	0.4	± 0.6	< 0.001	0.66 (0.63, 0.69)
Height (cm)	157.2	± 6.5	155.4	± 6.0	0.020	0.57 (0.54, 0.60)
Prepregnancy weight (kg)	59.9	± 13.6	50.6	± 8.5	< 0.001	0.74 (0.72, 0.78)
Body mass index (kg/m^2)	24.1	± 4.5	20.9	± 3.2	< 0.001	0.74 (0.71, 0.77)
Weight at delivery (kg)	76.0	± 13.1	65.2	± 9.8	< 0.001	0.77 (0.74, 0.80)
Pregnancy weight gain (kg)	16.2	± 4.2	14.7	± 4.8	0.013	0.59 (0.56, 0.63)
Gestational age (wk)	39.4	± 1.1	38.8	± 1.2	< 0.001	0.63 (0.59, 0.66)
Symphysis-fundal height (cm)	38.2	± 2.2	33.7	± 2.1	< 0.001	0.94 (0.92, 0.95)
Gestational DM (n,%)					< 0.001	NA
Not screened	20	(29.9)	687	(88.2)		-
Screened negative	41	(61.1)	84	(10.8)		-
Screened positive	6	(9.0)	8	(1.0)		-
Mode of delivery (n, %)					< 0.001	NA
Normal vaginal	22	(32.8)	494	(63.4)		-
Operative vaginal	13	(19.4)	112	(14.4)		-
Cesarean	32	(47.8)	173	(22.2)		-
Male infant (n, %)	46	(68.7)	427	(54.8)	0.030	0.57 (0.54, 0.60)

NA; frequency of valid data too small, or not applicable for prediction purposes.

Data collection

All clinical characteristics were extracted from obstetric case notes. These included maternal age, height, prepregnancy weight, weight before delivery, pregnancy weight gain, gestational age at delivery, symphysis-fundal height, mode of delivery, birth weight and newborn gender.

Data analysis

Cases and controls were compared for evidence of differences (*p* value) in clinical characteristics with t-tests, rank sum tests or exact probability tests as appropriate. Prediction by each characteristic was calculated by univariable logistic regression and presented as an area under the receiver operating characteristic (AuROC) curve and its 95% confidence interval (95% CI). Strong (high AuROC curve) and significant (p value < 0.05) clinical predictors were categorized into three levels to facilitate odds ratio calculation, under the multivariable logistic regression. Discriminative performance of the model was calculated by an AuROC curve. Regression coefficients of each level for each clinical predictor were divided by the smallest coefficient of the model and rounded to the nearest half (.5) to transform into an item risk score. Scores for each clinical predictor were added up to obtain a total risk score. Score prediction of macrosomia was done by using a total score as the only summary predictor in the logistic model. Discrimination of the score was presented with an AuROC curve. Calibration of the prediction was analyzed with Hosmer-Lemeshow statistics. Scores predicting risk and observed risk were compared and presented in a graph. Internal validation of the score was done with the bootstrap method (200 replications). Risk scores were categorized into three risk levels, high, moderate and low. Predictive ability of each risk score level was calculated and presented as a likelihood ratio of positive, 95% CI and its significance level.

The research proposal, data collection and analysis plan were approved by Lamphun Hospital Research Ethics Committee. Informed consents were not required in this retrospective data collection.

Table 2. — *Best multivariable clinical predictors, odds ratio (OR), 95% confidence interval (CI), logistic regression beta coefficient (β) and assigned item scores.*

Predictors	OR	95% CI	*p* value	β	Score
Parity					
0	1.00	reference	–	–	0
1	2.34	1.16, 4.72	0.017	0.85	1
> 1	6.23	2.22, 17.48	0.001	1.83	2.5
Gestational age (week)					
< 38	1.00	reference	–	–	0
38-39	2.07	0.53, 8.16	0.296	0.73	1
> 39	5.36	1.34, 21.45	0.018	1.68	2.5
Weight at delivery (kg)					
< 63	1.00	reference	–	–	0
63-80	8.04	1.76, 36.86	0.007	2.08	3
> 80	13.23	2.62, 66.78	0.002	2.58	3.5
Symphysis–fundal height (cm)					
< 35	1.00	reference	–	–	0
35-37	21.29	4.90, 92.48	< 0.001	3.06	4
> 37	142.27	31.58, 640.90	< 0.001	4.96	7

Table 3. — *Distribution of cases vs controls into low, moderate and high probability categories, likelihood ratio of positive (LHR+) and 95% confidence interval (CI).*

Probability categories	Score	Cases (n = 67) n	%	Controls (n = 779) n	%	LHR+	95% CI	*p* value
Low	< 5	0	(0)	422	(54.2)	0	–	< 0.001
Moderate	5-10	22	(32.8)	308	(39.5)	0.83	0.58, 1.18	0.299
High	> 10	45	(67.2)	49	(6.3)	10.68	7.76, 14.68	< 0.001
Mean ± SE	–	11.4	± 2.3	4.8	± 3.2			< 0.001

Results

There were a total of 67 cases of macrosomia and 779 controls. In comparison to controls, study cases were older (28.9 ± 5.6 vs 26.4 ± 5.3 years, $p < 0.001$), higher in gravidity (2.0 ± 0.9 vs 1.6 ± 0.8, $p < 0.001$) and parity

Fig. 1

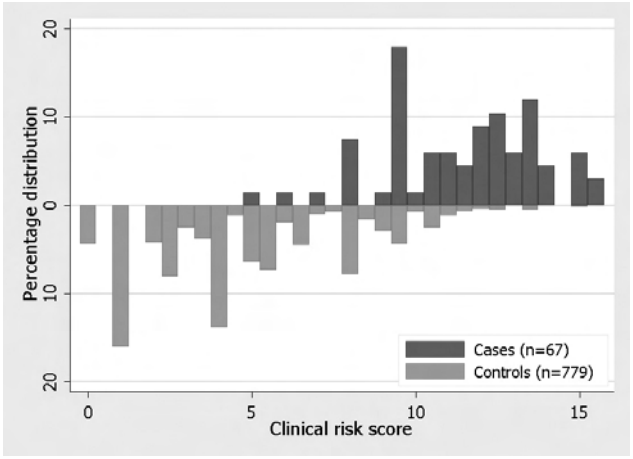

Fig. 2

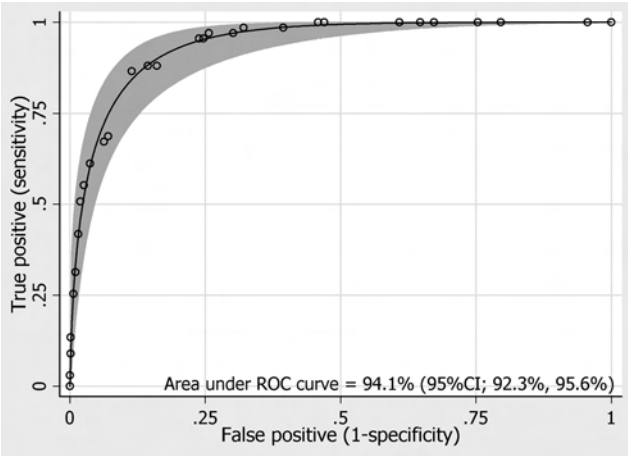

Fig. 3

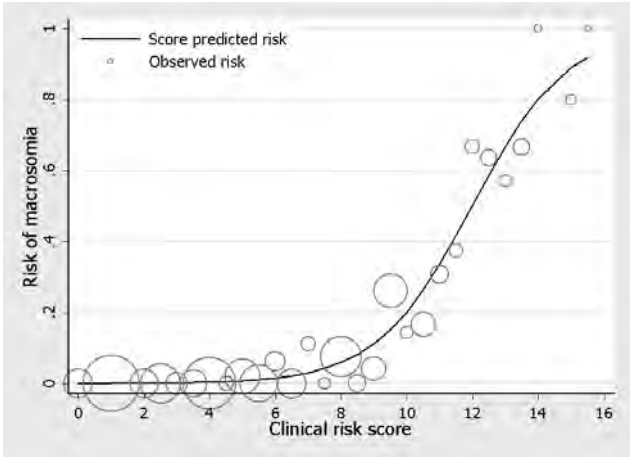

Figure 1. — Percentage distribution of clinical risk score of cases (n = 67) vs controls (n = 779).

Figure 2. — Area under receiver operating characteristic curve of clinical risk score and 95% confidence interval (CI) on prediction of macrosomia.

Figure 3. — Observed risk (circle) vs score predicted risk (solid line) of macrosomia, size of circle represent frequency of women in each score.

(0.8 ± 0.7 vs 0.4 ± 0.6, $p < 0.001$), were taller (157.2 ± 6.5 vs 155.4 ± 6.0 cm, p = 0.020), had more prepregnancy weight (59.9 ± 13.6 vs 50.6 ± 8.5 kg, $p < 0.001$), body mass index (24.1 ± 4.5 vs 20.9 ± 3.2 kg/m^2, $p < 0.001$), weight at delivery (76.0 ± 13.1 vs 65.2 ± 9.8 kg, $p < 0.001$), and total pregnancy weight gain (16.2 ± 4.2 vs 14.7 ± 4.8 kg, p = 0.013), and had larger symphysis-fundal height (38.2 ± 2.2 vs 33.7 ± 2.1 cm, $p < 0.001$). Cases had a higher proportion of GDM screening (70.1% vs 11.8%) and positive results (9.0% vs 1.0%, $p < 0.001$). More cesarean deliveries or operative vaginal deliveries (67.2% vs 36.6%, $p < 0.001$) and male infants (68.7% vs 54.8%, p = 0.030) were also observed. Among all clinical predictors, the prediction ability as measured by the AuROC curve was highest for symphysis-fundal height (Table 1).

The best multivariable clinical predictors for macrosomia were parity, gestational age at delivery, weight at delivery and symphysis-fundal height. These clinical predictors were each categorized into three levels; the optimal cut-off points for each characteristic was determined by the values at which the level yielded the smallest p values, and also the largest likelihood ratio obtained in logistic regression. An item score was assigned to each level of the four clinical characteristics by simple transformation of its logistic regression coefficient (Table 2). A summary risk score was obtained by adding up the item scores.

The discriminative ability of the derived risk score, which ranged from 0 to 15.5, could directly be observed by the different percentage distribution between cases and controls (Figure 1). The risk score predicted macrosomia with an AuROC curve of 94.1% (95% CI; 92.3, 95.6) (Figure 2) and with the p value for the Hosmer-Lemeshow goodness-of-fit test of 0.552. Internal validation by the bootstrapping method reduced the AuROC curve to 90.2%. When translating into absolute risks, the score predicted risk of macrosomia increased when the risk score moved upward, with close calibration to the actual or observed risks (Figure 3).

The risk scores were categorized into three risk groups, low (below 5) when the slope of the risk curve was lowest, moderate (5 to 10), and high (above 10) when the slope was highest, to facilitate clinical interpretation. The likelihood ratio of positive for macrosomia was 0 in the low risk category, 0.83 (95% CI; 0.58, 1.18) in the moderate and 10.68 (95% CI; 7.76, 14.68) in the high category (Table 3).

Discussion

Prediction of birth weight and macrosomia has been a challenge of practice in obstetrics. Undetected macrosomia results in perineal trauma, birth asphyxia and neonatal trauma related to surgical vaginal deliveries. On the other hand, false detection results in unnecessary cesarean delivery, followed by the risk of operative morbidity, mortality and an increase in costs of care [14]. Focus has been drawn mostly to high-risk pregnancy, especially among GDM. In day-to-day practice, a large proportion of macrosomic babies are born to non-gestational diabetic mothers and the majority of them were not detected before delivery [6, 7]. Focusing only on, and intervention given to, diabetic mothers are therefore not the global solution. We believe that prediction of macrosomia – not only in diabetic mothers – should be reconsidered.

Ultrasound and related techniques have been emphasized mainly when considering birth weight prediction [15, 16]. Their performance may be enhanced with more parameters [17], or in combination with clinical characteristics [10-13, 16, 18]. Although predictive accuracy varied from study to study, with some over or under estimation [6,19], prediction of birth weight and macrosomia is still universally accepted valuable, particularly in a preventive context. The earlier the prediction capacity, the more valuable it should be [11]. This may be true in areas where ultrasound is easily accessible, where adequate antenatal care services are also achieved. In remote areas of many developing countries, where ultrasound may not always be accessible, and/or in areas where antenatal care may be ignorant or inadequate, it is likely that macrosomia may not be recognized at all until the time of delivery. In such situation, ultrasound prediction may be inapplicable. Obstetricians may be faced with the risk of macrosomia at the time of labor. We believe that prediction of macrosomia at the time of labor using only clinical characteristics (without ultrasound facility) may still be valuable.

Clinical characteristics known to increase the risk of macrosomic or large-for-gestational-age babies were previous delivery of macrosomia [20], increasing maternal age [2, 4, 19-21], gravidity and/or parity [3, 4, 21], maternal height [2, 20], prepregnancy weight [2, 20-22], pregnancy weight gain [20, 23, 24], weight at delivery [3, 20], gestational age at delivery [2, 3, 20, 22] and symphysis-fundal height [15]. Many of these clinical characteristics are recorded and readily accessible in routine practice. On the other hand, a male infant, also reported as one of the risk factors [2, 4, 20] is not known to all pregnant women, and its value on prediction of macrosomia is therefore limited. Likewise, screening for GDM [1,20] is not universal in many parts of the world, and its prediction value is also limited, such as observed in our setting, where up to nearly 30% of cases and 90% of controls were not screened for GDM. Mode of delivery as has been used in some prediction models represented a consequence of macrosomia, not its predictor, and was therefore not considered applicable in our study.

In a univariable analysis, most of the above-mentioned clinical characteristics were significantly different between cases and controls. However, their prediction value varied. In multivariable analysis, when considering all clinical characteristics simultaneously, the best predictors were symphysis-fundal height, weight at delivery, parity and gestational age at delivery. This is not surprising, as many of the clinical characteristics are highly correlated, such as prepregnancy weight and weight at delivery, or pregnancy weight gain and symphysis-fundal height [20]. The predictive values of the four clinical characteristics chosen by the model have previously been reported [1, 10, 11, 13, 15, 16, 18, 19, 25]. Their practical values are also enhanced by their routine accessibility and simplicity in application.

In our setting, women who scored below 5 were free from macrosomia (none out of 422 women). In those who scored more than 10, the likelihood of macrosomia increased by approximately ten times. Forty-five out of 94 (47.9%) women in this category were correctly identified by the derived clinical risk score. In this category, it may be worth while to centralize pregnant women in better equipped maternity units, in case macrosomia may result in unexpected consequences. Although cesarean delivery is not routinely recommended to non-diabetic mothers with expected macrosomia, such risks and delivery options may be worth mentioning, to let pregnant women decide on their own risks.

Retrospective data collection obtained under routine clinical practice may be limited by its precision. The validity of the results should be evaluated with a planned prospective data collection with calibrated instruments.

Like any other risk score prediction approaches, our derived score is likely to be space and domain specific, due to a different patient mix across health care facilities. Clinical characteristics used as clinical predictors in our setting may not be directly applicable to other settings. Model adjustment, either selection of different clinical predictors, and/or different scoring weight, should always be considered for application to a new setting.

Conclusions

A simple clinical risk score may help obstetricians suspect macrosomia at the time of delivery in remote areas where antenatal care services are less than adequate. Women in a high-risk category may be informed about their risk or centralized to deliver in better equipped maternity units.

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References

[1] Henriksen T.: "The macrosomic fetus: a challenge in current obstetrics". *Acta Obstet Gynecol. Scand.*, 2008, *87,* 134.

[2] Bao C., Zhou Y., Jiang L., Sun C., Wang F., Xia W. *et al*.: "Reasons for the increasing incidence of macrosomia in Harbin, China". *BJOG*, 2011, *118*, 93.
[3] Adesina O.A., Olayemi O.: "Fetal macrosomia at the University College Hospital, Ibadan: a 3-year review". *J. Obstet. Gynaecol.,* 2003, *23,* 30.
[4] Akin Y., Cömert S., Turan C., Piçak A., Ağzikuru T., Telatar B.: "Macrosomic newborns: a 3-year review". *Turk. J. Pediatr.,* 2010, *52*, 378.
[5] Bjørstad A.R., Irgens-Hansen K., Daltveit A.K., Irgens L.M.: "Macrosomia: mode of delivery and pregnancy outcome". *Acta Obstet. Gynecol. Scand*., 2010, *89*, 664.
[6] Pundir J., Sinha P.: "Non-diabetic macrosomia: an obstetric dilemma". *J. Obstet. Gynaecol*., 2009, *29*, 200.
[7] Heywood R.E., Magann E.F., Rich D.L., Chauhan S.P.: "The detection of macrosomia at a teaching hospital". *Am. J. Perinatol.,* 2009, *26,* 165.
[8] Coomarasamy A., Connock M., Thornton J., Khan K.S.: "Accuracy of ultrasound biometry in the prediction of macrosomia: a systematic quantitative review". *BJOG*, 2005, *112,* 1461.
[9] Hackmon R., Bornstein E., Ferber A., Horani J., O'Reilly Green C.P., Divon M.Y.: "Combined analysis with amniotic fluid index and estimated fetal weight for prediction of severe macrosomia at birth". *Am. J. Obstet. Gynecol*., 2007, *196*, 333.e1.
[10] Mazouni C., Rouzier R., Ledu R., Heckenroth H., Guidicelli B., Gamerre M.: "Development and internal validation of a nomogram to predict macrosomia". *Ultrasound Obstet. Gynecol.,* 2007, *29,* 544.
[11] Nahum G.G., Stanislaw H.: "A computerized method for accurately predicting fetal macrosomia up to 11 weeks before delivery". *Eur. J. Obstet. Gynecol. Reprod. Biol*., 2007, *133,* 148.
[12] Pates J.A., McIntire D.D., Casey B.M., Leveno K.J.: "Predicting macrosomia". *J. Ultrasound Med*., 2008, *27*, 39.
[13] Siggelkow W., Schmidt M., Skala C., Boehm D., von Forstner S., Koelbl H. *et al*.: "A new algorithm for improving fetal weight estimation from ultrasound data at term". *Arch. Gynecol. Obstet.,* 2011, *283,* 469.
[14] Melamed N., Yogev Y., Meizner I., Mashiach R., Ben-Haroush A.: "Sonographic prediction of fetal macrosomia: the consequences of false diagnosis". *J. Ultrasound Med*., 2010, *29,* 225.
[15] Kraiem J., Chiha N., Bouden S., Ounaissa F., Falfoul A.: "Sonographic estimation of fetal weight at term: a proposal of a predictive score of a weight more than 4500 g". *Tunis. Med.,* 2004, *82*, 526.
[16] Liang J.Z., Xiao B., Li H., Zhuang L.: "Developing parameters for predicting macrosomia". *Sichuan Da Xue Xue Bao Yi Xue Ban.,* 2008, *39,* 635.
[17] Melamed N., Yogev Y., Meizner I., Mashiach R., Pardo J., Ben-Haroush A.: "Sonographic prediction of fetal macrosomia: the effect of sonographic fetal weight estimation model and threshold used". *Ultrasound Obstet. Gynecol*., 2011, *38*, 74.
[18] Lalys L., Pineau J.C., Guihard-Costa A.M.: "Small and large foetuses: Identification and estimation of foetal weight at delivery from third-trimester ultrasound data". *Early Hum. Dev.,* 2010, *86,* 753.
[19] Mongelli M., Benzie R.: "Ultrasound diagnosis of fetal macrosomia: a comparison of weight prediction models using computer simulation". *Ultrasound Obstet Gynecol*., 2005, *26,* 500.
[20] Tamarova S., Popov I., Khristova I.: "Risk factors for fetal macrosomia". *Akush. Ginekol. (Sofiia)*, 2005, *44,* 3.
[21] Wojcicki J.M., Hessol N.A., Heyman M.B., Fuentes-Afflick E.: "Risk factors for macrosomia in infants born to Latina women". *J. Perinatol*., 2008, *28,* 743.
[22] Denguezli W., Faleh R., Fessi A., Yassine A., Hajjaji A., Laajili H. *et al*.: "Risk factors of fetal macrosomia: role of maternal nutrition". *Tunis. Med*., 2009, *87*, 564.
[23] Ludwig D.S., Currie J.: "The association between pregnancy weight gain and birthweight: a within-family comparison". *Lancet,* 2010, *376,* 984.
[24] Walker L.O., Hoke M.M., Brown A.: "Risk factors for excessive or inadequate gestational weight gain among Hispanic women in a U.S.-Mexico border state". *J. Obstet. Gynecol. Neonatal. Nurs.,* 2009, *38,* 418.
[25] Hart N.C., Hilbert A., Meurer B., Schrauder M., Schmid M., Siemer J. *et al*.: "Macrosomia: a new formula for optimized fetal weight estimation". *Ultrasound Obstet. Gynecol*., 2010, *35,* 42.

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