Prediction of macrosomia by serial sonographic measurements of fetal soft-tissues and the liver in women with pregestational diabetes

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Received 22 October 2012; received in revised form 3 March 2013; accepted 12 March 2013

Abstract

Objectives. – This study aimed to determine whether antenatal ultrasound measurements of fetal soft-tissues and liver can predict macrosomia in women with pregestational diabetes.

Methods. – Fetal biometry, soft-tissue thickness (anterior abdominal wall [STAW], thigh [STT], upper arm [STA], scapular [STS]) and liver size were measured sonographically at 23, 28, 31 and 34 weeks of gestation. Large for gestational age (LGA) was defined as a birth weight greater than 90th percentile for gestational age on standard curves adjusted for maternal height and weight, parity and fetal gender. The area (± standard error) under receiver operating characteristic (AUROC) curves were also calculated.

Results. – A total of 29 pregnant women with pregestational diabetes were included, and a total of 663 measurements taken. Fifteen neonates were LGA. There was no significant difference in fetal soft-tissue thickness at 23, 28 and 31 weeks between the LGA and non-LGA neonates. In contrast, at 34 weeks, fetal soft-tissues were significantly thicker in LGA neonates (P < 0.05), but with no difference in liver surface area between the two groups. The specificity and sensitivity of 34-week ultrasonography to detect macrosomia was 78.6% and 66.7%, respectively, for abdominal circumference (AC), 71.4% and 93.3% for STT, 85.7% and 80.0% for STA, and 71.4% and 86.7% for STAW. No parameter was more powerful than the others. The best AUROC curves were found for AC (0.807), STT (0.821), STA (0.855) and STAW (0.821).

Conclusion. – Third-trimester sonographic measurements of fetal soft-tissue may help to detect macrosomia in pregnancies complicated by pregestational diabetes.

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Keywords: Diabetes mellitus; Pregnancy; Ultrasoundography; Macrosomia; Soft-tissues; Liver

Résumé

Détection de la macrosomie.

Objectif. – Évaluer, par un suivi longitudinal aux deuxième et troisième trimestres, la mesure des tissus mous et du foie comme marqueurs prédicifs de la macrosomie dans les grossesses de mères diabétiques.

Méthodes. – La biométrie fœtale, l’épaisseur des tissus mous (mur antérieur abdominal [STAW], cuisse [STT], bras [STA] et sous-scapulaire [STS]) ainsi que la surface du foie ont été mesurés par échographie à 23, 28, 31 et 34 SA. La macrosomie était définie comme un poids de naissance supérieur au 90e percentile des courbes personnalisées selon la taille et le poids de la mère, la parité, le sexe et l’âge gestationnel du fœtus. Les aires sous la courbe (ROC) ont été calculées pour chaque paramètre.

Résultats. – Vingt-neuf patientes suivies pour diabète prégestationnel ont été incluses. Six cent soixante-trois mesures ont été effectuées. Quinze nouveau-nés étaient macromes. Il n’y avait pas de différence significative entre les deux groupes pour l’épaisseur des tissus mous fœtaux à 23, 28 et 31 SA. En revanche, à 34 SA, la mesure des tissus mous fœtaux était significativement plus élevée chez les nouveau-nés macrosomes (P < 0.05). La surface du foie n’était pas significativement différente entre les deux groupes. La spécificité et la sensibilité de l’échographie de 34 SA étaient de 78.6 et 66.7 %, respectivement, pour la circonférence abdominale (AC), 71.4 et 93.3 % pour le STT, 85.7 et 80.0 % pour le STA, et 71.4 et 86.7 % pour le STAW. Les aires sous la courbe (AUC) étaient significatives pour l’AC (AUC = 0.807), le STT (AUC = 0.821), le STA (AUC = 0.855) et le STAW (AUC = 0.821).

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1262-3636/S – see front matter © 2013 Elsevier Masson SAS. All rights reserved.
http://dx.doi.org/10.1016/j.diabet.2013.03.004
Conclusion. — Les mesures échographiques de tissus mous fetaux au troisième trimestre apparaissent comme un outil supplémentaire pour la détection de la macrosomie chez les fetsus de mères suivies pour diabète prégestationnel.
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Mots clés : Diabetes mellitus ; Grossesse ; Échographie ; Macrosomie ; Tissus mous ; Foie

1. Introduction

Macrosomia (defined as a birth weight greater than 4–4.5 kg) is three times more frequent in diabetic than in non-diabetic pregnancies [1,2]. Fetal complications of a diabetic pregnancy are the result of maternal hyperglycaemia rather than type of diabetes [3]. The increase in fetal weight is linked to organomegaly (especially of the liver) and fat deposition [4,5]. Macrosomia is associated with severe perinatal complications [6]. Shoulder dystocia is ten times more frequent in neonates weighing more than 4500 g with diabetic mothers and can lead to brachial plexus palsy [7]. It is therefore reasonable to attempt to detect macrosomia antenatally to reduce these risks.

The accuracy of detecting macrosomia antenatally by estimating fetal weight (EFW) ranges from 15–79% compared with 40–52% for clinical estimations [8]. However, comparisons of 31 formulae for EFW showed that all were poor for the detection of macrosomia [9]. Hadlock et al. [10] found that head size, abdominal circumference (AC) and femur length were slightly superior to other measures for the detection of macrosomia. The mean absolute error in measurement was approximately 10%, or a 250–500 g difference compared with the expected value [11]. Jazayeri et al. [12] showed that an AC greater than 35 cm in the two weeks prior to delivery had a positive predictive value (PPV) of 93% for the detection of macrosomia. However, AC measurement was not superior to EFW and not sufficient on its own to predict macrosomia without taking other factors into account [13].

It is possible that macrosomia can be predicted by soft-tissue measurements. Deposition of fetal fat tissue takes place predominantly during the third trimester [14]. Close to term, 75% of body fat is found in subcutaneous tissue [15]. The macrosomic fetus has more marked development of this subcutaneous fat, particularly in cases with maternal diabetes [16]. Different sonographic parameters have been investigated as markers of fetal macrosomia, including measurements of fetal liver and soft-tissues, ratio of thigh subcutaneous tissue to femur length, and abdominal wall thickness, all of which are increased in diabetic pregnancies [17–24]. Buhling et al. [25] recently demonstrated a good correlation between these prenatal sonographic assessments and postnatal measurements. However, no study has evaluated the relevance of these markers longitudinally or established a standardized threshold value for each marker.

For this reason, the present study aimed to evaluate soft-tissue and liver measurements longitudinally through the second and third trimesters as predictive markers of macrosomia in women with pregestational diabetes.

2. Methods

This prospective study was approved by the ethics committee for research in gynaecology-obstetrics (CEROG) of the French College of Gynaecologists and Obstetricians, and was carried out in a level-III university maternity hospital between November 2010 and June 2011. Women with pregestational diabetes were followed through a multidisciplinary programme, and received their first and second trimester ultrasound evaluations via a referring physician who proposed their inclusion in the study. An informative letter was given to the selected patients to obtain their oral consent to participate. Ultrasoundography was then performed during the fifth (US 1, 23 weeks), sixth (US 2, 28 weeks), seventh (US 3, 31 weeks) and eighth month (US 4, 34 weeks) of pregnancy. These times corresponded to the diabetic and obstetric follow-ups generally carried out in our department. All examinations were performed via the transabdominal route using a Voluson E8 Expert ultrasound system (GE Healthcare, Waukesha, WI, USA). Seven ultrasonographers were used for the study: one was the referring physician (P.D.) at our institution for diabetes patient management; while the other six were trained by him for best practices in taking the measurements. The first ten measurements were performed in the presence of the referring physician. An illustrated document in the ultrasound room could also be used to control the quality of their measurements. Twin pregnancies and patients who had undergone fewer than three of the four planned ultrasounds were excluded from the study.

At each ultrasound examination, fetal biometrics (biparietal diameter, head circumference, AC and femur length) and measurements of soft-tissue thickness and liver size were recorded. AC measurement was taken from a transverse section of the abdomen at the level of the umbilical vein complex. The percentiles used for EFW were derived from those described by Hadlock et al. [10], using the formula based on measurements of head circumference, biparietal diameter, femur length and AC. Anterior abdominal wall soft-tissue thickness (STAW) was measured on the usual AC section 2 cm laterally from the insertion of the umbilical cord. Calipers were carefully placed to measure the distance from the outermost skin edge to the innermost margin of the anterior abdominal wall. Soft-tissue measurements were also taken of the arm (STA), thigh (STT) and scapular area (STS). At these three sites, measurements of subcutaneous tissue thickness were obtained in duplicate at the midlevel of the femoral diaphysis as described elsewhere (Fig. 1) [22]. Measurement of liver surface area (LSA) was done on a transverse abdominal section. Reference points used for estimation of liver width were the external capsule of the liver and junction of the umbilical vein and, for liver length, a perpendicular axis between the outermost edges of the liver (Fig. 2). Quality of the
measurements was verified by a review of the printed images by the referring clinician (P.D.) and the study investigator (C.G.). Various aspects of the image measurements, such as appropriate section, correct caliper placement and adequate magnification were classified as either acceptable or unacceptable.

Measurements of soft-tissues and liver size did not influence medical care. If macrosomia was discovered on classical measurements (AC, EPW), the patient’s management was performed according to French guidelines [26].

The following demographic data were collected: maternal age; body mass index (BMI); type of diabetes according to the White classification; and parity. Labour was induced at gestational weeks 38–39. Obstetric evaluation included term and method of delivery, and birth weight and percentile. Large for gestational age (LGA) was defined by a birth weight greater than 90th percentile for gestational age, and adjusted for maternal height and weight, parity and fetal gender [27].

Qualitative variables were frequency and percentage, and quantitative variables were median and interquartile range. To compare the demographic data in the two groups, the Chi² or Fisher’s exact test was used for qualitative variables, and the Mann-Whitney U test for quantitative variables. Soft-tissue and liver measurements were compared between the two groups using a linear mixed model. Variables were transformed into ranks according to the Conover method [28]. This model is an extension of analysis of variance, taking into account the repeated measures for each subject. The fixed effects were group and time, and the random effect was the subject. Parameters that were significantly different between the two groups were dichotomized using a receiving operating characteristics (ROC) curve. Discriminatory power was considered good if the area under the ROC curve (AUROC) was greater than 0.8. The threshold value that best discriminated between the two groups was selected using the Youden index to maximize sensitivity and specificity. $P < 0.05$ was considered statistically significant. Statistical analyses were performed using SAS software (SAS Institute Inc., Cary, NC, USA).

3. Results

A total of 29 women were consecutively included in our study between November 2010 and June 2011; no one was excluded. Characteristics of the LGA and appropriate for gestational age (AGA) groups are presented in Table 1. The mean times of the first, second, third and fourth ultrasounds were 23.1 [22–24] weeks, 28 [26.5–29] weeks, 31 [30–32] weeks and 34 [33–35] weeks, respectively. Of our 29 women, 69% had induced labour at a median time of 38.5 [37.5–39] weeks. Birth weight was significantly higher in the LGA group (3940 g versus 3020 g in the AGA group; $P < 0.001$), as was height (50 cm versus 48 cm, respectively; $P < 0.001$). There was no significant difference in any other characteristic between the two groups.

Overall, 663 fetal measurements were taken and all were classified as acceptable after rereading. However, the number of measurements should have been 696, but some measurements were not done usually due to an oversight of the sonographers. The details for each criterion are shown in Table 2. Comparison of AC between the two groups showed no significant differences on the first three ultrasound examinations, whereas the ultrasound at 34 weeks (US 4) showed a significantly higher AC value in the macrosomia (LGA) versus AGA group (329 mm versus 302 mm, respectively; $P = 0.01$). In fact, comparison of anthropometric measurements between the LGA versus AGA group at 34 weeks showed significant differences for all measures: STA was 6.1 mm versus 4.5 mm ($P = 0.001$); STAW was 7.1 mm versus 5.55 mm ($P = 0.006$); STS was 5.6 mm versus 4.6 mm ($P = 0.04$); and STT was 6.2 versus 4.75 ($P = 0.006$) in thickness, respectively. In addition, the thigh thickness to femur length ratio was greater at 34 weeks in the LGA than AGA group (0.8 versus 0.1, respectively; $P = 0.008$).

Also, liver length measurements were significantly different between the two groups at US 3 (71.3 mm versus 58.5 mm;
Table 1
Clinical characteristics of the study population, and their obstetric and neonatal outcomes.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>All  (^{(n = 29)})</th>
<th>LGA  (^{(n = 15)})</th>
<th>AGA  (^{(n = 14)})</th>
<th>(P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nulliparous</td>
<td>8 (27.6%)</td>
<td>4 (26.7%)</td>
<td>4 (29.8%)</td>
<td>1</td>
</tr>
<tr>
<td>Body mass index (kg/m(^2))</td>
<td>27.5 [21.7–31]</td>
<td>28.5 [21.7–35]</td>
<td>25.5 [21–31]</td>
<td>0.48</td>
</tr>
<tr>
<td>Type of diabetes</td>
<td></td>
<td></td>
<td></td>
<td>0.59</td>
</tr>
<tr>
<td>Type 1</td>
<td>18 (62.0%)</td>
<td>10 (66.7%)</td>
<td>8 (57%)</td>
<td></td>
</tr>
<tr>
<td>Type 2</td>
<td>11 (38.0%)</td>
<td>5 (33.3%)</td>
<td>6 (43%)</td>
<td></td>
</tr>
<tr>
<td>Gestational age (weeks)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gestational age at delivery (weeks)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Induction of labour</td>
<td>20 (69.0%)</td>
<td>9 (60%)</td>
<td>11 (79%)</td>
<td>0.43</td>
</tr>
<tr>
<td>Caesarean section</td>
<td>12 (41.4%)</td>
<td>8 (53.3%)</td>
<td>4 (28.6%)</td>
<td>0.18</td>
</tr>
<tr>
<td>Vaginal delivery</td>
<td>17 (58.6%)</td>
<td>7 (46.7%)</td>
<td>10 (71.4%)</td>
<td>0.181</td>
</tr>
<tr>
<td>Instrumental delivery</td>
<td>8/17</td>
<td>3/7</td>
<td>5/10</td>
<td></td>
</tr>
<tr>
<td>Shoulder dystocia</td>
<td>3 (10.3%)</td>
<td>3 (20%)</td>
<td>0 (0%)</td>
<td>0.22</td>
</tr>
<tr>
<td>Postpartum haemorrhage</td>
<td>3 (10.3%)</td>
<td>2 (13.3%)</td>
<td>1 (7.1%)</td>
<td>1</td>
</tr>
<tr>
<td>Birth weight (g)</td>
<td>3430 [3050–3940]</td>
<td>3940 [3680–4190]</td>
<td>3020 [2750–3190]</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>50 [48–50]</td>
<td>50 [50–51]</td>
<td>48 [47–49]</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

LGA: large for gestational age; AGA: appropriate for gestational age; US: ultrasound.
Results are presented as medians [1st–3rd quartiles] or as \(n\) (%).

\(P = 0.005\), but were no longer different at US 4. In addition, LSA was the only measurement that was significantly different between the two groups at US 2 (1890 mm\(^2\) versus 1250 mm\(^2\); \(P = 0.005\)) and remained different at US 3, but not at US 4.

Evaluation of the curves (Table 3) showed an AUROC greater than 0.8 for AC (0.807), STT (0.821), STA (0.855) and STAW (0.821; Fig. 3). On the other hand, the AUROC was less than 0.8 for the other parameters: 0.786 for thigh-to-femur ratio; 0.736 for STS; and 0.629 for LSA. Specificity and sensitivity in the detection of macrosomia were 78.6% and 66.7% for AC, 71.4% and 93.3% for STT, 85.7% and 80% for STA, and 71.4% and 86.7% for STAW, respectively.

Thus, our present study was able to define a threshold value for the detection of macrosomia at US 4 (34 weeks) for each parameter: 312.5 mm for AC; 5.25 mm for STT; 5.5 mm for STA; and 6.35 mm for STAW.

4. Discussion

The aim of our study was to determine the value of soft-tissue and liver measurements as predictive markers of macrosomia in women with pregestational diabetes, and our study has confirmed that these values may be useful for the sonographic detection of fetal macrosomia in diabetic women. Measurements were significantly larger in macrosomic fetuses at US 4 (week 34). However, LSA did not appear to be a useful supplementary tool. Also, longitudinal assessment of these parameters showed that they were not predictive of fetal macrosomia when measured during the second trimester and that significant differences appeared much later on in pregnancy.

Macrosomia due to maternal diabetes is characterized by accumulation of subcutaneous fat in the upper part of the fetal body [9]. Measurement of subcutaneous tissue on the trunk could therefore reflect this feature. Thickening of the subcutaneous tissue of the arm and scapular area was also noted, thereby confirming previous data [29,30]. STAW measurement had the best AUROC value as well as good sensitivity and specificity (85.7% and 80.0%, respectively). However, little data are available on the measurement of scapular tissue. Greco et al. [21] found thicker scapular tissue in a population of fetuses with diabetic mothers compared with a control group: 4.3 mm versus 3.5 mm at week 31 (\(P < 0.05\)) and 5.4 mm versus 4.4 mm at week 37. Our present study also found a significant difference between the two groups, although sensitivity and specificity were low (69.2% and 73.3%, respectively).

STAW measurements have also been proposed as a tool for the detection of macrosomic fetuses in diabetic women, given the good correlation between this measure and birth weight at term [29,30]. Higgins et al. [24] took 335 measurements of STAW between 30 and 38 weeks of gestation in women followed for pregestational or gestational diabetes. Their results showed greater values at week 33 for macrosomic fetuses (5.4 versus
Table 2
Ultrasound (US) measurements of abdominal circumference (AC), fetal subcutaneous tissue and liver in large for gestational age (LGA) vs appropriate-for-gestational-age (AGA) fetuses.

<table>
<thead>
<tr>
<th></th>
<th>US 1 (23 weeks)</th>
<th>US 2 (28 weeks)</th>
<th>US 3 (31 weeks)</th>
<th>US 4 (34 weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>LGA</td>
<td>AGA</td>
<td>P</td>
</tr>
<tr>
<td>Gestational age (weeks)</td>
<td>29</td>
<td>23</td>
<td>24</td>
<td>0.16</td>
</tr>
<tr>
<td>AC (mm)</td>
<td>29</td>
<td>191</td>
<td>189.3</td>
<td>0.69</td>
</tr>
<tr>
<td>STA (mm)</td>
<td>26</td>
<td>2</td>
<td>2.1</td>
<td>0.42</td>
</tr>
<tr>
<td>STT (mm)</td>
<td>26</td>
<td>2</td>
<td>2.2</td>
<td>0.32</td>
</tr>
<tr>
<td>Thigh/femur ratio</td>
<td>26</td>
<td>0.05</td>
<td>0.05</td>
<td>0.34</td>
</tr>
<tr>
<td>STAW (mm)</td>
<td>25</td>
<td>2.1</td>
<td>2.2</td>
<td>0.98</td>
</tr>
<tr>
<td>STS (mm)</td>
<td>25</td>
<td>2</td>
<td>2.4</td>
<td>0.75</td>
</tr>
<tr>
<td>Liver length (mm)</td>
<td>26</td>
<td>49</td>
<td>47</td>
<td>0.67</td>
</tr>
<tr>
<td>Liver surface area (mm²)</td>
<td>26</td>
<td>1445</td>
<td>1377</td>
<td>0.42</td>
</tr>
</tbody>
</table>

n: number of measurements; STA: soft-tissue in arm; STT: soft-tissue in thigh; STAW: soft-tissue in abdominal wall; STS: soft-tissue in scapular area.
Data are presented here as medians [1st–3rd quartiles]; statistically significant findings are shown in bold.
Table 3
Area under the receiver operating characteristic curve (AUROC), threshold value, and sensitivity and specificity for detecting large-for-gestational-age neonates using ultrasonography measurements at 34 weeks of gestation.

<table>
<thead>
<tr>
<th>Metric</th>
<th>AUROC</th>
<th>Threshold value</th>
<th>Specificity (%)</th>
<th>Sensitivity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC (mm)</td>
<td>0.807</td>
<td>312.5</td>
<td>78.6</td>
<td>66.7</td>
</tr>
<tr>
<td>STT (mm)</td>
<td>0.821</td>
<td>5.25</td>
<td>71.4</td>
<td>93.3</td>
</tr>
<tr>
<td>STA (mm)</td>
<td>0.855</td>
<td>5.5</td>
<td>85.7</td>
<td>80</td>
</tr>
<tr>
<td>Thigh-to-femur ratio</td>
<td>0.786</td>
<td>0.086</td>
<td>71.4</td>
<td>80</td>
</tr>
<tr>
<td>STAW (mm)</td>
<td>0.821</td>
<td>6.35</td>
<td>71.4</td>
<td>86.7</td>
</tr>
<tr>
<td>STS (mm)</td>
<td>0.736</td>
<td>5.15</td>
<td>69.2</td>
<td>73.3</td>
</tr>
<tr>
<td>Liver length (mm)</td>
<td>0.683</td>
<td>72.5</td>
<td>57.1</td>
<td>80</td>
</tr>
<tr>
<td>Liver surface area (mm²)</td>
<td>0.629</td>
<td>2613.75</td>
<td>57.1</td>
<td>80</td>
</tr>
</tbody>
</table>

AC: abdominal circumference; STT: soft-tissue in thigh; STA: soft-tissue in arm; STAW: soft-tissue in abdominal wall; STS: soft-tissue in scapular area.

4.7 mm in AGA fetuses; P = 0.04) with a sensitivity of 79% and specificity of 48% to detect macrosomia. Our present study also found increased values (6.35 versus 4.5 mm in LGA versus AGA fetuses, respectively) for soft-tissue thickness at US 4 (34 weeks). This difference was not explained by the additional week of pregnancy, but by our shorter interval of measurement (2 weeks, between weeks 33 and 35). Our study also found higher PPVs: 71.4% for specificity and 86.7% for sensitivity.

The results in the literature for thigh thickness/femur length ratio are mixed. According to Santolaya-Fargas et al. [22], this measure had better sensitivity and specificity (82% and 96%) than AC (44% and 98%) and EFW (82% and 85%). In another study evaluating this measure for the detection of macrosomia in non-diabetics, the authors could find no differences between the controls and macrosomia group [31]. Our results confirm this latter study with better AUROCs for AC (0.807) than for thigh/femur ratio (0.786). Thus, this measure does not appear to contribute meaningfully to the detection of macrosomia. Measurement of STT alone could, in contrast, be a possible marker of macrosomia, even though its inclusion...
in a formula for EFW did not lead to better detection [32].

In our present study population, liver measurements did not support previous data described by Mirghani et al. in gestational diabetes [18]. Liver length was measured on a coronal section between weeks 21 and 24 and showed a significant difference between diabetic and control populations, with a difference of 5 mm between the two groups (36 mm versus 31 mm, respectively; \( P < 0.001 \)). This increase in liver size is related to hyperglycaemia, which favours fat storage in this organ in the fetus [33]. Our present measurements of liver size and surface area were taken in a sagittal plane. However, landmarks are extremely difficult to locate accurately when taking this measurement. Anderson et al. [33] compared two measurements by the same operator (intraoperator) and by 12 operators (interoperator), and reported the reproducibility of these measures. The intraobserver difference was 3.06 mm [95% CI: 2.68–3.59] and the interobserver difference was 2.17 mm [95% CI: 0.59–4.83] with poor intra- and interobserver correlations [0.77, 95% CI: 0.63–0.87; and 0.84, 95% CI: 0.51–0.99, respectively] for liver length in fetuses with diabetic mothers. It is possible that our group sizes were too small to show a difference between the LGA and AGA groups for a measure with a larger interval than other measures of subcutaneous tissue (the interval was 6–8 mm for liver length compared with <3.5 mm for soft-tissue measurements).

Higher values for subcutaneous tissue in the upper limb compared with the thigh were expected. However, our values were similar between these two locations at week 34 in the macrosomia group (6.13 mm for arm and thigh, 5.74 mm for scapular). Buhling et al. [25] also found similar measurements for the thigh and arm. These results suggest that the distribution of subcutaneous fat may be more homogeneous and affect all body areas without necessarily predominating in the upper extremities of the trunk. Parretti et al. [29] found more marked differences between these two locations, although their upper-limb measurements were taken in a transverse plane while our measurements were made in a sagittal plane.

Different operators performed our measurements, as the objective was to perform a practical rather than explanatory study. Thus, the inter- and intraoperator variability of these measurements were also not assessed. Nevertheless, our ultrasonographers were trained in the best practices for these measurements, and all sections were reread and validated by two investigators.

5. Conclusion

Measurement of subcutaneous tissue on a 34-week ultrasound scan in fetuses with diabetic mothers appears to be a useful supplementary tool for the detection of macrosomia. The findings of this pilot study and the resulting definition of threshold measurements may now be integrated in a further study to define a score including other risk factors for macrosomia (such as HbA1c and BMI) and the measurement of neonatal skin folds in the first 48–72 h of life.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References