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Prediction of fetal macrosomia using two-dimensional and three-dimensional ultrasound

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ABSTRACT

Objective: The estimation of the fetal weight by three-dimensional (3D) ultrasound (US) with fractional thigh volume (TVol) has been suggested to be more accurate than two-dimensional (2D) US particularly within the context of fetuses at risk of macrosomia. The objective of this study was to compare the accuracy of 2D US and 3D US with two different methods of projection for the identification of fetal macrosomia at term.

Study design: Prospective study which included women at risk for fetal macrosomia referred for fetal biometry between 34^{+0}-36^{+6} weeks. The estimated fetal weight (EFW) was computed using 2D US and the Hadlock Model IV or through 3D US and the Model VI by Lee et al. The projection of the EFW at the time of delivery was performed by using Yudkin's chart percentiles and the gestation-adjusted projection (GAP) method.

Results: Overall, 230 patients were included. Paired comparison between 2D-US-EFW and 3D-US-EFW with either method of projection of the EFW at birth suggested different properties of the techniques, being 2D-US-EFW associated with higher sensitivity and 3D-US-EFW with higher specificity, PPV and LR + . At ROC curve no difference was found in the prediction of birthweight ≥90th centile using 2D-US-EFW or 3D-US-EFW (AUC 0.831, 95%CI 0.768-0.894 versus AUC 0.860, 95%CI 0.799-0.920, respectively, p 0.37) nor in the prediction of birthweight >95th centile with 2D-US-EFW compared to 3D-US-EFW (0.803, 95%CI 0.731-0.874 versus 0.866, 95%CI 0.805-0.926, respectively, p 0.07). Similarly, a non-significant difference in the accuracy of the prediction of birthweight >4000 g (AUC 0.788, 95%CI 0.716-0.859 for 2D-US-EFW vs AUC 0.802, 95%CI 0.723-0.880 for 3D-US-EFW, p 0.72) and >4500 g (0.828, 95%CI 0.720-0.936 for 2D-US-EFW vs 0.858, 95%CI 0.759-0.956 for 3D-US-EFW, p 0.71) with the GAP method could be demonstrated.

Conclusions: Within a population at risk of fetal macrosomia the performance of 3D-US-EFW is similar to that of 2D-US-EFW in the prediction of macrosomia at term regardless of the method used for the projection of the EFW, however different properties were noted between the two techniques. Such finding suggests a potential complementary role of the techniques which warrants evaluation in future research.

Introduction

Fetal macrosomia can be defined as birthweight above 4000 g regardless of the gestational age or as birthweight above the 95th/97th percentile for the given gestation [1–4] and is an acknowledged risk factor for intrapartum dystocia and other maternal and perinatal complications [5,6].

The evaluation of the estimated fetal weight (EFW) at term is currently not routinely indicated given its limited accuracy [7–10]. Additionally, national and international societies have so far omitted to recommend how to manage the pregnancies where a macrosomic/LGA fetus is suspected. Nonetheless, early induction of suspected overgrown fetuses may reduce the likelihood of shoulder dystocia [1], and a randomized controlled trial (RCT) demonstrated that the elective induction between 37^{+0} and 38^{+6} weeks of singleton pregnancies with an EFW above the 95th percentile between 36 and 38 weeks of gestation is associated with a significant reduction of shoulder dystocia and associated morbidity with no increase in the caesarean section rate compared to expectant management [11].

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The antenatal US assessment of the EFW by means of conventional two-dimensional (2D) US [12] is known to become increasingly imprecise at the extremes of the distribution of the EFW and particularly in the setting of suspected fetal overgrowth [13]. Available data has shown that the Hadlock IV model [12] represents the most accurate method for the estimation of the fetal weight with a systematic error of 7–10% for fetuses with EFW between 1500 and 4000 g [14] and of 13% for macrosomic fetuses [15].

The use of 3D US EFW with fractional thigh volume (TVol) has been suggested to be more accurate compared to 2D US particularly within the context of fetuses at risk of macrosomia [16–19]. In this study we aimed to evaluate and compare the accuracy of 2D versus 3D US for the prediction of macrosomia at birth.

Methods

This was prospective study conducted at the University Hospital of Parma, Italy, between March 2015 and June 2018. All patients with nonanomalous singleton pregnancies and acknowledged risk factors for fetal macrosomia – which included a medical history of diabetes mellitus, maternal obesity defined as body mass index above 30 kg/m^2, or obstetric risk factors such as gestational diabetes [20], previous history of fetal macrosomia (i.e. birthweight >4000 g) or suspected fetal overgrowth at symphysis-to-fundal height assessment (i.e. $\geq$95th percentile for the given gestation) or US performed in the third trimester (i.e. EFW $\geq$95th percentile for the given gestation) – were referred to a dedicated antenatal clinic for the US estimation of the fetal weight between 34^{+0} and 36^{+6} weeks of gestation. Pregnancy dating was based upon first trimester ultrasound. Patients were considered eligible for the study purposes in the case of availability of labor and postnatal outcomes.

All sonographic examinations were performed by three (AK, MGC, EM) maternal-fetal medicine specialists using US machines equipped with low frequency 2D and 3D transabdominal probes. The 2D measurements of the biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC) and femur length (FL) were obtained and the EFW was computed (2D-US-EFW) using the Hadlock IV model [12], which was considered for the antenatal care plan. Intra- and inter-operator reproducibility of the US measurements was preliminarily tested. Additionally, as per local protocol, 3D US volumes of the fetal thigh were collected starting from the longitudinal view of the magnified proximal femoral diaphysis, including the soft tissue, and adjusting the gain and the acoustic focal zone in order to obtain an optimal definition of the thigh contours. One volume for each patient was acquired. Prior to the volume acquisition the width of the Y-plane was set at an angle of 85 degrees and the quality of the image was set at "extreme". In all cases the 3D volumes were collected in the absence of fetal movements and of compression on the fetal soft tissues and stored for offline measurement of the fractional thigh volume (TVol) as previously described [16], which allowed to compute the 3D-US-EFW through the Model VI by Lee et al [19].

The EFW obtained with 2D and 3D US was plotted on the growth charts by Yudkin et al. [21], thus obtaining the 2D-US-EFW-Yudkin and the 3D-US-EFW-Yudkin. The EFW percentile was assumed to be retained from the index growth scan until delivery. Moreover, both the 2D-US-EFW and the 3D-US-EFW at scan were projected at term using the gestation-adjusted projection (GAP) [22] and the 2D-US-EFW-GAP and the 3D-US-EFW-GAP were computed. The EFW at birth with either method was compared with the references for birthweight and birthweight centile corrected for gender of the Italian neonatal charts [23].

Information concerning maternal age, ethnicity, parity, gestation at the onset of labor and body mass index (BMI) were collected from patient notes and recorded. After delivery, intrapartum and neonatal outcome data were collected from patient case notes. Outcome measures included the mode of delivery and labour and perinatal outcomes.

Cases were excluded from data analysis in the case of suboptimal quality of the 3D US volumes which were used to compute the 3D-US-EFW and the 3D-US-GAP.

Ethics approval for this study was granted by the local ethics committee of the University Hospital of Parma.

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 20 (IBM Inc., Armonk, NY, USA). The 2D-US-EFW and the 3D-US-EFW were correlated by means of the Pearson's correlation coefficient, as were 2D-US-EFW-GAP and 3D-US-EFW-GAP. Receiver-operating characteristic (ROC) curves were constructed for the prediction of neonates weighting $\geq$90th and $\geq$95th centile and $\geq$4000 and $\geq$4500 g using the GAP method. The method of DeLong et al. [24] was used for the comparison of the ROC curves. The agreement between the estimated birthweight according to the the Yudkin's centile and the GAP methods with 2D (2D-US-EFW and 2D-US-EFW-GAP, respectively) and 3D US (3D-US-EFW and 3D-US-EFW-GAP) and the actual birthweight was evaluated following the parameters described by Bland and Altman [25].

Sensitivity, specificity, positive and negative predictive values (PPV and NPV, respectively), positive and negative likelihood ratios (LR + and LR-, respectively) for the identification of cases with birthweight $\geq$90th centile and $\geq$95th centile with the projection of EFW centile according to the Yudkin curve and with birthweight at term $\geq$4000 and $\geq$4500 g according to the GAP method were evaluated using the 2D and 3D methods.

Data were shown as mean (range) or as number (percentage) unless otherwise stated. $p < 0.05$ was considered as statistically significant. This study was reported according to the STARD guidelines [26].

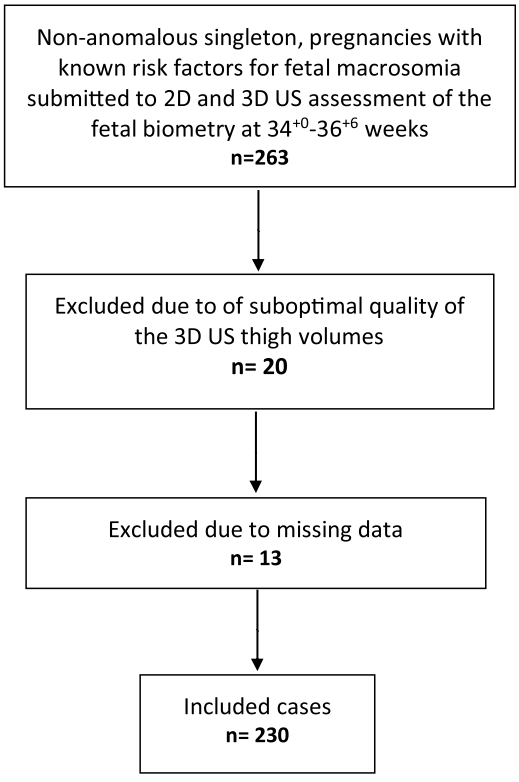

Fig. 1. Flow chart (according to STARD guidelines) (26) for inclusion of cases.

Results

Overall, 263 women were recruited over the study period, of whom 230 were eligible after the evaluation of the inclusion and the exclusion criteria (Fig. 1).

The demographic features and perinatal outcomes of the included cases are summarized in Table 1. Within our population at risk for fetal macrosomia, birthweight percentile above the 90th and the 95th percentile were recorded in 56 (24.3%) and 42 (18.3%) cases, respectively, while birthweight above 4000 and 4500 g occurred in 48 (20.9%) and 10 (4.3%) cases, respectively. An EFW >90th percentile was recorded in 82 cases (35.7%) according to 2D-US-EFW and in 53 fetuses (25.2%) according to 3D-US-EFW, while an EFW >95th percentile was found in 53 (23.0%) and 31 (13.5%) cases using the 2D-US-EFW and the 3D-US-EFW methods, respectively; the GAP method yielded a term EFW > 4000 g in 44 (19.2%) cases according to the 2D-US-EFW-GAP and 26 (11.3%) cases according to the 3D-US-EFW-GAP, while a term EFW > 4500 g was projected in 9 (3.9%) and 5 (2.1%) fetuses using the 2D-US-EFW-GAP and the 3D-US-EFW-GAP methods, respectively.

The relationship between the EFW percentile and the birthweight percentile yielded a significant correlation both for the 2D-US-EFW centile (0.654, r^2 0.430, p < 0.001) and for the 3D-US-EFW centile (0.678, r^2 0.460, p < 0.001) (Supplementary Fig. 1). Similarly, a significant correlation was found for 2D-US-EFW-GAP and for 3D-US-EFW-GAP (0.600, r^2 0.360, p < 0.001 and 0.629, $r^2$0.396, p < 0.001, respectively) (Supplementary Fig. 2). At Bland and Altman scatterplots a better agreement with term birthweight of the 3D-US-EFW-GAP method compared to the 2D-US-EFW-GAP was identified. The same was noted for the 3D-US-EFW compared to the 2D-US-EFW with both 90th and 95th centiles (Supplementary Fig. 3).

Sensitivity, specificity, PPV and NPV, LR + and LR- for birthweight >90th and >95th percentile using the Yudkin method and for term birthweight >4000 and >4500 g using the GAP method were reported in Tables 2 and 3, respectively. Overall, 2D-US-EFW centile was associated with the highest sensitivity, while 3D-US-EFW showed higher specificity, PPV and LR + compared to 2D-US-EFW. Similar results were noted when evaluating the GAP method, which showed the highest specificity and PPV for the detection of birthweight ≥4000 g with 3D-US and the highest LR + for birthweight ≥4500 g. At sub-analysis conducted on a limited cohort of fetuses who screened positive at 2D US for EFW ≥90th centile (Supplementary table 1a) and EFW ≥95th centile (Supplementary table 1b) the higher specificity and LR + of 3D-US-EFW-GAP in the identification of the more severe degrees of fetal overgrowth was confirmed.

The ROC curve yielded a similar accuracy in the prediction of birthweight ≥90th centile using 2D-US-EFW or 3D-US-EFW (AUC 0.831, 95% IC 0.768-0.894 versus AUC 0.860, 95% IC 0.799-0.920, respectively, p 0.37) and of birthweight >95th centile with 2D-US-EFW compared to 3D-US-EFW (0.803, 95% CI 0.731-0.874 vs 0.866, 95% CI 0.805-0.926, respectively, p 0.07) (Fig. 2). Moreover, a non-significant difference in the accuracy in the prediction of birthweight >4000 g and >4500 g using 2D-US-EFW-GAP or 3D-US-EFW-GAP was found (AUC 0.788, 95% CI 0.716-0.859 vs AUC 0.802, 95% CI 0.723-0.880, respectively, p 0.72 for birthweight >4000 g and AUC 0.828, 95% IC 0.720-0.936 vs AUC 0.858, 95% IC 0.759-0.956, respectively, p 0.71 for birthweight >4500 g) (Fig. 3) (Table 4 and 5)

Table 1
Baseline data characteristics and perinatal outcomes of the study population. Data are presented as mean (range) or n (%).

Age (years) Median (range)	32.6 (18 – 45)
BMI at conception (kg/m^2) Median (range)	28.2 (17.8 – 47.4)
Parity N (%)	Nulliparae 89 (38.7%)
Ethnicity N (%)	- White (Caucasian, Arabic) 147 (63.9%) - African 42 (18.3%) - Asian 32 (14.3%) - Other (Caribbean, South American, Mixed) 8 (3.5%)
Risk factor for fetal macrosomia N (%)	- BMI >30 kg/m^2 87 (37.8%) - Suspected fetal macrosomia at US or SFH assessment in the third trimester 57 (24.8%) - History of fetal macrosomia 22 (9.6%) - Diabetes (GDM + DM) 85 (37%)
Gestation at US examination (weeks+days) Median (range)	36^{+1} (34^{+0} – 36^{+6})
Induction of labour N (%)	Yes 99 (43%)
Gestational age at delivery (weeks +days) Median (range)	39^{+1} (36^{+1} – 41^{+6})
Neonatal gender N (%)	Male 140 (61.0%)
Birth Weight (grams) Median (range)	3682 (2520 – 6100)
Mode of delivery N (%)	Spontaneous vaginal delivery 143 (62.2%) Vacuum delivery 13 (5.6%) Caesarean section 74 (32.2%)
Third degree tear N (%)	4 (1.7%)
Postpartum haemorrhage >1000 mls N (%)	11 (4.8%)
Shoulder dystocia N (%)	1 (0.4%)
Umbilical cord arterial pH < 7.00 N (%)	0 (0.0%)
APGAR < 5 at 5 minute N (%)	3 (1.3%)
Admission to NICU N (%)	1 (0.4%)

N 230 unless otherwise stated.
BMI: body mass index.
EFW: estimated fetal weight.
US: ultrasound.
SFH: symphysis-to-fundal height.

Discussion

Within the study population no significant difference could be demonstrated in the accuracy between 2D US and 3D US for either method and for either birthweight cut-off, however the paired comparison suggested different properties of the techniques. More specifically, 2D-US-EFW centile was associated with the highest sensitivity, while the 3D-US methods yielded higher specificity, PPV and LR + in the identification of birthweight >90th and 95th percentiles and >4000 and 4500 g.

The identification of fetal macrosomia is of crucial importance for the clinical management in relation to the timing and the mode of delivery. The limited reliability of the available US techniques for the antenatal estimation of the fetal weight is acknowledged as a major issue particularly within the context of fetal macrosomia [13], and for this reason magnetic resonance imaging is being investigated as an adjunct tool in order to improve the accuracy in the antenatal detection of fetal overgrowth [27]. Previous US data has suggested a strong correlation between the percentage of fetal soft tissue and the degree of error in the estimation of the fetal weight [28,29]. The assessment of the fetal fat mass by means of the 3D US assessment of the TVol has been suggested as a proxy of the nutritional status of the fetus being able to accurately identify conditions of impaired growth including macrosomia [28–32].

To our knowledge there is little data describing a paired prospective comparison of 2D-US-EFW and 3D-US-EFW using two different methods for the estimation of the fetal weight projected at term gestation. In our work no difference could be demonstrated

Table 2
Sensitivity, specificity, positive (PPV) and negative (NPV) predictive value, positive (LR+) and negative (LR-) likelihood ratios of 2D-US-EFW and 3D-US-EFW for the prediction of birth weight ≥90th centile and ≥95th centile in the study population.

Method	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	LR+ (95% CI)	LR- (95% CI)
2D-US-EFW ≥90th centile	71.4% (57.8–82.7)	75.9% (68.8–82.0)	48.8% (41.1– 56.5)	89.2% (84.4– 92.6)	3.0 (2.2 –4.0)	0.4 (0.3– 0.6)
2D-US-EFW ≥95th centile	59.5% (43.3– 74.4)	85.1% (79.2– 89.9)	47.2% (36.9– 57.7)	90.4% (86.7– 93.2)	4.0 (2.6 –6.1)	0.5 (0.3– 0.7)
3D-US-EFW ≥90th centile	73.2% (59.7– 84.2)	90.2% (84.8–94.2)	70.7% (59.9– 79.6)	91.28% (87.1–94.2)	7.5 (4.6 –12.1)	0.3 (0.2– 0.5)
3D-US-EFW ≥95th centile	50.0% (34.2– 65.8)	94.6% (90.4– 97.4)	67.7% (51.7–80.5)	89.5% (86.2– 92.0)	9.4 (4.8 –18.5)	0.5 (0.4– 0.7)

US: ultrasound.
EFW: estimated fetal weight.

Table 3
Sensitivity, specificity, positive (PPV) and negative (NPV) predictive value, positive (LR+) and negative (LR-) likelihood ratios of 2D-US-EFW and 3D-US-EFW for the prediction of birth weight ≥4000 g and ≥4500 g projected by GAP method.

Method	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	LR + (95% CI)	LR- (95% CI)
2D-US-EFW-GAP ≥4000g	45.8% (31.4 – 60.8)	87.9% (82.3 – 92.3)	50.0% (37.8–62.2)	86.0% (82.5–88.9)	3.8 (2.3–6.2)	0.6 (0.5– 0.8)
2D-US-EFW-GAP ≥4500g	30.0% (6.7 – 65.3)	97.3% (94.2 – 99.0)	33.3% (12.7–63.2)	96.8% (95.3–97.9)	11.0 (3.2 –37.7)	0.7 (0.5– 1.1)
3D-US-EFW-GAP ≥4000g	33.3% (20.4 – 48.4)	94.5% (90.1 – 97.3)	61.5% (43.7–76.7)	84.3% (81.4–86.8)	6.1 (2.9– 12.5)	0.7 (0.6– 0.9)
3D-US-EFW-GAP ≥4500g	20.0% (2.52 – 55.6)	98.6% (96.1 – 99.7)	40.0% (11.1–78.0)	96.4% (95.2–97.4)	14.7 (2.8 –78.2)	0.8 (0.6–1.1)

US: ultrasound.
EFW: estimated fetal weight.
GAP: gestation-adjusted projection.

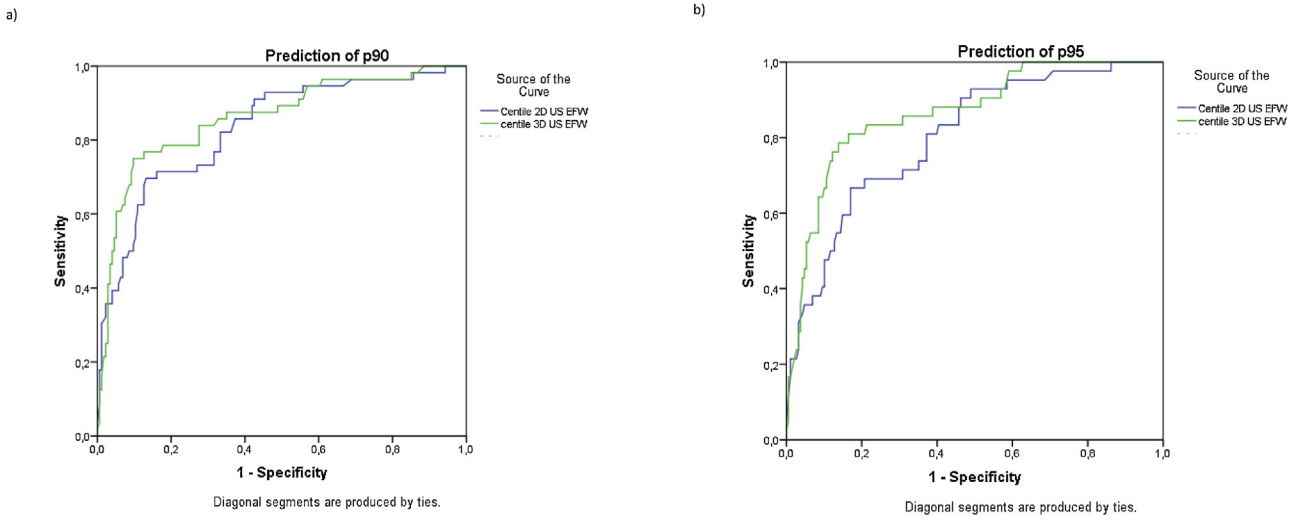

Fig. 2. Receiver Operating Curves for the prediction of birthweight ≥ 90th centile (a) and ≥ 95th centile (b) with 2D-US-EFW (blue line) and 3D-US-EFW (green line).

between 2D and 3D US estimation of the fetal weight with either method for the projection of the EFW – i.e. EFW percentile and GAP. 2D-US-EFW centile appeared to be associated with the highest sensitivity for the identification of birthweight ≥95th centile, while a trend was noted in favour of 3D US in terms of specificity, particularly for the identification of conditions of birthweight ≥95th percentile and ≥4500 g. However, a statistically significant difference between the two methods could not be demonstrated for either (percentile or gram) birthweight cut-off. The results of our work are consistent with those reported by Gibson et al. [33] but are in disagreement with those from a small cohort of pregnancies complicated by diabetes, in which 2D-US-EFW was found to perform better than 3D-US-EFW for the prediction of birthweight >4000 g and >4500 g [34]. On the other hand, the highest specificity and LR + for 3D-US-EFW-GAP in fetuses weighting on or above 4500 g was also demonstrated within a selected a cohort of diabetic women [35].

Albeit in the absence of a widely acknowledged management options in fetuses at risk of macrosomia, a RCT has shown the beneficial effects of anticipated induction of labor of fetuses with EFW >95th percentile [11]. Given the major clinical implications related to the prenatal identification of fetuses at risk of macrosomia [32], the higher specificity, PPV and LR + of 3D US compared to 2D US – which we found in our work – suggest that the TVol method might represent the modality of choice in order to confirm or exclude suspected fetal overgrowth. Being associated with the highest sensitivity for birthweight ≥95th centile, 2D-US-EFW might represent the best tool for the screening of the large fetuses, while 3D-US-EFW could be considered for the confirmation of the fetal overgrowth, particularly in its more extreme degree (i.e. birthweight ≥95th centile or ≥4500 g). On this ground, it is uncertain whether a two-step approach consisting in the screening of fetal overgrowth by 2D-US-EFW centile followed by 3D-US-EFW only of the cases who screened positive may improve the detection of fetal macrosomia compared to a one-step approach with either method. Such strategy for the prenatal prediction of fetal macrosomia was also suggested in a recent retrospective study [36]. In our study only one in four patients was referred due to

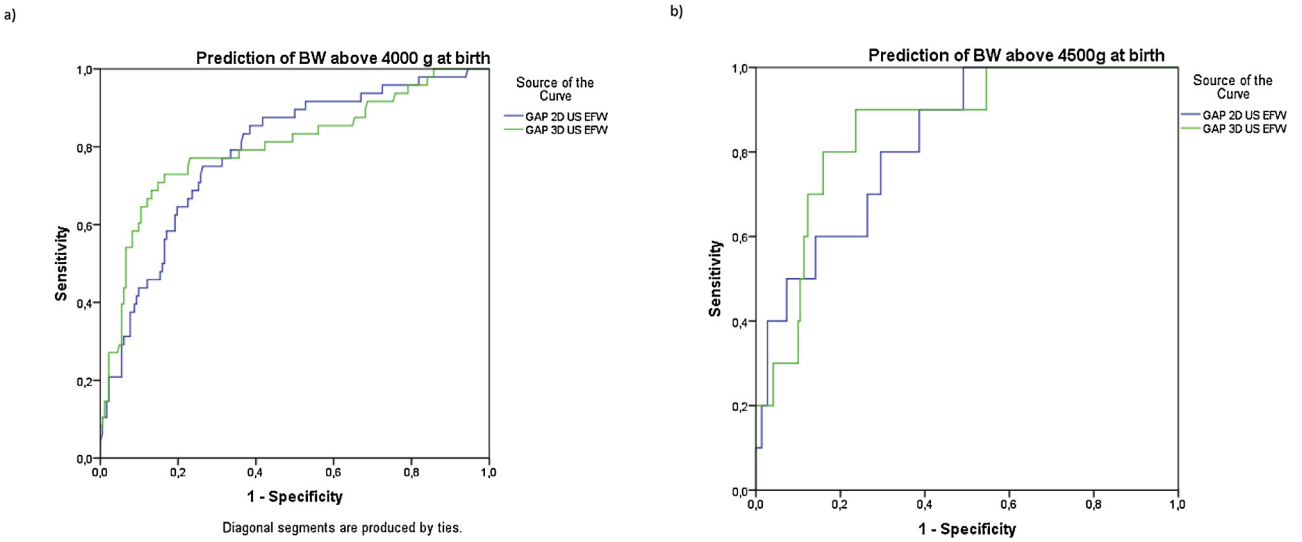

Fig. 3. Receiver Operating Curves for the prediction of birthweight ≥ 4000 g (a) and ≥ 4500 g (b) based on prenatal 2D-US-EFW with the gestation-adjusted projection (GAP) method (blue line) and 3D-US-EFW with GAP method (green line).

Table 4
Sensitivity, specificity, positive (PPV) and negative (NPV) predictive value, positive (LR+) and negative (LR-) likelihood ratios of 3D-US-EFW centile and 3D-US-EFW-GAP in 82 fetuses with EFW ≥90th centile at 2D-US-EFW.

Method	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	LR + (95% CI)	LR- (95% CI)
3D-US-EFW ≥90th centile	85.0% (70.2 – 94.3)	38.1% (23.6 – 54.4)	56.7% (43.2–69.4)	72.7% (49.8–89.3)	1.3 (1.0 –1.8)	2.5 (1.1–5.8)
3D-US-EFW ≥95th centile	55.2% (35.7 – 73.6)	62.3% (47.9 – 75.2)	44.4% (27.9–61.9)	71.7% (56.5–84.0)	1.5 (0.9 –2.4)	1.4 (0.9–2.2)
3D-US-EFW-GAP ≥4000g	38.7% (21.9 – 57.8)	82.4% (69.1 – 91.6)	57.1% (34.0–78.2)	68.9% (55.7 –80.1)	2.2 (1.0 – 4.6)	1.3 (1.0– 1.8)
3D-US-EFW-GAP ≥4500g	33.3% (4.0 – 77.7)	96.1% (88.9 – 99.2)	40.0% (5.3–85.3)	94.8% (87.2–98.6)	8.4 (1.7 –41.2)	1.4 (0.8– 2.5)

US: ultrasound.
EFW: estimated fetal weight.
GAP: gestation-adjusted projection.

Table 5
Sensitivity, specificity, positive (PPV) and negative (NPV) predictive value, positive (LR+) and negative (LR-) likelihood ratios of 3D-US-EFW centile and 3D-US-EFW-GAP in 53 fetuses with EFW ≥95th centile at 2D-US-EFW.

Method	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	LR + (95% CI)	LR- (95% CI)
3D-US-EFW ≥90th centile	45.8% (31.4 – 60.8)	87.9% (82.3 – 92.3)	50.0% (37.8–62.2)	86.0% (82.5–88.9)	3.8 (2.3–6.2)	0.6 (0.5– 0.8)
3D-US-EFW ≥95th centile	30.0% (6.7 – 65.3)	97.3% (94.2 – 99.0)	33.3% (12.7–63.2)	96.8% (95.3–97.9)	11.0 (3.2– 37.7)	0.7 (0.5– 1.1)
3D-US-EFW-GAP ≥4000g	33.3% (20.4 – 48.4)	94.5% (90.1 – 97.3)	61.5% (43.7 -76.7)	84.3% (81.4–86.8)	6.1 (2.9– 12.5)	0.7 (0.6– 0.9)
3D-US-EFW-GAP ≥4500g	20.0% (2.52 – 55.6)	98.6% (96.1 – 99.7)	40.0% (11.1 -78.0)	96.4% (95.2–97.4)	14.7 (2.8– 78.2)	0.8 (0.6– 1.1)

US: ultrasound.
EFW: estimated fetal weight.
GAP: gestation-adjusted projection.

suspected EFW ≥95th percentile at screening US and in less than one in five a 2D-US-EFW ≥95th centile was eventually confirmed. The sub-analysis conducted on a restricted cohort of fetuses with EFW ≥95th percentile at 2D US supported the potential role of 3D US coupled with the GAP method for the antenatal confirmation of fetal overgrowth, however definitive conclusions cannot be drawn given the limited number of cases included in our work. Further prospective or randomized trials are required in order to evaluate whether the 3D US confirmation of fetal overgrowth suspected at 2D US is associated with an improved accuracy in the antenatal diagnosis of macrosomia and, most importantly, with an improvement of the maternal and perinatal outcomes should delivery be indicated by the antenatal US confirmation of fetal overgrowth.

The original design of the study together with the prospective data collection and the large number of included cases, which account for the largest cohort so far reported, represent major strengths of the study. On the other hand, one limitation is that the 2D US and 3D US measurements were performed by different operators, however all the investigators were trained maternal-fetal medicine specialists and inter-operator reproducibility was preliminarily tested. Additionally, the technical skills needed to perform the semi-automated measurement of the TVol may represent a potential source of error and preclude its dissemination and implementation outside the context of referral centres.

In conclusion, our study suggests that within a selected cohort of pregnant women at risk for fetal macrosomia the use of 3D US for the estimation of the fetal weight is not associated with an improved detection of fetal macrosomia. However, paired comparison of the two techniques yielded higher sensitivity for 2D US and higher specificity, PPV and LR + for 3D US in the antenatal identification of fetal macrosomia. Therefore, 3D US may represent a more accurate tool in order to confirm or exclude fetal

overgrowth following 2D US detection, thus supporting clinical decisions when induction of labor is considered. Such findings are worth being evaluated in future studies.

Declaration of Competing Interest

All the Authors state no financial disclosures nor conflict of interest related to the content of this work.

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None.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ejogrb.2019.10.003.

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