

Clinical yield of fetal echocardiography for suboptimal cardiac visualization on obstetric ultrasound

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Abstract

Objective: Suboptimal cardiac imaging on obstetric ultrasound is a frequent referral indication for fetal echocardiography, even in the absence of typical risk factors for fetal cardiac disease. The clinical profile of patients and findings of examinations performed for such an indication are not well defined. Given the increased cost, time and resource utilization of fetal echocardiography, we sought to determine the clinical findings of such referrals.

Study Design: We performed a single-center review of such referrals from January 2010 to June 2016. Patients with commonly accepted indications for fetal echocardiography were excluded. Demographic variables and echocardiogram findings were collected. Findings were classified as (1) "normal," (2) "probably normal," if minor pathology could not confidently be excluded, or if minor findings were noted that were expected to resolve, or (3) "abnormal." Rates of pathology were determined with comparison of nonobese and obese populations.

Results: A total of 583 gestations in 562 women were included (median gestational age 23.3 weeks, range 19.0–38.4). The median body mass index (BMI) was 34.6 kg/m² (range 17.2–66.3 kg/m²). The majority of women were obese (BMI \geq 30 kg/m² in 74.6%). Overall, 574 of 583 examinations (98.5%) were normal or "probably normal." Pathology was noted in 9 fetuses (1.5%), 3 of whom required intervention (0.5%). No ductal dependent lesions were diagnosed. There was no significant difference in pathology rates between nonobese and obese mothers.

Conclusions: We found a low fetal cardiac anomaly rate in studies performed for suboptimal views on obstetric ultrasound. The majority of women referred for this indication were obese. The practice of routine referral for this indication deserves further evaluation.

KEYWORDS

congenital heart disease, fetal echocardiography, maternal obesity, suboptimal views

1 | INTRODUCTION

Heart defects are among the most common congenital abnormalities, affecting approximately 6–9 per 1000 newborns, and are a leading cause of infant morbidity and mortality.^{1,2} Fetal cardiac screening assessment via ultrasound is commonly performed during a second trimester anatomic survey, and includes assessment of the four-chamber view and ventricular outflow tracts—although it may be more extensive depending on the examiner.^{3,4} Anecdotally, a common referral indication for fetal echocardiography is incomplete or suboptimal

visualization of the fetal cardiac anatomy on this screening ultrasound, usually due to restricted acoustic windows or adverse fetal position. Often, such referrals are made in the absence of typical maternal or fetal risk factors for congenital heart defects, such as a suspected cardiac anomaly. In the absence of such risk factors, one might presume that the rate of heart disease in these patients would be similar to an unselected population, or perhaps even lower, given that no anomaly was seen on a screening examination.⁵ However, there may be unrecognized heart disease that makes visualization difficult, and this population might actually have a higher rate of heart defects. Additionally,

maternal obesity, which is often associated with restricted acoustic windows, has been identified as a potential independent risk factor for congenital heart defects.^{6–9}

Given the increased cost, time, resource utilization and potential for parental stress associated with fetal echocardiography,¹⁰ our objective was to examine a single center's experience with referrals for incomplete or suboptimal visualization of the fetal heart in the absence of commonly accepted maternal or fetal indications,^{11–13} with particular attention to the clinical findings of these examinations.

2 | MATERIALS AND METHODS

This was a single-center retrospective review of all referrals from January 2010 through June 2016 for fetal echocardiography due to incomplete or suboptimal evaluation of fetal cardiac anatomy on obstetric ultrasound. Patients were referred by one of two maternal-fetal medicine groups at Montefiore Medical Center and North Bronx Healthcare Network (Jacobi Medical Center and North Central Bronx Hospital), both in the Bronx, New York.

2.1 | Subject selection

Patients were identified through review of the Fetal Heart Program referral database at the Children's Hospital at Montefiore for indications that included the following: "poor views of fetal heart," "limited," or "incomplete" evaluation due to "obesity," "maternal body habitus," "adverse fetal lie," or other technical factors that may impair visualization such as "abdominal scarring" and "twin gestation." Patients were also included who were referred for inability to obtain a specific fetal cardiac view (eg, aortic arch, left-ventricular outflow, right-ventricular outflow, four-chamber).

Patients with commonly accepted indications for fetal echocardiography were excluded.^{11–13} It is important to note that maternal obesity was not considered an exclusion criterion, as it is not a universally accepted referral indication for fetal echocardiography. Furthermore, while there is data to suggest a small increased risk of fetal congenital heart disease in this population, it is a significant contributing factor to poor visualization of fetal cardiac anatomy, and therefore important to include.

2.2 | Data collection

Variables collected included the following patient demographics: maternal age and gestational age at time of fetal echocardiogram, height, weight, and body mass index (BMI)—measured preferably in early pregnancy—race, ethnicity, and specific indication (suboptimal views only, suboptimal views due to maternal body habitus [MBH], suboptimal views due to other reasons without mention of MBH, suboptimal views of specific structure[s] with or without mention of MBH). Maternal obesity was defined as a BMI ≥ 30 kg/m².

Fetal echocardiography was performed by a pediatric cardiac sonographer with images reviewed by an attending fetal cardiologist, who often acquired additional images, prior to discharge of the patient.

The majority of examinations were performed using a Philips iE33 ultrasound machine with a C5-1 curved array or S8-3 sector array transducer (Philips Best, The Netherlands).

Findings from fetal echocardiography were obtained from the official report and classified as either (1) "normal," if no structural, functional, or rhythm abnormalities were noted or suspected; (2) "probably normal," if the report indicated that no significant pathology was suspected, though minor pathology could not confidently be excluded; or if there were minor findings that would not be expected to have a significant clinical impact (eg, "cannot exclude small ventricular septal defect," occasional premature atrial contractions, or mild constriction of the ductus arteriosus with normal right ventricular size and function); and (3) "abnormal," if there was a definitive diagnosis of pathology, regardless of the severity, or if there was suspicion for postnatal aortic coarctation. Mild tricuspid regurgitation was considered a normal finding.¹⁴ For patients with multiple fetal echocardiograms, the final determination of pathology was made from the most recent examination. For abnormal findings and possible pathology, specifics of the abnormality were recorded, including whether the lesion would require catheter or surgical intervention.

The quality of each echocardiogram was recorded as either technically good or technically difficult, as determined by the interpreting physician in the official echocardiogram report, along with which specific anatomic structures were identified as being poorly visualized. Additional data collected included number of repeat fetal echocardiograms and postnatal findings, if available.

2.3 | Statistical analysis

A descriptive summary of patient variables was performed. Pathologic yield was calculated as number of abnormal findings divided by number of fetal echocardiograms performed. Bivariate associations of patient characteristics with mother's obesity status (obese, BMI ≥ 30 mg/m² vs nonobese, BMI < 30 mg/m²) were evaluated by the chi-square test for categorical variables and the two-sample *T* test or Wilcoxon rank-sum test for continuous variables depending on the distribution of the data. Pathologic yield was compared between obese and nonobese mothers by the logistic regression with generalized estimating equations taking into account mothers with twins. Data were analyzed by using SAS software (version 9.4; SAS Institute Inc., Cary, North Carolina, USA).

3 | RESULTS

Among the 3072 referrals for fetal echocardiography during the study period, 833 mentioned limited cardiac views (27.1%). Of these, 583 gestations in 562 mothers were included (21 twin gestations). The majority of exclusions were for patients who also had maternal or fetal indications that would warrant a fetal echocardiogram.

The patient demographics and referral indications are summarized in Table 1. The median maternal age was 28 years (range 17–44) and the median gestational age at the time of the fetal echocardiogram was 23.3 weeks (range 19.0–38.4). Maternal BMI was available in 382 patients, 71.7% from the first trimester and 26.4% from the second.

TABLE 1 Patient demographics and referral indications, N = 562

	Median (Range) or N (%)
Maternal age (years)	28 (17–44)
Gestational age (weeks)	23.3 (19.0–38.4)
Weight (kg), N = 382	91.3 (42.3–183)
BMI (kg/m ²), N = 382	34.6 (17.2–66.3)
Race	
White	131 (23.3%)
African American	144 (25.6%)
Other or Unknown	287 (51.1%)
Ethnicity	
Hispanic/Latino	206 (36.7%)
Non-Hispanic/Latino	227 (40.4%)
Other or Unknown	129 (23.0%)
Indications	
Suboptimal views only	121 (21.5%)
Suboptimal views due to MBH	265 (47.2%)
Suboptimal views due to other reason without mention of MBH	61 (10.9%)
Suboptimal views of specific structure(s)	115 (20.5%)

Abbreviations: BMI, body mass index; MBH, maternal body habitus.

The median BMI was 34.6 kg/m² (range 17.2–66.3 kg/m²). The majority of women were obese, with a BMI \geq 30 kg/m² (74.6%), and 30.1% had a BMI \geq 40 kg/m². The largest proportion of referral indications were related to maternal body habitus (47.2%).

Overall, 76/562 patients (13.5%) had repeat examinations, including 3 patients with twins who had reevaluation of both fetuses. Of the patients with repeat studies, most had either 1 (76%) or 2 (21%) repeat examinations. One patient had 3 and one had 6 repeat studies (mild ductal constriction that remained stable). In all, there were 102 repeat examinations, which when added to the initial examinations resulted in a total of 685 fetal echocardiograms.

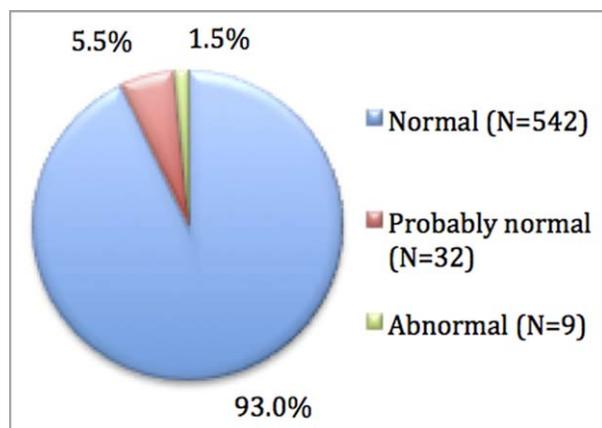


FIGURE 1 Findings of fetal echocardiography. Of 583 gestations, findings of fetal echocardiography were normal in 542 (93.0%) and probably normal in 32 (5.5%). There were 9 cases of pathology (1.5%), 3 of which required intervention

Difficult imaging was noted in 66% of the reports of the initial echocardiograms. The three most common structures to be poorly visualized were, in order, the pulmonary arteries, aortic arch, and pulmonary veins.

Findings of fetal echocardiography are displayed in Figure 1. Overall, 542 of 583 examinations (93.0%) were normal, and another 32 (5.5%) were probably normal. Pathology was noted in 9 patients (1.5%). One patient had an erroneous diagnosis of abdominal situs inversus on fetal echocardiography, which was caused by mistaking the gallbladder for the stomach. This was correctly identified by the maternal-fetal medicine specialists as an error prior to delivery, so the fetal echocardiogram findings were considered normal.

Pathologic findings and postnatal findings are summarized in Table 2. Of the 9 patients with pathology, 5 (0.9% of total) had findings concerning for lesions that would either definitively or possibly need intervention. These consisted of 1 patient with truncus arteriosus, 1 with tetralogy of Fallot and mild right ventricular outflow tract obstruction, 1 with a moderate to large membranous ventricular septal defect, and 2 with potential arch obstruction (1 with severe isthmus hypoplasia and high concern for aortic coarctation, and 1 with mild isthmus hypoplasia and less concern).

Of these 5 patients, the anatomy was confirmed postnatally in both the truncus arteriosus and the moderate/large membranous ventricular septal defect, which required surgical repair. The patient with a high suspicion of aortic coarctation due to severe hypoplasia of the aortic isthmus did not end up having any significant heart disease. The patients with the mild hypoplasia of the aortic isthmus and the tetralogy of Fallot with mild right ventricular outflow tract obstruction transferred care during their pregnancy and no follow-up information is available. Assuming the patient with mild isthmus hypoplasia did not require intervention (since suspicion was low), and that the patient with tetralogy of Fallot would require nonurgent surgical repair, there would be 3 cases requiring intervention (0.5% of total), none of which were ductal dependent.

The majority of findings that were “probably normal” were for the inability to exclude small ventricular septal defects (19/32). There were 4 patients each with occasional premature atrial contractions and mild constriction of the ductus arteriosus.

TABLE 2 Abnormal fetal echocardiography findings

Definitive pathology or high concern for significant pathology (N = 9; 1.5%)	N	Postnatal follow-up
Ventricular septal defect		
Moderate to large	1	Confirmed
<Moderate	3	Not available
Concern for arch hypoplasia		
Severe isthmus hypoplasia	1	No pathology
Mild isthmus hypoplasia	1	Not available
Tetralogy of Fallot with mild right ventricular outflow tract obstruction	1	Not available
Truncus arteriosus (type I vs II)	1	Confirmed
Mild ascending aortic dilation	1	Confirmed

TABLE 3 Comparison of nonobese and obese populations

	Nonobese (BMI < 30 kg/m ² , N = 97)	Obese (BMI ≥ 30 kg/m ² , N = 285)	P value
Maternal age (years)	28.6 (6.1)	28.9 (6.2)	.70
Gestational age (weeks)	23.5 (2.6)	23.9 (2.6)	.15
Weight (kg)	66.2 (8.7)	104.3 (22.0)	
Race			.001
White	32.0%	20.0%	
African American	13.4%	31.2%	
Other or Unknown	54.6%	48.8%	
Ethnicity			.96
Hispanic/Latino	36.1%	36.1%	
Non-Hispanic/Latino	40.2%	38.9%	
Other or Unknown	23.7%	24.9%	
Pathologic findings	3/99 (3.0%)	3/299 (1.0%)	.27

Abbreviation: BMI, body mass index.
Data reported in Mean (SD) or %.

The comparisons of the nonobese and obese populations are reported in Table 3. African American mothers represented a larger proportion of the obese population in comparison with the nonobese. There were no differences in ethnicity. Pathologic findings were present in 3/99 (3.0%) of the examinations performed in nonobese and 3/299 (1.0%) of those performed in obese mothers. This was not a statistically significant difference.

4 | DISCUSSION

In this cohort of 583 gestations in 562 mothers referred for suboptimal visualization of the fetal heart, there were 9 abnormal findings identified for a pathology rate of 1.5%. Of these, 3 lesions required intervention (0.5% of total), none of which were ductal dependent.

There is little available data specific to the clinical yield of fetal echocardiography for suboptimal visualization on obstetric ultrasound. One recent single-center investigation reported an increase in referrals for suboptimal imaging from 5% to 22% over a decade, accounting for a greater proportion of referrals than any other indication. The rate of pathologic findings was 2.8%, lowest among all indications.¹⁵

While we now have data to suggest that the clinical yield for this indication is low, rates of 1.5% to 2.8% are still higher than the rates of congenital heart disease in the neonatal population. A scientific statement from the American Heart Association suggests that it is “reasonable” to perform fetal echocardiography at risk levels of ≥2%–3%, while it is recommended in risk level of >3%.¹¹ At rates of 1%–2%, the benefits of fetal echocardiography are less clear.

The yield for suboptimal imaging may vary depending on several factors, including the underlying patient risk factors in the referral population, and the experience and practice style of the referring providers. The referrals in our investigation were from maternal-fetal medicine specialists. The general practice of our referrers was to perform an anatomy scan at 18–20 weeks gestation. If imaging was suboptimal, women were typically brought back 2 weeks later for a repeat attempt

prior to referring for fetal echocardiography. Given this practice style, one might presume the rate of heart disease in our referrals may be lower than in centers that refer after a single unsuccessful attempt.

The rates of maternal obesity in our cohort were quite high. Maternal obesity has been identified as a potential risk factor itself for congenital heart defects. Odds ratios for congenital heart defects in severe/morbid obesity are reported as 1.3–1.5, and there appears to be a “dose response” with higher rates in more obese patients.^{6–9} An increased pathology rate was not detected in obese mothers in the current investigation; however, our study was not powered to detect such a difference. While maternal obesity on its own is not yet a commonly accepted referral indication, given the current rates of maternal obesity and medico-legal pressures that encourage practitioners not to miss any potential pathology, it is understandable why an indication for suboptimal imaging is more common than previously. Also, while it did not reach statistical significance, the pathology rate in our cohort was actually higher in nonobese patients (3.0% vs 1.0%). When imaging is reported as limited in a patient who would not be expected to have poor views, this could raise suspicion that there is underlying pathology that is not fully recognized by the referring provider (eg, limited visualization of the right ventricular outflow in a tetralogy of Fallot).

Our study also demonstrates some of the potential negative consequences of this referral strategy. A total of 102 repeat fetal echocardiograms were performed, often for suboptimal views on the initial fetal echocardiogram. This repeat testing significantly increases costs and time expenditures. Additional imaging also creates the opportunity for diagnostic error and uncertainty. There was one false diagnosis of abdominal situs inversus. There was also a case with high concern for postnatal arch obstruction that ended up with no significant heart disease. When there is ventricular size discrepancy and concern for a hypoplastic aortic arch, a false positive diagnosis of arch obstruction is not uncommon.^{16,17} Finally, we included the category of “probably normal” to highlight some of the diagnostic uncertainty of fetal echocardiography, which is only increased in the setting of poor acoustic

windows. These studies were not expected to have any significant pathology, or had minor pathology that was expected to resolve. Nonetheless, this uncertainty may contribute to parental stress and anxiety.

Careful consideration should be given to what the optimal cardiac screening strategy is in women with suboptimal views. One strategy to reduce the number of referrals, while not missing important diagnoses, could be to improve the technique of the screening sonographers via collaboration between fetal echocardiography and referral centers. Another possibility is to increase the time allotted for anatomic surveys when a patient would be reasonably expected to have suboptimal views (obesity, abdominal scarring). Telemedicine could also provide a mechanism for a fetal echocardiography centers to review screening cardiac views remotely, and if they are considered satisfactory, a referral may be avoided.^{18,19}

This study has several important limitations. First, as a single center investigation, its findings may not be representative of the experiences at different centers. This is particularly important with regards to who performs prenatal screening, as this may affect pathologic yield. Also, postnatal ascertainment of fetal diagnosis was not possible in the majority of patients due to difficulty linking maternal with neonatal records, and independent review of the fetal echocardiogram images was not performed. Maternal records were also incomplete, as many patients were referred from outside centers, and comprehensive data on comorbidities could not be collected. And, importantly, the low numbers of pathologic diagnoses in this study make it difficult to accurately determine the yield for this indication, as the addition or subtraction of just a few cases of pathology changes the rate significantly. Finally, the low rates of pathology precluded an analysis identifying potential variables associated with a higher risk of having a pathologic finding.

We found a pathologic yield of 1.5% on fetal echocardiography performed for the indication of suboptimal cardiac views on screening obstetric ultrasound. Out of a total of 583 examinations, 3 lesions requiring intervention were diagnosed (0.5% of total), none of which were ductal dependent. Given this low yield, the practice of referral for fetal echocardiography after a suboptimal obstetric screening deserves further evaluation. A multicenter investigation is needed to determine the rates of pathology in a larger population and factors associated with pathology.

CONFLICT OF INTEREST

None.

AUTHOR CONTRIBUTIONS

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