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Screening for fetal growth disorders by clinical exam in the era of obesity

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Abstract

Objective—To evaluate the performance of clinical estimation of fetal weight as a screening test for fetal growth disorders and then to estimate the effect of maternal body mass index (BMI) on its screening efficiency.

Study Design—This was a retrospective cohort study of patients referred for third trimester ultrasound for the indication of “size unequal to dates”. Patients with medical co-morbidities which may alter their *a priori* risk for fetal growth disorders were excluded. The incidence of fetal growth disorders as well as amniotic fluid disturbances was determined for each group and then compared across maternal BMI categories of <25 kg/m^2, 25-30 kg/m^2, ≥30 kg/m^2, and ≥40 kg/m^2. To evaluate the accuracy of clinical estimation of fetal weight in predicting fetal growth disorders, the sensitivity, specificity, positive predictive value, negative predictive value, likelihood ratios, as well as number needed to scan (NNS) was calculated and compared across BMI categories.

Results—Of 51,366 patients, 1,623 were referred for the indication of size > dates and 1,543 for the indication of size < dates. The incidence of fetal growth disorders in each referral group was low and was not significantly different across BMI categories. The sensitivity and specificity were 9.7% and 96.6% for predicting neonatal birth weight (BW) >90th%ile and 13.5% and 96.7% for predicting BW <10th%ile. The NNS to detect one neonate with a BW <10th%ile ranged from 5-19 while the NNS to detect one neonate with a BW >90th%ile ranged from 6-13 across BMI categories.

Conclusion—Overall, clinical estimation of fetal weight yields a low detection rate of fetal growth abnormalities; however, its screening efficiency is not adversely impacted by maternal BMI.

Keywords

body mass index; clinical estimation of fetal weight; fundal height measurement; fetal growth

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Conflict of Interest

The authors report no conflicts of interest.

Introduction

Clinical estimation of fetal weight is a routine component of prenatal visits, with the primary goal of identifying a population of patients at risk for fetal growth disorders who will then be referred for subsequent ultrasound evaluation. The most common clinical method used to estimate fetal weight is symphysis-fundal height measurement; however, Leopold maneuvers may also be used. Test performance characteristics for fundal height measurement in the prediction of fetal growth disorders have been widely variable in prior studies, likely due to variability in measurement technique.[1-7] To date, there has only been one randomized controlled trial evaluating the utility of antenatal fundal height measurements. Results from this trial demonstrated no improvement in the detection of small for gestational age (SGA) growth and no improvement in neonatal outcomes when employing the practice of serial fundal height measurements into routine prenatal care.[8] In 2009, a Cochrane systematic review concluded that there was a lack of evidence to evaluate the use of fundal height measurements in prenatal care.[9]

In the absence of a more effective screening method, recent research has focused on the incorporation of maternal characteristics to improve the efficiency of fundal height measurement for detecting fetal growth disorders. Results have been conflicting as to whether maternal characteristics such as height, weight, parity and ethnicity actually improve this screening efficiency.[7,10-12] A recent study by Sparks *et al* demonstrated notable differences in the test performance characteristics of fundal height measurement among particular subgroups of maternal age, parity, and ethnicity; however, only marginal differences in sensitivity and specificity were noted when comparing subgroups of maternal body mass index (BMI).[7] Given the growing obesity epidemic in the United States, the objectives of this study were to evaluate the overall test performance characteristics of clinical estimation of fetal weight in screening for fetal growth disorders and then to estimate the effect of maternal BMI on these screening efficiencies.

Materials and Methods

This is a retrospective cohort study using the perinatal database from Washington University Medical Center from 1990-2009. Institutional review board approval from Washington University was obtained. All patients who present for ultrasound to our tertiary care obstetric referral center for any indication are routinely entered into our perinatal database at the time of ultrasound exam. This database contains detailed information including maternal demographic information, obstetrical history, ultrasound reports, pregnancy complications, delivery information, and neonatal outcomes. This perinatal database is maintained by a dedicated nurse outcome coordinator who is responsible for collecting all delivery and neonatal outcome information by patient questionnaire and/or telephone follow up interview as well as searching electronic medical records. In the event that a patient is unable to be contacted, the referring physician office is contacted in an attempt to obtain complete outcome information. Patients who experienced an intrauterine fetal demise or preterm delivery <28 weeks' gestation as well as those with incomplete outcome information or multiple gestations were excluded. Additionally, patients with any co-morbidities which

would alter their *a priori* risk for developing a fetal growth disorder were excluded. These co-morbidities included chronic hypertension, systemic lupus erythematosus, gestational diabetes mellitus, and pre-existing diabetes mellitus.

Our study cohort was divided into three groups based on referral for ultrasound evaluation for fetal growth in the third trimester (defined as >27 weeks' gestation) and the indication for referral. The first group was comprised of patients referred for the indication of size greater than dates (S>D). S>D was used as a surrogate marker for increased fundal height measurement or clinical suspicion for macrosomia on exam. The second group was comprised of patients referred for the indication of size less than dates (S<D), a surrogate marker for decreased fundal height measurement or clinical suspicion for small for gestational age growth pattern on exam. The third group was comprised of those patients who were not referred for any subsequent ultrasound evaluation in the third trimester and were, therefore, considered to have a clinical estimation of fetal weight within normal limits. This group was defined as the "screen negative" group. For patients who underwent more than one third-trimeter ultrasound exam, the indication for referral and estimated fetal weight (EFW) from the first ultrasound in the third trimester (index ultrasound) was used.

Baseline maternal characteristics were compared between the S>D group and the screen negative group as well as between the S<D group and the screen negative group. Categorical variables were compared using a chi-square or Fisher's exact test, as appropriate, and normally, distributed continuous variables were compared using a Student's t-test. Given that an abnormal fundal height measurement can be caused by disturbances in either fetal growth or amniotic fluid, the incidence of abnormal fetal growth and/or abnormal amniotic fluid volume was determined for each study group. Abnormal fetal growth was defined as EFW>90th%ile for gestational age, EFW<10th% for gestational age, or EFW<5th%ile for gestational age, as diagnosed at the time of the index ultrasound. We hypothesized that abnormal fundal height would be most discriminate in detecting extremes of fetal growth abnormalities; therefore, both EFW <10th%ile and <5th%ile for gestational age were evaluated as outcomes. Polyhydramnios was defined as an amniotic fluid index (AFI) >25.0 cm, and oligohydramnios was defined either by an AFI <5.0 cm or measuring <5th%ile for gestational age. The incidence of actual birth weight >90thile, <10thile, and <5th%ile for gestational age was also determined for each study group. EFW and birth weight percentiles were established using national standards derived from the Alexander growth curve.[13] The accuracy of clinical estimation of fetal weight in the prediction of fetal growth disorders was determined by constructing 2 × 2 contingency tables from which sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and likelihood ratios (LR) were calculated.

In order to evaluate the screening efficiency of clinical estimation of fetal weight for detecting LGA, 2 × 2 tables were constructed by defining the exposure as "referral for S>D" vs. "screen negative" and the outcome as the presence or absence of a birth weight >90th%ile for gestational age. For deliveries occurring at ≥37 weeks' gestation, the outcome of birth weight >4000 grams was also evaluated. Finally, the number needed to scan (NNS) to detect one abnormal birth weight was determined. To evaluate the effect of maternal BMI on the accuracy of clinical suspicion for LGA, the study cohort was stratified into categories

of BMI<25 kg/m^2, 25-29.9 kg/m^2, ≥30 kg/m^2, and ≥40 kg/m^2. BMI was obtained through patient self-report on routine questionnaire administered at the time of the first ultrasound in our unit. Test performance characteristics were calculated for each fetal growth disorder by BMI stratum. Additionally, the incidence of each fetal growth disorder was compared across BMI categories using a chi-square test for trend. This analysis was then repeated for clinical suspicion for SGA, by defining the exposure as "referral for S<D" vs. "screen negative" and the outcome as the presence or absence birth weight <10th%ile for gestational age.

Given the potential time lag between fundal height measurement and delivery, a sub-analysis was performed to evaluate the screening efficiency of fundal height for abnormal EFW and/or AFI on index ultrasound. For this analysis, exposure was defined as "referral for S>D" vs. "referral for other indications" and "referral for S<D" vs. "referral for other indications." Patients with multiple indications for ultrasound were carefully evaluated to determine if any indication was a suspected growth disorder in order to assign them to the appropriate exposure group. Patients referred for third trimester ultrasound for other indications were considered to have a normal clinical estimation of fetal weight. Outcomes were EFW >90th%ile and/or polyhydramnios and EFW <10th%ile and/or oligohydramnios. P-values <0.05 were considered statistically significant. All statistical analyses were performed using STATA 10, Special Edition (College Station, TX).

Results

Of 51,366 patients who met inclusion criteria, , 14,063 (27.3%) were referred for at least one additional ultrasound evaluation in the third trimester. Of these, 1,623 (11.5%) were referred for the indication of S>D, 1,543 (11.0%) were referred for the indication of S<D, and 10,897 (77.5%) were referred for other indications. The remaining 37,273 patients were not referred for any third trimester ultrasound evaluation. The mean gestational age at the time of the index third trimester ultrasound was 34.2 ± 3.4 weeks in those referred for S>D and 33.3 ± 3.1 weeks in those referred for S<D. Compared to those who were not referred for third trimester ultrasound, those referred for S>D on average were younger, had a higher BMI, and were more likely to have a history of a previous baby weighing greater than 4000 grams. Alternatively, compared to those not referred for third trimester ultrasound, those referred for S<D were more likely to be younger, have a lower BMI, a lower gravidity and parity, were more likely to report tobacco use, and were more likely to have a history of previous baby weighing less than 2250 grams, or approximately 5 pounds. (Table 1)

We found low rates of fetal growth and amniotic fluid disorders in those referred for abnormalfundal height measurement. Only 15. 8% of patients referred for S>D actually had an EFW>90th%ile for gestational age and/or polyhydramnios at the time of the index third trimester ultrasound. Of those referred for S<D, only 11.1% had an EFW<10th%ile for gestational age and/or oligohydramnios, and only 6.1% had an EFW<5th%ile for gestational age and/or oligohydramnios at the time of the index third trimester ultrasound. Similar low rates of infant birth weight extremes were observed in both of these groups as well. (Table 2) There was a higher incidence of birth weight >90th%ile for gestational age in those referred for S>D compared to those with a normal clinical estimation of fetal weight. (27. 5% v. 11.1%; p<0.001) There was also a higher incidence of birth weight <10th%ile for

gestational age (23.1% v. 6.1%; p<0.001) and birth weight <5th%ile for gestational age (10.7% v. 2.5%; p<0.001) in those referred for S<D compared to those with a normal clinical estimation of fetal weight.

Test performance characteristics were then calculated for the detection of extremes of actual birth weight across BMI strata. In those women with a clinical estimation of fetal weight which was greater than expected for gestational age, the sensitivity and specificity for detecting an actual infant birth weight >90th%ile were 9.7% and 96.6%, respectively. As maternal BMI increased, there was a trend toward increasing sensitivity, decreasing specificity, and decreasing NPV. PPV remained generally stable across BMI strata; however, positive LRs were lowest in those with a BMI ≥40 kg/m^2 Overall, the number needed to scan (NNS) to detect one infant with a birth weight >90th%ile was 6 but did range as high as 13 in those with a BMI ≥40 kg/m^2. When evaluating only those patients who delivered at ≥37 weeks' gestation, the sensitivity and specificity for detecting an infant birth weight >4000 grams were 8.8% and 96.4%, respectively. Again, as maternal BMI increased, a trend of increasing sensitivity, decreasing specificity, and decreasing NPV was observed. The NNS to detect one infant with a birth weight >4000 grams ranged from 7-12, and was highest in those with a BMI≥40 kg/m^2. (Table 3)

Comparing those patients with a clinical estimation of fetal weight which was less than expected for gestational age to those who were screen negative, the overall sensitivity and specificity for detecting a infant birth weight <10th%ile were 13.5% and 96.7%, respectively. The NNS to detect one infant with a birth weight <10th%ile was 6. With increasing maternal BMI, there was a trend toward decreasing sensitivity as maternal BMI increased to ≥30 kg/m^2, after which there was no further change in sensitivity. Specificity initially increased from 92.5% to 98.3% as BMI increased from <25 kg/m^2 to 25-29.9 kg/m^2 and then remained constant. PPV, NPV and LR+ remained relatively constant with increasing maternal BMI. (Table 4) Similar trends were noted when evaluating the accuracy of fundal height for the prediction of antenatal fetal growth and amniotic fluid disorders, including EFW >90th%ile and /or polyhydramnios and EFW <10th%ile and/or oligohydramnios. (Table 5)

Finally, the incidence of fetal growth disorders was compared across BMI categories by ultrasound indication. In those referred for the indication of S>D, there was no statistically significant difference in the incidence of EFW>90th%ile and/or polyhydramnios (p=0.55) or in the incidence of actual birth weight >90th%ile (p=0.12) across BMI categories. (Figure 1A) Similarly, in those referred for S<D, there was no statistically significant difference in the incidence of EFW <10th%ile and/or oligohydramnios (p=0.88) or in the incidence of actual birth weight <10th%ile (p=0.62) across BMI categories. (Figure 1B)

Discussion

Our study demonstrates that clinical estimation of fetal weight, a tool used every day in obstetric practice, has an overall poor screening efficiency for fetal growth disorders. The incidence of abnormalities in fetal growth and/or amniotic fluid disturbances was 15.8% in those referred for S>D and 11.1% in those referred for S<D. Notably, 11.1% of patients with

a normal clinical estimation of fetal weight delivered a neonate weighing >90th%ile for gestational age and 6.1% delivered a neonate weighing <10th%ile for gestational age. We also found no statistically significant difference in the incidence of fetal growth disorders across BMI categories using clinical estimation of fetal weight as a screening tool. While the sensitivity for detecting birth weight >90th%ile with clinical estimation of fetal weight did increase with increasing BMI, the maximum sensitivity obtained was only 18.9% in the most obese patients. It has been suggested that clinical estimation of fetal weight in obese patients is more likely to produce falsely elevated estimates, therefore capturing a larger proportion of those fetuses who are large for gestational age (LGA).[7] In contrast, the maximum sensitivity for detecting birth weight <10th%ile reached a minimum of 6.8% in those with a BMI ≥30 kg/m^2, likely due to clinical overestimation of fetal weight in these obese patients. Maternal BMI did have an effect on the specificity and NPV for detecting birth weight >90th%ile, with a maximum specificity of 98.1% and a maximum NPV of 90.9% in those patients with a BMI<25 kg/m^2.

Results from our study are similar to that of a prior study by Sparks *et al.* which evaluated a population of 448 women who were referred for ultrasound for the indication of “size unequal to dates”. Their study demonstrated a sensitivity and specificity of 17.3% and 93.1%, respectively, in the detection of brith weight <10th%ile for gestational age and a sensitivity and specificity of 16.6% and 95.4%, respectively, in the detection of birth weight >90th%ile for gestational age. When evaluating overweight and obese women alone, they observed a similar decrease in sensitivity for the detection of birth weight <10th%ile and increase in sensitivity for birth weight >90th%ile; however, these changes had only minimal impact on their overall findings.[7] Our study validates these findings in a much larger patient population.

In contrast, Gardosi *et al.* has previously demonstrated that maternal weight had a statistically significant effect on clinical estimation of fetal weight using fundal height measurements.[12] Plotting serial fundal height measurements on customized antenatal growth charts incorporating maternal characteristics of height, weight, parity, and ethnicity, Gardosi *et al.* further demonstrated an increased antenatal detection rate of both SGA and LGA babies compared to the plotting of fundal height measurements based on gestational age only.[10] Despite these positive findings, the effect of maternal BMI alone was not investigated in this trial.

SGA is associated with significant perinatal morbidity and mortality, and antepartum detection frequently leads to increased antenatal surveillance in an attempt to minimize these risks.[14-16] Alternatively, LGA is associated with an increased risk of birth trauma; therefore, detection of LGA during the antepartum period may alter decisions regarding mode of delivery.[17,18] Given the implications of missing a case of either SGA or LGA and the ease and relative low cost of obtaining a third trimester ultrasound for fetal growth, the NNS observed in our study initially appear to be reasonable, ranging from 6-13 in the detection of LGA and 5-19 in the detection of SGA. However, if you consider that, by convention, 10% of the population should measure <10th%ile for gestational age and an additional 10% should measure >90th%ile for gestational age, 2 cases of abnormal fetal growth should be

detected for every 10 patients scanned. Therefore, the seemingly low NNS observed in our study are virtually no better than what would be observed by chance alone.

Strengths of our study include our large sample size and our robust perinatal database from which our data was extracted. This database contains neonatal outcome information, including birth weight, for all patients undergoing antenatal sonography at our institution. This allowed us to calculate test performance characteristics for clinical estimation of fetal weight by evaluating birth weight data for those who were referred for third trimester ultrasound on the basis of abnormal fundal height measurement and those who were not referred for third trimester ultrasound for any indication and, therefore, assumed to have a normal fundal height measurement. Our large sample size also allowed to stratify our analysis by maternal BMI categories and to evaluate for trends, rather than simply dichotomizing BMI into obese and non-obese as has been done in prior studies.[7] Finally, we were able to exclude patients with other medical co-morbidities such as chronic hypertension and diabetes which would alter a patient's *a priori* risk for fetal growth disorders. This allowed us to improve the likelihood that patients in our cohort were being referred for third trimester fetal growth ultrasound on the basis of abnormal clinical estimation of fetal weight alone. Additionally, these exclusions also increased the likelihood that patients referred for ultrasound for “other indications” were unlikely to also have a clinical suspicion for a fetal growth disorder.

Our study is not without limitations, including its retrospective study design. Data extraction is dependent on chart review, thereby allowing for the potential of misclassification bias. For example, BMI was calculated from self-reported height and weight; however, prior studies have shown that these self reports can be used as accurate measures of overweight and obesity prevalence.[19,20] Additionally, we used the surrogate marker of ultrasound referral for the indication of “size unequal to dates” to define abnormal clinical estimation of fetal weight. Using our database, we were unable to determine the technique used to clinically estimate fetal weight; however, fundal height measurement is the most common technique utilized in the United States and is routinely performed at each prenatal visit. Certainly, the technique of clinical estimation of fetal weight as well as the threshold for ultrasound referral may vary by provider; however, this makes our results more generalizable to providers in routine clinical practice. We were also unable to record the level of experience of the provider performing the clinical estimation of fetal weight. It is possible that more junior level providers may be more likely to obtain less reliable estimates; however, a recent study suggests that clinician bias is more dependent on knowledge of gestational age prior to the measurement and less dependent on the level of provider experience.[21] Again, inclusion of a wide range of provider experience increases the generalizability of our results. Finally, it is possible that a proportion of patients in the “screen negative” group were actually referred to a different center for third trimester ultrasound due to abnormal clinical estimation of fetal weight which may bias our estimates of screening efficiency. However, when we performed a sub-analysis to evaluate the utility of clinical estimation of fetal weight for the prediction of abnormal EFW, our control group was defined as those who had a third trimester ultrasound at our institution for an indication other than abnormal clinical estimation of fetal weight, and similar trends in screening efficiency were observed.

In conclusion, results from this large retrospective study demonstrate a low detection rate of fetal growth abnormalities when using clinical estimation of fetal weight as a screening tool. Most importantly, the detection rates observed in this study were not adversely impacted by increasing maternal BMI. While an isolated act of clinically assessing fetal weight may take only minutes, the aggregate amount of time spent serially collecting these measurements at each prenatal visit in order to achieve a detection rate of abnormal fetal growth which is no better than chance alone may have significant impact on health care cost and effort. Results from this study bring to question the utility of third trimester ultrasound referral on the basis of abnormal clinical estimation of fetal weight alone, highlighting the need for further research into more efficient strategies to screen for fetal growth disorders.

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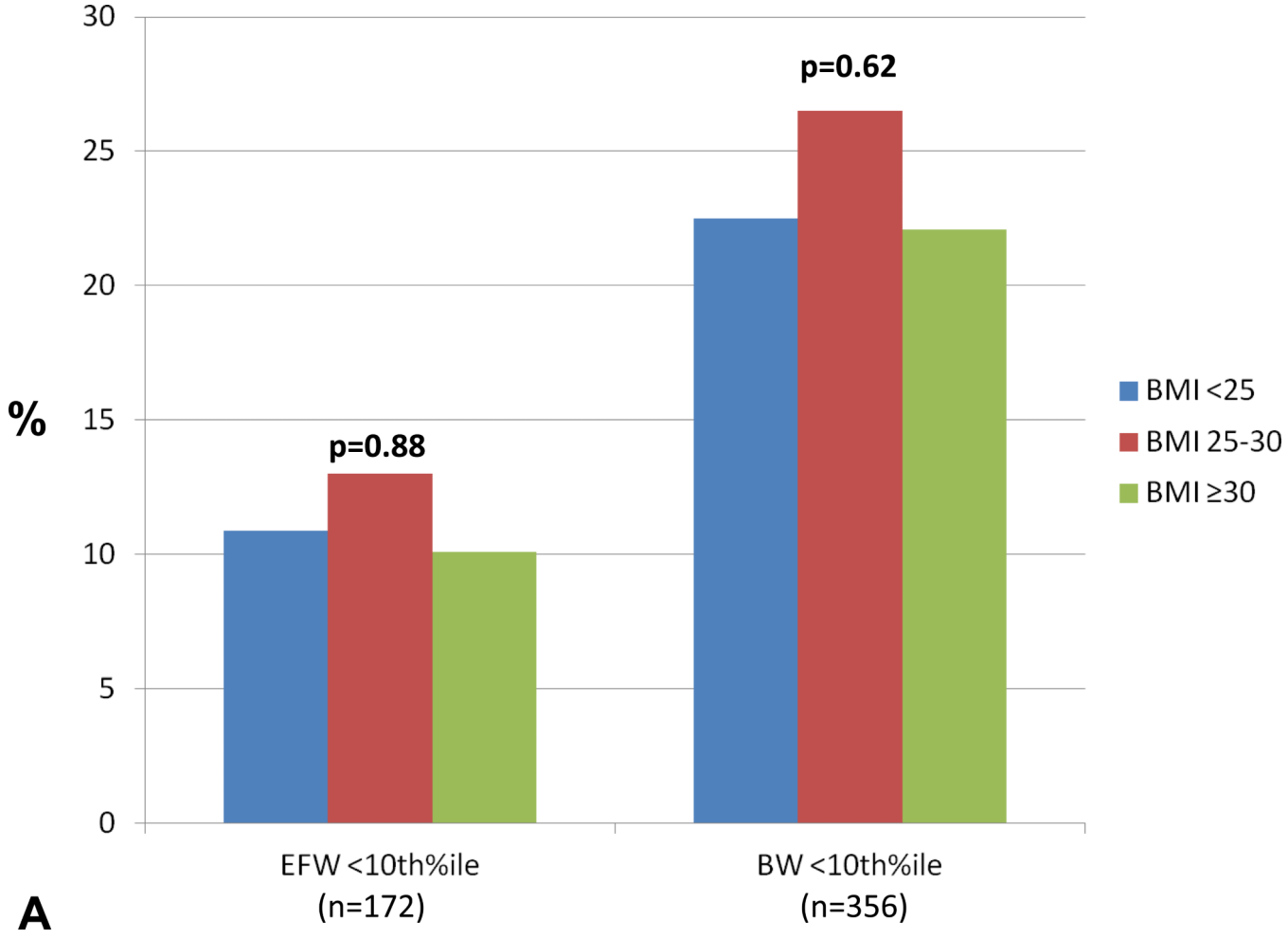

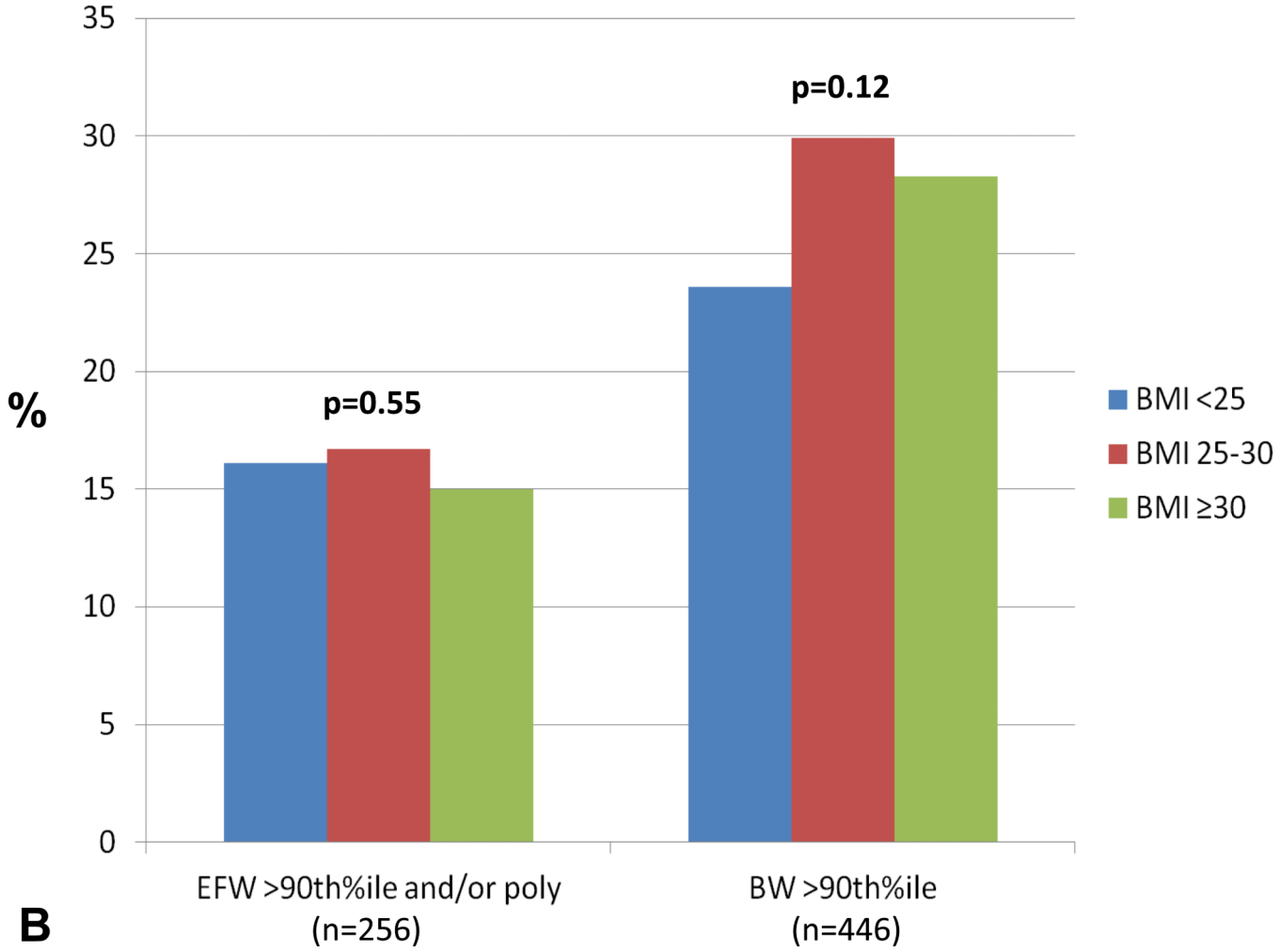

Figure 1.

Incidence of fetal growth disorders across BMI categories in those referred for the indication of A) "Size < Dates" and B) "Size > Dates"

BMI=body mass index; EFW=estimated fetal weight; BW=birth weight

Table 1

Baseline Characteristics of the Study Groups

	Size > Dates (n=1,623)	Screen Negative (n=37,273)	p	Size < Dates (n=1,543)	Screen Negative (n=37,273)	p
Maternal Age (yrs)	29.9 ± 5.5	30.2 ± 6.4	0.02	28.5 ± 6.1	30.2 ± 6.4	<0.001
Maternal BMI (kg/m^2)	30.3 ± 7.4	26.2 ± 5.7	<0.001	23.5± 4.9	26.2± 5.7	<0.001
BirthWeight (grams)	3680 ± 498	3387 ± 536	<0.001	3022 ± 560	3387 ± 536	<0.001
Caucasian	61.7%	64.0%	0.06	57.0%	64.0%	<0.001
African American	22.9%	21.4%	0.17	24.4%	21.4%	0.006
Gravidity	2.6 ± 1.6	2.6 ± 1.6	0.48	2.3 ± 1.6	2.6 ± 1.6	<0.001
Parity	1.0 ± 1.2	1.0 ± 1.1	0.36	0.8 ± 1.0	1.0 ± 1.1	<0.001
Tobacco Use	6.3%	10.9%	<0.001	12.6%	10.9%	0.03
Previous Baby>9lbs	13.4%	5.6%	<0.001	2.2%	5.6%	<0.001
Previous Baby<5lbs	5.1%	5.1%	0.95	6.6%	5.1%	0.007

*Data expressed as percentages and mean ± standard deviation

**BMI=body mass index

Table 2

Incidence of Fetal Growth and Amniotic Fluid Disorders by Third Trimester Ultrasound Indication

Ultrasound Indication	%EFW >90th%ile and/or polyhydramnios (n=624)	% EFW<10th%ile and/or oligohydramnios (n=714)	%EFW<5th%ile and/or oligohydramnios (n=502)
Size > Dates (n=1,623)	256 (15.8%)	29 (1.8%)	21 (1.3%)
Size < Dates (n=1,543)	9 (0.6%)	172 (11.1%)	94 (6.1%)
Other Indications (n=10,897)	359(3.3%)	513 (4.7%)	387 (3.5%)

	Birth Weight >90th%ile (n=5,563)	Birth Weight <10th%ile (n=3,857)	Birth Weight <5th%ile (n=1,676)
Size > Dates (n=1,623)	446 (27.5%)	32 (2.0%)	11 (0.7%)
Size < Dates (n=1,543)	33 (2.1%)	356 (23.1%)	165 (10.7%)
Other Indications (n=10,897)	952 (.7%)	1,188 (10.9%)	561 (5.1%)
Screen Negative (n=37,273)	4,132 (11.1%)	2,281 (6.1%)	39 (2.5%)

*EFW=estimated fetal weight

Table 3

Screening Efficiency of Clinical Estimation of Fetal Weight in the Prediction of Fetal Macrosomia

	Birth Weight >90th%ile for Gestational Age (n=4,578)					
BMI	**Sensitivity**	**Specificity**	**PPV**	**NPV**	**LR+**	**NNS**
BMI<25 (n=19,627)	5.6% (4.6-6.8)	98.1% (97.9-98.3)	23.6% (19.7-27.8)	90.9% (90.5-91.3)	2.0 (3.4-2.7)	7
BMI 25-29.9 (n=10,963)	9.5% (8.1-11.2)	96.6% (96.2-97.0)	29.9% (25.8-34.3)	87.5% (86.9-86.9)	2.8 (2.8-3.4)	6
BMI ≥30 (n=8,306)	15.9% (13.9-18.0)	92.6% (92.0-93.2)	28.3% (25.0-31.7)	85.8% (85.0-86.6)	2.2 (1.9-2.5)	7
BMI ≥40 (n=1,341)	18.9% (14.1-24.5)	87.5% (85.4-89.4)	24.6% (18.5-31.5)	83.3% (81.1-85.4)	1.5 (1.1-2.0)	13
All	9.7% (8.9-10.6)	96.6% (96.4-96.8)	27.5% (25.3-29.7)	88.9% (88.6-89.2)	2.8 (2.6-3.1)	6

	Birth Weight >4000 grams (n=4,653)					
BMI	**Sensitivity**	**Specificity**	**PPV**	**NPV**	**LR+**	**NNS**
BMI<25 (n=18,093)	4.9% (4.0-6.0)	98.0% (97.8-98.2)	23.0% (19.0-27.4)	89.6% (89.2-90.1)	2.5 (2.0-3.1)	8
BMI 25-29.9 (n=10,123)	8.2% (6.8-9.7)	96.3% (95.9-96.7)	27.4% (23.3-31.8)	86.1% (85.4-86.8)	2.2 (1.8-2.7)	8
BMI ≥30 (n=7,603)	15.5% (13.5-17.6)	92.4% (91.7-93.0)	28.7% (25.3-32.2)	84.6% (83.7-85.5)	2.0 (1.7-2.4)	8
BMI ≥40 (n=1,214)	19.6% (14.6-25.3)	87.2% (84.9-89.2)	25.7% (19.4-33.0)	82.6% (80.2-84.9)	1.5 (1.1-2.1)	12
All	8.8% (8.0-9.7)	96.4% (96.2-96.6)	26.8% (24.6-29.1)	87.6% (87.3-88.0)	2.4 (2.2-2.7)	7

*BMI=body mass index; PPV=positive predictive value; NPV=negative predictive value; LR+=positive likelihood ratio; NNS=number needed to scan

Table 4

Screening Efficiency of Clinical Estimation of Fetal Weight in the Prediction of Small for Gestational Age Neonates

	Birth Weight <10th%ile for Gestational Age (n=2,637)					
BMI	**Sensitivity**	**Specificity**	**PPV**	**NPV**	**LR+**	**NNS**
BMI<25 (n=20,342)	17.3% (15.4-19.3)	92.5% (94.9-95.5)	22.5% (20.1-25.0)	93.5% (93.2-93.9)	3.6 (3.2-4.1)	6
BMI 25-29.9 (n=10,740)	9.7% (7.5-12.2)	98.3% (98.0-98.5)	26.5% (21.0-32.6)	94.4% (94.0-94.8)	5.6 (4.2-7.4)	5
BMI ≥30 (n=7,734)	6.8% (4.7-9.4)	98.4% (98.1-98.7)	22.1% (15.8-29.7%)	94.1% (93.5-94.6)	4.3 (2.9-6.2)	6
BMI ≥40 (n=1,178)	6.8% (2.2-15.1)	98.6% (97.8-99.2)	25.0% (8.7-49.1)	94.0% (92.5-95.3)	5.0 (1.9-13.3)	19
All	13.5% (12.2-14.9)	96.7% (96.5-96.9)	23.1% (21.0-25.3)	93.9% (93.6-94.1)	4.1 (3.7-4.6)	6

*BMI=body mass index; PPV=positive predictive value; NPV=negative predictive value; LR+=positive likelihood ratio; NNS=number needed to scan

Table 5

Screening Efficiency of Clinical Estimation of Fetal Weight in the Detection of Antenatal Fetal Growth Disorders and/or Amniotic Fluid Disturbances

EFW >90th%ile for Gestational Age and/or Polyhydramnios (n=615)					
BMI	**Sensitivity**	**Specificity**	**PPV**	**NPV**	**LR+**
BMI<25 (n=5,789)	32.9% (26.6-39.6)	93.4% (92.7-94.0)	16.1% (12.8-19.9)	97.3% (96.8-97.7)	4.9 (4.0-6.1)
BMI 25-29.9 (n=3,251)	42.1% (34.8-49.6)	87.5% (86.3-88.6)	16.7% (13.4-20.4)	96.2% (95.4-96.9)	3.4 (2.9-4.1)
BMI ≥30 (n=3,480)	50.0% (43.1-56.9)	81.2% (79.8-82.5)	15.0% (12.5-17.8)	96.1% (95.3-96.8)	2.7 (2.3-3.1)
BMI ≥40 (n=828	55.6% (40.0-70.4)	79.8% (76.8-82.6)	13.7% (9.0-19.5)	96.9% (95.3-98.1)	2.7 (2.0-3.7)
All	41.6% (37.7-45.6)	88.5% (87.9-89.1)	15.8% (14.0-17.6)	96.7% (96.4-97.0)	3.6 (3.3-4.0

EFW <10th%ile for Gestational Age and/or Oligohydramnios (n=685)					
BMI	**Sensitivity**	**Specificity**	**PPV**	**NPV**	**LR+**
BMI<25 (n=6,504)	32.8% (28.1-37.8)	83.2% (82.2-84.1)	10.9% (9.2-12.8)	95.2% (94.6-95.7)	1.9 (1.7-2.3)
BMI 25-29.9 (n=3,028)	18.6% (13.0-25.3)	92.8% (91.8-93.7)	13.0% (9.0-18.0)	95.1% (94.3-95.9)	2.6 (1.8-3.6)
BMI ≥30 (n=2,908)	15.3% (11.4-19.9)	93.9% (93.3-94.6)	11.9% (8.8-15.5)	95.4% (94.8-95.9)	2.5 (1.9-3.4)
BMI ≥40 (n=665)	7.5% (1.6-20.4)	97.3% (95.7-98.4)	15.0% (3.2-37.9)	94.3% (92.2-95.9)	2.8 (0.8-9.0)
All	25.1% (21.9-28.5)	88.3% (87.7-88.9)	11.1% (9.6-12.8)	95.3% (94.9-95.7)	2.1 (1.9-2.5)

*BMI=body mass index; PPV=positive predictive value; NPV=negative predictive value; LR+=positive likelihood ratio