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ORIGINAL ARTICLE

Status of Antenatal Detection of Congenital Heart Defects in a Northern Indian Population and Factors Influencing it

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Abstract
Objective To evaluate the antenatal detection rate (ADR) of congenital heart defects (CHDs) in the northern part of India and also to assess the factors affecting the same.
Methods This was a prospective study performed at a tertiary referral center for pediatric cardiac care in northern India and included 200 consecutive infants (including neonates). A detailed history was obtained from the parents based on a protocol which included antenatal, birth and postnatal details including age at CHD detection. Patients with postnatal diagnosis of atrial septal defects, patent ductus arteriosus, partial anomalous pulmonary venous return, coronary and vascular ring anomalies and coarctation of aorta were excluded.
Results Median age of detection of CHD was 1 mo (range = 1 d–11 mo). Fetal echocardiography (FE) was done in 23 (11.5%) patients; CHD was detected in 21 of them, giving an overall antenatal detection rate (ADR) of CHD as 10.5%. Fifteen of them were referred to a pediatric cardiologist for FE while in 8 patients, FE was performed by sonologist or fetal medicine specialist. Median gestational age at referral to a regional pediatric cardiologist for FE was 24 wk (range = 18–36 wk). Most important factor affecting the ADR was total number of ultrasounds during pregnancy, with ADR being higher in those having four or more ultrasound examinations.
Conclusions Antenatal detection rate for CHD was very low. Referral for a focused fetal echocardiography during pregnancy is poor and those referred are done at very late stages of pregnancy. Measures that can help in improving the detection include following a strict protocol for cardiac screening, extending the screening to include the outflow tracts and early referral to fetal or pediatric cardiologists in case of minimal suspicion.

Keywords Antenatal detection rate · Congenital heart defects · Fetal echocardiography

Introduction

Congenital heart defects (CHDs) are the most common congenital malformation [1]. The prevalence of CHD is estimated to be 8 per 1000 live births [2–4]. It is thus six times more common than chromosomal anomalies and three times more common than neural tube defects [5]. Cardiac evaluation is usually confined to pregnancies at high risk of CHD like those with family history of CHD, or presence of extracardiac malformations. However studies have shown that up to 86% of CHD's are detected in pregnancies with no high risk factors [2]. Antenatal detection of CHD provides opportunities to counsel parents, to screen for other extracardiac malformations, appropriate management of pregnancy and planning of delivery. In severe cases, it also provides an opportunity to the parents to discontinue the pregnancy. Also antenatal detection of CHD reduces the perinatal and post operative mortality and morbidity [6]. Thus antenatal detection of CHD remains crucial and cardiac evaluation during the routine obstetric ultrasound scan is the most efficient way

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of detecting or suspecting a cardiac lesion which can then be confirmed by fetal echocardiography.

The aim of present study was to evaluate the antenatal detection rate (ADR) of CHD in a northern Indian population and also to assess the factors affecting the same.

Material and Methods

This was a prospective study performed at a tertiary referral center for pediatric cardiac care in northern India. The study included 200 consecutive infants (below 1 year of age, including neonates) who were referred to authors either for a clinical suspicion of heart defect or for a second opinion, or who had been diagnosed to have CHD. A detailed history was obtained from the mother based on a protocol which included antenatal details like place of antenatal care, total number of ultrasound examinations during pregnancy, result of level 2 or anomaly scan and whether CHD was detected antenatally or not. In cases where CHD was detected antenatally, it was enquired whether the patient was referred for a fetal echocardiogram (FE) or not and at what gestational age was the referral done. In cases who had a fetal echocardiogram, the reports were reviewed for complete cardiac diagnosis, specialist performing the fetal echocardiogram (pediatric/fetal cardiologist or sonographer/fetal medicine specialist) and gestational age at FE. Other details noted in the history included presence of any extracardiac or chromosomal anomaly, family history of CHD, postnatal age at CHD detection and the main symptom leading to diagnosis.

The patients were divided into two groups based on the place of antenatal care *i.e.*, whether it was a district place (group A) or a smaller place than a district (group B). The CHD's were also classified into two groups: Group 1 included anomalies that typically have an abnormal four chamber image and included lesions like atrioventricular septal defects (AVSD), corrected transposition of great arteries (c-TGA), Ebstein's anomaly, inlet or mid muscular ventricular septal defects (VSD) or single ventricular lesions (hypoplastic left heart syndrome, tricuspid atresia, pulmonary atresia with intact interventricular septum). Group 2 included CHD's that typically have a normal four chamber image and this included defects like tetralogy of Fallot (TOF), truncus arteriosus, complete transposition of great arteries (TGA), double outlet right ventricle (DORV) and perimembranous VSD.

Patients with postnatal diagnosis of atrial septal defects (ASD), patent ductus arteriosus (PDA), partial anomalous pulmonary venous return (PAPVR), coronary and vascular ring anomalies were not included in the study as these lesions are difficult to diagnose on FE. The authors also excluded patients with coarctation of aorta since antenatal diagnosis of coarctation remains difficult.

Descriptive analysis were carried out. Categorical variables are presented as numbers and percentages while continuous variables are presented as median (range) or mean (standard deviation). Pearson Chi square test or Fisher's exact test (whichever was applicable) were applied for comparison of different groups. A p value of less than 0.05 was considered statistically significant. Statistical Package for the Social Sciences (SPSS) software (SPSS-Inc., Chicago, IL) was used for the statistical analysis.

Results

The study cohort consisted of 200 neonates and infants diagnosed with a variety of CHD's. It included 54 females and 146 males. Median age of CHD detection by postnatal echocardiography was 1 mo (range = 1 d –11 mo). The most common symptom leading to diagnosis was cardiac murmer (73 patients). Other presenting symptoms included tachypnea (32 patients), tachycardia (7 patients), cyanosis (29 patients), episode of lower respiratory tract infection (25 patients), feeding difficulty (7 patients), neonatal jaundice (1 patient) and failure to thrive (1 patient). Three patients were diagnosed to have CHD during evaluation for Down's syndrome and one was diagnosed while being managed for birth asphyxia. The various types of CHD in the cohort are shown in Table 1.

Of 200 babies, 21 were diagnosed antenatally giving an overall antenatal detection rate (ADR) for CHD of 10.5%. FE was done in 23 patients and CHD was detected in 21 of them. Flow chart showing the subdivision of patients who had a fetal echocardiogram done is presented as Fig. 1. In the remaining 2 cases (patient no. 6 and 14 in Table 2), though FE was performed, it was reported as normal; however, both these babies were later diagnosed to have CHD after birth on post natal echo (one had a perimembranous VSD while other had perimembranous VSD with coarctation of aorta).

Of the 21 antenatally detected cases, 15 were referred to a pediatric cardiologist for FE while in 8 patients, FE was performed by a sonologist or fetal medicine specialist. Patients were referred for FE at a median gestational age of 24 wk (range = 18–36 wk). The details of patients who had a FE are shown in Table 2.

The commonest CHD detected in the entire cohort was ventricular septal defects (VSD), however the ADR for VSD was only 4.8%. One hundred twenty-seven patients had those CHD's in which the 4C view can be normal in fetal life while 73 patients had lesions potentially detectable on 4C view (Table 3).

Table 1 Postnatal echocardiographic diagnosis

Type of CHD	Number of cases
Large perimembranous ventricular septal defect (VSD)	57
Large VSD (Inlet/muscular/apical)	17
VSD-outlet	6
Multiple VSD	5
Small muscular VSD	10
VSD with coarctation of aorta/Interrupted arch	8
VSD with AP window	1
Severe aortic stenosis (AS)	1
Atrio ventricular septal defects (AVSD)	15
Double inlet left ventricle (DILV)	2
Double outlet right ventricle (DORV) with VSD	7
Double outlet right ventricle with VSD and pulmonary stenosis	4
Mitral atresia (MA)	1
Pulmonary atresia (PA) with intact interventricular septum (IVS)	3
Pulmonary atresia with ventricular septal defect	6
Severe pulmonary stenosis (PS)	1
Truncus arteriosus	1
Tricuspid atresia (TA)/VSD	7
Total anomalous pulmonary venous return (TAPVC)	6
Transposition of great arteries (TGA) with intact ventricular septum	5
Transposition of great arteries (TGA) with VSD	7
Transposition of great arteries (TGA) with VSD with pulmonary stenosis	3
Tetralogy of fallot	20
Rhabdomyoma	1
HLHS	2
Corrected transposition of great arteries	4

AP Aorto-pulmonary; *HLHS Hypoplastic left heart syndrome*; For other abbreviations see bottom of Table 2

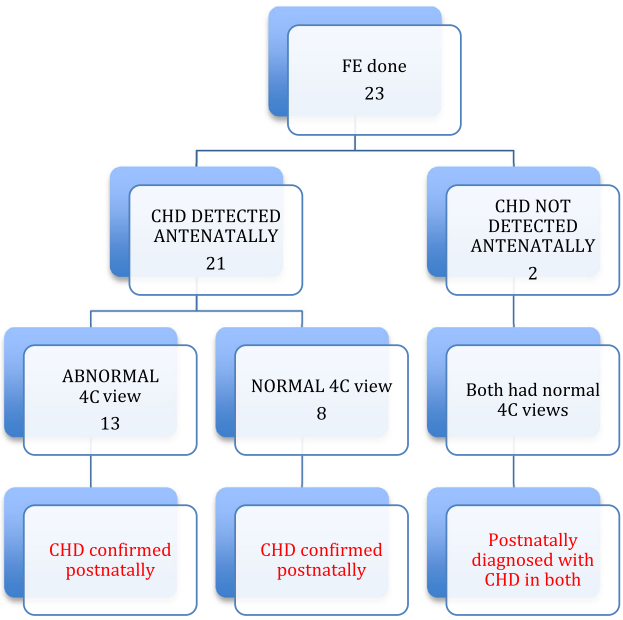

Fig. 1 Flow chart showing the subdivision of patients who had a fetal echocardiogram done. *CHD* Congenital heart defect

The ADR was higher for CHD's detectable on four chamber view (12.3%) compared to those that are not detectable on four chamber view (9.4%). However this difference did not achieve statistical significance ($p = 0.52$). ADRs for individual cardiac lesion are shown in Table 4.

Comparing the ADR according to the place of antenatal care authors found that ADR was 11.1% in those evaluated at district level place while the ADR was 6.6% in those evaluated at places smaller than a district (Table 5). However this difference also did not achieve statistical significance ($p = 0.35$).

Of the 200 patients, in 121, the mother had at least 4 ultrasound evaluations throughout the pregnancy while in 79 the mother had three or less ultrasounds. There were two cases in which the mother did not have even a single ultrasound evaluation throughout the pregnancy. Correlating the detection of CHD with the total number of ultrasound examinations during pregnancy, it was found that the CHD detection was significantly higher ($p = 0.01$) in the

Table 2 Details of cases with fetal echocardiography

Patient no.	FE done by	Referred to pediatric cardiologist	Referral age	Antenatal diagnosis	Postnatal diagnosis	Place of ANC
1	SL	No	–	Rhabdomyoma	Rhabdomyoma	District
2	SL	No	–	Abnormal	Unbalanced AVSD	District
3	PC	Yes	36	HLHS	HLHS	District
4	PC	Yes	26	TGA/VSD	TGA/VSD/PS	<District
5	PC	Yes	26	TOF	TOF	District
6	SL	No	–	Normal	VSD-PM/COA	District
7	PC	Yes	24	VSD-PM	VSD-PM	<District
8	PC	Yes	23	Posterior muscular VSD	Posterior muscular VSD	District
9	PC	Yes	18	TGA/VSD	TGA/VSD	District
10	FM	No	–	Tricuspid atresia/ Hypoplastic RV	Pulmonary atresia/hypoplastic RV and tricuspid valve	District
11	PC	Yes	32	DILV/DORV/Hypoplastic RV/COA	Criss-cross ventricles/DORV/COA	District
12	PC	Yes	24	VSD-small muscular	VSD-small muscular	District
13	SL	No		VSD/Hypo Arch	VSD-PM/IAA	District
14	SL	No	–	Normal	VSD-PM	District
15	PC	Yes	23	VSD-M	VSD-M	District
16	PC	Yes	19	TOF	TOF	District
17	SL	No	–	VSD	TGA/VSD	District
18	PC	Yes	28	TA/VSD	TA/VSD/PS	District
19	FM	No	–	TA/VSD	TA/VSD	District
20	PC	Yes	30	AVSD/MA/Hypo LV/ DORV/PA	AVSD/MA/Hypo LV/DORV/PA	District
21	PC	Yes	23	VSD	AVSD	District
22	PC	Yes	24	AVSD	AVSD	District
23	PC	Yes	30	AVSD	AVSD	District

ANC Antenatal care; *AVSD* Atrioventricular septal defects; *COA* Coarctation of aorta; *DILV* Double inlet left ventricle; *DORV* Double outlet right ventricle; *FM* Fetal medicine specialist; *HLHS* Hypoplastic left heart syndrome; *IAA* Interrupted aortic arch; *LV* Left ventricle; *MA* Mitral atresia; *PA* Pulmonary atresia; *PC* Pediatric cardiologist; *PS* Pulmonary stenosis; *RV* Right ventricle; *SL* Sonologist; *TA* Tricuspid atresia; *TGA* Transposition of great arteries; *TOF* Tetralogy of Fallot; *VSD-M* Ventricular septal defects-muscular; *VSD-PM* Ventricular septal defects-perimembranous

Table 3 Grouping of CHD according to appearance of 4C view

Group	Total no.	CHD detected antenatally	ADR (%)
1 (Normal 4C)	127	12	9.4
2 (Abnormal 4C)	73	9	12.3

CHD Congenital heart defects; *ADR* Antenatal detection rate

group of mothers who had more than three ultrasound examinations compared to those having lesser.

Ten patients also had extracardiac anomalies of which 7 had Down's syndrome, 1 had clubfoot and digital anomalies, 1 had single kidney and 1 had multiple anomalies including short left upper limb with dysmorphic facies and renal anomaly. These structural anomalies were not detected prenatally. Also 2 patients had single umbilical artery but were not referred for FE.

None of the patients had a family history of CHD.

Discussion

The authors evaluated the antenatal detection rate for CHD for the first time in a cohort of neonates and infants representing the northern part of India. Though all the mothers except two had multiple ultrasound examinations during pregnancy, only 23 (11.5%) fetuses were suspected of having cardiac anomaly and thus had a FE done and only 15 (7.5%) were referred to a fetal/pediatric cardiologist for an expert opinion. This indicates a poor referral rate. Also the overall ADR for all kinds of CHD was 10.5%. This is significantly less than the ADR for CHD in various other

Table 4 ADR of individual cardiac lesions

CHD	Cases detected antenatally	Total cases	ADR (%)
Ventricular septal defect (VSD)	5	104	4.8
Tetralogy of fallot	2	20	10
Transposition of great arteries with VSD	3	10	30
Transposition of great arteries/intact ventricular septum	0	5	0
Total anomalous pulmonary venous return	0	6	0
Tricuspid atresia/VSD	2	7	28.5
Hypoplastic left heart syndrome	1	2	50
Pulmonary atresia/VSD	0	6	0
Pulmonary atresia/intact ventricular septum	1	3	33
Mitral atresia	0	1	0
Double outlet right ventricle/VSD	1	11	9
Atrioventricular septal defect	5	15	33
Corrected transposition of great arteries	0	4	0
Double inlet left ventricle	0	2	0
Severe aortic stenosis (AS)	0	1	0
Severe pulmonary stenosis (PS)	0	1	0
Truncus arteriosus	0	1	0
Rhabdomyoma	1	1	100

ADR Antenatal detection rate; *CHD* Congenital heart defects

Table 5 Grouping of CHD detection according to place of antenatal care

Group	Total no.	CHD detected antenatally	ADR (%)
A (District)	170	19	11.1
B (less than District)	30	2	6.6

ADR Antenatal detection rate; *CHD* Congenital heart defects

studies from different countries which ranged from 28 to 75% [5, 7–10]. However no Indian data on ADR for CHD was available for comparison.

ADR was higher at district level places (11.1%) compared to smaller regions (6.6%). Though the difference did not achieve statistical significance but it correlates with the findings of Quartermain [8] who demonstrated that ADR for CHD showed significant variation across regions. This may probably be due to lack of adequate facilities which include both lack of technical facilities and lack of imaging expertise as well as access to fetal echocardiography [8, 11].

The combined ADR for lesions having abnormal 4CV was 12.3%. However the ADR for lesions that have a normal 4CV was only 9.4%. This probably indicates a lack of uniformity in the technique of cardiac screening during the routine obstetric ultrasound with some centers using only 4CV for cardiac screening. It is well documented that cardiac screening using the extended basic imaging techniques which includes the outflow tract view (OFT) leads to an increase in ADR [10, 12]. Sklansky et al. [13] in their cohort found that an abnormal 4CV detected 63% of CHD's while addition of OFT view increased the ADR to 91%. Studies have also shown that the skill of the operator also affects the ADR. According to Hunter et al. [14], major CHD detection rates increased from 17 to 36% after two years training of sonographers in visualization of 4CV and OFT views. Thus appropriate training for cardiac screening and a routine use of a fixed protocol including the OFT view is essential to improve the ADR.

An important finding of this study is that 8 patients who had a FE and were diagnosed with CHD of variable severity were not referred to a fetal/pediatric cardiologist. Antenatal diagnosis of CHD is important but equally important is their referral to a fetal/pediatric cardiologist not only for confirming the diagnosis but also for a detailed prognostication and counseling. This is also necessary for appropriate management of pregnancy and planning of delivery especially in cases of duct dependent pulmonary or systemic circulation. Patients who were diagnosed but not referred were delivered unplanned in peripheral centers and such babies often reach the cardiac center late and in a

compromised state which in turn increases the postoperative morbidity and mortality. Another important aspect is the age at referral. A previous study by authors' has revealed that in this part of the country, the mean gestational age at referral for FE for those diagnosed to have CHD was 27 wk [15]. In the present study also, authors have noted that those who were referred to a fetal or pediatric cardiologist for FE were referred quite late with a mean age at referral being 24 wk. Delayed referral limits the options for the patients and therefore, it is strongly recommended that patients should be referred for FE between 16 and 20 wk of gestation.

The present study had certain limitations. The number of CHD cases detected antenatally was very small and this could have probably skewed some of the statistical results. Also, the details of anomaly scan or level 2 ultrasound were not available in many patients, hence it is difficult to comment whether all patients had a systematic evaluation or not.

Conclusions

The antenatal detection rate for CHD was very low and lack of adequate training in fetal echocardiography is an important factor. Certain measures that can help in improving the detection include following a strict protocol for cardiac screening, extending the screening to include the outflow tracts and early referral to fetal or pediatric cardiologists in case of minimal suspicion. Gestational age at referral for FE remains important and patients should be referred before 20 wk of gestation. By improving the antenatal detection of CHD, we can definitely improve the postnatal and post operative outcome of such babies.

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Compliance with Ethical Standards

Conflict of Interest None.

Ethical Approval The ethics committee was not involved as it was a part of routine history taking during the evaluation of every patient. Informed consent was obtained.

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References

1. Lee K, Khoshnood B, Chen L, Wall SN, Cromie WJ, Mittendorf RL. Infant mortality from congenital malformations in the United States, 1970–1997. Obstet Gynecol. 2001;98:620–7.
2. Mitchell SC, Korones SB, Berendes HW. Congenital heart disease in 56,109 births: incidence and natural history. Circulation. 1971;43:323–31.
3. Hoffmann JIE, Christianson R. Congenital heart disease in a cohort 19,502 births with long-term follow up. Am J Cardiol. 1978;42:641–7.
4. Ainsworth SB, Wyllie JP, Wren C. Prevalence and clinical significance of cardiac murmurs in neonates. Arch Dis Child Fetal Neonatal Ed. 1999;80:F43–5.
5. Carvalho JS, Mavrides E, Shinebourne EA, Campbell S, Thilaganathan B. Improving the effectiveness of routine prenatal screening for major congenital heart defects. Heart. 2002;88:387–91.
6. Peake LK, Draper ES, Budd JL, Field D. Outcomes when congenital heart disease is diagnosed antenatally versus postnatally in the UK: a retrospective population-based study. BMC Pediatr. 2015;15:58.
7. Chew C, Halliday JL, Riley MM, Penny DJ. Population-based study of antenatal detection of congenital heart disease by ultrasound examination. Ultrasound Obstet Gynecol. 2007;29:619–24.
8. Quartermain MD, Pasquali SK, Hill KD, et al. Variation in prenatal diagnosis of congenital heart disease in infants. Pediatrics. 2015;136:e378–85.
9. Friedberg MK, Silverman NH, Moon-Grady AJ, et al. Prenatal detection of congenital heart disease. J Pediatr. 2009;155:26–31.
10. Van Velzen CL, Clur SA, Rijlaarsdam ME, et al. Prenatal detection of congenital heart disease—results of a national screening program. BJOG. 2016;123:400–7.
11. Trines J, Fruitman D, Zuo KJ, Smallhorn JF, Hornberger LK, Mackie AS. Effectiveness of prenatal screening for congenital heart disease: assessment in a jurisdiction with universal access to health care. Can J Cardiol. 2013;29:879–88.
12. Sainz JA, Zurita MJ, Guillen I, et al. Prenatal screening of congenital heart defects in population at low risk of congenital defects. A reality today. An Pediatr (Barc). 2015;82:27–34.
13. Sklansky MS, Berman DP, Pruetz JD, Chang RKR. Prenatal screening for major congenital heart disease. J Ultrasound Med. 2009;28:889–99.
14. Hunter S, Heads A, Wyllie J, et al. Prenatal diagnosis of congenital heart disease in the northern region of England: benefits of a training programme for obstetric ultrasonographers. Heart. 2000;84:294–8.
15. Nair A, Radhakrishnan S. Evaluation of referral pattern for fetal echocardiography at a tertiary care center in northern India and its implications. J Obstet Gynaecol India. 2016;66:258–62.