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Evaluation of the Screening Performance of Ultrasonographic Abdominal Circumference and Estimated Fetal Weight in Predicting Small for Gestational Age Newborns

Yusuf DAL[1], Fatih AKKUS[2], Sebnem KARAGUN[1], Ahmet Zeki NESSAR[1], Sefanur Gamze KARACA[1], Hakan AYTAN[3], Ayhan COSKUN[1]

Mersin, Türkiye

ABSTRACT

OBJECTIVES: We aimed to evaluate the screening performance of estimated fetal weight (EFW) and abdominal circumference (AC) measurements in predicting newborns with birth weight (BW) less than the 10th percentile for birth age (BW <10p).

STUDY DESIGN: Three hundred thirty-one pregnant women who met the inclusion and exclusion criteria were included in this retrospective cohort study. The groups were divided into two groups: those diagnosed with FGR (FGR group) and those not diagnosed (non-FGR)after the 32nd week of gestation. Demographic and obstetric histories, ultrasonographic and clinical features, and neonatal outcomes of the groups were recorded, and comparisons between the groups were conducted. The screening performances of AC and EFW were compared for predicting newborns with BW<10p and assessing neonatal outcomes.

RESULTS: AC or EFW measures below 10% (AC<10p or EFW<10p) demonstrated the highest screening performance for BW<10p, with 91.7% sensitivity and 91% specificity. AC<10p demonstrated the highest performance in predicting neonatal intensive care unit (NICU) admission, with 75.9% sensitivity and 89.1% specificity. For neonates with a 5-minute APGAR score of less than 7, AC<10p or EFW<10p had 88.2% sensitivity and 69.7% specificity.

CONCLUSION: This study shows that AC and EFW measurements can be used together or separately to predict newborns who are small for their gestational age (SGA). Using values below 10% of either AC or EFW together gives the best results in terms of sensitivity and specificity.

Keywords: Abdominal circumference; Estimated fetal weight; Fetal growth restriction; Small for gestational age newborn

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[1] *Department of Obstetrics and Gynecology, Division of Perinatology, Mersin University Faculty of Medicine, Mersin, Türkiye*
[2] *Department of Obstetrics and Gynecology, Division of Perinatology, Necmettin Erbakan University Faculty of Medicine, Konya, Türkiye*
[3] *Department of Obstetrics and Gynecology, Mersin University Faculty of Medicine, Mersin, Türkiye*

Address of Correspondence: *Yusuf Dal*
Department of Obstetrics and Gynecology, Perinatology Department, Mersin University Faculty of Medicine, TR-33110, Mersin, Türkiye
dryusufdal@gmail.com

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OCID IDs of the authors:
FA: 0000-0001-7037-9165 *YD: 0000-0001-7162-4644*
AZN: 0000-0003-2985-0212 *SK: 0000-0003-2339-1609*
HA: 0000-0002-2553-7715 *SGK: 0000-0003-1595-2621*
AC: 0000-0002-2887-9649

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Introduction

Fetal growth restriction (FGR) is a common complication of pregnancy that can lead to adverse perinatal outcomes (1). Various maternal, fetal, and placental events are involved in the etiology of FGR (2). Although it is estimated to occur in up to 10% of pregnancies, the actual prevalence is not clear, as the prevalence may depend on the definition used, the individualized growth potential of each fetus is not always taken into account or used, and we cannot always identify fetuses that are structurally small but without an underlying pathology (1).

There is uncertainty about the definition of FGR, and the optimal definition is a matter of debate. The most important reason for these uncertainties is terminological inconsistencies. The most obvious reason for the confusion in the definition is the difficulty in distinguishing between a fetus that is structurally small and meets its growth potential and a small fetus that cannot realize its growth potential due to the underlying pathological condition (1). Previously, ultrasonographic estimated fetal weight (EFW) less than the 10th percentile for gestational age (EFW<10p) was defined as FGR; however, in

recent years, various associations have proposed a change to include isolated abdominal circumference (AC) measurements less than the 10th percentile for gestational age (AC<10p) (1-3).

Various studies have compared the diagnostic value of EFW and AC measurements in detecting small-for-gestational-age (SGA) newborns, and these studies have yielded different results (4-9). In this study, we aimed to evaluate the screening performance of EFW and AC measurements used in the diagnosis of FGR in predicting newborns with birth weight (BW) below the 10th percentile for birth age (BW<10p).

Material and Method

This retrospective cohort study was conducted between January 2021 and January 2024 at a tertiary center, one of the main referral hospitals for high-risk pregnancies in the region. The study utilized electronic and ultrasonographic measurement records of pregnant women, both with and without a diagnosis of FGR. The local ethics committee approved the study on December 13, 2023 (Decision No. 2023/870). All procedures involving human participants were conducted in accordance with the ethical standards of the 1964 Helsinki Declaration and its later amendments in 2000. Written, informed consent was obtained from all participants.

Patient selection: The inclusion criteria for this study are singleton pregnancies, both with and without a diagnosis of FGR, after the 32nd week of gestation. FGR was diagnosed according to The American College of Obstetricians and Gynecologists (ACOG) criteria (ultrasonographic EFW or AC <10th percentile according to gestational week), updated in 2021 (1). The groups comprised pregnant women whose gestational ages were matched within the same period. Exclusion criteria were those diagnosed with FGR before the 32nd week of gestation; multiple pregnancies; major structural anomalies; placental anomalies; those with missing ultrasonographic measurements and demographic data; fetuses with incomplete medical records; and aneuploidies and syndromes.

Data and measurements: Baseline data collected for analysis included age and obstetric history; gestational week; body mass index (BMI); history of FGR in previous pregnancies; smoking status; maternal medical history; gestational week at diagnosis; ultrasonographic characteristics (millimeters (mm) and percentiles of AC, grams and percentiles of EFW, deepest vertical pocket of amniotic fluid (DVP), umbilical artery Doppler findings; gestational age at delivery; mode of delivery; neonatal outcomes (BW and BW percentile, fetal sex, APGAR scores at 1 and 5 minutes, fetal gender and 5th minute APGAR scores, umbilical cord pH values, NICU admission status). The gestational week was confirmed based on a reliable last menstrual date, first-trimester crown-rump length, or early second-trimester biparietal diameter (BPD). The timing criteria were in accordance with the Society for Maternal-Fetal Medicine (SMFM) and ACOG recommendations (10).

A Samsung HS60 ultrasound machine (Samsung Medison Co., Ltd., Seoul, Korea) with a 2-5 MHz convex probe was used for all measurements. All scans were performed by maternal-fetal medicine specialists according to standardized fetal biometry guidelines (11). BPD, head circumference (HC), AC, and femur length (FL) were obtained adhering to standard recommendations for fetal biometric measurements. EFW was calculated from these four parameters using the Hadlock formula (12). EFW and AC percentiles were calculated according to Fetal Medicine Foundation (FMF) fetal and neonatal population weight charts (13). A Doppler evaluation of the umbilical artery was performed in all cases. Assessment results were calculated from the free-floating portion of the umbilical cord. For the assessment of amniotic fluid, the DVP without umbilical cords or fetal parts was measured. DVP≤2.0 cm was considered a decrease in amniotic fluid volume; DVP>2 cm and ≤8.0 cm were considered normal amniotic fluid volumes; and DVP>8 cm was considered an increase in amniotic fluid volume (11). Newborn SGA was diagnosed with a birth weight <10th percentile for gestational age according to the Alexander birth weight chart (14).

Statistical analysis

Statistical analyses of this study were performed using the programs Statistical Package for Social Sciences (SPSS) version 22 and Jamovi (version 2.3). Kolmogorov-Smirnov and Shapiro-Wilk tests were used to assess the conformity of the data to a normal distribution. Data conforming to the normal distribution were presented as mean ± standard deviation (SD), and data deviating from the normal distribution were presented as median (min-max). Categorical data are expressed as n (%). An independent t-test was used for continuous data with a normal distribution, the Mann-Whitney U test was used for data deviating from the normal distribution, and the Chi-square or Fisher's exact test was used to compare two groups for categorical data. The diagnostic performance of different percentiles of AC and EFW in the diagnosis of BW<10p was evaluated by receiver operating characteristic (ROC) analysis in Jamovi software (15). Sensitivity, specificity, positive, and negative predictive values (PPV and NPV), false-positive rate (FPR), Youden's index, area under the curve (AUC), and 95% confidence interval were obtained from the ROC analysis. In addition, the performance of AC and EFW, when used separately or together, in predicting NICU admission and a 5-minute APGAR score below 7 was compared. The statistical significance level was set at $p<0.05$.

Results

The study included 331 pregnant women, 221 of whom received no FGR diagnosis at any gestational week (non-FGR group), and 110 of whom received an FGR diagnosis after 32

weeks of gestation (FGR group). Table I compares the sociodemographic and maternal characteristics between the groups. There were no statistically significant differences between the groups in terms of maternal age, gravida, parity, height, weight, and BMI (p values 0.236, 0.241, 0.384, 0.403, 0.929, and 0.780, respectively). The history of FGR in previous pregnancies was significantly higher in the FGR group (21.8% vs. 4.5%, p=0.001). Smoking was observed in 21.8% of mothers in the FGR group, compared to 7.2% in the non-FGR group (p=0.001). Maternal medical conditions, including chronic hypertension, pregestational diabetes, and the combination of chronic hypertension and pregestational diabetes, were significantly more common in the FGR group (p=0.001). There was no significant difference between the two groups regarding hematologic, neurologic, cardiac, thyroid, and renal diseases.

Table II shows a comparison of the groups' clinical and ultrasound measurement characteristics. The FGR group had a rate of 80.9% with sufficient amniotic fluid, while the non-FGR group had a rate of 94.1%. The distributions of oligohydramnios and anhydramnios showed significant differences (p=0.001). In umbilical artery Doppler findings, the rate of normal findings was 72.7% in the FGR group and 99.5% in the non-FGR group (p=0.001). The FGR group exhibited higher rates of loss of flow and reverse flow findings. In the FGR group, the mean gestational week and cesarean section rates were also significantly different (36.92±2.07 vs. 38.16±1.30 for mean gestational week, p=0.001, and 53.6% vs. 34.4% for cesarean section rate, p=0.001).

The FGR group had a significantly lower mean body weight (2421.55±387.54 grams vs. 3163.98±361.31 grams for BW, p=0.001; 7 (range 1 to 17) vs. 48 (range 6 to 99) for BW percentile, p=0.001). In terms of the SGA rate, it was 3.6% in the non-FGR group and increased to 80.9% in the FGR group (p=0.001). There was no statistically significant difference between the groups in terms of fetal gender (p=0.079). 1st and 5th minute APGAR scores were significantly lower in the FGR group (p=0.001 for both). Umbilical cord pH values were significantly lower in the FGR group (7.23±0.17 vs. 7.32±0.06, p=0.001). The median time from diagnosis to delivery was calculated as 14 days for both groups, but the range was 0 to 49 days in the non-FGR group and 0 to 42 days in the FGR group, and this difference was found to be statistically significant (p=0.002). The study found a statistically significant difference (p=0.001) between the NICU admission rates of 7.7% in the non-FGR group and 60% in the FGR group (Table III).

Table IV shows how the use of AC and EFW measurements performs in predicting BW<10p. If AC was below 3%, sensitivity was determined as 38.1%, specificity as 100%, FPR as 0%, PPV as 100%, and NPV as 79.5%. If AC was

Table I: *Sociodemographic and maternal characteristics of the groups.*

		Non-FGR (n=221)	FGR (n=110)	p
Age (year)		29.56±5.27	30.33±6.03	0.236*
Gravidity		2.62±1.24	2.80±1.54	0.241*
Parity		1 (0-5)	1 (0-6)	0.384**
Height (cm)		162.38±5.94	161.81±5.48	0.403*
Weight (kg)		68.67±12.32	68.55±12.67	0.929*
BMI (kg/m^2)		25.96±4.66	26.11±4.30	0.780*
History of FGR (OR:2.4)		10 (4.5%)	24 (21.8%)	**0.001*** **
Smoking (OR:1.7)		16 (7.2%)	24 (21.8%)	**0.001*** **
Maternal medical condition	No disease	183 (82.8%)[a]	67 (60.9%)[b]	**0.001*** **
	Chronic hypertension	13 (5.9%)[a]	15 (13.6%)[b]	
	Pregestational diabetes	4 (1.8%)[a]	11 (10.0%)[b]	
	Chronic hypertension + Pregestational diabetes	0 (0.0%)[a]	2 (1.8%)[b]	
	Hematologic disease	7 (3.2%)[a]	3 (2.7%)[a]	
	Neurological disease	5 (2.3%)[a]	3 (2.7%)[a]	
	Cardiac disease	3 (1.4%)[a]	5 (4.5%)[a]	
	Thyroid disease	4 (1.8%)[a]	1 (0.9%)[a]	
	Renal disease	2 (0.9%)[a]	3 (2.7%)[a]	

*FGR, Fetal growth restriction; cm, Centimeter; kg/m^2, Kilogram/square meter; OR, Odds ratio. *Independent t test, **Mann-Whitney U test, ***Chi-square test. a-b The same letters indicate that there is no statistical difference; different letters indicate that there is a statistical difference. A value of p<0.05 is significant. Bold p values indicate statistical significance.*

Table II: *Comparison of clinical and ultrasound measurement features in pregnancies with and without fetal growth restriction.*

		Non-FGR (n=221)	FGR (n=110)	p
Gestational week		35.92±1.74	35.26±2.15	0.003*
AC (mm)		314.72±19.32	277.45±19.79	0.001*
AC (percentile)		41 (10-97)	6 (1-20)	0.001**
EFW (gram)		2730.47±403.21	2152.39±378.72	0.001*
EFW (percentile)		48 (10-97)	8 (1-19)	0.001**
Amniotic fluid volume (DVP)	Normal	208 (94.1%)[a]	89 (80.9%)[b]	0.001***
	Oligohydramnios	6 (2.7%)[a]	15 (13.6%)[b]	
	Anhydroamniosis	2 (0.9%)[a]	6 (5.5%)[b]	
	Polyhydroamniosis	5 (2.3%)[a]	0 (0.0%)[a]	
Umbilical artery Doppler	Normal	220 (99.5%)[a]	80 (72.7%)[b]	0.001***
	Absent end-diastolic velocity	0 (0.0%)[a]	20 (18.2%)[b]	
	Reversed end-diastolic velocity	1 (0.5%)[a]	10 (9.1%)[b]	
Birth week		38.16±1.30	36.92±2.07	0.001*
Cesarean section rate (OR:1.3)		76 (34.4%)	59 (53.6%)	0.001***

*FGR, fetal growth restriction; mm, millimeter; DVP, deepest vertical pocket; OR, odds ratio. *Independent t test, **Mann-Whitney U test, ***Chi-square test. a-bThe same letters indicate that there is no statistical difference; different letters indicate that there is a statistical difference. A value of p<0.05 is significant. Bold p values indicate statistical significance.*

Table III:. *Comparison of neonatal characteristics of the groups.*

		Non-FGR (n=221) (n=221)	FGR (n=110)	p **0.001***
Birth weight (grams)		3163.98±361.31	2421.55±387.54	**0.001****
Birth weight (percentile)		48 (6-99)	7 (1-17)	**0.001*****
SGA rate (OR:11.03)		8 (3.6%)	89 (80.9%)	
Fetal gender	Male	110 (49.8%)	66 (60.0%)	0.079***
	Female	111 (50.2%)	44 (40.0%)	
APGAR score 1st minute		8 (3-9)	6 (0-9)	**0.001****
APGAR score at 5th minute		9 (6-10)	8 (0-10)	**0.001****
Umbilical cord pH		7.32±0.06	7.23±0.17	**0.001***
Diagnosis to delivery (day)		14 (0-49)	14 (0-42)	**0.002****
NICU admission (OR:4.01)		17 (7.7%)	66 (60.0%)	**0.001*****

*FGR, fetal growth restriction; SGA, small for gestational age; NICU, neonatal intensive care unit; OR, odds ratio. *Independent t test, **Mann-Whitney U test, ***Chi-square test. A value of p<0.05 is significant. Bold p values indicate statistical significance.*

Table IV: *Evaluation of abdominal circumference and estimated fetal weight criteria for SGA screening*

Criteria	Sensitivity (%)	Specificity (%)	FPR	PPV (%)	NPV (%)	AUC (95%CI)
AC<3 percentile	38.1	100.0	0.0	100.0	79.5	0.691 (0.621-0.761)
AC<10 percentile	85.5	97.0	3.0	92.2	94.1	0.913 (0.870-0.956)
EFW<3 percentile	21.6	99.5	0.5	95.4	75.4	0.606 (0.535-0.678)
EFW<10 percentile	63.9	91.8	9.2	76.5	86.0	0.779 (0.717-0.841)
AC<10 percentile and EFW<10 percentile	57.7	97.8	2.2	91.8	84.8	0.778 (0.714-0.842)
AC<10 percentile or EFW<10 percentile	91.7	91.0	9	80.9	96.3	0.914 (0.876-0.952)

SGA, small for gestational age; AC, abdominal circumference; EFW, estimated fetal weight; FPR, false-positive rate; PPV: positive-predictive value; NPV, negative-predictive value; AUC, Area under the curve.

below 10%, it showed a higher performance with sensitivity 85.5%, specificity 97%, FPR 3%, PPV 92.2%, and NPV 94.1%. With EFW below 3%, sensitivity was determined as 21.6%, specificity as 99.5%, FPR as 0.5%, PPV as 95.4%, and NPV as 75.4%. The results obtained with EFW below 10% were found to be 63.9% in sensitivity, 91.8% in specificity, 9.2% in FPR, 76.5% in PPV, and 86.0% in NPV. When AC and EFW measurements are used together (AC<10p and EFW<10p), sensitivity was determined as 57.7%, specificity as 97.8%, FPR as 2.2%, PPV as 91.8%, and NPV as 84.8%. If any of the AC or EFW measurements were less than 10% (AC<10p or EFW<10p), it worked the best, with a sensitivity of 91.7%, a specificity of 91%, an FPR of 9%, a PPV of 80.9%, and an NPV of 96.3% (Figure 1).

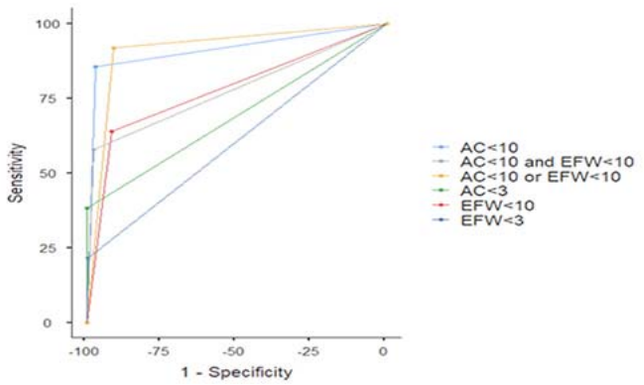

Figure 1: *ROC analysis of abdominal circumference percentiles and estimated fetal weight percentiles to predict SGA.*

Table V shows the screening performance of AC measurement and EFW for NICU admission, as well as a low APGAR score (<7). For NICU admission, the use of AC<10p had the highest AUC value (0.825) with a sensitivity of 75.9% and specificity of 89.1% (Figure 2), whereas for neonates with a 5-minute APGAR score of less than 7, the use of AC<10p or EFW<10p showed the highest AUC value (0.790) with a sensitivity of 88.2% and specificity of 69.7% (Figure 3).

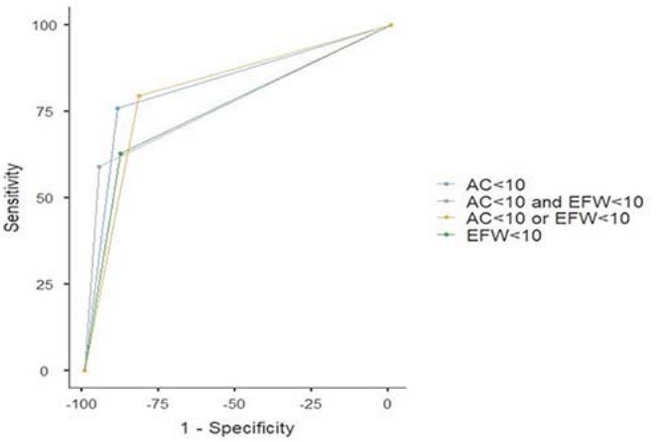

Figure 2: *ROC analysis of abdominal circumference percentiles and estimated fetal weight percentiles to predict NICU admission*

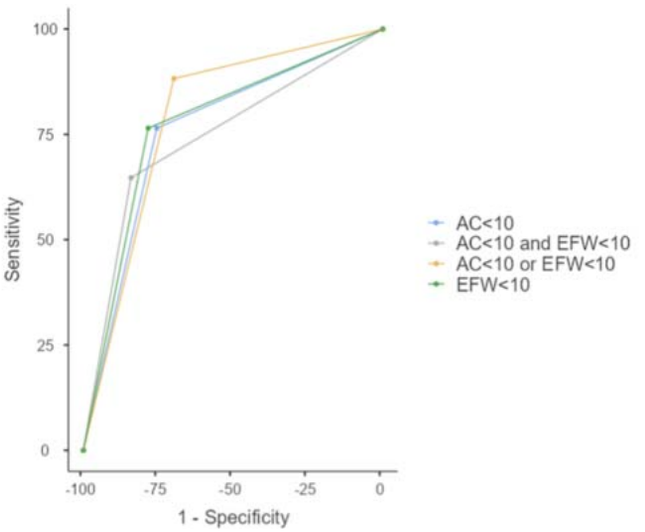

Figure 3*: ROC analysis of abdominal circumference percentiles and estimated fetal weight percentiles to predict 5th minute APGAR score <7*

Table V: *Evaluation of the screening performance of abdominal circumference and estimated fetal weight for NICU admission and low APGAR score (<7).*

For NICU admission	**Sensitivity (%)**	**Specificity (%)**	**FPR**	**PPV (%)**	**NPV (%)**	**AUC (95%CI)**
AC<10 percentile	75.9	89.1	10.9	70.0	91.7	0.825 (0.767-0.884)
EFW<10 percentile	62.6	88.3	11.7	64.2	87.6	0.755 (0.688-0.822)
AC<10 percentile and EFW<10 percentile	59.0	95.1	4.9	80.3	87.4	0.771 (0.703-0.839)
AC<10 percentile or EFW<10 percentile	79.5	82.2	17.8	60.0	92.3	0.809 (0.752-0.866)
For 5th minute APGAR score <7	**Sensitivity (%)**	**Specificity (%)**	**FPR**	**PPV (%)**	**NPV (%)**	**AUC (95%CI)**
AC<10 percentile	76.4	75.4	24.6	14.4	98.3	0.760 (0.640-0.880)
EFW<10 percentile	76.4	78.3	21.7	16.0	98.4	0.774 (0.655-0.894)
AC<10 percentile and EFW<10 percentile	64.7	84.0	16.0	18.0	97.7	0.744 (0.608-0.880)
AC<10 percentile or EFW<10 percentile	88.2	69.7	30.3	13.6	99.1	0.790 (0.693-0.887)

AC, abdominal circumference; EFW, estimated fetal weight; FPR, false-positive rate; PPV: positive-predictive value; NPV, negative-predictive value; AUC, Area under the curve.

Discussion

The uncertainty and lack of consensus regarding the definition of FGR in the literature, as well as inconsistencies between SGA and FGR terminology, may lead to the misdiagnosis of structurally small but healthy babies or the underdiagnosis of potentially vulnerable fetuses. These situations also affect the optimal management of the fetus and create uncertainty about the timing of delivery. Improved ultrasound technology and increased knowledge will allow us to more easily identify these fetuses. In this context, we hypothesized that an ideal AC measurement may be important for the diagnosis of FGR. In our study, we found that the use of AC<10p or EFW<10p values separately according to gestational week provides high sensitivity and specificity for screening newborns with BW<10p compared to the use of each separately.

Different criteria are used for the sonographic diagnosis of FGR in various populations, resulting in varying estimates of SGA neonates and adverse outcomes (16). FGR is generally used to identify small fetuses that have not reached their intrauterine growth potential and are at higher risk of poor perinatal outcomes than normally grown fetuses (17). SGA refers to a newborn with a BW<10p for gestational age, according to either population or customized standard (18). However, newborns, defined as SGA, comprise a heterogeneous population. The BW<10p definition for SGA includes approximately 20% of structurally small but healthy newborns (19,20). Therefore, the terminologies FGR and SGA overlap significantly with each other. However, since not all fetuses with FGR have BW<10p, this definition is difficult to use in practice and may cause uncertainties in management (21,22). Fetuses diagnosed with FGR are not always SGA at birth, and SGA newborns are often diagnosed with growth restriction on prenatal ultrasound (23). In our study, we observed that 89 newborns (80.9%) in the group with FGR and 8 newborns (3.6%) in the group without FGR had BW<10p.

The criteria to be used to define FGR have long been a matter of debate. There is a need for more research to further clarify diagnosis and management. In this process, various studies have been conducted to determine the optimal definition and management. However, it seems that there is no complete consensus in the studies. A systematic review concluded that AC<10p has a higher detection rate than EFW<10p for predicting SGA newborns in low-risk pregnancies (4). Di Lorenzo et al. found that EFW was more strongly associated with SGA and severe SGA than AC in their study of 1,848 singletons between 30 and 33 weeks of gestation (5). In a prospective cohort of 5,515 singleton pregnancies screened at 35-37 weeks of gestation, Fadigas et al. found that EFW outperformed any biometric parameter in predicting SGA and severe SGA (6). A study of 4,702 singleton pregnancies screened at 30 to 34 weeks of gestation reported no difference between AC and EFW in predicting SGA (24). In a similar study, AC and EFW performances were compared for the prediction of FGR, and no difference was found between both parameters (25).

Recent guidelines also state that AC measurement can be used in the diagnosis of FGR. ACOG and SMFM state that EFW or AC should be below the 10th percentile for gestational age for the definition of FGR (1, 2). The diagnostic criteria for FGR also differ between countries. The United Kingdom and Canada use an AC measurement lower than the 10th percentile for diagnosis, and New Zealand uses an AC cut-off point lower than the 5th percentile for diagnosis (26). AC can show a gestational age-appropriate growth pattern compared to other biometric measurements (27). AC growth is also a strong indicator of fetal nutritional status (28). Therefore, we thought that an optimal ultrasonographic AC measurement could make a significant contribution to the diagnosis of FGR. In our study, we found that we can underestimate fetuses with BW<10p when only EFW<10p is used for diagnosis, and that AC<10p has a better predictive value than EFW<10p. Additionally, when EFW and AC measurements are used separately for diagnosis, we can predict fetuses with BW<10p. We found that AC<10p may show better screening performance for fetuses. In their study by Rad et al., where they investigated various definitions of FGR as screening tests for SGA, sensitivity and AUC were 50.68% and 0.743, respectively, when EFW <10p was used as the definition for the diagnosis of FGR. When AC <10p was used, these were determined to be 64.2% and 0.806. When AC<10p or EFW<10p was used, sensitivity and AUC were found to be 67.5% and 0.821, respectively, and AUC was at its highest value when AC<10p or EFW<10p was used as the FGR definition (9). In the studies of Pressman et al., the definition of EFW<10p or AC<10p had the highest sensitivity for detecting neonatal SGA, followed by the definition of AC<10p, and finally the definition of EFW<10p (29).

In our study, the potential benefits of AC and EFW measurements in determining the risk of NICU admission and low APGAR scores were also investigated. We found that the AC<10p criterion may have the best performance in screening newborns for NICU admission. We found that newborns with a 5th-minute APGAR score below 7 have better predictive value when AC<10p or EFW<10p criteria are used separately. A study has shown that an AC growth rate below the 10th percentile is a risk factor for adverse perinatal outcomes in SGA fetuses (30). Cavallaro et al. also reported an association between fetal AC growth rate and adverse perinatal outcomes in SGA neonates. They suggested that the AC growth rate may contribute to a decrease in false-positive results (31).

Limitations of our study: The retrospective design of this single-center study may limit the generalizability of the results to other populations. The study's strength lies in its execution at a tertiary care center, a professional and effective NICU for

risky pregnancies. Although the exclusion of FGR before the 32nd week of gestation (early-onset FGR) could be considered a limitation, we anticipate that varying gestational weeks will impact fetal growth and development differently. Therefore, the strength of our study is that only FGRs were included after the 32nd week of gestation (late-onset FGR). Additionally, other strengths include the application of standardized protocols for all patients, the homogeneity of the study groups, and the large number of variables investigated.

Conclusion

Therefore, determining appropriate follow-up methods, identifying fetuses that won't benefit from waiting, and determining when to intervene all depend on a complete diagnosis of FGR. Although the results of EFW components may vary among evaluators, AC measured on an appropriate cross-section may be more consistent. Our study found that performance for predicting neonatal SGA was significantly improved using the combination of EFW<10p or AC<10p compared to using either independently. Additionally, our study showed that the AC percentile may have predictive value for neonatal outcomes. To confirm these findings, large-scale prospective studies involving other assessment methods and larger populations may be useful.

Declarations

Ethics approval and consent to participate: All participants signed informed written consent before being enrolled in the study. The study was reviewed and approved by the ethics committee of Mersin University (Ethics approval reference number: 2023/870, date 13.12.2023). All procedures were performed according to the Declaration of Helsinki.

Availability of data and materials: The data supporting this study is available through the corresponding author upon reasonable request.

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Authors' contributions: YD., AC.: Concept, author, design, data processing, analysis, and interpretation. YD., FA., HA.: Analysis and interpretation, design, statistical analysis. AZN., SGK.: Data collection, processing, analysis. YD., ŞK.: Audit, statistical analysis, design. AC., HA., FA.: Control, concept. All authors read and approved the final manuscript.

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