Fetal abdominal subcutaneous tissue thickness measured by ultrasound at term is associated with birth weight and mode of delivery

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Summary

Purpose: To determine if measurement of fetal abdominal subcutaneous tissue thickness (FASTT) at term can predict birth weight, mode of delivery and perinatal outcome. *Methods*: A prospective study with 352 normal, singleton pregnancies in the vertex presentation examined with real-time ultrasound at 37-39 weeks' gestation. *Results*: FASTT was positively correlated with birth weight (Pearson's, $r = 0.784$, $p < 0.001$). Fetuses with low FASTT were more likely to be delivered through normal vaginal delivery (7.8 ± 0.1 mm), while higher FASTT was correlated with operative vaginal delivery (7.9 ± 0.2 mm) and cesarean section (8.6 ± 0.3 mm) (ANOVA, $p = 0.034$). In contrast, FASTT was not correlated with intrapartum CTG, labor duration and Apgar scores. *Conclusions*: In normal pregnancies, FASTT at term is positively associated with birth weight. With increasing FASTT the likelihood of operative vaginal and cesarean delivery increases. FASTT is not associated with perinatal outcome.

Key words: Fetal abdominal subcutaneous tissue thickness; Birth weight; Mode of delivery.

Introduction

Prenatal estimation of fetal weight is very important in clinical decision making. Prenatal diagnosis or exclusion of fetal growth disorders can be vital in deciding the timing and route of delivery. To date, the most accurate method for prediction of fetal weight has not been established [1]. The two most common prenatal methods of predicting birth weight are clinical estimation and ultrasonographic measurements [2, 3]. Clinicians can estimate birth weight by palpating the abdomen, measuring the fundal height and integrating their personal experience with the woman's obstetrical history. Fetal weight can be estimated sonographically from one of the many published formulas, which use measurements of a variety of fetal body parts [1]. Optimal weight prediction formulas use sonographic measurements of the fetal head, abdomen and femur [4, 5]. However, both methods have limitations if weight estimation is done at term, especially for macrosomic fetuses [1-3].

Sonographic measurements of fetal soft tissues, including measurement of the fetal abdominal subcutaneous tissue thickness (FASTT), have been studied previously as predictive factors of fetal weight [6-14]. On a transverse section of the fetal abdomen, the fetal abdominal subcutaneous tissue appears as a well-delineated echogenic line and its thickness can be readily measured. It has been shown that FASTT measurement at term is useful for ruling out macrosomia, can predict low birth weight and might potentially predict intrauterine growth restriction (IUGR) irrespective of fetal weight [7]. Furthermore, it correlates with established factors of fetal nutrition [8]. We conducted a prospective study in order to determine if FASTT measurement in normal pregnancies at 37-39 weeks can predict birth weight, mode of delivery and perinatal outcome.

Materials and Methods

FASST was measured in 352 normal singleton pregnancies; all data were collected prospectively. Women participating in this study have been in parallel evaluated for other prenatal variables with corresponding results already published elsewhere [9]. An independent academic board had previously approved the study protocol, and the study was conducted in accordance with the Declaration of Helsinki of 1975 on human experimentation. Women with a history of previous cesarean section or uterine surgery were excluded, as well as women with medical problems in the current pregnancy, in particular diabetes mellitus, hypertension, cardiac disease, renal disease, and women under any sort of medication. Gestational age was estimated from the first day of the last menstrual period. There were 153 nulliparous (43.5%), 127 primiparous (36.1%), 54 with two births (15.3 %) and 18 women of higher parity (5.1%). Fetal presentation was vertex in all cases.

All women were examined ultrasonographically by the same operator at 38 ± 1 weeks gestation. A real-time ultrasonographic device (SCANNER 900, Pie Data Medical, Holland) was used. Longitudinal fetal lie and vertex presentation were documented

Revised manuscript accepted for publication April 10, 2007

Figure 1. — A representative scan showing measurement of the fetal abdominal subcutaneous tissue thickness with a real-time ultrasound device.

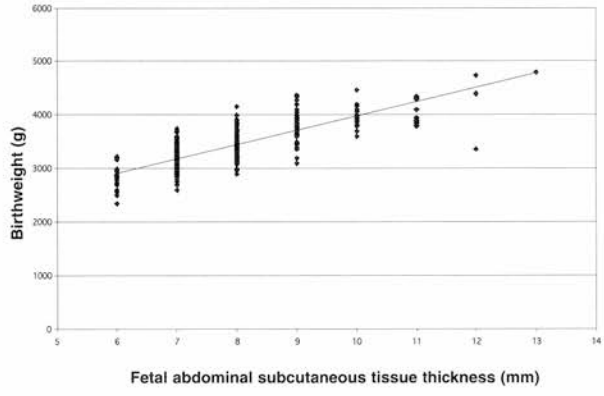

Figure 2. — Correlation of fetal abdominal subcutaneous tissue thickness to birth weight (n = 352).

on ultrasound. The FASTT was measured as previously described [6] in the anterior third of the abdomen, at the same transverse plane where the abdominal circumference (AC) is routinely measured. The calipers were placed at the outer and inner edge of the echogenic subcutaneous tissue line. In Figure 1 a representative picture of FASTT measurement is presented. Ultrasound examination was preceded by typical history and clinical evaluation, including assessment of Bishop Score and intrapartum CTG. All women were delivered by healthcare providers blinded to the findings of the ultrasound examination at 38 ± 1 weeks. Women were followed-up in respect to the following parameters: mode of delivery (normal, operative vaginal or cesarean delivery), confirmation of fetal presentation and birth weight (BW). There were no neonates with congenital malformations or genetic disorders.

Antenatal and postnatal data were entered into an electronic database (Microsoft Access® 1997). Data were described as mean and standard error of the mean (SEM). The *t*-test and ANOVA were used to detect differences between groups for numerical parameters, while chi-square was used for categorical parameters. The LSD test was used for post-hoc comparisons. Pearson's test was used for correlation of FASTT with other variables. A receiver operating characteristic (ROC) curve was constructed in order to determine a FASST cut-off value with the highest sensitivity and specificity for predicting the mode of delivery. A multiple stepwise linear regression model was used to evaluate independent variables as predictors of BW; $p < 0.05$ was considered statistically significant in all tests. SPSS for Windows version 11 (SPSS Inc., IL, USA) was used for the statistical analysis.

Results

FASTT measured at 38 ± 1 weeks' gestation in normal singleton pregnancies was found to be 7.8 ± 0.1 mm (mean ± SEM) with a range of 6-13 mm. Table 1 illustrates the BW according to FASTT measurements. FASTT was positively correlated with BW (Pearson's, r = 0.784, $p < 0.001$, line equation: BW = 264.94 · FASTT + 1323.2, Figure 2). In a multiple stepwise linear regression analysis FASTT was the only predictor of BW (R^2 = 0.615, $p < 0.001$), whereas all other variables, namely parity, amniotic fluid volume, placental grade and gestational week at delivery were excluded from the model.

Table 1. — *Birth weight according to FASTT measurements.*

FASTT	n	%	Mean BW (g)	SEM (g)	Minimum BW (g)	Maximum BW (g)
6 mm	38	10.8	2833	34	2350	3230
7 mm	114	32.4	3178	23	2600	3750
8 mm	117	33.2	3464	24	2900	4160
9 mm	50	14.2	3786	39	3100	4370
10 mm	21	6.0	3924	45	3600	4470
11 mm	8	2.3	4068	78	3800	4340
12 mm	3	0.8	4167	415	3360	4740
13 mm	1	0.3	4800	–	–	–
Totale	**352**	**100.0**				

FASTT: Fetal abdominal subcutaneous tissue thickness, BW: birthweight, SEM: standard error of the mean.

Table 2 illustrates mode of delivery according to FASTT. Women who had normal vaginal delivery had fetuses with the lowest FASTT (7.8 ± 0.1 mm), followed by those with operative vaginal delivery (7.9 ± 0.2 mm) and cesarean section (8.6 ± 0.3 mm) (ANOVA, p = 0.034). Statistical significance was reached for the difference between normal vaginal delivery and cesarean section groups (post-hoc LSD, p = 0.010) as well as the difference between operative vaginal delivery and cesarean section groups (post-hoc LSD, p = 0.042). In a further sub-analysis, these differences were even bigger for the nulliparous women (n = 153, ANOVA, p = 0.009, normal vaginal delivery vs cesarean section: post-hoc

Table 2. — *Mode of delivery according to FASTT measurements.*

FASTT	Normal vaginal delivery		Operative vaginal delivery		Cesarean section	
	n	%	n	%	N	%
6 mm	34	9.7	4	1.1	0	0.0
7 mm	89	25.3	21	6.0	4	1.1
8 mm	91	25.9	20	5.7	6	1.7
9 mm	38	10.8	8	2.3	4	1.1
10 mm	14	4.0	5	1.4	2	0.6
11 mm	6	1.7	0	0.0	2	0.6
12 mm	2	0.6	1	0.3	0	0.0
13 mm	1	0.3	0	0.0	0	0.0
Total	**275**	**78.1**	**59**	**16.8**	**18**	**5.1**

LSD, $p = 0.002$; operative vaginal delivery versus cesarean section: post-hoc LSD, $p = 0.007$) but disappeared for parous women (n = 199, ANOVA, $p = 0.160$). A ROC curve was constructed to determine a cut-off point for FASTT as a predictor of normal vaginal delivery: FASTT values of less than 7.5 mm had a sensitivity of 55% and a specificity of 38% whereas FASTT values of less than 8.5 mm had 22% and 71%, respectively. Overall, FASTT at 38 ± 1 weeks was positively correlated with the mode of delivery (Pearson's, r = 0.119, $p = 0.025$).

FASTT was not correlated with the intrapartum CTG (Pearson's, r = - 0.119, $p = 0.720$), duration of labor (r = 0.039, $p = 0.467$) and Apgar scores at 1 (r = 0.016, $p = 0.769$) and 5 min (r = 0.004, $p = 0.936$).

Discussion

The fetus accumulates most of its body fat during the third trimester. Total fetal fat increases from 4% of body weight at 28 weeks' gestation to 14% at 40 weeks. Near term, approximately 75% of body fat is found in the subcutaneous adipose tissue. Animal data have indicated that fetal fat stores are second only to liver weight in reflecting impaired growth, while large-for-gestational-age fetuses show an increase in subcutaneous tissue. Neonatal studies have also found a good correlation between skinfold thickness and birth weight [10].

In the present study 352 normal singleton pregnancies were studied prospectively. FASTT was measured at the same section as the AC at 37-39 weeks and a correlation with the mode of delivery was found. Fetuses with low FASTT were more likely to be delivered through normal vaginal delivery. With increasing FASTT the probability of operative vaginal delivery and cesarean section was higher. This was especially true for nulliparae but not for parous women. Only standard indications for operative delivery were used; detection of increased FASTT did not affect decision for operative delivery since health care providers at labor were blinded to the ultrasonographic findings documented at 38 ± 1 weeks. To the best of our knowledge, there are no other studies evaluating the possibility that FASTT could predict the mode of delivery. The difference between nulliparae and parous women could be due to dissimilarities in the physiology of labor and delivery.

FASTT was also well correlated with birth weight. Moreover, using multiple stepwise linear regression analysis, FASTT was found to be the only predictor of birth weight among other variables. These results are in agreement with those of three previously published studies [6-8]. Petrikovski *et al.* [6] evaluated the role of FASTT in predicting fetal macrosomia in 133 term fetuses. Mean tissue thickness differed significantly between normal and macrosomic fetuses and there was a significant positive correlation with birth weight. The authors concluded that measurement of FASTT is useful for ruling out macrosomia. Gardeil *et al.* [7] evaluated the role of FASTT in predicting growth restriction in 137 unselected women with singleton pregnancies. Infants with subcutaneous fat less than 5 mm at 38 weeks (n = 51) were almost five times more likely to have a birth weight below the 10th percentile than those with subcutaneous fat of 5 mm or more (n = 75). The authors stressed that although measurement of FASTT cannot replace the ultrasonographic estimation of fetal weight, it is a simple and fast technique that could be used as a screening test and complement existing sonographic parameters. Furthermore, Skinner *et al.* [8] measured FASTT in 100 singleton pregnancies at 40-42 weeks and evaluated if it correlates with established indices of fetal growth restriction. Correlations with liquor volume, abdominal circumference, ponderal index, and triceps and subscapular skinfold thickness were found.

Hill *et al.* [10] studied the fetal subcutaneous tissue thickness at the levels of the AC, the mid-calf, and the mid-thigh in normal-sized (n = 244), macrosomic (n = 38), and growth-retarded fetuses (n = 13) between 15-42 weeks' gestation. They concluded that neither growth restriction nor macrosomia could be reliably predicted with these sonographic measurements. However, the question of whether FASTT is correlated with birth weight was not directly addressed and there were only a small number of women examined at term or post-term (23 between 37-39 weeks, as in our study and 17 women between 40-42 weeks).

Controversy exists concerning the role of other sonographic measurements of soft tissues in other parts of the fetal body in predicting fetal weight and distinguishing abnormalities of fetal growth [11-15]. Abramowicz *et al.* [11] reported that the mean cheek-to-cheek diameter was significantly different between normal and macrosomic fetuses. Sood *et al.* [12] measured humeral soft tissue thickness in 95 fetuses at risk for macrosomia and found that it had a significant correlation with birth weight and was more sensitive, but less specific, than the estimated fetal weight (EFW) in predicting macrosomia. It should be noted, however, that in these studies not only subcutaneous tissue but also the muscle layer was included in the measurement. Santolaya-Forgas *et al.* [13] noted that fetal thigh subcutaneous tissue-to-FL ratio has a greater sensitivity than the AC and EFW formula for the intrapartum identification of large-for-gestational-age fetuses. Chauhan *et al.* [14] challenged the results of these three studies. After evaluation of cheek-to-cheek diameter, thigh soft tissue thickness, ratio of thigh soft tissue-to-FL, upper arm subcutaneous tissue and EFW derived from a formula incorporating AC, FL and upper arm subcutaneous tissue in 100 pregnancies at or after 36 weeks, they concluded, that measurements of soft tissue are not superior to clinical or classical sonographical predictions in identifying macrosomic fetuses. Likewise, Rothmensch *et al.* [15] concluded after examination of 178 nondiabetic women at 37-41 weeks, that the thigh subcutaneous thickness-to-FL ratio is a poor sonographic predictor of fetal macrosomia, and that it does not improve EFW by conventional sonographic parameters. It should be noted, that none of these five studies included measurement of the FASTT.

Conclusion

Our study showed that FASTT measurement at the level of the AC at term, normal pregnancies is associated with the rate of operative vaginal and cesarean delivery in nulliparous, but not in parous women. In agreement with the findings of other authors, FASTT is associated with birth weight, while there was no correlation with perinatal outcome. Future studies should further delineate the usefulness of measuring FASTT at term in clinical decision-making

References

[1] Nahum G.G., Stanislaw H.: "Ultrasonographic prediction of term birth weight: how accurate is it?". *Am. J. Obstet. Gynecol.*, 2003, *188*, 566.

[2] Chauhan S.P., Hendrix N.W., Magann E.F., Morrison J.C., Kenney S.P., Devoe L.D.: "Limitations of clinical and sonographic estimates of birth weight: Experience in 1034 parturients". *Obstet. Gynecol.*, 1998, *91*, 72.

[3] Sherman D.J., Arieli S., Tovbin J., Siegel G., Caspi E., Bukovsky I.: "A comparison of clinical and ultrasonic estimation of fetal weight". *Obstet. Gynecol.*, 1998, *91*, 212.

[4] Hadlock F.P., Harrist R.B., Sharman R.S., Deter R.L., Park S.K.: "Estimation of fetal weight with the use of head, body and femur measurements – A prospective study". *Am. J. Gynecol. Obstet.*, 1985, *151*, 333.

[5] Vintzileos A.M., Campbell W.A., Rodis J.F., Bors-Koefoed R., Nochimson D.J.: "Fetal weight estimation formulas with head, abdominal, femur and thigh circumference measurements". *Am. J. Obstet. Gynecol.*, 1987, *157*, 410.

[6] Petrikovsky B.M., Oleschuk C., Lesser M., Gelertner N., Gross B.: "Prediction of fetal macrosomia using sonographicaly measured abdominal subcutaneous tissue thickness". *J. Clin. Ultrasound.*, 1997, *25*, 378.

[7] Gardeil F., Greene R., Stuart B., Turner M.J.: "Subcutaneous fat in the fetal abdomen as a predictor of growth restriction". *Obstet. Gynecol.*, 1999, *94*, 209.

[8] Skinner J., O'Donoghue K., Gardeil F., Greene R., Turner M.J.: "Is fetal abdominal subcutaneous fat comparable with established indices of growth restriction?". *J. Obstet. Gynaecol.*, 2001, *21*, 439.

[9] Assimakopoulos E., Zafrakas M., Garmiris P., Goulis D.G., Athanasiadis A.P., Dragoumis K., Bontis J.: "Nuchal cord detected by ultrasound at term is associated with mode of delivery and perinatal outcome". *Eur. J. Obstet. Gynecol. Reprod. Biol.*, 2005, *123*, 188.

[10] Hill L.M., Guzick D., Boyles D., Merolillo C., Ballone A., Gmiter P.: "Subcutaneous tissue thickness cannot be used to distinguish abnormalities of fetal growth". *Obstet. Gynecol.*, 1992, *80*, 268.

[11] Abramowicz J.S., Sherer D.M., Bar-Tov E., Woods J.R. Jr.: "The cheek-to-cheek diameter in the ultrasonographic assessment of fetal growth". *Am. J. Obstet. Gynecol.*, 1991, *165*, 846.

[12] Sood A.K., Yancey M., Richards D.: "Prediction of fetal macrosomia using humeral soft tissue thickness". *Obstet. Gynecol.*, 1995, *85*, 937.

[13] Santolaya-Forgas J., Meyer W.J., Gauthier D.W., Kahn D.: "Intrapartum fetal subcutaneous tissue / femur length ratio: an ultrasonographic clue to fetal macrosomia". *Am. J. Obstet. Gynecol.*, 1994, *171*, 1072.

[14] Chauhan S.P., West D.J., Scardo J.A., Boyd J.M., Joiner J., Hendrix N.W.: "Antepartum detection of macrosomic fetus: clinical versus sonographic, including soft-tissue measurements". *Obstet. Gynecol.*, 2000, *95*, 639.

[15] Rotmensch S., Celentano C., Liberati M., Malinger G., Sadan O., Bellati U., Glezerman M.: "Screening efficacy of the subcutaneous tissue width/femur length ratio for fetal macrosomia in the non-diabetic pregnancy". *Ultrasound Obstet. Gynecol.*, 1999, *13*, 340.

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