ORIGINAL ARTICLE

CONGENITAL HEART DEFECTS IN INFANTS WITH A CONGENITAL DIAPHRAGMATIC HERNIA: A SINGLE-CENTER EXPERIENCE

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Objectives: Congenital heart disease (CHD) is the most common congenital anomaly and in association with diaphragmatic hernia (DH) develops significant morbidity and mortality outcomes. We aimed to determine the frequency of CHD in patients with DH and the effect of their relationship at our center.

Methodology: This retrospective study considered all patients with congenital DH, who were referred to the pediatric cardiology Clinic of Imam Reza Hospital to evaluate for congenital heart disorders from March 2002 and December 2019. Findings were divided into two groups: normal structure heart and minor anomalies and major congenital heart disease that needs follow-up and interferes with surgical planning.

Results: Twenty-five cases of congenital heart disease were identified, 17 patients were male (68%), and the mean age of cases was 5.5 months. Moreover, 17 patients (68%) suffered from CHD which was the major congenital heart disease in 10 cases (40%). Eight patients (32%) were diagnosed with normal echocardiography or minor defects such as patent foramen oval or floppy mitral valve with no mitral regurgitation. The most common CHD was ventricular septal defect, observed in six patients (24%). The most frequent non-cardiac malformations were gastrointestinal anomalies, chest deformity and genitourinary anomalies.

Conclusion: The most common anomaly in the infants with a congenital diaphragmatic hernia is congenital heart diseases, particularly septal defects. Cardiac consultation in in patients with a congenital diaphragmatic hernia is significant, which is recommended for all the patients before surgery.

Keywords: congenital diaphragmatic hernia, congenital heart defects, echocardiography, infant

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INTRODUCTION

Congenital diaphragmatic hernia (CDH) is a rare and life-threatening malformation with the incidence rate of one up to four per 10000 live births. CDH refers to a disorder in diaphragm formation and closure that is located typically on the posterior outer side of the diaphragm and is mostly observed on the left side (Bochdalek hernia). Morgagni hernia is the herniation of omentum or viscera to the chest via Morgagni foramen in the anterior part of the diaphragm.[1]

The Bochdalek and Morgagni hernias are accounts for 70% and 27% of the cases, respectively. The Bochdalek hernia occurs in 85% of patients on the left, in 13% of the patients on the right, and in 2% of the cases on both sides of the diaphragm. Therefore, it could make the abdominal viscera to enter the chest, lead to the impairment of thee lung and the pulmonary vessels.[1,2]

CDH, an isolated diaphragmatic lesion might be associated with a congenital syndrome, chromosomal abnormality, etc. Complex CDHs accounting 30-40 % make the mortality rate higher than the non-complex CDH. The pulmonary hypoplasia is a prognostic factor in isolated CDH patients and the low oxygen saturation level could clinically mimic congenital heart anomalies.[1-3]

Congenital cardiac anomalies, the independent risk factor for CDH poor prognosis, are associated with 10-15% and 25-40% of non-syndromic and syndromic CDH, respectively. Ventricular Septal Defect (VSD, 29%), the most common type of CHD, has a great association with the diaphragmatic hernia during the neonatal period.[4] The CHDs including hypoplastic left

heart syndrome, Tetralogy of Fallot with pulmonary atresia, arch obstruction, coarctation of the aorta, transposition of the great arteries, and truncus arteriosus, are also observed.[3,4]

Prenatal imaging including ultrasound and pulmonary MRI is roughly performed on 75% of the prenatal CHDs.[7] Lung size measurement is an accurate method to diagnose pulmonary hypoplasia and the lung-to-head circumference ratio (LHR) is also a significant prognostic predictor, which is measured regarding the head circumference through four directions. The lower the ratio, the poorer the prognosis; the more the liver and stomach enter the chest, the lower the prognosis.[8]

Persistent pulmonary hypertension (PPHN), the main predictor for neonatal mortality, increases the pulmonary vascular resistance and causes the right-sided heart failure.[7-9] The genetics basis is concerned with more than 35% of the CDH cases, therefore genetic counseling appears mandatory for next pregnancies and prenatal management.[5] To the best of our knowledge, the present issue was not evaluated in our region and we aimed to determine the frequency of the CDH and CHD in Northeastern neonate population of Iran.

METHODOLOGY

The study was approved by the Institutional Ethics Committee of Mashhad University of Medical Sciences (IR.MUMS.MEDICAL.REC.1397.345). In this retrospective study, all CDH-diagnosed infants who referred to or consulted by pediatric cardiologist were evaluated in Imam Reza Hospital, Mashhad, Iran, from March 2002 to December 2019.

The study's population comprised of all neonates and infants admitted to or consulted at cardiology care unit of a tertiary hospital of Mashhad University of Medical Sciences, Mashhad, Iran. The medical records were reviewed and collected using a structured checklist.

The first year of age as the survival rate was noted. The neonates were classified postnatal into two groups: the patients with normal heart structure and minor anomalies such as (patent foramen ovale) PFO, (persistent left superior vena cava) LSVC, and (floppy mitral valve) FMV with insignificant (mitral regurgitation) MR having no impact on the surgery, and the patients with major CHD-associated anomalies such as VSD, (atrial septal defect) ASD, (Tetralogy of Fallot) TOF or complex CHD, which interfere with surgical planning. The significant non-cardiac or genetic anomalies were also reviewed. Moreover, medical records with missing data, including diagnosis or clinical outcome data, were excluded. All the CHD cases were confirmed by postnatal echocardiography officially performed by an experienced pediatric cardiologist.

The collected data were coded and analyzed using SPSS software Version 16. The data were summarized into simple frequency tables, graphs, and charts. The chi square test was used to evaluate distribution of variables between groups ($p<0.05$ was considered significant).

RESULTS

A total of twenty-five infants with a confirmed diagnosis of DH within the study period were identified at the intended hospital. The most common CHD were found septal defects (10 cases, 40%), large vessels abnormality (6 cases, 24%), right-side obstruction (3 patients, 12%), left-side obstruction (3 patients, 12%), and complex CHD (one case, 4%). Furthermore, eight patients (32%) were identified with normal echocardiography or minor anomalies such as PFO (patent foramen oval) and FMV who lacked MR (floppy mitral valve without mitral regurgitation), Figure 1.

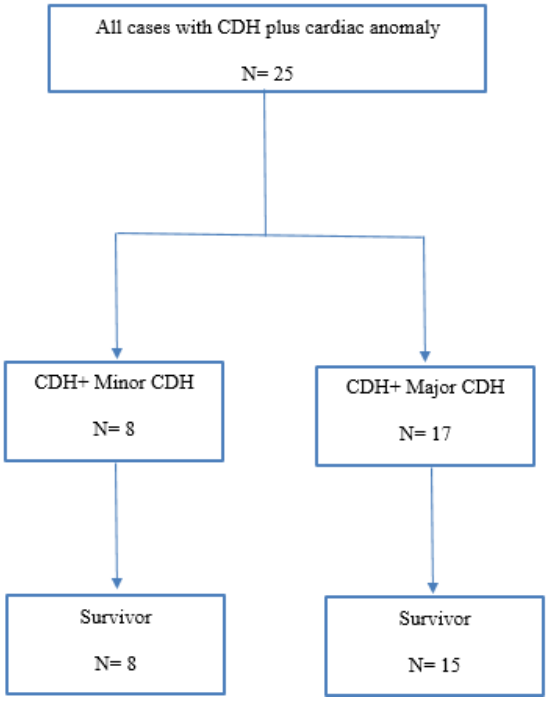

Figure 1: A schematic outline of the study

The characteristics of the examined patients who were referred to the hospital for pre-surgery (n=18, 72%) or cardiac consultations (n=7, 28%) were shown in Table

1, these patients were referred by pediatric surgeons (n=10), pediatricians (n=12) and family physicians (n=4). According to the study's results, an abnormal cardiac murmur was found in 13 infants (52%). Twenty-one neonates (84%) were found to suffer from dyspnea, and cyanosis and tachycardia were observed in four (16%) and five patients (20%), respectively. It should be noted that in all examined cases, the position of the heart was generally abnormal in chest radiography.

Several cases were found to suffer from non-cardiac-associated anomalies, including cleft palate (one case, 4%), ectopia cordis (one case, 4%), gastroschisis (one case, 4%), malrotation (three cases, 12%), midgut volvulus (two cases, 8%), and esophageal atresia and tracheoesophageal fistula (one case, 4%). Two cases of Downs' syndrome (8%) and one case of cerebral palsy, inguinal hernia, and hypothyroidism (4%) were identified. Moreover, two cases (8%) were found to suffer from another kind of neurological abnormality and two cases (8%) were reported to have chest deformity. The hypertrophic pyloric stenosis, annular pancreas, liver hemangioma, cirrhosis, and biliary atresia were not observed in any of the patients examined in the study. None of the patients had limb defects, and no infant had a family history of stillbirth, child death, or heart diseases.

Table 1: Patients' characteristics

	N (%)
Gender	
Male	17 (68)
Female	8 (32)
Delivery method	
Normal vaginal delivery	12 (48)
Cesarean section	13 (52)
Consanguineous marriage	
Yes	8 (32)
No	17 (68)
Preterm labor	
Yes	4 (16)
No	21 (84)
Echocardiography findings	
Major CHD	**17(68)**
Septal Defects	10(40)
Ventricular Septal Defects (VSD)	6 (24)
Atrial Septal Defects (ASD)	2 (8)
Atrioventricular Septal Defects (AVSD)	2 (8)
Right side Obstructive Lesions	3(12)
Tetralogy of Fallot (TOF)	1(4)
Pulmonary Stenosis (PS)	1(4)
Pulmonary atresia (PA)	1(4)
Left side Obstructive Lesions	3(12)
Congenital Mitral Stenosis (MS)	1(4)
Congenital Mitral Regurgitation (MR)	2(8)
Complex CHD*	1(4)
Normal CHD	
NL or FMV without MR	8(32)

**Complex heart disease are those patients with heterotaxy syndrome or who need a univentricular approach*

Gastrointestinal surgery was performed on seven cases (28%) in one step, including three patients with malrotation (12%), two patients with midgut volvulus (8%), one patient with ectopic cordis, gastroschisis (4%), and one patient with EA and TEF (4%). It is noted that twenty-three patients (92%) survived the study and two patients (8%) died due to pulmonary complications which had TOF, and the other unspecific complex CHD.

The congenital heart defects need to be further defined. Isolated VSD needs to be defined as large, small or multiple and whether muscular PM or DCSA. Similarly ASD needs further clarity on size and type. Same is true for MS and PS.

DISCUSSION

In this study, twenty-five infants with concurrent congenital diaphragmatic hernias and CHD were studied. The most common type of congenital heart defect was septal defects anomalies (ASD and VSD). Also, several systemic abnormalities included gastrointestinal anomaly, chest deformity, genitourinary anomaly, neurologic and endocrine disorder and Downs' syndrome were included.

In a systematic review, showed that 15% of the examined neonates (4427 of 28974 neonates) with CDH also had heart defects, in which 42% were suffered from major cardiac diseases. Although it is indicated that the survival rate was significantly lower in patients with major cardiac diseases, the prognosis of major cardiac anomalies was found to be significantly higher than previous studies (72% vs. 32%). Moreover, the CHD incidence were estimated to be lower in CDH patients (15% vs. 54%). According to Montalava (2019), 10% of the infants examined in his study required cardiac intervention during infancy. Most of the children with minor heart diseases received medical treatment; however, their findings are consistent with our current study's results, as four patients (16%) underwent cardiac surgery and twenty-one patients (84%) received medical management.[11]

Delayed surgery improved pulmonary and cardiovascular function in newborns with CDH and

promoted surveillance compared to early surgery at birth. Moreover, it was found that interventions such as extracorporeal membrane oxygenation (ECMO), HFOV (high-frequency oscillatory ventilation), INO (inhaled nitric oxide), surfactant injection, and mechanical ventilation promoted the baby's respiratory status, reduced pulmonary artery blood pressure, and stabilized the patient's status. The study was showed that 12-16% of neonates who survived the hernia surgery suffered from pulmonary complications, malnutrition, and growth retardation due to gastroesophageal reflux disease, neurodevelopmental and musculoskeletal disorders, multiple hospitalizations, and further surgeries. Sepsis rarely occurred in neonates suffering from CDH and that coagulase-negative staph was the most common germ in 24% of the cases. The risk factors of infection were identified birth weight, neonatal instability, the presence of a central venous catheter, chest tube, endotracheal tube catheter, and long-term hospitalization. Also, it was revealed that administration of antibiotics before performing the surgery and sterility control in the NICU reduced the chances of sepsis.[12]

Three fundamental bases for the possibility of postnatal and delayed CDH treatment to reduce the total morbidity rate: (1) Maintaining intensive oxygenation and ventilation and preventing ventilator-induced lung damage, (2) Stabilizing the patients who undergo ECMO, and (3) Managing pulmonary hypertension.[13]

The incidence rate of congenital diaphragmatic hernia was 2.3 in every 10000 live births varying in different geographical locations. It was found that major risk factors were more prevalent in the male fetus and older mothers (above 35 years old) and the hernias were more common in chromosomal disorders and genetic syndromes. These findings are consistent with the results obtained in the current study, where the majority of the patients were male.

We suggested several parent-related risk factors for CDH, including the education level, mother's smoking, alcohol consumption during pregnancy, obesity, multiple pregnancies, and underlying diseases (e.g., diabetes and hypertension).[14]

The fetal echocardiography insufficient for identifying major structural heart defects at large sample of patients with trained pediatric cardiologists and may be used to guide clinical management, particularly regarding ECMO candidacy.[15]

The incidence of diaphragmatic hernia was 1 in 2000 live births, estimating that 1000 babies were born annually with CDH in the United States which most of them were diagnosed prior to birth. They also found that prognosis is depending on the degree and severity of pulmonary hypoplasia and pulmonary hypertension. Numerous studies have proved that the likelihood of mortality in neonates diagnosed with hernias depends on birth weight, gestational age, the first- and fifth-minute Apgar scores, hernia repair strategy (e.g. patch repair), and other associated congenital anomalies particularly heart disease. The study is almost consistent with the present study, showing the mortality rate among the CDH patients with CHD is three times higher than those merely suffering from diaphragmatic hernia.[16]

Joseph et al. (2005) showed 208 of 2636 patients (10.6%) had major heart diseases including VSD, double outlet right ventricle (DORV), total anomalous pulmonary venous connection (TAPVC) , transposition of the Great Arteries (TGA), PS, and aortic arch obstruction. Patients with hernia without and with major heart diseases were accounted 70% and 41.1%, respectively. It also indicated that the survival rate decreased from 47% to 5% in patients with a single ventricle anomaly compared to biventricular anomalies.[17]

The prognosis of patients with isolated CDH might be predicted by imaging techniques and genetic testing during pregnancy. In fetuses with poor prognosis, end-luminal tracheal occlusion help improve the lungs and prevent pulmonary hypoplasia.

The identified pulmonary hypoplasia and its severity by fetal echocardiography can be a prognosis indicator. CHD seems to have a significant impact on the outcome of infants with CDH. The combination of the congenital anomalies leads to a lower survival rate than an isolated disorder.[18]

The most common associated anomaly in children with EA/TEF are congenital heart disease especially septal defects and the commonest cardiac treatment are medical treatment.[16]

The impact of CDH on quality of life seems to be important and must be understood by clinicians who treat these children and their parents.[19]

The limitation of the study were the small sample size and restricted time due to the poor assistance of patients. To be conducted in more than one academic center is also required.

CONCLUSION

In infants with CDH, cardiac and non-cardiac associated anomalies are prevalent, in which

congenital heart diseases (CHD) especially VSD are the most common. Noncardiac associated anomalies including gastrointestinal disorders, chest deformity, and genitourinary disorders are observed that highly influence the prognosis and the mortality rate. Although prenatal diagnosis provides better chances for managing maternal and fetal care and planned delivery, none of the patients examined in this study had a prenatal diagnosis. Cardiac consultation is recommended for all such patients before surgery. Moreover, paying attention during prenatal care for these remarkable association with cardiac anomalies is notable.

AUTHORS' CONTRIBUTION

HMMS and FZ: Concept and design, data acquisition, interpretation, drafting, final approval, and agree to be accountable for all aspects of the work. HMMS, SSG, ZAS, and FZ: Data acquisition, interpretation, drafting, final approval and agree to be accountable for all aspects of the work.

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