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Original Research Article

Feasibility of fetal echocardiography screening during first trimester in a low-risk population

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ABSTRACT

Background: Prenatal identification of cardiac defect gives families the opportunity to receive counselling regarding the anticipated fetal and neonatal outcomes. Screening and diagnosis of congenital heart disease in the first trimester has increased over the past decade as almost all CHDs are already established by that time. Objective was to assess the feasibility of screening through first trimester echocardiography by a trained observer in low-risk populations.
Methods: The study was conducted on a sample of 500 antenatal mothers of gestational age between 11-13 weeks+6 days attending a teaching hospital. Maternal age, weight, height, body mass index, parity, gestational age, obstetric history and past history were recorded. In addition to first trimester ultrasound screening for aneuploidy in foetuses, a simplified echocardiographic examination was performed. After obtaining the appropriate fetal position, Crown-rump length was documented. Nuchal translucency thickness was recorded. After examination with 2-dimensional sonography, the operator obtained the tricuspid flow and ductus venosus flow. Color flow mapping was applied for evaluating the 4-chamber view and three vessel tracheal views. Specific criteria developed for the 4-chamber view, 3 vessel trachea view, tricuspid flow and ductus venosus flow was used to assess feasibility.
Results: Good feasibility was observed for all the views, with tricuspid flow showing 96% feasibility, Ductus Venosus showing 95% feasibility, 3VT view showing 90.1% feasibility and 4CV view having 89.7% feasibility. There was no significant association found between maternal BMI, CRL and the feasibility of fetal cardiac screening.
Conclusions: Encouraging results of this study indicates the feasibility of fetal cardiac screening in low-risk population.

Keywords: Congenital heart disease, Fetal echocardiography, First trimester, Feasibility, Low risk, Infants

INTRODUCTION

Congenital heart disease (CHD) is the most frequent birth defect, estimated to be about 8 per 1000 live births.[1] The impact of congenital heart disease is huge. Fetal death, fetal growth restriction, and perinatal morbidity and mortality are more among foetuses with CHD, especially in cases with late detection. Long term survival rates are as meagre as 15-40%in certain conditions.[2] Prenatal identification of cardiac defect gives families the opportunity to receive counselling regarding the anticipated fetal and neonatal outcomes.[3] Screening and diagnosis of CHD in the first trimester has increased over the past decade as almost all CHDs are already established by that time. Several researchers have reported the importance of first-trimester fetal echocardiography, both transabdominal and transvaginal, particularly in high-risk populations.[4,5] In high-risk populations, screening carried

out by experts has shown that echocardiographic examinations are particularly effective in ruling out CHD in apparently normal cases, with a very high negative predictive value. However, most CHDs occur in low-risk populations.[6] Not many studies have focused on first-trimester fetal heart examination, in low-risk groups.[7] It has been reported that low-risk populations receive a heart-rate evaluation at the first trimester along with anoptional evaluation of the symmetry of the four cardiac chambers.[8]

The fetal cardiac screening examinations in the first-trimester in low-risk populations need not be the same as the screening in high-risk populations. Hence, a scaled down fetal echocardiographic examination has been used for early detection of severe CHD.[9] It was expected that such conditions would be of the functionally univentricular type, amenable to palliative surgery. Major defects like complete obstruction of any of the cardiac valves would also be detected by this type of screening. Such defects are associated with poor prognosis after surgical repair and termination of the pregnancy may be an appropriate form of management.[10] Because of the clearly unambiguous fact that first trimester discovery leads to easier pregnancy termination and a reduction in women's emotional, physical, and psychological anguish, detecting deformity earlier than 12 weeks is advisable.[11]

Aim and objectives

The present study aimed to assess the technical feasibility of screening through first trimester echocardiography in antenatal patients of gestational age between 11-13 weeks+6 days attending the obstetrics and gynaecology Outpatient department in a teaching hospital in a low-risk population.

METHODS

A feasibility study was conducted on antenatal mothers of gestational age between 11-13 weeks+6 days attending the obstetrics and gynaecology out patient department in a teaching hospital from June 2018 to June 2019. A sample of 500 was estimated by assuming that three vessels and trachea view were normal in 76.6% cases and 95% confidence level and a relative error of 4% (5% of proportion). Antenatal mothers presenting with bleeding per vaginum, abdominal pain or multiple gestations were excluded. Mothers with already known fetal anomalies were also excluded. Objectives of the study were explained to the participants and the consent was obtained from them. Maternal age, weight, height, body mass index, parity, gestational age, obstetric history and past history were recorded. In addition to ultrasound screening in the first trimester for aneuploidy in foetuses, a simplified echocardiographic examination was performed in only 2 views rather than usual five or six views obtained during the second trimester scan. Scan time was not modified. A single trained operator certified by the Fetal Medicine foundation performed the foetal ultrasound either trans-abdominally (4-8-MHzto check hybrid transducer) or trans-vaginally (5-9-MHz hybrid transducer) with a Voluson E8 (GE Medical Systems, Zipf, Austria) ultrasound scanner.

Table 1: Criteria for evaluating feasibility of heart examination by ultrasound scan.

Parameters	Points
Four-chamber view	
Symmetrical axial chest view antero-posterior diameter ≈ left-to-right diameter	1
Visualization of spine and initial part of one rib to each side	1
Two atrio-ventricular filling flow patterns	2
Two separate atrio-ventricular filling flow patterns, from atria to apex of ventricles	2
Two symmetrical atrio-ventricular filling flow patterns	2
Total points	8
Three vessels and trachea view (“V” sign)	
Symmetrical axial chest view anteroposterior diameter ≈ left-to-right diameter	1
Visualization of spine and initial part of one rib to each side	1
Two separate filling flow patterns	2
Convergence of the two filling flow patterns (V-shaped)	2
Two symmetrical filling flow patterns	1
Two antegrade filling flow patterns	1
Total points	8
Ductus venosus	
Magnification (the fetal thorax and abdomen occupy the whole image)	1
Mid-sagittal view	1
Sample volume 0.5-1 mm	2
Insonation angle less than 30°	2
Low filter: 50-70 Hz	1
High sweep-speed 2-3 cm/sec (3-6 wave forms)	1
Total points	8
Tricuspid flow	
Magnification (the fetal thorax occupies most of the image)	1
Apical four chamber view	2
Sample volume size (2-3 mm) and position 2	2
Insonation angle (<30 deg from direction of IVS) 2	2
High sweep-speed 2-3 cm/sec (3-6 wave forms)	1
Total points	8

The mechanical index for B-mode imaging and the soft tissue thermal index in the color flow mode were set not to exceed a value of 1. The above-mentioned standardized settings allowed for accurate cardiac imaging and shortened scan duration to fulfil the ALARA (as low as reasonably achievable) principle.[12] After obtaining the appropriate fetal position, the CRL was documented. Nuchal translucency thickness was recorded. After

examination with 2-dimensional sonography, the operator obtained the tricuspid flow and ductus venosus flow.[13-16] Color flow mapping was applied to evaluate the 4-chamber view (ventricular filling) and three vessel tracheal view (aortic arch and ductus arteriosus at their confluence: the V sign).[17] A specific criteria (scoring system) has been developed for the 4-chamber view, 3 vessel trachea view, tricuspid flow and ductus venosus flow.[9] These criteria have been identified to reveal the quality of information in the images, and they were used by an expert assessor to establish scores for the image, as given in (Table 1).

These scores were analysed with respect to the maternal body mass index (<20, 20-25, >25), fetal CRL category (45-54 mm,55-64 mm,65-74 mm,75-84 mm), parity, mode of conception, maternal age, fetal heart examination duration, number of sittings, association with other comorbidities like gestational diabetes, gestational hypertension etc. The visualized heart segments were recorded into a database after the examinations.

The feasibility of fetal echocardiography was measured by the number of adequate cardiac examinations (visualization of 4-chamber view, 3-vessel trachea view, tricuspid flow, ductus venosus flow). The time taken for fetal examination was calculated from the start to the conclusion of the study for each patient. If the operator chose to re-examine the heart, that time period was added to the final time. The time for adjustment of setting was not considered.

Statistical analysis

Data analysis was done using Ri386 3.6.3. Continuous variables were represented by mean±standard deviation. Categorical variables were represented by frequency tables. Categorical data was compared using Chi-square test with simulation, $p<0.05$ was considered statistically significant.

RESULTS

The median maternal age in the study population was 26 years, the mean gestational age was 12 weeks and the mean body mass index was 23.1. Out of the 500 subjects, data from 495 subjects were analysed as the other 5 subjects were in their second trimester. Of these subjects, only 3 had a history of third-degree consanguinity. Spontaneous conception was reported by 475 (96%) subjects, 11 (2.2%) had Intra Uterine insemination, 5 (1%) had Ovulation induction and 1 (0.2%) subject had IVF conception. Primigravida constituted 272 (54.8%) subjects and multigravida constituted 223 (45.2%) subjects. A summary of these characteristics of study subjects is described in (Table 2). A personal history of congenital heart disease was reported by 5 mothers. There were 9 subjects who reported fetal anomalies, both chromosomal and structural malformations detected in the previous pregnancies. The mean Nuchal translucency was 1.52±0.4. Increased Nuchal Translucency >95th percentile and 99th percentile was seen in 19 subjects. The mean CRL was found to be 59.56±7.29.

Table 2: Summary of characteristics of study subjects.

Factors	Sub-category	N	%
Age (years), Mean±SD=26.42±4.12, Median (Range)=26 (17, 39)	≤20	29	5.86
	21-30	390	78.79
	31-40	76	15.35
Gravida	Primi	272	54.95
	Multi	223	45.05
BMI (kg/m^2), Mean±SD=23.92±4.57, Median (Range)=23.1 (14.8, 43.1)	Underweight	44	8.89
	Normal	276	55.76
	Overweight	118	23.84
	Obese	57	11.52
Gestational age (weeks)	11	98	19.80
	12	302	61.01
	13	95	19.19
Mode of conception	Intra Uterine Insemination	11	2.22
	IVF	1	0.20
	ICSI	3	0.61
	Ovulation induction	5	1.01
	Spontaneous	475	95.96
Family H/O CHD	Yes	0	0.00
	No	495	100.00
Consanguinity	Non - consanguineous	492	99.39
	Consanguineous	3	0.61

Nasal bone was assessed in 485 (97%) subjects, absent in 10 (2%) subjects, and could not be assessed in 2 (1%) subjects. The values of the Ultrasound Heart Examination feasibility are given in (Table 3).

Table 3: Distribution of subjects by basic heart examination.

Factors	Sub-category	N	%
Four chamber view	Missing	2	0.40
	3-7	49	9.90
	8	444	89.70
VSIGN	Missing	9	1.82
	3-7	40	8.08
	8	446	90.10
Mode of examination	TA	427	86.26
	TA+TVS	68	13.74
Tricuspid flow	Missing	6	1.21
	3-7	11	2.22
	8	478	96.57
Ductus venosus flow	Missing	6	1.21
	3-7	18	3.64
	8	471	95.15
Number of sittings	1	413	83.43
	2	67	13.54
	3	15	3.03

Four Chamber View (4 CV) was seen to be feasible (score 8/8) in 448 (89.6%) subjects. In 50 (10%) subjects it was described as sub optimal (score 3-7). This may have been due to any abnormality present or may be due to poor quality of the image. However, no case was deemed technically infeasible. About 0.4% (N=2) of cases were not assessed. The three-vessel trachea view (3 VT) view was deemed feasible (score 8/8) in 45 (90.2%) subjects. It was described as suboptimal (score 3-7) in 40 (8%) subjects. No assessment was done in 9 (1.8%) cases. Tricuspid flow was found to be normal (score 8/8) in 482 (96.4%) subjects. It is described as suboptimal in 12 (2.4%) subjects. No assessment was done in 6 (1.2%) cases. Ductus venosus flow view was observed to be feasible (score 8/8) in 474 (94.8%) subjects. It is described as suboptimal (score 3-7) in 19 (3.8%) subjects. No assessment was done in 6 (1.2%) subjects. Trans-abdominal examination alone was done among 432 cases, whereas in 68 cases, an additional trans-vaginal ultrasound was performed, as only trans-abdominal examination was considered inadequate due to poor visualization or as complementary to the transabdominal exams. The average time taken for a transabdominal examination was 15.22 minutes. The minimum duration was 5 minutes and maximum duration was 47 minutes. Mean duration for transvaginal and transabdominal examinations was 25.5 minutes with minimum duration being 8 minutes and maximum duration being 57 minutes. Majority of basic heart examinations (417, 83.4%) were performed in a single sitting. Two sittings were needed in 68 (13.6%) subjects and three sittings were needed for 15 (3%) subjects. The association of the feasibility scores with BMI and CRL were analysed by Chi square test and described in (Table 4-7).

Table 4: Association of maternal BMI and CRL with basic heart examination (4CV).

Factors	Sub-category	4CV, N (%)		P value
		3-7	8	
BMI category	Underweight	4 (9.09)	40 (90.91)	0.6577
	Normal	27 (9.78)	249 (90.22)	
	Overweight	10 (8.47)	108 (91.53)	
	Obese	8 (14.55)	47 (85.45)	
Fetal crown rump length (mm)	45-54	18 (15.13)	101 (84.87)	0.1679
	55-64	20 (8.33)	220 (91.67)	
	65-74	10 (8.7)	105 (91.3)	
	75-84	1 (5.26)	18 (94.74)	

Table 5: Comparison of maternal BMI and CRL with Basic heart examination (3VT).

Factors	Sub-category	3VT, N (%)		P value
		3-7	8	
BMI category	Underweight	1 (2.38)	41 (97.62)	0.3443
	Normal	21 (7.72)	251 (92.28)	
	Overweight	13 (11.11)	104 (88.89)	
	Obese	5 (9.09)	50 (90.91)	
Fetal crown rump length (mm)	45-54	12 (10.08)	107 (89.92)	0.4973
	55-64	20 (8.44)	217 (91.56)	
	65-74	8 (7.21)	103 (92.79)	
	75-84	0 (0)	19 (100)	

Table 6: Comparison of maternal BMI and CRL with tricuspid flow.

Factors	Sub-category	Tricuspid flow, N (%)		P value
		3-7	8	
BMI category	Underweight	0 (0)	43 (100)	0.3668
	Normal	7 (2.55)	267 (97.45)	
	Overweight	4 (3.42)	113 (96.58)	
	Obese	0 (0)	55 (100)	
Fetal crown rump length (mm)	45-54	0 (0)	119 (100)	0.1534
	55-64	6 (2.53)	231 (97.47)	
	65-74	5 (4.39)	109 (95.61)	
	75-84	0 (0)	19 (100)	

Table 7: Comparison of maternal BMI and CRL with ductus venosus flow.

Factors	Sub-category	Ductus venosus flow, N (%)		P value
		3-7	8	
BMI category	Underweight	0 (0)	43 (100)	0.5392
	Normal	10 (3.65)	264 (96.35)	
	Overweight	5 (4.27)	112 (95.73)	
	Obese	3 (5.45)	52 (94.55)	
Fetal crown rump length (mm)	45-54	2 (1.71)	115 (98.29)	0.4563
	55-64	11 (4.58)	229 (95.42)	
	65-74	5 (4.39)	109 (95.61)	
	75-84	0 (0)	18 (100)	

The scores for the 4 CV and for the 3 VT view cross section did not differ significantly between patients grouped according to BMI <20, BMI 20-25, or BMI >25. However, patients with BMI <20 had higher 4 CV and 3 VT view scores than did those with BMI >25. The scores for the 4 CV and 3 VT view cross-sections did not differ significantly when patients were grouped according to CRL and analysed by Chi-square test. However, patients with CRL <55 mm had considerably lower 4 CV and 3 VT cross- sectional scores than those with CRL >75 mm. The scores for 4 CV was 8/8 among 4 mothers who had CHD and in one of the five mothers who had CHD, the score was 3-7. Regarding the 3 VT views, 3 mothers with CHD presented score of 8/8 while the remaining two had scores of 3-7. Abnormalities in previous pregnancies were seen in 9 mothers, out of which 8 mothers presented a 4 CV score of 8/8 and only one mother had a score 3-7. Similar observation was also made regarding 3 VT scores.

DISCUSSION

Fetal echocardiography is regularly carried out in patients at high risk of conceiving a baby with congenital heart disease. Nonetheless, half of the neonates diagnosed with CHD, lack a definable risk factor. Consequently, fetal heart examination in all pregnancies is essential to improve the detection rate.[18] Although routine ultrasound screening in the first trimester is well established to detect chromosome defects and some structural abnormalities,[19] a detailed systematic examination of the fetal heart is rarely practiced in scans during 11 and 13+6 weeks. The present study was designed to assess the feasibility of a basic heart examination, without the need to change the methods used for routine ultrasound screening by a trained observer in a low-risk CHD population by obtaining cross sections of the 4 CV and 3 VT views using predefined quality criteria.[9] The study demonstrated the feasibility of 4 CV view to be 89.6% and that of 3 VT view to be 90.2 %. The combined feasibility of both 4 CV and 3 VT views were 83.8%. This encouraging result is comparable to a previous study whose feasibility of 4 CV and 3VT views was 86% and 79% respectively. The combined feasibility of both 4CV and 3 VT views was seen in 73 % of patients.[9]

In this study, 50 (10%) 4CV images and 40 (8%) 3 VT views were deemed sub-optimal or atypical. These cases were reviewed with a second trimester scan to prevent potential anxiety. As the highest yields in the diagnosis of CHD are in patients who are referred because of a previous abnormal screening, incomplete and suboptimal visualization or suspicious findings may warrant re-examination at a later stage.[18] Additionally, it is well known that some CHDs can progress during fetal life.[19,20] Therefore, first-trimester echocardiography may not replace the examinations later in pregnancy when indicated. Transabdominal and transvaginal examinations have their own set of advantages and disadvantages.[21] Transabdominal imaging is best suited for measurement of Nuchal translucency due to the panoramic view and scope for manipulation. Transvaginal examination helps in high resolution imaging of fetal anatomy. In the present study, for 432 cases, only trans-abdominal examination was done. In 68 cases an additional trans-vaginal examination was performed, as only a trans-abdominal examination

was considered inadequate. Transabdominal sonography is known to be better accepted by patients. However, in some situations, such as in obese women and those with a retroverted uterus, transvaginal scanning shows better results.[22-24] It has been reported in the literature that for viewing of the foetal heart, transvaginal examination is superior to the transabdominal technique.[25] Vimpelli et al conclude from their study that, in the late first trimester, foetal heart examination is possible, and conventional echocardiographic images may be acquired in the majority of foetuses utilising transvaginal examination.[26] The duration of fetal echocardiography has been previously reported to be about 10 minutes where as the present study furnished with an almost comparable mean duration of 15 minutes for trans-abdominal examination and a mean duration of 25 minutes in case of trans-vaginal examination.[27] The less time taken for the procedure represents a lesser fetal exposure time to increased energy. BMI and CRL are known to impact foetal cardiac evaluation.[28] In the present study, maternal BMI and CRL were studied for their possible relation to feasibility but there was no statistically significant association. This finding is comparable to previous studies where no statistical significant association was found.[10]

The strength of this research is that it is one of the few studies done to assess the feasibility of a first trimester basic heart examination by following new criteria for assessing the quality of obtaining 4 CV view, 3VT view, Tricuspid flow and Ductus Venosus flow. In addition, it helped us to modify the examination protocols in our Unit to expand the scope of the first trimester ultrasound beyond aneuploidy screening. When the results showed that in some cases, a few views were not recorded, we initiated the usage of a scan checklist to ensure complete examinations in all patients. This checklist has undergone multiple revisions and is currently a very useful tool in our armamentarium. Though no CHD was reported during the study period, the incorporation of the echocardiographic protocol enabled us in the detection of major CHDs like hypoplastic heart, transposition of great vessels, Double outlet right ventricle etc. in the subsequent years. A major limitation is that the suboptimal heart scores that were obtained were not followed until second trimester fetal echocardiography to look for any development of CHD. Another limitation is that the study focused only on feasibility and did not address the relevance of CHD detection with a simplified cardiac examination.

CONCLUSION

The excellent feasibility of a trained operator in performing a simplified fetal echocardiography during the first trimester ultrasound examination in a low-risk population was demonstrated. It is therefore crucial to encourage development of this concept in low-risk populations to identify potential problems as early as possible. In most cases, reassurance can be given to the parents by performing this basic heart examination.

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