OBSTETRICS

Maternal rest improves growth in small-for-gestational-age fetuses (<10th percentile)

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BACKGROUND: Optimal management of fetuses diagnosed as small for gestational age based on an estimated fetal weight of <10th percentile represents a major clinical problem. The standard approach is to increase fetal surveillance with serial biometry and antepartum testing to assess fetal well-being and timing of delivery. Observational studies have indicated that maternal rest in the left lateral position improves maternal cardiac output and uterine blood flow. However, maternal bed rest has not been recommended based on the results of a randomized clinical trial that showed that maternal rest does not improve fetal growth in small-for-gestational-age fetuses. This study was conducted to revisit this question.

OBJECTIVE: This study aimed to determine whether maternal bed rest was associated with an increase in the fetal biometric parameters that reflect growth after the diagnosis of a small-for-gestational-age fetus.

STUDY DESIGN: A retrospective study was conducted on fetuses who were diagnosed as small for gestational age because of an estimated fetal weight of <10th percentile for gestational age. The mothers were asked to rest in the left lateral recumbent position. Fetal biometry was performed 2 weeks after the diagnosis. All fetuses before entry into the study had a previous ultrasound that demonstrated an estimated fetal weight of >10th percentile. To assess the response to bed rest, the change in fetal biometric parameters (estimated fetal weight, head circumference, abdominal circumference, and femur length) after the recommendation of bed rest was computed for 2 periods: (1) before the diagnosis of a weight of <10th percentile vs at the time of diagnosis of a weight of <10th percentile and (2) at the time of diagnosis of a weight of <10th percentile vs 2 weeks after maternal bed rest. For repeated measures, proportions were compared using the McNemar test, and percentile values were compared using the Bonferroni Multiple Comparison Test. A *P* value of <.05 was considered significant. To describe changes in the estimated fetal weight without bed rest, 2 control groups in which the mothers were not placed on bed rest after the diagnosis of a small-for-gestational-age fetus were included.

RESULTS: A total of 265 fetuses were observed before and after maternal bed rest. The following were observed in this study: (1) after 2 weeks of maternal rest, 199 of 265 fetuses (75%) had a fetal weight of >10th percentile; (2) the median fetal weight percentile increased from 6.8 (interquartile range, 4.4—8.4) to 18.0 (interquartile range, 9.5—29.5) after 2 weeks of bed rest; (3) similar trends were noted for the head circumference, abdominal circumference, and femur length. In the groups of patients who were not asked to be on bed rest, a reassignment to a weight of >10th percentile at a follow-up examination only occurred in 7 of 37 patients (19%) in the Texas-Michigan group and 13 of 111 patients (12%) in the Colorado group compared with the bed rest group (199/265 [75%]) (*P*<.001).

CONCLUSION: Patients who were prescribed 2 weeks of bed rest after the diagnosis of a fetal weight of <10th percentile had an increase in weight of >10th percentile in 199 of 265 fetuses (75%). This increase in fetal weight was significantly higher than that in the 2 control groups in which bed rest was not prescribed. This observation suggests that bed rest improves fetal growth in a subset of patients.

Key words: abdominal circumference, bed rest, Doppler velocimetry, estimated fetal weight, femur length, fetal growth restriction, head circumference, left lateral recumbent position, longitudinal study, middle cerebral artery, small for gestational age, umbilical artery

Introduction

Optimal management of fetuses diagnosed as small for gestational age (SGA) based on an estimated fetal weight (EFW) of <10th percentile represents a major clinical problem.[1–10] The standard approach is to increase fetal surveillance with serial biometry[4,11–15] and antepartum testing to assess fetal well-being (fetal heart rate monitoring, biophysical profile, amniotic fluid volume, Doppler velocimetry, and cardiac function)[1,16–21] and timing of delivery.[1,22–26] Observational studies have indicated that maternal rest in the left lateral position improves maternal cardiac output and uterine blood flow.[27–31] However, maternal bed rest has not been recommended on the basis of the results of a randomized clinical trial that showed that maternal rest does not improve fetal growth in SGA fetuses.[32] As a result of this study, professional societies (the American College of Obstetricians and Gynecologists [ACOG],[22] the Society for Maternal-Fetal Medicine [SMFM],[23] the International Federation of Gynecology and Obstetrics [FIGO],[24] and the International Society of Ultrasound in Obstetrics and Gynecology [ISUOG])[25] do not recommend maternal rest for the management of the fetus with an EFW of <10th percentile. This study aimed to determine the effect of complete maternal rest in patients with an SGA fetus.

Materials and Methods

Study design

This was a retrospective longitudinal study of patients with SGA fetuses with

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AJOG at a Glance

Why was this study conducted?

This study aimed to determine whether bed rest can improve growth in small-for-gestational-age fetuses (fetal weight of <10th percentile).

Key findings

After bed rest, 199 of 265 fetuses (75%) with an estimated fetal weight (EFW) of <10th percentile increased their weight to >10th percentile. The median EFW percentiles were 6.8 (interquartile range, 4.4—8.4) before maternal bed rest and 18 (interquartile range, 9.5—29.5) after maternal bed rest.

What does this add to what is known?

To date, the role of maternal bed rest in improving fetal growth remains unknown. Bed rest in the left lateral position has been shown to improve maternal cardiac output and uterine blood flow. Our study reports that patients who are prescribed bed rest in the left lateral position show an improved growth of the following fetal biometric parameters: head circumference, abdominal circumference, femur length, and EFW.

an EFW of <10th percentile who had a second ultrasound examination 2 weeks after the SGA diagnosis. The overall design of the study consisted of examining the changes in dimensions of fetal biometric parameters, including EFW, head circumference (HC), abdominal circumference (AC), and femur length (FL), before the diagnosis of an SGA fetus, at the time of diagnosis of SGA, and 2 weeks after bed rest was prescribed. This retrospective study included 2 control groups of patients from centers that did not prescribe bed rest after the diagnosis of an SGA fetus.

Bed rest group

Fetuses with a diagnosis of an EFW of <10th percentile were identified using an ultrasound database (Sonultra, Los Angeles, CA). Pregnant patients were referred for fetal ultrasound examination by their healthcare provider between 2005 and 2021 to 1 of 3 outpatient maternal-fetal medicine imaging centers located in Pasadena, Tarzana, and Lancaster, California. The referring obstetricians were from a large geographic area that included obstetrical delivery facilities at 8 hospitals in Los Angeles County.

The HC, AC, and FL were measured using standard techniques. Gestational age was determined from ultrasound measurements of the crown-rump length in the first trimester of pregnancy and/or from the biparietal diameter, HC, AC, and FL in the second trimester of pregnancy.[33] Using the Hadlock equation,[34,35] the EFW and corresponding weight percentile[36] were computed from the HC, AC, and FL. Evaluation of EFW, HC, AC, and FL percentiles; placental location; and screening for structural malformations were performed during the second and third trimesters of pregnancy.[33,34,36] Fetuses with structural malformations were excluded from the study. All third-trimester fetuses underwent pulsed Doppler evaluation of the umbilical artery, after which the resistance index (RI) was measured and classified as abnormal if the values were >95th percentile.[37] The middle cerebral artery pulse wave Doppler (RI) was measured and classified as abnormal if <5th percentile.[38] Once a fetus with an EFW of <10th percentile was identified, the following recommendations were made to the mother: (1) begin lying in the left lateral recumbent position and avoiding the supine position during the waking

TABLE 1
Demographics of the study and control groups

Variable	Bed rest group (n=265)	Texas-Michigan study group (n=37)	Colorado study group (n=111)
Maternal age (y)	31.0±6.6	29.7±9.8	28.7±5.4
Maternal race			
White	156 (59%)	24 (65%)	96 (86%)
African American	16 (6%)	11 (30%)	7 (6%)
Asian	19 (6%)	3 (8%)	4 (4%)
Hispanic	74 (28%)	5 (14%)	—
Other	—	3 (8%)	7 (6%)
Parity			
0	187 (71%)	19 (51%)	55 (50%)
1	47 (18%)	12 (32%)	31 (28%)
2	25 (9%)	4 (11%)	20 (18%)
>3	7 (3%)	3 (8%)	8 (7%)
Hypertensive disorders	4 (2%)	7 (19%)	7 (6%)
Diabetes mellitus	6 (2%)	2 (5%)	1 (1%)
Thyroid disease	3 (1%)	1 (3%)	9 (8%)

Data are presented as mean±standard deviation or number (percentage).
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TABLE 2
Ultrasound findings of the 3 study groups

Abnormal findings	Bed rest group (n=265)	Texas-Michigan study group (n=37)	Colorado study group (n=111)
Umbilical artery Doppler resistance			
Abnormal umbilical artery RI of >95th percentile[37]	20 (8%)	6 (16%)	15 (14%)
Absent or reverse diastolic velocity of the umbilical artery	3 (1%)	1 (3%)	0 (0%)
Normalization of umbilical artery RI after bed rest	6 (2%)	N/A	N/A
Middle cerebral artery Doppler resistance			
Middle cerebral artery RI[38]	27 (10%)	6 (16%)	6 (5%)
Normalization of the middle cerebral artery RI after bed rest	10 (4%)	N/A	N/A
Uterine artery notching			
Bilateral notching	21 (8%)	10 (27%)	8 (7%)
Unilateral notching	23 (9%)	4 (11%)	1 (1%)
Fetal cardiac dysfunction			
Right of left ventricular disproportion	19 (8%)	4 (11%)	13 (12%)
Tricuspid regurgitation	7 (3%)	N/A	7 (6%)
Right-sided pericardial effusion	39 (15%)	10 (27%)	12 (11%)
Amniotic fluid index			
<5 cm	29 (11%)	1 (3%)	1 (1%)

N/A, not available; *RI*, resistance index.
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hours; (2) at the end of every hour of resting, arise, walk, stretch, and attend to personal needs for 5 to 10 minutes; and (3) return 2 weeks after the initiation of maternal rest for ultrasound assessment of fetal growth. Monitoring of patient compliance following the recommendation for maternal rest occurred through verbal communication between the physician and patient during the follow-up ultrasound examination. The analysis of the data was approved by the Pearl Institutional Review Board (Pearl IRB number: 23-FEDC-103).

TABLE 3
Gestational age in weeks for the bed rest and control groups

Variable	Quartile measurements		
Weeks of gestation	25th	50th	75th
Bed rest group			
Before the diagnosis of SGA	19.2	22.6	27.6
At the time of diagnosis of SGA	27.7	31.6	33.0
2 wk after maternal bed rest	30.2	33.6	35.5
Texas-Michigan control group			
At the time of diagnosis of SGA	27.0	30.0	33.0
2 wk after maternal bed rest	30.0	33.0	35.0
Colorado control group			
At the time of diagnosis of SGA	26.0	29.0	31.0
2 wk after maternal bed rest	30.0	32.0	34.0

SGA, small for gestational age.
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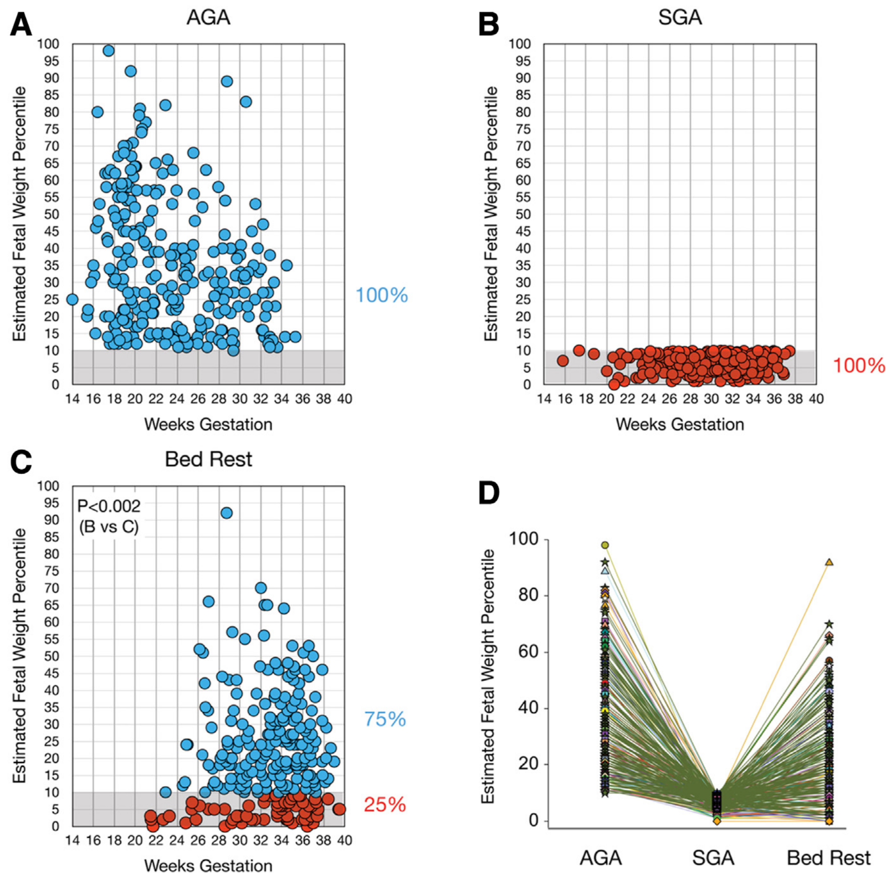
Control group

The control group consisted of 2 cohorts, one at sea level and one at 5000 feet above sea level, in which an EFW of <10th percentile was identified but the patients were not asked to begin maternal rest. These 2 cohorts were part of ongoing studies of fetal growth in which the first author (G.R.D.) had participated as a consultant and was familiar with the study design for both groups in which maternal rest was not offered after the diagnosis of an EFW of <10th percentile (the Texas-Michigan cohort [n=37; Baylor IRB criteria: H-45622; approved on May 11, 2021] and the Colorado cohort [n=111; COMIRB number: 14-1360; approved on May 29, 2015]).

FIGURE 1
EFW percentile values plotted against gestational age



A, Distribution of the EFW percentiles in AGA fetuses before the diagnosis of an EFW of <10th percentile. **B,** Distribution of the EFW percentiles at the time of the diagnosis of an EFW of <10th percentile in SGA fetuses SGA. **C,** Distribution of EFW percentile measurements after 2 weeks of maternal rest. **D,** Percentile plots for each fetus. The *blue dots* are values >10th percentile, and the *red dots* are values <10th percentile.

AGA, appropriate for gestational age; *EFW*, estimated fetal weight; *SGA*, small for gestational age.

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Statistical analysis for the intervention group

The EFW, HC, AC, and FL percentile measurements for each fetus were graphically plotted vs gestational age for the following periods: (1) examination before the diagnosis of an EFW of <10th percentile in which the fetuses were appropriate for gestational age (AGA); (2) at the time of diagnosis of an EFW of <10th percentile or SGA; and (3) 2 weeks after the initiation of maternal rest. Using the McNemar analysis, fetuses for each of the following groups were analyzed: (1) before diagnosis (AGA) vs diagnosis of an EFW of <10th percentile (SGA) and (2) diagnosis of an EFW of <10th percentile (SGA) vs 2 weeks after the initiation of maternal rest. A *P* value of <.05 was considered significant.

The median, 25th percentile, and 75th percentile were computed for each of the percentiles for the EFW, HC, AC, and FL before the diagnosis of an EFW of <10th percentile (AGA), at the time of diagnosis of an EFW of <10th percentile (SGA), and after bed rest. Using the nonparametric Bonferroni Multiple Comparison Test (NCSS 22, Kaysville, UT), the percentile measurements for the EFW, HC, AC, and FL were compared for the abovementioned periods. A *P* value of <.05 was considered significant. To examine the effect of gestational age on the EFW percentiles for each of the abovementioned periods, restricted cubic splines were used to determine the contribution of the effect of gestational age (R; version 4.2.3; R Foundation for Statistical Computing, Vienna, Austria, 2023).

The frequency in which SGA fetuses in the 2 control centers, which did not recommend bed rest, were reassigned by an EFW of <10th or >10th percentile after 3 weeks after the diagnosis of an SGA fetus. The proportion of reassignments was compared with the bed rest group using chi-square analysis. A *P* value of <.05 was considered significant.

Results

Bed rest group

There were 265 patients assigned to the bed rest group. The clinical characteristics of patients in this group are presented in Table 1, and the ultrasound findings are presented in Table 2.[37,38] Neonatal information was not available for analysis.

The gestational ages at which patients underwent ultrasound examination before the diagnosis of SGA, at the time of diagnosis of SGA, and 2 weeks after bed rest are displayed in Table 3. There was no significant contribution of gestational age to the EFW percentile measurements.

Changes in biometric parameter percentiles before and after bed rest

Estimated fetal weight. The individual values for the EFW percentiles for each fetus are plotted in Figure 1, A to C. The change in percentiles for each fetus is illustrated in Figure 1, D. By design, all fetuses were AGA with an EFW of >10th percentile before the diagnosis of SGA. After 2 weeks of maternal rest, 199 of 265 fetuses (75%) had an EFW of >10th percentile. (McNemar test, *P*<.001). The median percentile increased from 6.8 (interquartile range [IQR], 4.4—8.4) to 18.0 (IQR, 9.5—29.5) (Bonferroni Multiple Comparison Test, *P*<.05) (Table 4 and Figure 2).

TABLE 4
Distribution of the percentile for biometric parameters before the diagnosis of SGA, at the time of diagnosis, and 2 weeks after bed rest for all fetuses who were exposed to maternal bed rest (n=265)

Variable	Quartile measurements		
Estimated fetal weight percentile	25th	50th	75th
Before the diagnosis of SGA	19.0	32.0	48.0
At the time of diagnosis of SGA	4.4	6.8	8.4
2 wk after maternal bed rest	9.5	18.0	29.5
Abdominal circumference percentile			
Before the diagnosis of SGA	22.5	34.0	49.0
At the time of diagnosis of SGA	2.0	5.0	8.8
2 wk after maternal bed rest	6.0	17.0	31.5
Head circumference percentile			
Before the diagnosis of SGA	24.0	38.0	48.0
At the time of diagnosis of SGA	11.0	29.9	43.7
2 wk after maternal bed rest	18.0	33.0	47.0
Femur length percentile			
Before the diagnosis of SGA	22.0	36.0	52.0
At the time of diagnosis of SGA	4.0	9.7	18.0
2 wk after maternal bed rest	7.0	18.0	34.5

The percentiles were derived from the corresponding *z* score of each biometric parameter.

SGA, small for gestational age.

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Abdominal circumference. The individual values for the AC percentiles for each fetus are plotted in Figure 3, A to C. The change in percentiles for each fetus is illustrated in Figure 3, D. Of note, 245 of 265 AGA fetuses (92%) had an AC of >10th percentile before the diagnosis of SGA, which decreased to 45 of 265 fetuses (17%) at the time of diagnosis of SGA. After 2 weeks of maternal rest, 177 of 265 fetuses (67%) had an AC of >10th percentile (McNemar test, $P<.001$). After maternal bed rest, the median AC percentile increased from 5.0 (IQR, 2.0−8.8) to 17.0 (IQR, 6.0−31.5) (Bonferroni Multiple Comparison Test, $P<.05$) (Table 4 and Figure 2).

Head circumference. The individual values for the HC percentiles for each fetus are plotted in Figure 4, A to C. The change in percentiles for each fetus is illustrated in Figure 4, D. Of note, 255 of 265 AGA fetuses (96%) had an HC of >10th percentile before the diagnosis of SGA, which decreased to 208 of 265 fetuses (78%) at the time of diagnosis of SGA. After 2 weeks of maternal rest, 227 of 265 fetuses (86%) had an HC of >10th percentile (McNemar test, $P<.006$). After maternal bed rest, the median HC percentile increased from 29.9 (IQR, 11.0−43.7) to 33.0 (IQR, 18.0−47.0) (Kruskal Wallis for repeated measures, $P<.05$) (Table 4 and Figure 2).

Femur length. The FL percentiles for each fetus are plotted in Figure 5, A to C. The change in percentiles for each fetus is illustrated in Figure 5, D. Of note, 253 of 265 AGA fetuses (95%) had an FL of >10th percentile before the diagnosis of SGA, which decreased to 131 of 265 fetuses (49%) at the time of diagnosis of SGA. After 2 weeks of maternal rest, 187 of 265 fetuses (71%) had an FL of >10th percentile (McNemar test, $P<.006$). After maternal bed rest, the median FL percentile increased from 9.7 (IQR, 4.0−18.0) to 18.0 (IQR, 7.0−34.5) (Bonferroni Multiple Comparison Test, $P<.05$) (Table 4 and Figure 2).

Comparison between the intervention and the control groups diagnosed with an estimated fetal weight of <10th percentile in which maternal rest was not part of the clinical recommendations

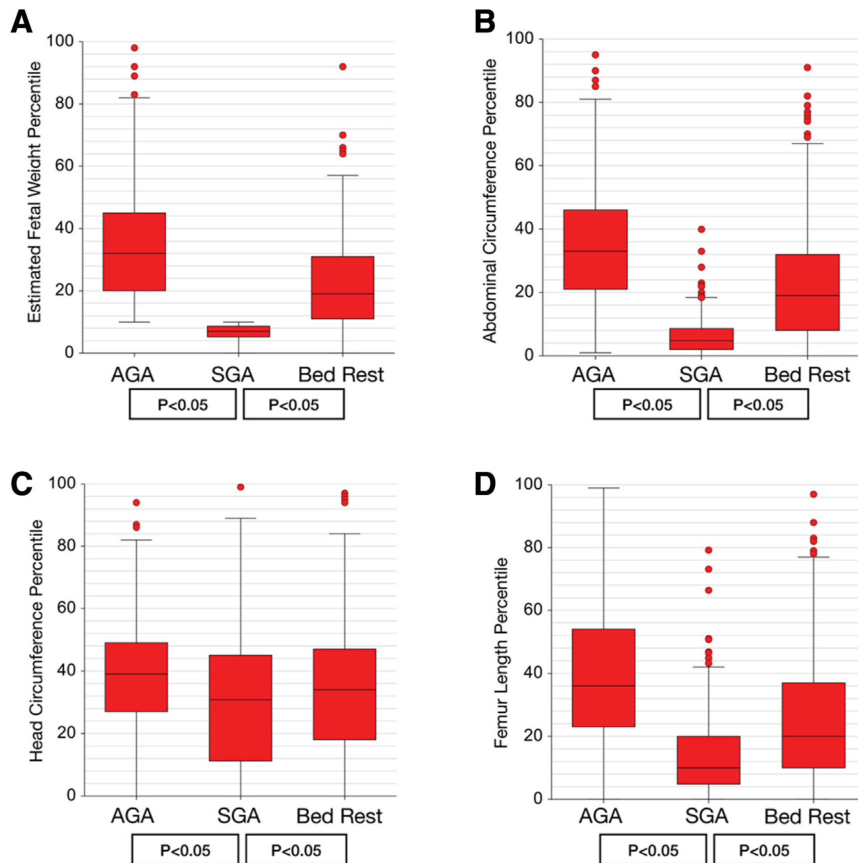
The clinical characteristics of patients in the control groups are summarized in Table 1, and the ultrasound findings are summarized in Table 2.[37,38] The Texas-Michigan cohort identified 37 fetuses using the same diagnostic criteria as those in the bed rest group with an EFW of <10th percentile. The gestational ages at which patients underwent ultrasound examination at the time of diagnosis and 3 weeks after the diagnosis in patients who were not prescribed bed rest are presented in Table 3. Of the 37 fetuses with an EFW of <10th percentile, only 7 (19%) became AGA after the diagnosis of SGA, which is significantly lower than the 199 of 265 fetuses (75%) in the bed rest group ($P<.001$).

In the Colorado study group, 111 fetuses were identified using the same diagnostic criteria as those in the bed rest group. The gestational ages at which patients underwent ultrasound examination at the time of diagnosis and 3 weeks after the diagnosis in patients who were not prescribed bed rest are presented in Table 3. Of the 111 fetuses diagnosed with SGA, 13 (12%) became AGA at the follow-up examination. This was significantly less than in the bed rest group (13/111 [12%] in the Colorado study group vs 199/265 [75%] in the bed rest group; $P<.001$).

Growth trends following the initiation of maternal rest

Figure 6 illustrates 3 examples of EFW growth profiles and the corresponding percentage and number of fetuses in each group. Figure 6, A, demonstrates a sustained acceleration of growth of the EFW of >10th percentile after the implementation of maternal rest (168 [63%]). Figure 6, B, demonstrates fetuses who increased their growth of the

FIGURE 2
Box and whiskers plots



The mean, 25th percentile, and 75th percentile are displayed from the quartile distribution of the percentile measurements for the estimated fetal weight (**A**), abdominal circumference (**B**), head circumference (**C**), and femur length (**D**).

AGA, appropriate for gestational age; *SGA*, small for gestational age.

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EFW along the growth curve but remained below the 10th percentile after the implementation of maternal rest (49 [19%]). Figure 6, C, demonstrates fetuses who increased their EFW after maternal rest but had a deceleration of the EFW at the time of the last examination (48 [18%]).

Discussion

Principal findings

First, fetuses with an EFW of <10th percentile had a response to maternal rest in which 199 of 265 fetuses (75%) had increased EFW of >10th percentile. Second, in 265 fetuses, there was a significant increase in the number with measurements >10th percentile after maternal rest for the HC, AC, and FL. Third, in fetuses with an EFW of <10th percentile from the control groups in which the patients were not placed at maternal rest after the diagnosis of an EFW of <10th percentile, there was a significantly lower percentage who demonstrated an increase in the EFW of >10th percentile for the Texas-Michigan cohort (7/37 [19%]) and the Colorado cohort (13/111 [12%]) at the follow-up examination than the study cohort of 199 of 265 fetuses (75%) ($P<.0001$). Comparing these 2 cohorts with the bed rest group suggests that the increase in fetal growth at the 2-week follow-up examination may be the result of maternal rest.

Results in the context of what is known

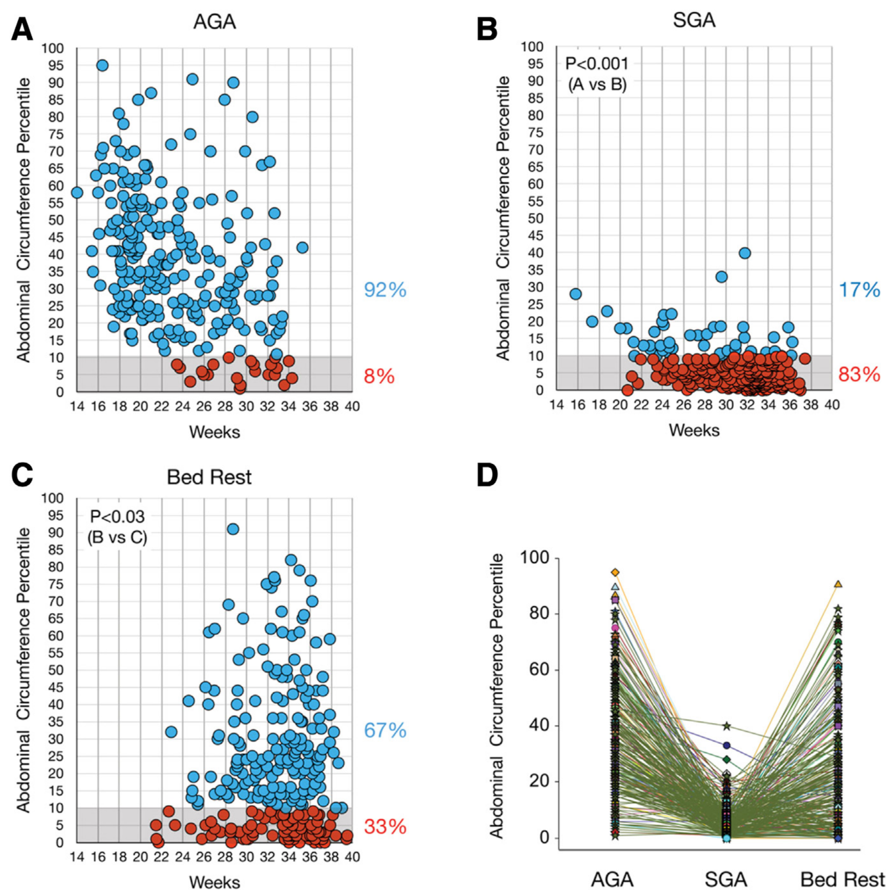
The Cochrane Library reviewed the effect of bed rest on fetal growth in 1996, 2010, and 2020 and found only 1 study published in 1987 by Laurin and Persson,[32] who evaluated 107 patients whose EFW was <2 standard deviations below the mean. Of the 107 patients, 49 were placed on complete bed rest in the hospital, and 58 were evaluated as outpatients who were instructed to rest only on weekends.[32] The fetuses were evaluated at 2-week intervals. There was no significant difference in the mean EFW before delivery between hospitalized and ambulatory patients.[32] The authors concluded that in-hospital bed rest was not beneficial for improved fetal growth or pregnancy outcome.[32,39] This study referenced in the Cochrane review has been cited in publications by the SMFM, FIGO, and the German Society of Gynecology and Obstetrics,[23,24,32,40] as support for suggesting that maternal rest does not improve fetal growth after the diagnosis of a fetus with an EFW of <10th percentile.

Although bed rest has been prescribed for several obstetrical complications, in general, the evidence of the benefit of bed rest has not been shown to be beneficial and has been the subject of controversy in the medical and nonmedical literature.[41–45] Currently, there is no option that has demonstrated improvement in growth in fetuses with an EFW of <10th percentile.[45] In a recent study, Roberts et al[46] reported improved neonatal outcomes in fetuses who were diagnosed with growth restriction after 26 weeks of gestation and had resolution of growth restriction before delivery. The current study suggests that there may be a role for maternal bed rest that could increase growth to >10th percentile in fetuses with an original diagnosis of an EFW of <10th percentile.

Response of the head and abdominal circumferences and femur length to maternal rest

Head circumference. During growth restriction, there is an increase in blood

FIGURE 3
AC percentile values plotted against gestational age



A, Distribution of the AC percentiles in AGA fetuses before the diagnosis of an EFW of <10th percentile. **B,** Distribution of the AC percentiles at the time of the diagnosis of an EFW of <10th percentile in SGA fetuses. **C,** Distribution of AC percentile measurements after 2 weeks of maternal rest. **D,** Percentile plots for each fetus. The *blue dots* are values >10th percentile, and the *red dots* are values <10th percentile.

AC, abdominal circumference; *AGA*, appropriate for gestational age; *EFW*, estimated fetal weight; *SGA*, small for gestational age.

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flow to the brain, which is first detectable in the anterior cerebral artery, followed by the middle cerebral artery, and finally the posterior cerebral artery.[47,48] When the pathologic process is sustained, brain growth deceleration may occur, which manifests as a decrease in the HC. Unlike the AC, the HC demonstrated less of a decrease in growth from before the diagnosis to the diagnosis of an EFW of <10th percentile, suggesting that brain sparing occurs in some of the fetuses.

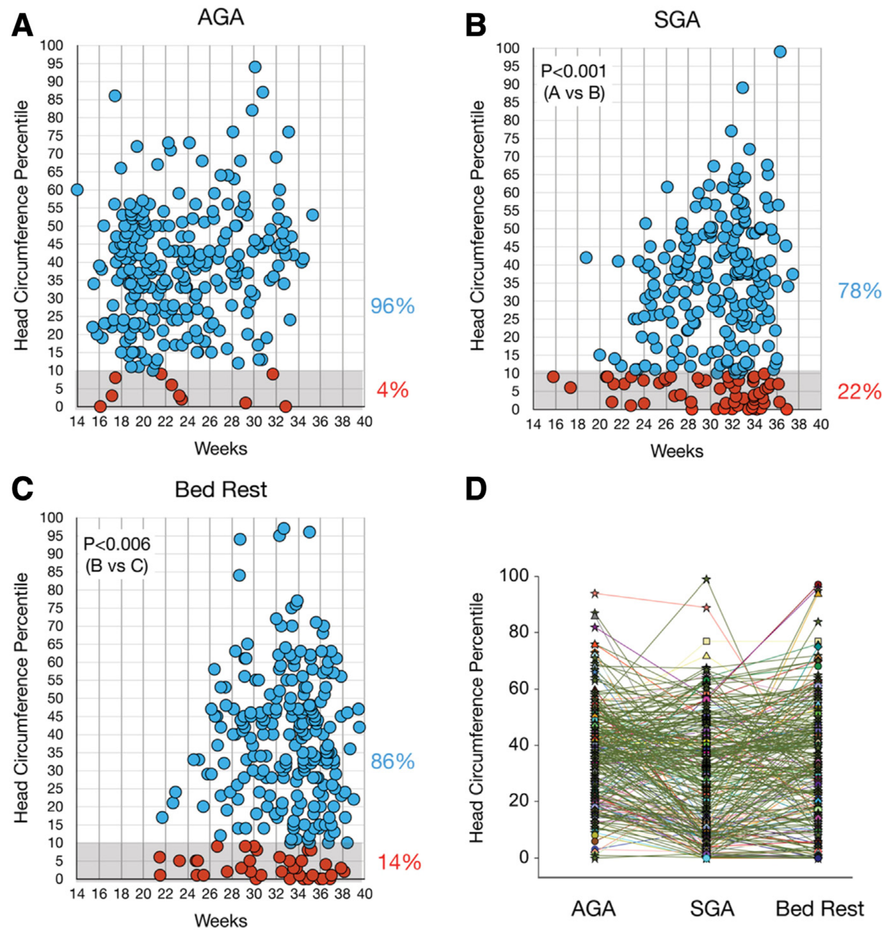
Abdominal circumference. After maternal rest, the AC significantly increased to >10th percentile. Because of parallel circulation,[49] the fetus distributes blood from the right ventricle to the ductus arteriosus into the descending aorta, whereas the left ventricle provides blood to the upper body and brain. As a result of placental dysfunction, blood may be shunted away from the liver to the right atrium, resulting in decreased growth of the liver, which is the main organ comprising the image obtained for AC measurement. In 2022, Marchand et al[50] examined 1316 fetuses with an EFW of <10th percentile to determine which biometric measurements (HC, BPD, AC, and FL) and ratios (FL-to-AC and HC-to-AC) predicted an abnormal fetal weight. Between 34 and 39 weeks of gestation, the AC was the best predictor of a fetus with an EFW of <10th percentile (sensitivity of 90%, specificity of 91%, positive predictive value of 74%, and negative predictive value of 97%).[50] These findings were consistent with previous observations that the AC is the most frequent biometric measurement that changes with growth restriction.[51]

Femur length. At the time of diagnosis of an EFW of <10th percentile, the percentage of fetuses with an FL of <10th percentile was the second most common abnormal measurement other than decreased AC. In 2012, Goetzinger et al[52] reported a small FL that was associated with decreased growth and premature delivery. In the current study, an FL of <10th percentile at the time of diagnosis of an EFW of <10th percentile significantly improved after maternal rest.

The rationale for resting in the left lateral position

As changes in blood flow to the maternal heart result in compression of the inferior vena cava (IVC) when the pregnant patient is supine, investigators using magnetic resonance imaging (MRI) have examined the effect of placing the patient in the left lateral position.[27] In a study by Higuchi et al[27] in 2015, it was reported that there was no increase in IVC blood flow when the patient went from the supine position to a 15° left lateral tilt (3.2 vs 3.0 mL). However, there was a significant increase in IVC blood flow using a 30° left lateral tilt (3.2 vs 11.5 mL) and a 45° left lateral tilt (3.2 vs 10.9 mL).[27] Although there are several techniques to measure stroke volume and cardiac output,[28] investigators using Doppler ultrasound and MRI have reported that cardiac output is decreased in the supine position compared with the left lateral position.[29–31] In an MRI study by Rossi et al,[31] the authors examined pregnant women at 20 weeks of gestation and reported a significant increase in ejection fraction (8%) and stroke volume (27%) of the left ventricle when the patient was in the left lateral position compared with the supine position. At 32 weeks of gestation, there

FIGURE 4
HC percentile values plotted against gestational age



A, Distribution of the HC percentiles in AGA fetuses before the diagnosis of an EFW of <10th percentile. **B,** Distribution of the HC percentiles at the time of the diagnosis of an EFW of <10th percentile in SGA fetuses. **C,** Distribution of HC percentile measurements after 2 weeks of maternal rest. **D,** Percentile plots for each fetus. The *blue dots* are values >10th percentile, and the *red dots* are values <10th percentile.

AGA, appropriate for gestational age; *EFW*, estimated fetal weight; *HC*, head circumference; *SGA*, small for gestational age.

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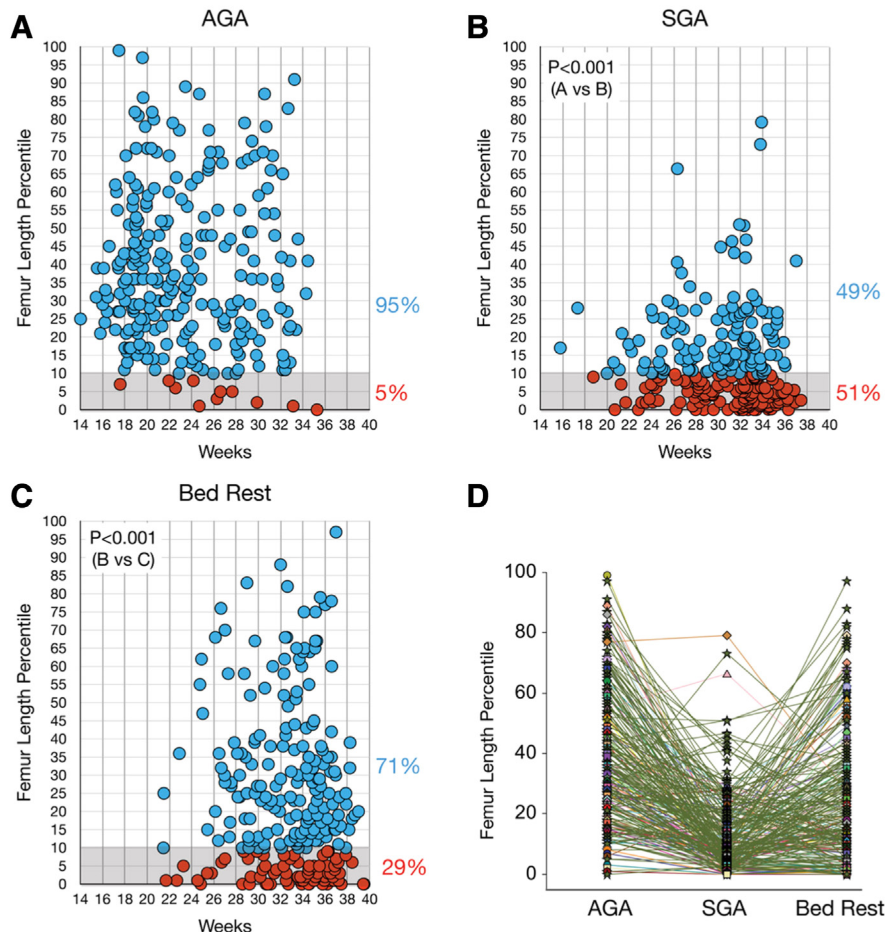
was a significant increase in ejection fraction (11%), end-diastolic volume (21%), stroke volume (35%), and cardiac output (24%) when the patient was in the left lateral position compared with the supine position.[31] In a recent study by Couper et al[53] using MRI to evaluate blood flow in the maternal, placental, and fetal circulations, the left lateral maternal position resulted in increased blood flow and delivery of oxygen to the fetus compared with the supine position. Investigators have reported an increase in the fetal middle cerebral artery pulsatility index when patients were in the left lateral position in both high-risk and low-risk pregnancies.[54] In addition, the fetal urine production and amniotic fluid index have been demonstrated to increase when the patient went from the supine position to the left lateral position.[55,56]

In a recent study by Ling et al[57] in 2021, the authors measured maternal cardiac output, systemic vascular resistance, EFW, and cerebroplacental ratio throughout pregnancy and classified the results by fetal weight groups (<10th percentile, 10th to 19.99th percentile, 20th to 29.99th percentile, 30th to 69.99th percentile, and 70th to 99th percentile). Although the sequential change in cardiac output was similar for all fetal weights as a function of gestational age, fetuses with an EFW of <10th percentile had the lowest maternal cardiac output measured during the third trimester of pregnancy compared with those with weights of >10th percentile.[57] As maternal cardiac output is the lowest when the EFW is <10th percentile, there is a potential to increase maternal cardiac output in this group of fetuses by maternal resting in the left lateral recumbent position.

Problems with the maternal supine position when resting

When patients were requested to begin maternal rest after the diagnosis of an EFW of <10th percentile, 1 option was resting in either the supine position or the left lateral position. Supine maternal rest has been reported not to be advantageous for pregnant women. In 1964, Kerr et al[58] reported that the IVC was obstructed when the third-trimester pregnant patient was in the supine position, resulting in venous flow returning to the heart by way of ascending lumbar veins and the complex of veins surrounding the spinal canal that coalesced with the ascending azygous vein. In 2021, Hughes et al[59] reported findings from an MRI study of the IVC and found that the spinal venous plexus increased its blood flow when the patient was supine and the IVC flow was decreased, thus maintaining adequate blood flow to the heart. These findings are in contrast to what Ueland et al[60] reported in 1969, namely, that there was little change in cardiac output between the supine position and the left lateral position until 24 weeks of pregnancy, after which the cardiac output decreased in the late third trimester of pregnancy for the supine position. The change in cardiac output was the result of decreased stroke volume, as the heart rate remained constant.[60] These findings have recently been reaffirmed in a study of 400 pregnant women in which using the suprasternal notch to measure cardiac blood flow demonstrated an increase in heart rate during pregnancy and a decreased

FIGURE 5
FL percentile values plotted against gestational age



A, Distribution of the FL percentiles in AGA fetuses before the diagnosis of an EFW of <10th percentile. **B,** Distribution of the FL percentiles at the time of the diagnosis of an EFW of <10th percentile in SGA fetuses. **C,** Distribution of FL percentile measurements after 2 weeks of maternal rest. **D,** Percentile plots for each fetus. The *blue dots* are values >10th percentile, and the *red dots* are values <10th percentile.

AGA, appropriate for gestational age; *EFW*, estimated fetal weight; *FL*, femur length; *SGA*, small for gestational age.

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stroke volume in the third trimester of pregnancy with a corresponding decrease in cardiac output.[61] In addition, investigators have reported that sleeping in the supine position was associated with a decrease in fetal weight and an increase in the stillbirth rate.[62–69]

Clinical implications

Although the ACOG, SMFM, ISUOG, and FIGO referenced a study conducted in 1987 that found no difference in fetal growth for 107 patients who had been placed on hospital rest or who were ambulatory with resting only on weekends, there is a paucity of research examining whether maternal rest in the left lateral recumbent position improves growth when the EFW is <10th percentile.[23–25,40] The current study is relevant because it examines the effect of maternal rest when fetuses are identified with an EFW of <10th percentile. All 265 fetuses in the bed rest group had a previous EFW of >10th percentile, thus demonstrating a deceleration of growth and separating them from fetuses who were constitutionally small. In the current study, 199 of 265 fetuses (75%) in the bed rest group accelerated their EFW to >10th percentile.

Research implications

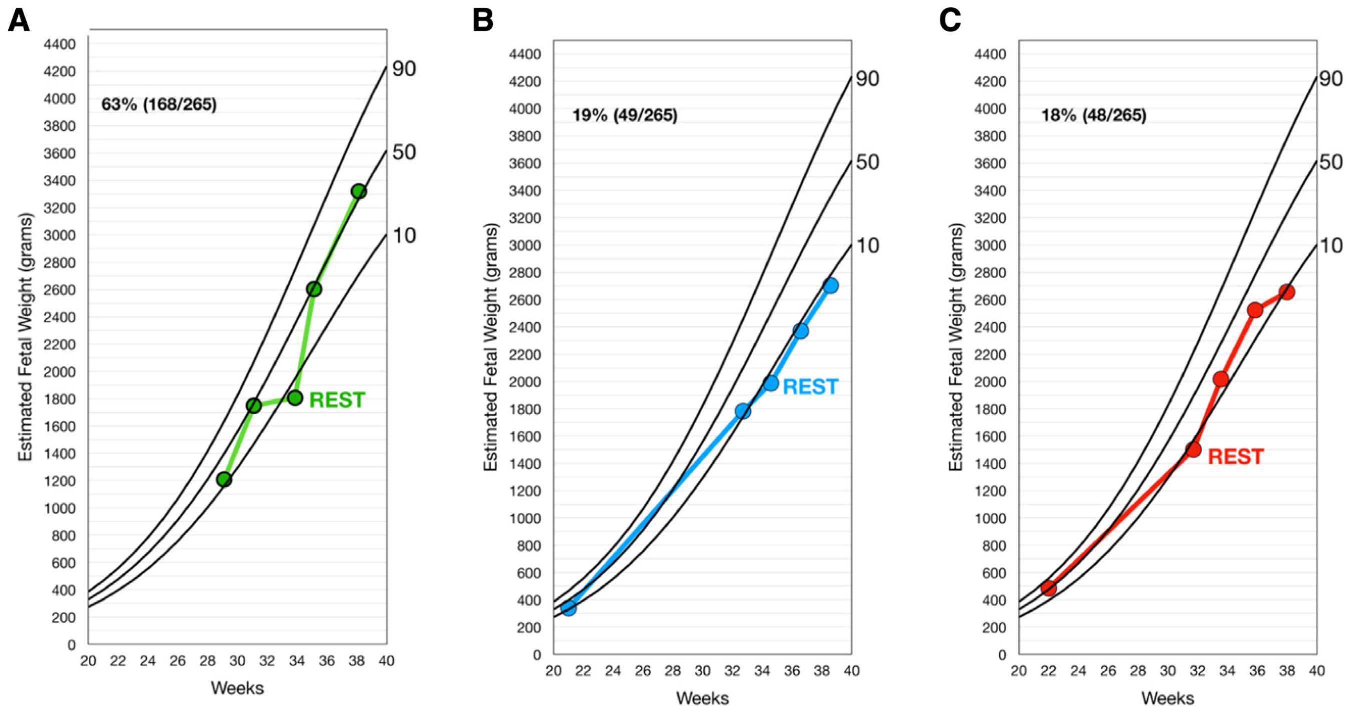
The current study suggests that bed rest in the left lateral position is an effective intervention to improve growth with an EFW of <10th percentile. It is important to identify the amount of rest required to observe an acceleration of fetal growth of >10th percentile. If a significant increase in the EFW percentile could occur with fewer hours of rest, that would be preferable for the patient. Therefore, randomized studies could examine the effect of various durations of rest to determine the fetal response. In addition, studies could examine whether maternal rest improves neonatal outcomes in this group of fetuses.[70–72] Finally, as fetal programming of the cardiovascular system occurs when fetuses have an EFW of <10th percentile, it would be important to evaluate those newborns who responded to maternal rest while in utero to determine whether improved fetal growth resulted in a decrease of the postnatal cardiovascular and other changes associated with poor fetal growth.[73–79]

Strengths and limitations

The strength of the current study is the number of fetuses with an EFW of <10th percentile who were identified to be normal before the development of an EFW of <10th percentile. In addition, the clinical recommendations for maternal rest were consistent for each patient. There were several limitations:

1. There was no allocation of fetuses from the California bed rest group to a control group of non–bed rest patients because of the first author's preference for recommending maternal rest from his clinical experience and the results of a survey in which bed rest was recommended by maternal-fetal medicine specialists in 1994.[80]
2. There was no neonatal follow-up. Therefore, the effect of bed rest on neonatal outcomes remains unknown.

FIGURE 6
The 3 common growth trends after the initiation of maternal bed rest



The percentage and number of fetuses for each category are listed for all fetuses with an EFW of <10th percentile. **A,** The EFW accelerated >10th percentile after maternal bed rest and maintained the growth >10th percentile (168 [63%]). **B,** The EFW did not accelerate >10th percentile after maternal bed rest but maintained a normal rate of growth (49 [19%]). **C,** The EFW growth rate decelerated at the last examination (48 [18%]).

EFW, estimated fetal weight.

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3. Compliance was not assessed other than by verbal inquiry at the follow-up examination 2 weeks after the diagnosis of an EFW of <10th percentile.
4. No result of antepartum testing was available.

Although the study might be considered as "hypothesis generating," a randomized controlled study would be appropriate to test the hypothesis that bed rest improves fetal growth when the EFW is <10th percentile.

Conclusions

Our results suggest that maternal bed rest increases growth in a subset of fetuses with an EFW of <10th percentile.

References

1. Lees CC, Romero R, Stampalija T, et al. Clinical Opinion: the diagnosis and management of suspected fetal growth restriction: an evidence-based approach. Am J Obstet Gynecol 2022;226:366–78.
2. Leon-Martinez D, Lundsberg LS, Culhane J, Zhang J, Son M, Reddy UM. Fetal growth restriction and small for gestational age as predictors of neonatal morbidity: which growth nomogram to use? Am J Obstet Gynecol 2023;229:678.e1–16.
3. Stampalija T, Wolf H, Mylrea-Foley B, et al. Reduced fetal growth velocity and weight loss are associated with adverse perinatal outcome in fetuses at risk of growth restriction. Am J Obstet Gynecol 2023;228(71):e1–10.
4. Gardosi J, Hugh O. Stillbirth risk and smallness for gestational age according to Hadlock, INTERGROWTH-21st, WHO, and GROW fetal weight standards: analysis by maternal ethnicity and body mass index. Am J Obstet Gynecol 2023;229:547.e1–13.
5. Baschat AA. Pathophysiology of fetal growth restriction: implications for diagnosis and surveillance. Obstet Gynecol Surv 2004;59:617–27.
6. Baschat AA. Arterial and venous Doppler in the diagnosis and management of early onset fetal growth restriction. Early Hum Dev 2005;81:877–87.
7. Baschat AA. Planning management and delivery of the growth-restricted fetus. Best Pract Res Clin Obstet Gynaecol 2018;49:53–65.
8. Baschat AA, Galan HL, Bhide A, et al. Doppler and biophysical assessment in growth restricted fetuses: distribution of test results. Ultrasound Obstet Gynecol 2006;27:41–7.
9. Deter RL, Dicker P, Lee W, et al. Growth patterns and cardiovascular abnormalities in SGA fetuses: 2. Normal growth and progressive growth restriction. J Matern Fetal Neonatal Med 2022;35:2818–27.
10. Ananth CV, Vintzileos AM. Distinguishing pathological from constitutional small for gestational age births in population-based studies. Early Hum Dev 2009;85:653–8.
11. Hiersch L, Melamed N. Fetal growth velocity and body proportion in the assessment of growth. Am J Obstet Gynecol 2018;218:S700–11.e1.
12. Pacora P, Romero R, Jung E, et al. Reduced fetal growth velocity precedes antepartum fetal death. Ultrasound Obstet Gynecol 2021;57:942–52.
13. Bommarito PA, Cantonwine DE, Stevens DR, et al. An application of group-based trajectory modeling to define fetal growth phenotypes among small-for-gestational-age births

in the LIFECODES Fetal Growth Study. Am J Obstet Gynecol 2023;228:334.e1–21.
14. Hugh O, Cowan J, Butler E, Gardosi J. Fetal size vs growth: comparative analysis of 3 models of growth velocity based on third trimester estimated fetal weights for identifying stillbirth risk. Am J Obstet Gynecol 2023 [Epub ahead of print].
15. Butler E, Hugh O, Gardosi J. Evaluating the Growth Assessment Protocol for stillbirth prevention: progress and challenges. J Perinat Med 2022;50:737–47.
16. Baschat AA, Galan HL, Lee W, et al. The role of the fetal biophysical profile in the management of fetal growth restriction. Am J Obstet Gynecol 2022;226:475–86.
17. DeVore GR, Gumina DL, Hobbins JC. Assessment of ventricular contractility in fetuses with an estimated fetal weight less than the tenth centile. Am J Obstet Gynecol 2019;221:498.e1–22.
18. Hobbins JC, Gumina DL, Zaretsky MV, Driver C, Wilcox A, DeVore GR. Size and shape of the four-chamber view of the fetal heart in fetuses with an estimated fetal weight less than the tenth centile. Am J Obstet Gynecol 2019;221:495.e1–9.
19. Galan HL, Ferrazzi E, Hobbins JC. Intrauterine growth restriction (IUGR): biometric and Doppler assessment. Prenat Diagn 2002;22:331–7.
20. Rial-Crestelo M, Velasco-Santiago AR, Lubusky M, et al. Effect of maternal and fetal characteristics in feto-placental Doppler and impact of using adjusted standards in the definition of fetal growth restriction at term. Fetal Diagn Ther 2021;48:596–602.
21. Meler E, Mazarico E, Eixarch E, et al. Ten-year experience of protocol-based management of small-for-gestational-age fetuses: perinatal outcome in late-pregnancy cases diagnosed after 32 weeks. Ultrasound Obstet Gynecol 2021;57:62–9.
22. Fetal growth restriction: ACOG practice bulletin, number 227. Obstet Gynecol 2021;137:e16–28.
23. Society for Maternal-Fetal Medicine (SMFM), Martins JG, Biggio JR, Abuhamad A. Society for maternal-fetal medicine consult series #52: diagnosis and management of fetal growth restriction: (Replaces Clinical Guideline Number 3, April 2012). Am J Obstet Gynecol 2020;223:B2–17.
24. Melamed N, Baschat A, Yinon Y, et al. FIGO (international Federation of Gynecology and Obstetrics) initiative on fetal growth: best practice advice for screening, diagnosis, and management of fetal growth restriction. Int J Gynecol Obstet 2021;152(Suppl1):3–57.
25. Lees CC, Stampalija T, Baschat A, et al. ISUOG Practice Guidelines: diagnosis and management of small-for-gestational-age fetus and fetal growth restriction. Ultrasound Obstet Gynecol 2020;56:298–312.
26. Galan HL. Timing delivery of the growth-restricted fetus. Semin Perinatol 2011;35:262–9.
27. Higuchi H, Takagi S, Zhang K, Furui I, Ozaki M. Effect of lateral tilt angle on the volume of the abdominal aorta and inferior vena cava in pregnant and nonpregnant women determined by magnetic resonance imaging. Anesthesiology 2015;122:286–93.
28. Bijl RC, Valensise H, Novelli GP, et al. Methods and considerations concerning cardiac output measurement in pregnant women: recommendations of the International Working Group on Maternal Hemodynamics. Ultrasound Obstet Gynecol 2019;54:35–50.
29. Lee SW, Khaw KS, Ngan Kee WD, Leung TY, Critchley LA. Haemodynamic effects from aortocaval compression at different angles of lateral tilt in non-labouring term pregnant women. Br J Anaesth 2012;109:950–6.
30. Nelson DB, Stewart RD, Matulevicius SA, et al. The effects of maternal position and habitus on maternal cardiovascular parameters as measured by cardiac magnetic resonance. Am J Perinatol 2015;32:1318–23.
31. Rossi A, Cornette J, Johnson MR, et al. Quantitative cardiovascular magnetic resonance in pregnant women: cross-sectional analysis of physiological parameters throughout pregnancy and the impact of the supine position. J Cardiovasc Magn Reson 2011;13:31.
32. Laurin J, Persson PH. The effect of bedrest in hospital on fetal outcome in pregnancies complicated by intra-uterine growth retardation. Acta Obstet Gynecol Scand 1987;66:407–11.
33. Hadlock FP, Deter RL, Harrist RB, Park SK. Estimating fetal age: computer-assisted analysis of multiple fetal growth parameters. Radiology 1984;152:497–501.
34. Hadlock FP, Harrist RB, Sharman RS, Deter RL, Park SK. Estimation of fetal weight with the use of head, body, and femur measurements—a prospective study. Am J Obstet Gynecol 1985;151:333–7.
35. Gleason JL, Reddy UM, Chen Z, et al. Comparing population-based fetal growth standards in a US cohort. Am J Obstet Gynecol 2023 [Epub ahead of print].
36. Hadlock FP, Harrist RB, Martinez-Poyer J. In utero analysis of fetal growth: a sonographic weight standard. Radiology 1991;181:129–33.
37. DeVore GR, Medearis AL, Platt LD. The effect of altitude on the umbilical artery Doppler resistance. J Ultrasound Med 1992;11:317–20.
38. DeVore GR. The importance of the cerebroplacental ratio in the evaluation of fetal well-being in SGA and AGA fetuses. Am J Obstet Gynecol 2015;213:5–15.
39. Gülmezoglu AM, Hofmeyr GJ. Bed rest in hospital for suspected impaired fetal growth. Cochrane Database Syst Rev 2000;1996:CD000034.
40. Kehl S, Dötsch J, Hecher K, et al. In: . Intrauterine growth restriction. Guideline of the German society of gynecology and obstetrics (S2k-level, AWMF Registry No. 015/080, October 2016), . Vol 77. Geburtshilfe Frauenheilkd; 2017. p. 1157–73.
41. Kleeman A. The bed-rest hoax. Available at:. Harper's Magazine. 2015 https://harpers.org/archive/2015/12/the-bed-rest-hoax/#:~:text=venerable%20pregnancy%20treatment-,by%20Alexandra%20Kleeman,shifts%20your%20frame%20a%20little. Accessed May 10, 2024.
42. Pineles BL, Vial M, Castro T, et al. Ambulation for latency during expectant management of preterm prelabor rupture of membranes: a randomized controlled trial (AMBLE). Am J Obstet Gynecol MFM 2024;6:101218.
43. Greenwood L, Mastrobattista J, Mack L, Fox K, Lee W, Donepudi R. Impact of pelvic rest recommendations on follow-up and resolution of placenta previa and low-lying placenta. J Ultrasound Med 2023;42:2023–30.
44. Caro R, Fast J. Pregnancy myths and practical tips. Am Fam Phys 2020;102:420–6.
45. Walsh CA. Maternal activity restriction to reduce preterm birth: time to put this fallacy to bed. Aust N Z J Obstet Gynaecol 2020;60:813–5.
46. Roberts LN, Perkins H, Craig WY, Wax JR. Perinatal outcomes of pregnancies complicated by prenatally resolved fetal growth restriction. Am J Obstet Gynecol 2023 [Epub ahead of print].
47. Dubiel M, Gunnarsson GO, Gudmundsson S. Blood redistribution in the fetal brain during chronic hypoxia. Ultrasound Obstet Gynecol 2002;20:117–21.
48. Hernandez-Andrade E, Figueroa-Diesel H, Jansson T, Rangel-Nava H, Gratacos E. Changes in regional fetal cerebral blood flow perfusion in relation to hemodynamic deterioration in severely growth-restricted fetuses. Ultrasound Obstet Gynecol 2008;32:71–6.
49. Yudkowitz FS. Fetal-neonatal physiology and circulation. In: Santos AC, Epstein JN, Chaudhuri K, eds. Obstetric anesthesia. New York, NY: McGraw-Hill Education; 2015. Available at: https://accessanesthesiology.mhmedical.com/content.aspx?bookid=1364§ionid=82007440. Accessed May 10, 2024.
50. Marchand C, Köppe J, Köster HA, et al. Fetal growth restriction: comparison of biometric parameters. J Pers Med 2022;12:1125.
51. Gordijn SJ, Beune IM, Thilaganathan B, et al. Consensus definition of fetal growth restriction: a Delphi procedure. Ultrasound Obstet Gynecol 2016;48:333–9.
52. Goetzinger KR, Cahill AG, Macones GA, Odibo AO. Isolated short femur length on second-trimester sonography: a marker for fetal growth restriction and other adverse perinatal outcomes. J Ultrasound Med 2012;31:1935–41.
53. Couper S, Clark A, Thompson JMD, et al. The effects of maternal position, in late gestation pregnancy, on placental blood flow and oxygenation: an MRI study. J Physiol 2021;599:1901–15.
54. McLaren R, Kalgi B, Ndubizu C, Homel P, Haberman S, Minkoff H. The effect of maternal position on fetal middle cerebral artery Doppler indices and its association with adverse perinatal outcomes: a pilot study. J Perinat Med 2020 [Epub ahead of print].

55. Ülker K, Çeçen K, Temur İ, Gül A, Karaca M. Effects of the maternal position and rest on the fetal urine production rate: a prospective study conducted by 3-dimensional sonography using the rotational technique (virtual organ computer-aided analysis). J Ultrasound Med 2011;30:481–6.

56. Ulker K, Gül A, Ciçek M. Correlation between the duration of maternal rest in the left lateral decubitus position and the amniotic fluid volume increase. J Ultrasound Med 2012;31:705–9.

57. Ling HZ, Guy GP, Bisquera A, Nicolaides KH, Kametas NA. Maternal cardiac adaptation and fetal growth. Am J Obstet Gynecol 2021;224:601.e1–18.

58. Kerr MG, Scott DB, Samuel E. Studies of the inferior vena cava in late pregnancy. Br Med J 1964;1:532–3.

59. Hughes EJ, Price AN, McCabe L, et al. The effect of maternal position on venous return for pregnant women during MRI. NMR Biomed 2021;34:e4475.

60. Ueland K, Novy MJ, Peterson EN, Metcalfe J. Maternal cardiovascular dynamics. IV. The influence of gestational age on the maternal cardiovascular response to posture and exercise. Am J Obstet Gynecol 1969;104:856–64.

61. DeVore GR, Polanco B. Assessing maternal cardiac function by obstetricians: technique and reference ranges. Am J Obstet Gynecol 2023;229:155.e1–18.

62. Owusu JT, Anderson FJ, Coleman J, et al. Association of maternal sleep practices with pre-eclampsia, low birth weight, and stillbirth among Ghanaian women. Int J Gynecol Obstet 2013;121:261–5.

63. Anderson NH, Gordon A, Li M, et al. Association of supine going-to-sleep position in late pregnancy with reduced birth weight: a secondary analysis of an individual participant data meta-analysis. JAMA Netw Open 2019;2:e1912614.

64. Heazell A, Li M, Budd J, et al. Association between maternal sleep practices and late stillbirth – findings from a stillbirth case-control study. BJOG 2018;125:254–62.

65. Humphries A, Mirjalili SA, Tarr GP, Thompson JMD, Stone P. The effect of supine positioning on maternal hemodynamics during late pregnancy. J Matern Fetal Neonatal Med 2019;32:3923–30.

66. Ishkova A, Wilson DL, Howard ME, et al. The effect of body position on maternal cardiovascular function during sleep and wakefulness in late pregnancy. J Matern Fetal Neonatal Med 2022;35:2545–54.

67. O'Brien LM, Warland J, Stacey T, Heazell AEP, Mitchell EA. Maternal sleep practices and stillbirth: findings from an international case-control study. Birth 2019;46:344–54.

68. Silver RM, Hunter S, Reddy UM, et al. Prospective evaluation of maternal sleep position through 30 weeks of gestation and adverse pregnancy outcomes. Obstet Gynecol 2019;134:667–76.

69. Wilson DL, Fung AM, Skrzypek H, et al. Maternal sleep behaviours preceding fetal heart rate events on cardiotocography. J Physiol 2022;600:1791–806.

70. Lingam I, Okell J, Maksym K, et al. Neonatal outcomes following early fetal growth restriction: a subgroup analysis of the EVERREST study. Arch Dis Child Fetal Neonatal Ed 2023;108:599–606.

71. Caradeux J, Martínez-Portilla RJ, Martínez-Egea J, Ávila F, Figueras F. Routine third-trimester ultrasound assessment for intrauterine growth restriction. Am J Obstet Gynecol MFM 2024101294.

72. Mula C, Hidalgo J, Peguero A, et al. Third-trimester uterine artery Doppler for prediction of adverse outcome in late small-and adequate for-gestational-age fetuses. Minerva Obstet Gynecol 2023;75:440–8.

73. Amruta N, Kandikattu HK, Intapad S. Cardiovascular dysfunction in intrauterine growth restriction. Curr Hypertens Rep 2022;24:693–708.

74. Visentin S, Grumolato F, Nardelli GB, Di Camillo B, Grisan E, Cosmi E. Early origins of adult disease: low birth weight and vascular remodeling. Atherosclerosis 2014;237:391–9.

75. Demicheva E, Crispi F. Long-term follow-up of intrauterine growth restriction: cardiovascular disorders. Fetal Diagn Ther 2014;36:143–53.

76. Änghagen O, Engvall J, Gottvall T, Nelson N, Nylander E, Bang P. Developmental Differences in Left ventricular Strain in IUGR vs. control Children the First three months of Life. Pediatr Cardiol 2022;43:1286–97.

77. Youssef L, Miranda J, Paules C, et al. Fetal cardiac remodeling and dysfunction is associated with both preeclampsia and fetal growth restriction. Am J Obstet Gynecol 2020;222(79):e1–9.

78. Crispi F, Miranda J, Gratacós E. Long-term cardiovascular consequences of fetal growth restriction: biology, clinical implications, and opportunities for prevention of adult disease. Am J Obstet Gynecol 2018;218:S869–79.

79. Cruz-Lemini M, Crispi F, Valenzuela-Alcaraz B, et al. A fetal cardiovascular score to predict infant hypertension and arterial remodeling in intrauterine growth restriction. Am J Obstet Gynecol 2014;210:552.e1–22.

80. DeVore GR. The effect of an abnormal umbilical artery Doppler on the management of fetal growth restriction: a survey of maternal-fetal medicine specialists who perform fetal ultrasound. Ultrasound Obstet Gynecol 1994;4:294–303.

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