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Ultrasound fetal weight estimation in twin pregnancy

Kaouther Dimassi, Aymen Hammemi, Abir Karoui, Amel Triki, Mohamed Faouzi Gara

Obstetrics and Gynecology Unit Mongi Slim Hospital, La Marsa, Tunisia; Faculty of Medicine University Tunis El Manar, Tunis, Tunisia

Abstract

Objective: To assess the performance of ultrasound in twin's fetal weigt estimation (FWE), screening of low birth weight (LBW) and twin's weight discordance (TWD).

Methods: A prospective study including fifty twin pregnancies was carried out. Each patient underwent an ultrasonography with estimated fetal weight (EFW) up to 4 days before delivery. We calculated the median absolute difference (MAD) and the median absolute percentage error (MAPE) between EFW and birth weight (BW). The correlation and the concordance were also assessed. Finally, we calculated the sensitivity (Se), specificity (Sp), the positive predictive value (PPV) and the negative predictive value (NPV) of ultrasound in the diagnosis of the LBW and TWD.

Results: The MAD was equivalent for both twins. The MAPE was 7.7% [range: 0 to 32] for T1 and 8.2% [range: 0 to 27] for T2. The proportion of estimates beyond 10% of actual BW was 38% for T1. We have noted a significant correlation between EFW and BW for the both twins (R1=0.87; R2=0.89). In case of LBW, ultrasound had a se, sp, PPV and NPV respectively 90.32%, 76.82%, 80% and 87%. Ultrasound's performance in the diagnosis of TWD varied depending on the adopted threshold. Chorionicity, presentation and gestational age did not have any influence in the performance of FWE.

Conclusion: The Ultrasound is essential in the diagnosis and management of perinatal complications common in twins. Its performance is satisfactory in EFW and depends on the threshold adopted for the diagnosis of TWD.

Keywords: Ultrasound, twin pregnancy, estimated fetal weight, weight discordance, low birth weight.

Özet: İkiz gebelikte ultrason fetal ağırlık tahmini

Amaç: İkizlerin fetal ağırlık tahmininde (FWE), düşük doğum ağırlığının (LBW) ve ikizlerin ağırlık uyumsuzluğunun (TWD) taranmasında ultrason performansının değerlendirilmesi.

Yöntem: Elli beş gebenin dâhil edildiği prospektif bir çalışma gerçekleştirildi. Her bir hastaya, doğumdan dört gün öncesine kadar tahmini fetal ağırlık (EFW) için ultrasonografi uygulandı. Tahmini fetal ağırlık ile doğum ağırlığı (BW) arasındaki medyan mutlak farklılığı (MAD) ve medyan mutlak yüzde hatasını (MAPE) hesapladık. Korelasyon ve kondordansı da ayrıca değerlendirdik. Son olarak, düşük doğum ağırlığı ve ikizlerin ağırlık uyumsuzluğu tanısında ultrasonun hassasiyetini (Se), özgüllüğünü (Sp), pozitif prediktif değerini (PPV) ve negatif prediktif değerini (NPV) hesapladık.

Bulgular: Medyan mutlak farklılık, her iki ikiz için de eşdeğerdi. Medyan mutlak yüzde hatası, T1 için %7.7 [aralık: 0–32] ve T2 için %8.2 idi [aralık: 0–27]. Gerçek doğum ağırlığının %10'undan fazla tahminlerin oranı, T1 için %38'di. Her iki ikiz için de tahmini fetal ağırlık ve doğum kilosu arasında anlamlı bir korelasyon tespit ettik (R1=0.87; R2=0.89). Düşük doğum ağırlığında, ultrasonun hassasiyeti, özgüllüğü, pozitif prediktif değeri ve negatif prediktif değeri, sırasıyla %90.32, %76.82, %80 ve %87 idi. İkizlerin ağırlık uyumsuzluğu tanısında ultrason performansı, kabul edilen eşiğe bağlı olarak değişmiştir. Koryonisite, prezentasyon ve gebelik yaşı, fetal ağırlık tahmini üzerinde hiçbir etkiye sahip değildi.

Sonuç: Ultrason, ikizlerde yaygın olan perinatal komplikasyonların tanısı ve yönetiminde hayati öneme sahiptir. Ultrason, tahmini fetal ağırlığı için kabul edilebilir bir performans sergilemektedir ve ikizlerin ağırlık uyumsuzluğu tanısında kabul edilen eşik değere bağlıdır.

Anahtar sözcükler: Ultrason, ikiz gebelik, tahmini fetal ağırlık, ağırlık uyumsuzluğu, düşük doğum ağırlığı.

Correspondence: Kaouther Dimassi, MD. Mongi Slim Hastanesi Kadın Hastalıkları ve Doğum Kliniği, La Marsa, Tunus. e-mail: kaouther.dimassi@gmail.com

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Introduction

Multiple pregnancies are constantly increasing due to the frequent use of assisted reproductive techniques. Twin pregnancies have a higher risk compared to singleton pregnancies: their mortality rate is six times higher than singletons.[1] Neonatal morbidity is also increased. These kinds of pregnancies lead to many complications and above all prematurity and intrauterine growth retardation (IUGR).[2] Moreover, twin growth discordance (TGD) is a specific complication of these pregnancies. Thus, ultrasound monitoring seems to be important for the management of these pregnancies. For example, fetal weight estimation (FWE) allows detecting and monitoring fetal growth disorders. It also makes it possible to predict any necessary neonatal care in case of preterm delivery. Therefore, the accuracy of FWE is essential to good obstetrical management. However, the literature is poor concerning the validity of sonographic prediction of the fetal weight and the fetal weight discordance in twin pregnancies.

The aim of our study was to evaluate the performance of ultrasound in estimating the fetal weight in twin pregnancies, the diagnosis of TGD and prenatal diagnosis of low birth weight (LBW). We also studied the effects of different maternal and fetal related factors on this prediction.

Methods

Each patient underwent an ultrasound (US) exam with FWE up to 4 days before delivery. The US exam was performed using an ULTRASONIX, SONIX OP ultrasound machine (Ultrasonix Medical Corporation, Richmond, BC, Canada), with a curvilinear abdominal probe 3.5 MHz. The EFW was calculated using Hadlock formula:[3] Log 10 EFW= 1.3596-0.00386AC*FL+0.0064HC+0.00061BDP*AC+0.0424AC+0.174FL. Weight differences between twin fetuses were calculated as follows: (The weight of the largest twin – the weight of the smallest twin) / weight of the largest twin. This difference was calculated throughout pregnancy and upon delivery.

TGD was defined as a weight difference between twins of 20% and above.[4] The causes of twins' weight discordance (TWD) have not been studied.

Low birth weight (LBW) was defined by a birth weight (BW) below 2500 g.[5] In the literature, this value is known to increase the risk of morbidity and neonatal mortality significantly.[5] Oligohydramnios was defined by each twin's single deepest pocket <20 mm. In the literature, this measurement method appears to be the most appropriate in twin pregnancies.[6] Maternal obesity was defined as a body mass index (BMI) ≥35 kg/m^2 the day of delivery.[7] The following details were recorded:

- Age, parity, height, weight and BMI the day of delivery.
- The gestational age, chorionicity, fetal presentation, EFW for the first twin (EFW T1) and the second twin (EFW T2), each twin's single deepest pocket.

At birth, we also recorded the BW of the first twin (BW T1) and the second twin (BW T2). The EFW was compared to the actual BW. Data was recorded on a standard spreadsheet (Microsoft Excel; Microsoft Corporation, Redmond, WA, USA). Descriptive parameters are expressed as median [1st, 3rd quartiles]. Frequencies are presented as percentages.

The analysis was performed in several ways: percentage error was calculated by subtracting the actual BW from the EFW and then dividing the difference by the actual BW and multiplying by 100. The median absolute percentage error (MAPE), expressing the systematic error, was calculated from the percentage error. Absolute percentage error and median absolute percentage error (MAPE) were calculated the same way by using the absolute value of the difference between the EFW and the actual BW. The proportion of estimates within 10% of the actual BW was also calculated.

Correlation between BW and ultrasound EFW was demonstrated using the Pearson coefficient and agreement between these two measurements was assessed using Bland and Altman's plots.[8]

Statistical analysis was performed using XLSTAT 2014.4.09 (Addinsoft, New York, NY, USA); $p<0.05$ was considered statistically significant.

Percentage errors were compared using the Student's t test in reference to maternal body mass index (BMI), chorionicity, gestational age, fetal presentation. We calculated the sensitivity, specificity, negative predictive value (NPV) and positive predictive value (PPV) of EFW to detect TGD.

Results

During the study, we managed 2170 deliveries in our unit. Fifty patients met the inclusion criteria and a total of 100 fetuses were studied. Mean maternal age was 32 [range: 28 to 36] years. Mean BMI was 33.81 [range: 27 to 40] kg/m^2. Twenty eight patients (56%) had BMI >35 kg/m^2. Mean gestational age at delivery was 37 [range: 35 to 37] weeks. Time elapsed between sonography and delivery was 2.27 [range: 0 to 4] days. Forty patients delivered in our department, the other 10 patients delivered in a private clinic. Overall, there were 41 dichorionic diamniotic pregnancies (82%), and no case of monoamniotic pregnancies. **Table 1** details the results of comparison between EFW and actual BW for each twin.

Median absolute difference (MAD) was 155 g [range: 72 to 337.5] for T1 and 150 g [range: 100 to 266.5] for T2. The MAPE was 7.7% [range: 2.5 to 14.76] for T1 and 7.55% [range: 3.37 to 11.85] for T2 (p=0.8). Finally, the proportion of estimates beyond 10% of the actual BW was 38% for T1 and 34% for T2 (p=0.082). Thus, there was no significant difference in fetal weight estimation's performance between twins. We found a strong and significant correlation between EFW and BW for both fetuses. In fact, the correlation indexes were respectively R1=0.87 for T1 and R2=0.89 for T2.

Table 1. Differences between the birth weight (BW) and the estimated fetal weight (EFW) for both twins.

	1. twin	2. twin	p
Absolute difference (g)	155 [72–337.5]	150 [100–266.5]	0.50
Median absolute percentage (%) error	7.7 [2.5–14.76]	7.55 [3.37–11.85]	0.80
The propotion of estimates 10% of the actual BW	19 (%38)	17 (%34)	0.82

The linear regression analysis calculates the BW with the following formulas: for Twin 1 BW T1= 415.57+0.846*EFW T1, for Twin 2 BW T2= 65.68+ 0.963*EFW T2 (**Fig. 1)**.

Bland-Altman analysis for these variables is shown in **Fig. 2**. For T1, bias was 39.4 g (95% limits of agreement -580 g to +650 g). For T2, bias was 19.4 g (95% limits of agreement -550 g to +550). None of the parameters studied; obesity, term, chorionicity or presentation, has significantly hampered the performance of the ultrasound examination (**Table 2**). T1 weighed less than 2500 g in 28 cases (56%). LBW was more fre-

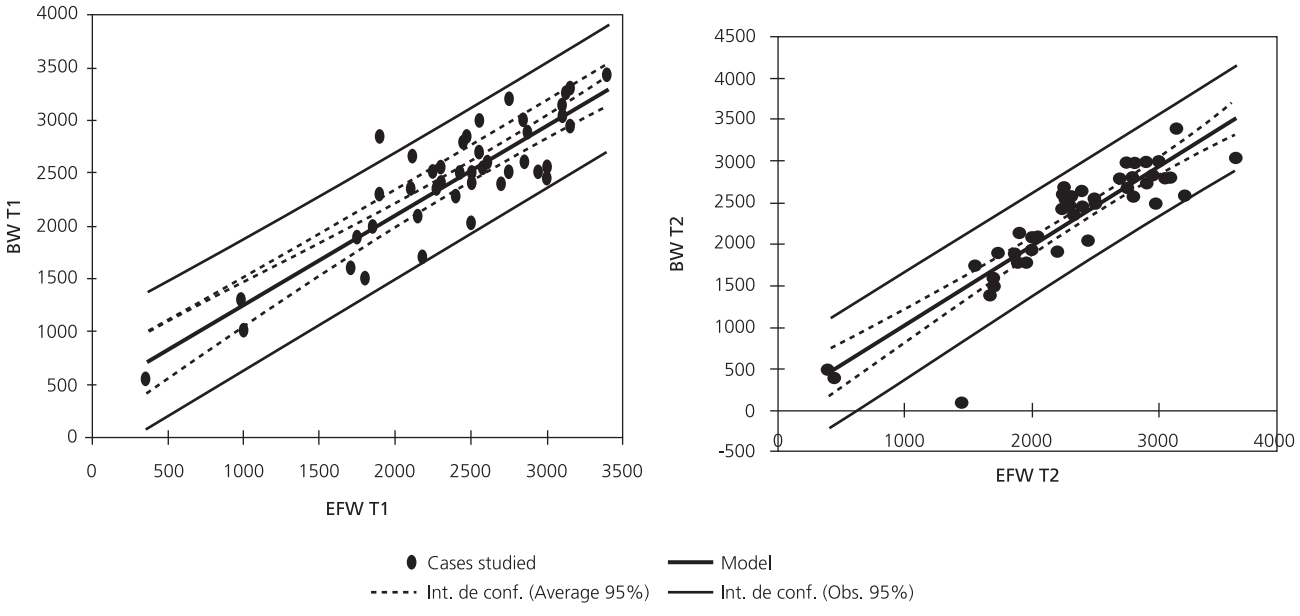

Fig. 1. Correlation between EFW and BW using Pearson linear regression. **BW T1:** first twin birth weight; **BW T2:** second twin birth weight; **EFW T1:** first twin estimated fetal weight; **EFW T2:** second twin estimated fetal weight.

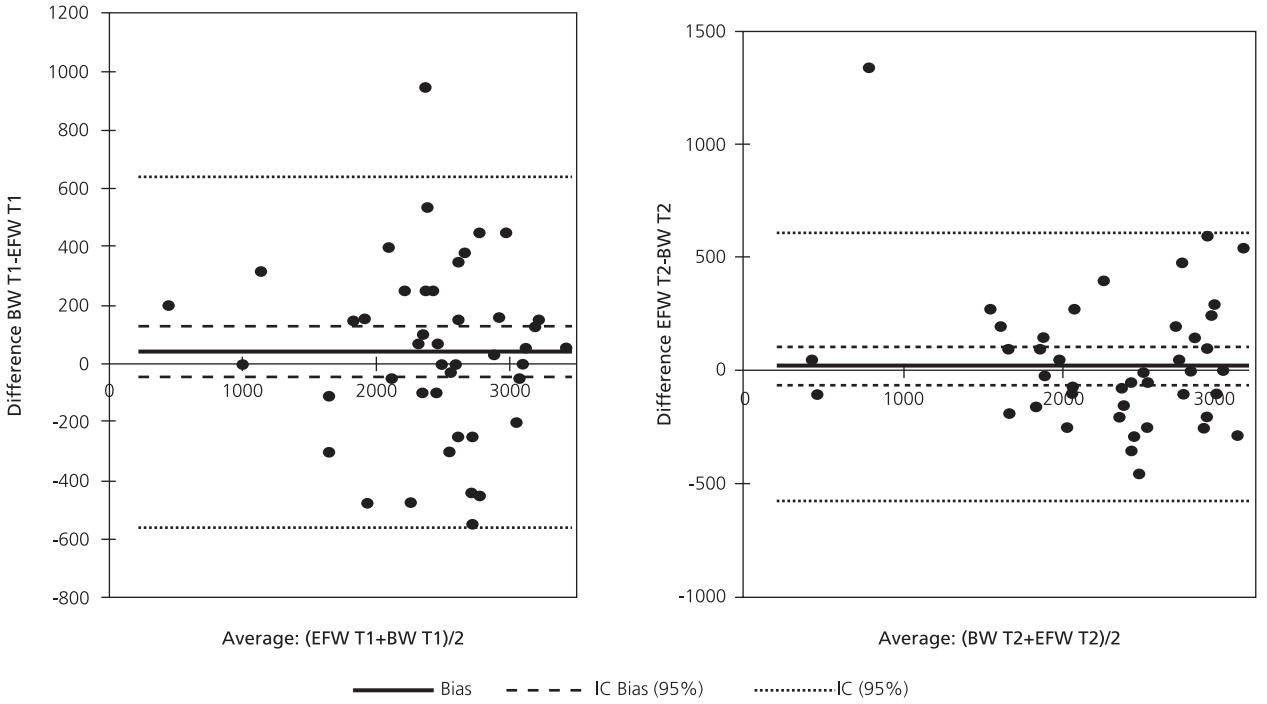

Fig. 2. Agreement analysis using Bland and Altman plots. **BW:** birth weight; **EFW:** estimated fetal weight; **T1:** first twin; **T2:** second twin.

quently noticed in T2: 34 cases (68%). Thus, sensitivity, specificity, NPV, PPV of ultrasound in the diagnosis of LBW in general and without differentiating between twins were 90%, 78%, 88%, and 83%, respectively. The prevalence of TWD above 20% was 32%. For the diagnosis of TWD, the sensitivity of ultrasound exam was 76.9%, specificity was 81.8%, PPV 62% and NPV 93.5%. We noticed that performance of ultrasound exam in the diagnosis of TWD were improved when the discordance's threshold adopted increased to 25% (**Table 3**).

Discussion

Actually, twin pregnancies represent 3% of live births.[1] These pregnancies have a high neonatal risk; prematurity and LBW. Moreover, TWD is a particular situation that should be taken into account in obstetrical decisions. Thus, the accuracy of ultrasound FWE in twins is essential for obstetrical management. Our study is still mainly limited by the small number of cases, however, this can be explained by the difficulty of recruiting during one year more cases meeting the strict inclusion criteria and scheduling a specialized US examination up to four days before delivery. Our results can be improved by a larger multicentric study involving more sonographers. We found good results concerning EFW in both twins with a MAD of 150-155 g [T1-T2]. Besides, the MAPE was 7.5–7.7% [T1-T2]. Thus, we can conclude that the performance of ultrasound in EFW in twin pregnancies is similar to singletons. This latter has been widely studied in the literature and the various publications attribute a MAPE ranging from 6 to 10%.[4]

These results are similar to those of Ivars et al.[9] with a MAD of 110–127 g [T1-T2] and a MAPE of 5.41–5.64% [T1-T2]. Nevertheless, the proportion of estimates beyond 10% of the actual BW was lower: 25% compared to 34% in our study. This seems paradoxical, especially as, in our study, the delay between US exam and delivery was lower (2.27 days vs. 7 days).[9] Additionally, similar results are reported by Danon et al.,[2] in their retrospective study over 278 twin pregnancies, with an interval of three days between US estimation and delivery. The proportion of estimates beyond 10% of the actual BW is 33.6%.

Table 2. Effects of different maternal and fetal related factors on ultrasound fetal weight estimations.

	1. ikiz	2. ikiz
Maternal obesity		
Obese: >35 kg/m^2	28 250 g [100;450]	28 150 g [100; 251.5]
No obese: <35 kg/m^2	22 154 g [50;250] **p=0.12**	22 190 g [75; 300] **p=0.08**
Gestational age: >32 weeks	46 150 g [100; 266.5]	46 154 g [72; 300]
Gestational age: <32 weeks	4 100 g [75; 150] **p=0.25**	4 200 g [100; 310] **p=0.38**
Chorionicity		
Dichorionic-diamniotic	41 150 g [50; 300]	41 150 g [75; 200]
Monochorionic-diamniotic	9 287 g [140.5; 455] **p=0.26**	9 150 g [100 ;184] **p=0.27**
Fetal presentation		
Cephalic ©	30 147 g [85; 327]	21 152 g [90; 254]
Breech (B)	19 136 g [78; 300.5]	17 126 g [100; 258.2]
Transverse (T)	1 156 g C-B; **p=0.21** C-T; **p=0.48** B-T; **p=0.47**	12 138 g [120; 266] C-B; **p=0.16** C-T; **p=0.23** B-T; **p=0.28**

We have found a strong correlation between EFWs and BWs. Similar conclusion is reported in literature.[9] The linear regression technique with the calculation of a correlation coefficient searches the existence of a linear relationship between the two values; it may be present in spite of a poor concordance between the two values. In order to estimate the best match between the two values, we performed a concordance study using Bland and Altman's method. The same method was used by Ivars et al.[9] In their work, the bias was +35 g for T1 and -23 g for T2. These results are similar to ours with a bias of +39.4 g for T1 and 19.4 g for T2. However, in our study, the limits of agreement were quite large so we have to improve these results.

Hadlock's formula used in our study is mainly used for singletons;[3] this subject has been discussed by many authors. For example, Ong et al.[10] compared several mathematical formulas EFW in twin pregnancies and did not find significant differences. Diaz-Garcia et al.[11] compared several formulas and found that Hadlock 2 was the most effective with the best proportion of estimates within 10% of the actual BW and a better prediction of TWD. As a conclusion, Hadlock formula would be a valid method for EFW in twin pregnancies.

Twin's weight discordance is considered to be moderate when it ranges from 25 to 30% and severe when it exceeds 30%.[4] This specific situation to multiple pregnancies is associated with high risk of morbidity and perinatal mortality[12,13] requiring monthly ultrasound monitoring to detect any growth abnormal-

Table 3. Performance of ultrasound in prenatal diagnosis of twin's weight discordance according to the adopted threshold.

	Sensitivity	Specificity	PPV	NPV
Threshold ≥%20	76.9%	81.8%	62%	93.5%
Threshold ≥%25	**81.5%**	**89.2%**	**74%**	**95.4%**

ities in time and consequently adapt obstetrical management. Doe example, almost all obstetrical teams recommend cesarean section since TWD is higher than 30% or in case of severe IUGR.[12] The prevalence of TWD varies according to the definition adopted; it is found in 10–29% of twin pregnancies.[6] In literature, the threshold adopted to define twins discordance ranges from 10 to 40%,[4] but 20% is the threshold commonly used.[10]

Ultrasound is the gold standard exam in prenatal screening of TWD.[6] Its performance depends on the adopted threshold. Thus, Mottet et al.,[4] in a series of 67 twin pregnancies found that the sensitivity of ultrasound is 80% for the detection of severe discordance (threshold ≥35%) and it decreases to 41% in case of moderate discordance (threshold ≥25%) and decreases to 20% in case of slight discordance (threshold ≥20%).[12] We report similar findings and we found that the performance of ultrasound decreases for a threshold of 20%. However, we found a higher sensitivity (>70%) in each used threshold. These results should be confirmed by a larger number of cases. Several groups have proposed other methods to improve sonographic prenatal diagnosis of TWD.[14,15] For example, Erkkola et al.[14] used the cephalic circumference but the PPV was low. Other authors have used the abdominal circumference (AC). They found the same sensitivity as using EFW.[16] Storlazzi et al.[7] have used other parameters to define the discrepancy as a difference of BIP >6 mm; a difference of CA >20 mm; femur length >5 mm. But the best predictive value was found using EFW.[7] Finally, and because of these low PPV, other studies proposed to associate biometric parameters to fetal Doppler to improve the performance of Us in the diagnosis of TWD and to better target fetuses at risk.[17,18]

In the other side, the NPV of ultrasound in screening TWD is excellent.[5] This could lead to the identification of twin pregnancies at lower risk and thus avoid excessive monitoring. LBW is the leading cause of infant mortality in the world. Approximately 40% of twins are born before 37 weeks and 20 to 30% are small for gestational age. Thus, prematurity and IUGR increase the incidence of LBW to 50–60%.[19] In this work, Us was relevant to predict LBW with a PPV 85% and a NPV 90%. These results should be confirmed in a larger series especially since in the literature, low PPV is often reported as 22–47%.[20,9]

Considering maternal and fetal factors that may affect the performance of ultrasound EFW, we studied: maternal obesity, chorionicity and fetal presentation. We concluded that any factor had a significant impact. Literature data are controversial. For example, about maternal obesity, some studies conclude that obesity leads to an overestimation of EFW.[21] Other authors[22] do not find significant differences between obese and non-obese patients. Finally, Ivars et al.[9] concluded that maternal obesity increases the performance of ultrasound. This may seem surprising; obesity being experienced in our daily practice as a difficulty. These conflicting results may be explained by differences in BW in obese and non-obese patients, or by using a more powerful ultrasound machine or sonographer's experience. A study measuring the time required to perform a twin's weight estimation in case of maternal obesity may improve our conclusion.

The chorionicity should be determined during the first trimester ultrasound, because this will determine the subsequent monitoring. For Ivars et al.,[9] chorionicity does not affect EFWs. On the other hand, and according to the same team,[9] the term was found as a factor positively influencing EFW (p=0.012) before 32 weeks. Finally, in literature, fetal presentation is not known to affect the performance of the US estimations.[23]

Conclusion

Ultrasound is essential in the diagnosis and management of perinatal complications common in twins. Its performance in the estimation of fetal weight is satisfactory; it allows anticipation and better management of neonatal premature births. However, its performance in the diagnosis of growth discordance is limited in terms of positive predictive value. On the other hand, the negative predictive value is excellent. This could lead to the identification of twin pregnancies at lower risk and thus prevent excessive obstetrical care.

Conflicts of Interest: No conflicts declared.

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