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ORIGINAL ARTICLE

Percutaneous Interventions in Congenital Heart Disease in the Kingdom of Bahrain

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Abstract

Background: The worldwide incidence of congenital heart disease (CHD) is 8-12/1000 live births. This results in a huge burden on societal resources. Recent advances in percutaneous interventions have resulted in fewer CHDs requiring surgery.

Aim: To analyze the percutaneous interventions in CHD performed in Bahrain.

Methods: This is a retrospective, descriptive study. All consecutive patients, who underwent percutaneous interventions for CHD, were analyzed from May 1, 2011 to December 31, 2017.

Results: A total of 285 patients, aged day one to 62 years old (mean age=10.7 years), and weight range of 2–113 kgs (mean weight=27.5 kg), underwent cardiac interventions. The procedures performed were: device closure of patent ducts arteriosus (PDA, 63), atrial septal defect (ASD, 63), ventricular septal defect (3), patent foramen ovale (2), balloon dilatation of pulmonary stenosis (41), diagnostic cardiac catheterization (73), balloon dilatation of re-coarctation of aorta (11), balloon dilatation of aortic stenosis (13), coarctation stenting (4), percutaneous pulmonary valve implantation (5), balloon atrial septostomy (2), and pulmonary valve perforation (1). Success rate of device closure of PDA and attempted-ASD was 95% and 85%, respectively. Balloon dilatation of aortic and pulmonary valvular stenosis, and recoarctation of the aorta, resulted in >50% reduction in the peak gradient and increase in narrowed segment. There was one mortality in a neonate, due to the perforation of right ventricular outflow tract (0.3%).

Conclusions: Percutaneous interventions were performed safely in infants and adults with CHD. Recent advances in catheter-based interventions and techniques will provide alternative options in managing CHD.

Keywords: Balloon valvuloplasty; Congenital heart disease; Device closure of septal defects; Percutaneous cardiac interventions; Pulmonary valve implantation

Introduction

Congenital heart defects (CHD) refers to gross structural abnormality of the heart, great arteries or great veins, present at birth.[1] The worldwide incidence of CHDs is 8 to 12 / 1000 live births.[2,3] In the past two to three decades, the field of interventional cardiology has experienced significant growth. Technological innovations have greatly advanced the treatment of cardiovascular disease in both children and adults with CHD. Interventional therapy has become an acceptable alternative treatment for many CHD, including closure of atrial septal defects (ASD), some types of ventricular septal defect (VSD), patent ductus arteriosus (PDA), dilatation of stenotic valves (aortic and pulmonary), dilation of stenotic vessels (branch pulmonary arteries), and coarctation of the aorta (COA). In some cases where the percutaneous approach is difficult or the patient still requires repair of other associated cardiac anomalies, a hybrid approach (surgical and catheter intervention) can now also be implemented, with its obvious advantages to the patient.

The aim of this study was to analyze the first data of various types of percutaneous cardiac interventions, performed for CHD in Bahrain and their outcome.

Materials & methods

This is a retrospective, descriptive study conducted at Mohammed Bin Khalifa Bin Salman Al Khalifa Cardiac Center, Bahrain Defence Force Hospital. Patients who underwent percutaneous interventions for CHD, were analyzed from May 1, 2011 to December 31, 2017. Patients with CHD, who underwent cardiac catheterizations, were included in the study. Authorization was obtained from the institution research and training committee, prior to the commencement of the study. Data were collected for all the patients who underwent cardiac catheterization for CHD (age range from day one to 62 years).

Statistical analysis

Data was directly recorded into a Microsoft Excel spreadsheet (Microsoft Inc., Redmond, Washington, USA) by the researchers for analysis. Statistical analysis was performed using IBM SPSS 25.0 software and descriptive analyses were performed.

Results

During the seven years of study, a total of 285 patients underwent cardiac catheterization (Figure 1), of which 208 (72.9%) were pediatric patients (<14 years of age), and 77 (27.1%) were adults. The age of patients ranged from one day to 62 years, with mean age of 10.7 years (Table 1). There were 169 (59.3%) female and 116 (40.7%) male patients, with female to male ratio of 1.4:1. The weight of patients ranged from 2–113 kgs, with mean weight of 27.5 kgs. The various types of cardiac interventions performed are detailed in Table 2.

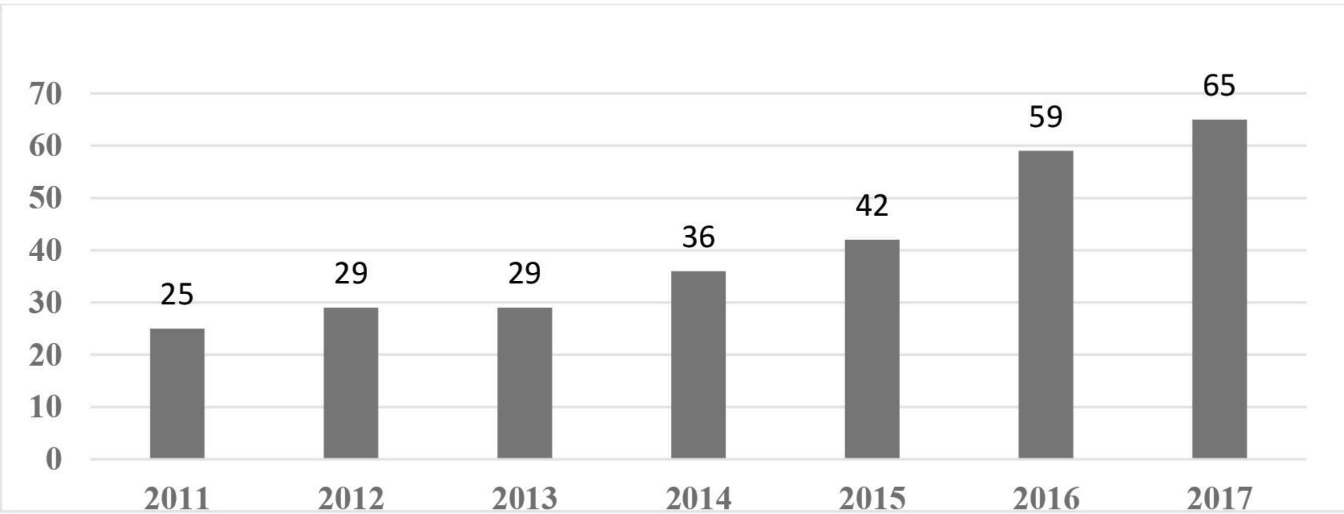

Figure 1. Number of procedures performed per each year

Table 1. Number of cases according to age

Age	2011	2012	2013	2014	2015	2016	2017	Total
1 day - month	2	1	4	6	1	2	8	24
2 months -1 year	6	6	3	12	8	9	6	50
2 - 5 years	9	9	8	8	18	15	20	87
6-10 years	5	1	6	4	2	5	7	30
11-13 years	2	5	3	2	1	2	2	17
> 14 years	1	7	5	4	12	26	22	77

Table 2. Interventional procedures per year

Procedure	2011	2012	2013	2014	2015	2016	2017	Total
ASD device closure	3	9	8	5	8	13	17	63
PDA evice closure	6	5	5	13	10	14	10	63
Balloon Pulmonary Valvuloplasty	7	5	7	3	3	8	8	41
Balloon Aortic Valvuloplasty			1	2	3		7	13
COA BD	2	2		2	3		2	11
COA Stenting				1		2	1	4
Diagnostic Catheterization	6	7	6	9	15	14	16	73
VSD Device closure			2	1				3
PPVI						3	2	5
Hybrid PPVI							1	1
PFO device closure	1					1		2
Balloon Atrial Septostomy	1					1		2
LPA Stent						1		1
RVOT Stent						1		1
Percutaneous PV Perforation						1		1
Pericardiocentesis							1	1
Total	25	29	29	36	42	59	65	285

ASD, Atrial Septal defect; ***PDA***, Patent ductus arteriosus; ***COA***, Coarctation of Aorta; **VSD**, Ventricular Septal defect; ***PPVI***, Percutaneous Pulmonary Valve Implantation; ***PFO***, Patent Foramen Ovale; ***LPA***, Left Pulmonary artery; ***RVOT***, Right ventricular Outflow tract; ***PV***, Pulmonary valve

ASD device closure and outcome

ASD device closure was performed using Amplatzer septal occluder (AGA Medical, Plymouth, Minnesota) and the outcome is described in Figure 2.

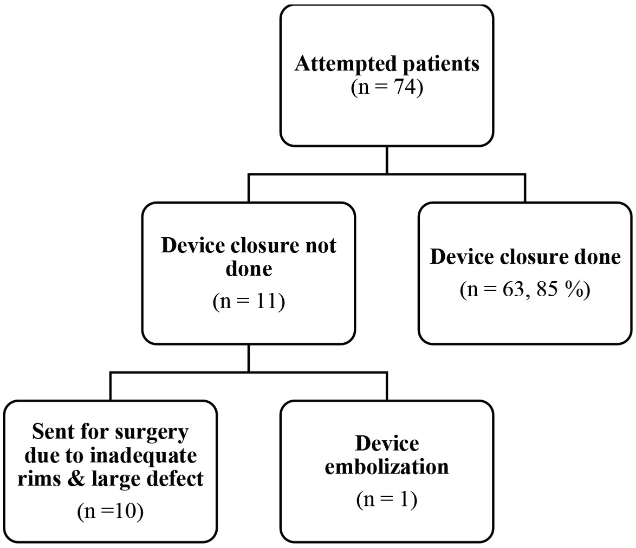

Figure 2. Outcome of ASD device closure

PDA device closure and outcome

Amplatzer Duct Occluder devices (AGA Medical, Plymouth, Minnesota) were used in all patients (n=66). Successful PDA device closure was performed in 63 patients (95%); the procedure was abandoned in three patients due to the smaller size of the defect and difficulty in crossing the PDA. A complication of arch obstruction occurred in only one child who was ventilator dependent from the neonatal age, with large significant PDA requiring larger PDA device to occlude. The child was weaned from ventilation and discharged. At follow up, he was found to have increased aortic-arch obstruction, requiring surgical arch repair.

Outcomes of VSD device closure

VSD device closure was attempted in five patients of whom three underwent successful device closure. Device closure could not be done in one patient, as the device was causing obstruction of tricuspid valve. Device embolization occurred in one patient, which was retrieved surgically.

Balloon pulmonary valvuloplasty (BPV) and outcome

A total of 41 patients underwent BPV: critical (7 neonates) and severe (34 neonates to adults) pulmonary stenosis,various balloon sizes of 1.2 times of the pulmonary valve annulus size. Successful procedure is accepted as at least 50% reduction in pulmonary valve gradient. The outcome of pre- and post-balloon dilatation by cardiac catheterization is presented in Figure 3.

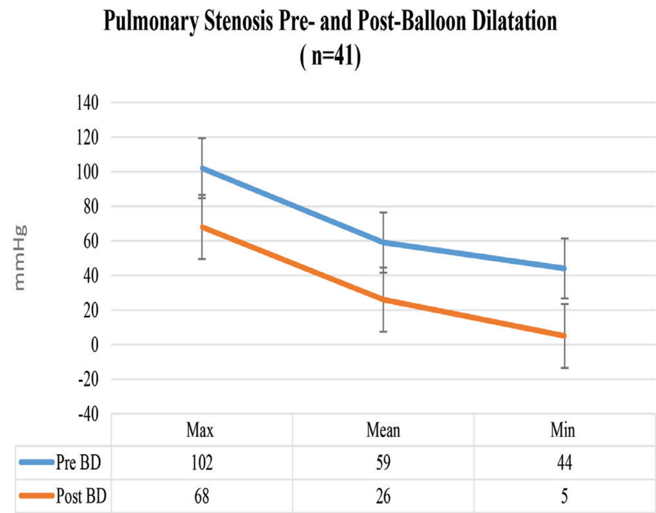

Figure 3. Cardiac catheterization data of pre- and post-BPV

Balloon aortic valvuloplasty (BAV) and outcome

A total of 11 patients underwent BAV using balloon sizes 80% of the aortic valve size. There were four patients with critical aortic stenosis (AS). The outcome of pre- and post-balloon dilatation by cardiac catheterization is presented in Figure 4.

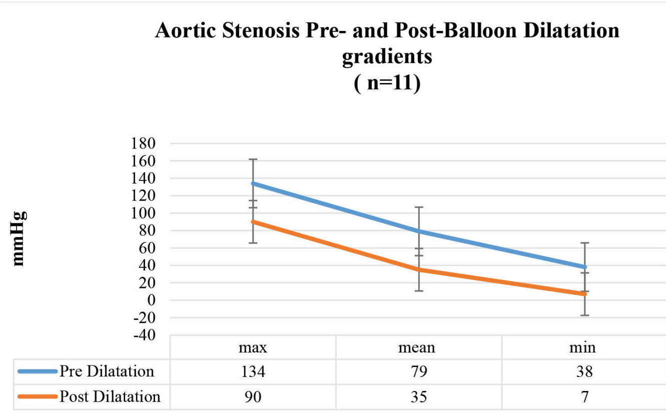

Figure 4. Cardiac catheterization data of pre- and post-BAV

Outcomes of COA

COA-balloon dilatation and COA-stenting was performed in 11 and 4 patients, respectively. The outcome of pre- and post-balloon dilatation by cardiac catheterization is presented in Figure 5.

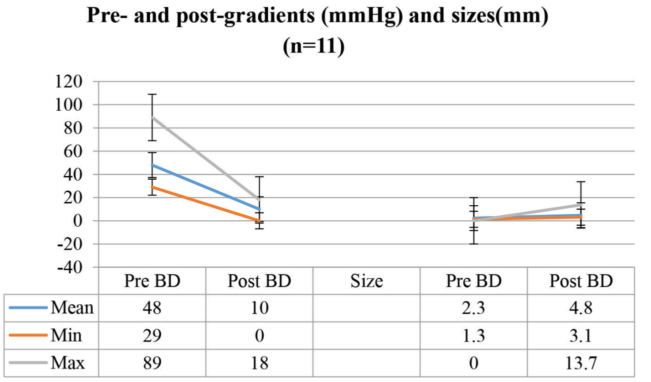

Figure 5. Cardiac catheterization data: pre- and post-COA balloon dilatation

Percutaneous Pulmonary Valve Implantation (PPVI) and outcome

Successful PPVI using Medtronic Melody pulmonary valve of 22 mm size was performed in five patients. Hybrid PPVI was performed in one patient, where right ventricular outflow tract plication was done through a small incision in left 2nd intercostal space by cardiac surgeon, followed by PPVI, during the same setting.

Emergency Percutaneous interventions

Emergency balloon atrial septostomy procedure was performed using Rashkind septostomy balloon in two neonates, with simple transposition of great arteries. Percutaneous Pulmonary valve perforation was performed in one neonate.

Complication

There was one mortality in a neonate with RVOT perforation (0.3%) during balloon dilatation of critical pulmonary stenosis. No complications such as endocarditis, stroke, catheterization site infection, or prolonged bleeding, were identified.

Discussion

We present our results and briefly review the current indications, techniques, results, and complications of interventional therapy, for CHD. The various lesions treated in the catheterization laboratory are divided on the basis of their physiological characteristics.

Left-to-Right Shunt Lesions

Atrial Septal Defect

ASDs account for approximately 19% of all CHD.[4] The ASD device closure provides good closure rates (97.9%) with similar or lower complication rates than open heart surgery.[5] Our ASD device closure rates were 85% because of inadequate rims and larger size of the defect.

Ventricular Septal defect

VSDs are the most common CHD found in children, with 30% incidence.[4] Only muscular and peri-membranous VSDs are suitable for device closure. The complication of complete heart block is higher for peri-membranous VSD device closure than that of the surgical closure.[5,6] There was no such complication among our patients.

Patent ductus Arteriosus

PDA represents 5–10% of all CHD, excluding those in premature infants. In infants beyond the neonatal period, device or coil closure has been advocated. Our successful PDA device closure rate was 95%.

Patent foramen ovale

PFO frequently persists into adulthood and are mostly asymptomatic. Some may present with cryptogenic stroke. Indications for PFO device closure are only for cryptogenic stroke in patients <60 years of age, with evidence of venous thrombosis on MRI. Trials[7,8,9,10] reported a lower incidence of recurrent stroke, after introduction of PFO device.[11] PFO device closure was performed in two patients in our study.

Obstructive lesions

Right-Sided Obstructive Lesions

Pulmonary stenosis

Isolated valvar PS represents 8–10% of all patients with CHD. Patients are usually asymptomatic. Indications for treatment include symptomatic patients, asymptomatic patients with severe PS (echocardiography doppler peak gradient >64 mmHg[12]) or evidence of right ventricular hypertrophy. The success rates are excellent for children with classical valvar PS.

In infants with membranous pulmonary atresia, radiofrequency perforation followed by balloon dilation has been successful in creating an open, right ventricular outflow tract. Successful opening of membranous pulmonary atresia was done in one patient in our study.

Left-Sided Obstructive Lesions

Valvar AS occurs in approximately 3–6% of patients with CHD.[4] Indications for intervention include neonates with critical AS, irrespective of the gradient, and infants and children with peak echocardiography gradient across the valve of >64 mmHg.[12] Balloon aortic valvulplasty was performed in 11 patients with at least 50 % reduction in aortic valve gradient.

Coarctation of Aorta (COA)

COA accounts for 5–8% of all CHD.[4] Surgical COA repair is carried out in neonates and infants with significant native COA. Balloon dilatation is reserved for cases of significant re-COA or in children >3 years of age, with native COA. Indications for balloon dilation of COA are hypertension, proximal to the coarctation (pressure gradient across the narrowed segment >20 mmHg) or angiographically severe COA. Endovascular stent implantation is an accepted modality for treatment of native and recurrent coarctation of the aorta in older children and adults. Balloon dilatation of COA was performed in 11 patients and 4 patients underwent successful COA stenting.

Percutaneous pulmonary valve implantation (PPVI)

PPVI was the first percutaneous intervention for the treatment of regurgitant valve lesions in humans.[13,14] The most common indication of pulmonary valve implantation is residual RVOT lesion after repair of CHDs.

Hybrid PPVI is indicated in patients with large aneurysmal RVOT. In this procedure, the cardiac surgeon makes a small incision in left second or third intercostal space and plicate the RVOT, and then the PPVI is performed by the cardiologist, at the same setting. This avoids cardiopulmonary bypass-open heart surgery in the patient; a patient underwent successful hybrid PPVI in our centre.

Conclusion

Complete anatomical correction of the lesions such as ASD and PDA, carries high success rates. Long-term follow up of these patients is in progress. This is the first study on the outcome of percutaneous interventions in CHD in Bahrain. The era of percutaneous valve implantation is progressing rapidly, and we expect, in coming years, we will witness the development of miniaturized valve delivery systems to enable implantation in neonates and children.

Conflict of Interest:

Authors have no conflict of interest to declare.

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None

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