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Three years of interventional pediatric cardiology experience in a newly built city hospital

Süleyman Sunkak, Mustafa Argun
Kayseri City Hospital, Kayseri, Turkey

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ABSTRACT

Aim: The importance of interventional methods in the treatment of congenital heart disease (CHD) is increasing. In this article, we retrospectively evaluated our angiography experience for the diagnosis and treatment of congenital heart diseases in the newly built Kayseri City Hospital for 3 years.

Material and Method: The demographic data of the patients, their diagnoses and information about interventions were evaluated retrospectively.

Results: In our center, 291 interventional procedures were performed in a 36-month period. 71 (24%) procedures were for diagnostic evaluation and 220 (76%) procedures were for treatment. 74 (25%) atrial septal defect (ASD) closure procedures, 9 (3%) ventricular septal defect (VSD) closure procedures and 62 (21.3%) patent ductus arteriosus (PDA) closure procedures were performed via percutaneous technique. Eleven of the patients who underwent PDA closure were <2500 g infants who hospitalized in the neonatal intensive care unit. Balloon valvuloplasty was performed for 17 (5.8%) pulmonary valvular stenosis and 9 (3%) aortic valvular stenosis. Balloon angioplasty was performed to aortic coarctation in 21 (7.2%) patients and stent angioplasty was performed in 4 (1.3%) patients. As rare procedures, stent angioplasty to ductus arteriosus in 4 (1.3%) patients, pericardiocentesis in 5 (1.7%) patients, and temporary pacemaker implantation in 1 patients were performed. Major complications occurred in 2 procedure for ASD closure, 1 procedure for stent implantation to the ductus arteriosus, and 1 procedure for aortic balloon valvuloplasty (1.3 %). Two patients died due to major complications related to angiographic procedures (0.68%).

Conclusion: Treatment of CHD with interventional methods should be preferred instead of surgery if anatomically appropriate, due to the lower rate of major complications, not requiring sternotomy, and shorter hospital stay. More experience is needed in pediatric cardiology teams who are new to these procedures.

Keywords: Congenital heart diseases, interventional treatments, city hospitals

INTRODUCTION

CHDs are the most common diseases among congenital anomalies, affecting 0.8% to 1.2% of live births all over the World (1). The incidence varies between 5-7.7% in the studies reported in Turkey (2). Mortality has decreased and survival rate has increased with easier access to health services, improvements in treatment methods and intensive care practice.

In recent years, many CHDs treated with surgery have become treatable with interventional methods. After the first balloon septostomy procedure was applied in 1966 as an interventional treatment, there have been many developments so far. Now, procedures such as balloon dilatations, device closure, stenting, transcatheter valve implantation have taken their place in interventional treatment in CHDs.

With the opening of the city hospital in Kayseri city in June 2018, interventional treatments for pediatric cardiac patients were started. In the new center, congenital heart defects such as ASD, VSD, and PDA are closed with the transcatheter method, and valve stenosis and coarctation are treated with balloon and stent applications. In this article, we retrospectively evaluated our experience in the interventional diagnosis and treatment of CHDs during the first 3 years.

MATERIAL AND METHOD

The study was carried out with the permission of Kayseri City Hospital Clinical Researches Ethics Committee (Date: 17.06.2021, Decision No: 409). All procedures were performed in accordance with ethical rules and the principles of the Declaration of Helsinki.

Corresponding Author: Süleyman Sunkak, suleymansunkak@gmail.com
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Diagnostic and therapeutic angiography procedures performed in the pediatric cardiology clinic of Kayseri City Hospital between 1 August 2018 and 1 August 2021 were evaluated retrospectively.

Before the angiography procedures, written consent inform was obtained from the parents. Before the procedure, complete blood count, liver and kidney function tests, HIV and hepatitis markers and chest X-ray were performed. All procedures were performed under general anesthesia. After the procedure, the patients were followed up in the pediatric cardiology service, if necessary, in the neonatal intensive care unit and in the pediatric intensive care unit.

The procedures were performed in the angiography unit of Kayseri City Hospital with Siemens Artis Icono® monoplane angiography device and GE Vivid7® transthoracic echocardiography device. Transesophageal echocardiography examination could not be performed during the procedure, unfortunately, due to the absence of a pediatric transesophageal echocardiography probe.

Demographic data of the patients and information about the procedures were obtained retrospectively from the hospital registry system and the archive of the angiography unit.

RESULTS

Between August 2018 and August 2021, a total of 301 angiography procedures (71 diagnostic and 230 therapeutic, 24% vs 76%) were performed. The age was 6.85 years (min: 1day-max: 17.9 years), body weight was 18.7 kg (min: 1.3-max: 85 kg). 46 patients were neonates who followed in the neonatal unit.

Atrial Septal Defect Closure

Transcatheter ASD closure was performed in 74 (25%) patients. 72 Amplatzer septal occluder® devices and 2 Occlutech ASD ocluder® devices were used. The largest device was 34 mm, the smallest device was 8 mm.

Complications

1. Device was removed surgically one day after the procedure because of the variable compression of the ascending aorta with the heartbeat (**Figure 1**).
2. Device embolized into the descending aorta and was removed with snare catheter. In this case, there was only one defect in all axis in TTE examination, and the device was implanted in this defect. However, after the device was released, it embolized into the aorta. This patient was evaluated with TEE in another center and a second posterior located defect was detected in the interatrial septum. The second larger defect was closed in the other center with the help of TEE, and the discs of the device also closed the adjacent small defect.

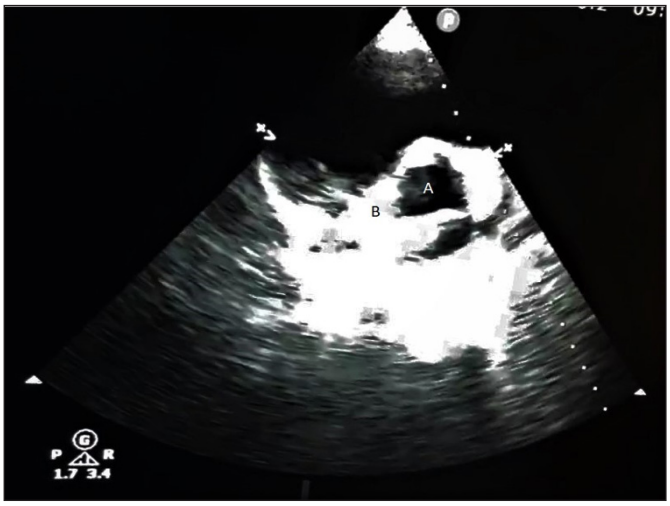

Figure 1. Compression of the aorta by the Amplatzer septal occluder device®

3. A 15-year-old girl admitted to the emergency clinic with headache and dizziness 3 days after the defect closure with a 34 mm ASO device. The ECG revealed first degree AV block. AV block resolved gradually after 2mg/kg/day prednisolone treatment. Steroid treatment was continued for 15 days. AV block did not recur in further follow-ups (**Figure 2**).

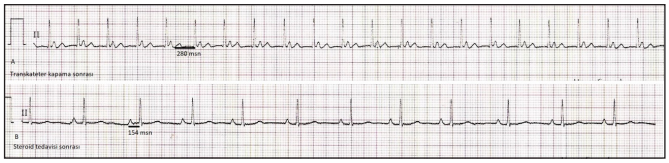

Figure 2. 1st degree AV block after transcatheter ASD closure

Complications such as cardiac perforation, peripheral vascular injury or cardiac erosion, which can be seen due to ASD closure, did not occur.

Pulmonary balloon valvuloplasty was performed in 2 patients during the ASD closure procedure. Jugular vein intervention was planned and the procedure was delayed for 8 years old girl because of interrupted inferior vena cava.

Patent Ductus Arteriosus Closure

PDA closure procedure was performed to 62 (21.3%) patients. 11 (3.7%) patients were hospitalized in the neonatal unit under 2500 grams and the lowest body weight was 900 grams. 18 procedures were closed antegradely, and the other 44 procedures were closed retrogradely. Seven of the premature PDAs were closed antegradely and 4 of them were closed retrogradely. 6 ADO I,® 11 ADO II,® 17 ADO II AS,® 25 Piccolo duct occluder®, 3 Cook coil® were used.

The largest device used was the 8x6 ADO I® device. In this procedure, the device (6x6 ADO I) embolized to the right pulmonary artery, was catched and removed with snare, and the PDA was closed with 8x6 ADO I® device.

In 2 procedures, the device could not be implanted, one of these patients was referred to surgery and the other to another more experienced center. No other complications occured during or after the procedure. The residual shunts seen in the control injection after implantation disappeared in the follow-up 1 month later.

Ventricular Septal Defect Closure

The procedure was performed to 9 (3%) patients. ADO I® was used in 2 case, ADO II® in 6 cases, and Amplatzer muscular VSD occluder® in 1 case. Since the defect was large and perimembranous aneurysm in one patient, the device could not be implantated in the defect and was referred to surgery. In a patient with 2 muscular (4 mm and 3 mm) VSDs, the large defect was closed retrogradely with a 6 mm Amplatzer muscular VSD occluder® device. After closure, a residual shunt was observed from the adjacent small defect. The residual shunt decreased in the follow-up, but persisted. No other complications occurred (**Figure 3**).

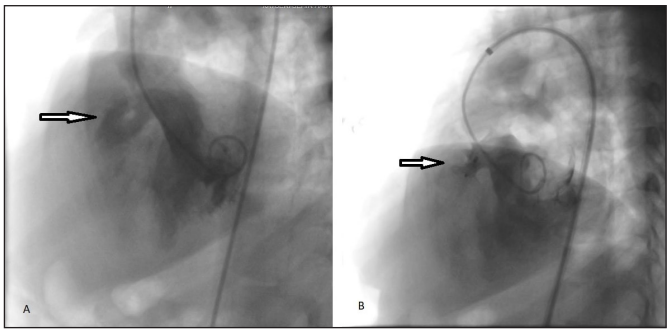

Figure 3. Closure of the VSD with the Amplatzer muscular VSD occluder device®

Pulmonary Balloon Valvuloplasty Procedure:

The procedure was applied to 17 (5.8%) patients. One procedure was performed with ASD closure. Osypka VACS II® balloons were used in one procedure and Numed Tyshak II® balloons were used in the other procedures.

6 patients were newborn patients with ductus-dependent critical pulmonary stenosis followed in the neonatal unit. Two of the critical pulmonary stenosis procedures failed. 1 patient was referred to surgery, and 1 patient was referred to another more experienced center. Except for 2 failed procedures, restenosis or re-balloon valvuloplasty were not needed for the other cases.

Two procedures were performed for palliation of residual pulmonary stenosis in a patient followed up with Tetralogy of Fallot. However, in one case, the procedure was insufficient due to hypoplasia of the annulus and PDA stent implantation was performed in the follow-up.

No complications occurred during or after the procedure. In the follow-up, no severe right heart failure or pulmonary insufficiency was observed to require valve replacement.

Aortic Balloon Valvuloplasty

Aortic balloon valvuloplasty was performed in 9 (3%) patients. Numed Tyshak II® balloons were used in the all procedures. Three patients had ductus arteriosus-dependent critical aortic stenosis in the neonatal period. Two procedures were performed with rapid pacing. Two patients had aortic coarctation at the same time, and balloon angioplasty was performed on the coarctation of aorta at the same procedure.

Left ventricular rupture developed in a newborn baby with endocardial fibroelastosis, borderline left ventricular cavity and mitral orifice. Emergency pericardiocentesis was performed and although the rupture was surgically repaired, the patient died. In one patient, the ascending aorta was hypoplasic and also had coarctation. Coarctation and valve stenosis recurred 1 month after balloon angioplasty and valvuloplasty, and surgical valvulotomy and coarctation repair were performed in another center.

Except for 1 major complication, no complication developed.

Other Procedures

Ductus arteriosus stent implantation was performed successfully in 4 (1.3%) patients (1 Tetralogy of Fallot, 1 interrupted aortic arch, 2 pulmonary atresia) and they were referred to elective surgery in the follow-up.

However, the procedure failed in a procedure, because the procedural wire could not be placed due to the vertical ductus arteriosus originating from the aortic arch (**Figure 4**), and a surgical central shunt was performed between the aorta and the pulmonary artery. In 1 patient, the stent embolized into the descending aorta and when it could not be removed by the transcatheter method, it was removed surgically, but the patient died in the follow-up.

Balloon angioplasty procedure for aortic coarctation was performed in 21 (7.2%) patients. 17 patients were diagnosed in the neonatal period. Numed Tyshak II® balloons were used as in other procedures. 9 patients in the neonatal period were recoarctated. Balloon angioplasty procedure was not repeated in patients who developed recoarctation. All recoarctation patients were surgically repaired. Femoral artery was used in all procedures, axillary artery or carotid artery were not used in any case. Complications did not occured. Middle aortic syndrome was diagnosed in a patient who was followed up with neurofibromatosis and hypertension. Angioplasty was performed with a Z-med balloon®. Middle aortic syndrome was resolved partially and the gradient decreased. Hypertension regressed in the follow-up (**Figure 5**).

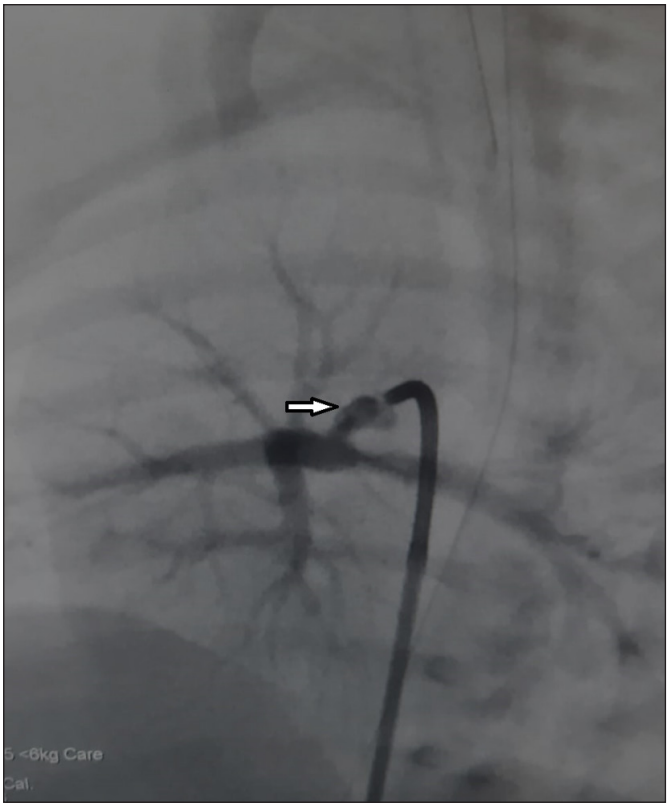

Figure 4. Vertical ductus arteriosus originating from the aortic arch, Arrow: Ductus arteriosus

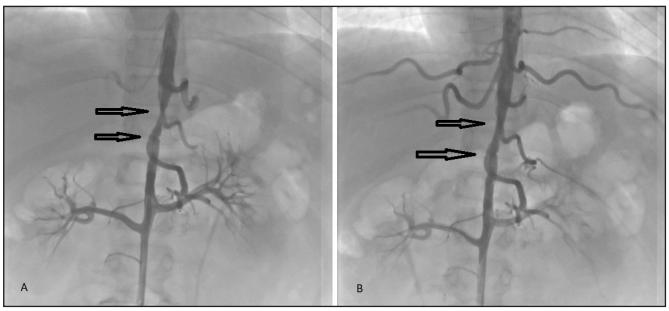

Figure 5. Treatment of middle aortic syndrome with balloon angioplasty

Stent implantation for aortic coarctation was performed in 4 (1.3%) patients. Numed CP stent® and Numed BIB® balloon were used in these cases. Numed bare CP stent® was used in one procedure due to its proximity to the subcalvian artery, and Numed covered CP stent® was used in the other 3 patients (**Figure 6**). No complications developed in the follow-up.

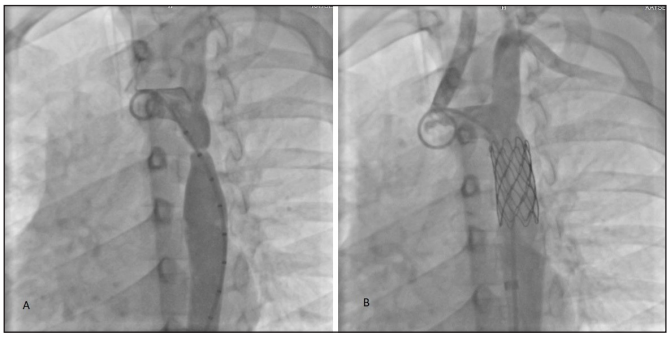

Figure 6. Treatment of aortic coarctation with Numed® covered stent

Pericardiocentesis was performed in 5 (1.7%) patients. 4 patients were diagnosed with viral myopericarditis. One patient was a 700-gram premature neonate who developed cardiac tamponade due to a central venous catheter. The procedure was performed with a 20G (pink) intraket, and minimal pericardial effusion remained at the end of the procedure. Any complications occurred during or after the procedure.

Temporary transvenous pacemaker was implanted to an infant who presented with syncope and was diagnosed with congenital complete AV block. Permanent pacemaker or ICD was not implanted in any patient, patients with indications were referred to another center.

71 diagnostic angiography procedures were performed for diagnostic and preoperative evaluation in cyanotic and acyanotic CHD. No complications developed during or after the procedure.

Table 1. Procedures and demographic data of patients. Values are expressed as median, 25th and 50th percentiles.

Procedures	Patient number	Body weight	Age
ASD closure	74 (25%)	25.5 (16.25-48.75)	7.29 (4.58-13.77) years
PDA closure	62 (21.3%)	12.5 (6.5-18.4)	1.6 (0.7-9.8) years
PDA closure (prematuer neonate)	11 (3.7%)	1.85 (1.52-2.2)	10.5 (8.25-23) day
VSD closure	9 (3.0%)	26.5 (16.5-39.5)	8.61 (3.66-11.31) years
Aortic balloon valvuloplasty	9 (3.0%)	6.2 (3.2-26.0)	2.0 (0.18-80.45) months
Pulmonary balloon valvuloplasty	17 (5.8%)	6.5 (3.7-12.7)	3.73 (0.02-33.09) months
Balloon atrial septostomy	14 (4.8%)	3.45 (2.97-3.82)	2.0 (1.0-6.25) days
Aortic balloon angioplasty	21(7.2%)	4.2 (3.6-6.95)	29.5 (13.5-170) days
Stent implantation in ductus arteriosus	4 (1.3%)	6.2 (3.2-26)	2, 8 days
Stent implantation in aortic coarctation	4 (1.3%)	38. 45. 57	12, 14, 15 years
Pericardiocentesis	5 (1.7%)	Min: 10 days, max: 15 years	700 g, 64 kg
Temporary transvenous pacemaker implantation	1 (0.3%)	4 months	7 kg
Diagnostic angiography	71 (24%)	6.3 (3.87-12.0)	4.7 (0.1-20.11) months
Total	291		

Statistical Analysis

The data were recorded in the IBM SPSS version 22.0 statistical package program. The distribution of demographic data of the patients was evaluated using the Shapiro-Wilks test. As descriptive statistics, mean ± standard deviation, median, and minimum maximum values were used for quantitative data, and numbers and percentages were given for qualitative data.

DISCUSSION

CHDs are the most common congenital anomalies. Its incidence varies between 1000/5-7.7 in studies conducted in our country (2). The treatment of CHDs is mainly surgical. However, the importance of interventional treatment methods is increasing with the developing technology and experience. After balloon atrial septostomy was performed for the first time by Rashkind and Miller in 1966, many advances were made in pediatric cardiology (3). Interventional treatments have now become the gold standard treatment for many congenital heart defects.

ASD is a common congenital heart defect seen in 1 in 1000 live births (4). Transcatheter closure has become the gold standard for secundum ASDs due to shorter hospital stay, no need for thoracotomy, and lower complication rate. Jalal et al. (4) experienced only 24 (1.8%) cases with major complications in 1326 transcatheter closure procedures. In our case series, major complication developed in 2 patients (device embolization and 1st degree AV block). The risk of AV block is <1% after transcatheter ASD closure.

TEE examination is widely used in ASD closure. The use of TEE allows better assessment of rims and defect size. However, it has been reported that ASD closure procedures can be performed safely with TTE in experienced centers (6). Performing the closure with TTE allows to avoid the complications of TEE itself and also saves time for the team. Although TEE is preferred for defects with insufficient rims, lower major and minor complication rates have been reported with TTE compared to TEE (6). Due to the absence of a pediatric TEE probe in our hospital, ASD closure procedures were performed only with TTE. If the correct evaluation with TEE could be made in the procedure where the device is embolized into the aorta, this major complication could have been prevented. However, in other cases, ASD closure with TTE was successfully performed. The absence of a TEE probe is a major shortcoming for a team with little experience. However, a careful TTE review partially corrected this shortcoming. Complications such as femoral vein or artery injuries, residual shunt, or cardiac erosion were not experienced (7).

Transcatheter closure is now the first choice in the treatment of PDA and the success rate is over 95% (8). With the newly developed devices, PDA can be closed both antegradely and retrogradely, and the use of smaller carrier systems has increased the success rate and reduced complications. However, complications such as device embolization, residual shunt, stenosis in the pulmonary arteries or descending aorta, and peripheral vascular injuries have been reported (9). In our center, transcatheter closure was not performed in 2 cases due to the large size of the defect, and the defects were surgically ligated.

With the increase in the frequency of application of assisted reproductive techniques, the frequency of PDA seen in premature babies has increased. The presence of PDA in premature infants prolongs the need for oxygen, length of hospital stay, and increases the rate of diseases such as retinopathy of prematurity (ROP) and necrotizing enterocolitis. Transcatheter or surgical closure of PDA becomes obligatory in premature babies who do not respond to medical treatment. Although surgical ligation was the only option in the first years, the transcatheter closure method is now successfully performed in experienced centers. In selected cases, transcatheter closure saves these neonates from thoracotomy. Hazeem et al. (10) reported that transcatheter closure of PDA in premature infants resulted in a shorter return to previous respiratory conditions when compared to surgical ligation. Narin et al. (11) found any difference between surgical ligation and transcatheter closure in terms of hospital stay in premature babies weighing <2 kg. Major complications such as peripheral vascular injury, stenosis in the left pulmonary artery or aort coarctation due to the device have been reported (10,11). Although complications such as stenosis and residual shunt occurred in the left pulmonary artery in our series, these conditions improved in the follow-up. Surgical ligation was performed in 2 cases and no complications developed in these patients. However, larger case series and longer follow-up times are needed to compare surgical ligation and transcatheter closure in premature infants. Inexperienced centers should be careful in terms of complications during and after PDA closure in extremely low birth weight babies.

First generation devices allowed only antegrade closure of the PDA. Passing from the pulmonary artery to the aorta for antegrade closure is technically difficult and prolongs the procedure time, especially in small-medium PDAs. Also, first generation devices need thicker delivery systems and the use of the femoral artery in small patients is risky. Today, devices such as ADO II® and Amplatzer Piccolo duct occluder® can be used both retrogradely and antegradely with thinner delivery systems. However,

the widest diameter of the ADO II® is 6 mm, and the Amplatzer Piccolo duct occluder® is 5 mm. Therefore, it is not possible to use these devices in PDAs with a narrowest diameter larger than 4 mm. Another necessity is premature babies. Although there is no definite body weight limit in the literature for the use of the femoral artery should be avoided, especially under 1000 grams. In our experience, the retrograde method was used in the majority of patients. However, there were also patients for whom we preferred the antegrade method according to the size of the defect and the patient's body weight.

VSD is the most common congenital heart disease with a rate of 20%. Surgical or transcatheter closure is recommended for cases with significant left to right shunts (12). Experience in closure of VSDs with the transcatheter method has been increasing over the years. Although transcatheter closure is not possible in all types of VSD, a significant proportion of defects can be closed with the transcatheter method. However, major complications such as device embolization, injury of the tricuspid and aortic valves, residual shunt, and AV block should not be ignored. Senaidi et al. (13) reported a 4.7% major complication rate in their transcatheter closure experience of 118 cases, and they stated device embolization as the most common major complication. Pamukçu et al. (12) reported one major complication (complete AV block that developed after 6 months) in 49 pediatric patients who were closed with the ADO II® device. Another problem in VSD closures is the residual shunt. The reason for the residual shunt is the mutiple defect or the use of a small device compared to the defect. In the series of 412 cases reported by Walavalkar et al. (14) residual shunt was observed in 34 patients (9.5%) in the first 24 hours, while it was observed in only 4 patients (3%) during the follow-up. In our series of 9 cases, no major complications were observed. One patient had 2 muscular VSDs, and the largest of these defects was closed with the Amplatzer muscular VSD occluder device and a residual shunt was observed from the adjacent defect. Transcatheter VSD closure can be performed in appropriate defect size and type in the presence of indication.

Congenital valvular aortic stenosis can be different clinical severity, from asymptomatic cases to ductus arteriosus-dependent critical aortic stenosis. Although bicuspid aortic valve is reported at a rate of 1.3% in autopsy reports, symptomatic aortic stenosis is less common (15). In many centers, balloon valvuloplasty for moderate and severe aortic stenosis has replaced surgical valvulotomy. Emergency balloon valvuloplasty is life-saving especially in cases if left ventricular systolic function is impaired in the neonatal period and prostaglandin E1 infusion is needed to maintain systemic blood flow. The most common complication of balloon valvuloplasty is aortic valve insufficiency. Varan et al. (16) reported moderate and severe valve insufficiency in 17 patients (26.2%) after valvuloplasty in their series of 65 cases. In order to reduce postprocedural valve regurgitation, the postoperative pressure gradient should be reduced to 30-35 mmHg, and the balloon diameter should be chosen to be 0.8-0.9 times the aortic annulus (16). In the follow-up of our patients, it was observed that aortic valve regurgitation ranged from minimal to first degree. Aortic regurgitation did not develop enough to require valve replacement. However, an important complication is left ventricular rupture. Ewer et al. (17) reported 3 myocardial perforations in 1004 cases in a multicenter study. In our series, in a case with borderline mitral orifice and left ventricular volume and accompanied by endocardial fibroelastosis, left ventricular perforation developed during the procedure and the patient died after surgery.

Pulmonary valvular stenosis is the most common right ventricular outflow tract stenosis and the first choice in treatment is transcatheter balloon valvuloplasty. Balloon valvuloplasty is life-saving especially in ductus arteriosus-dependent critical stenosis in the neonatal period. Isolated valvular pulmonary stenosis rarely requires surgery and balloon valvuloplasty is highly effective. In the series of 1200 cases by El-Saeidi et al. (18) the success rate of the procedure was reported as 78.7% in the neonatal period, 82.9% in the infant period and 84.5% in the childhood. In our series, the procedure failed because the valve could not be passed in one patient with critical stenosis in the neonatal period. Other procedures were successful. Complications of the procedure are cardiac perforation, arrhythmia, cardiac arrest and pulmonary valve insufficiency in the long term (18). Cardiac arrest developed during the procedure in 2 newborns with critical stenosis who required prostaglandin E1 infusion and CPR was performed, but the procedures of these patients were completed successfully. Cardiac perforation did not develop. Pulmonary insufficiency, the most common complication, was mild and moderate. Pulmonary insufficiency that was severe enough to develop right ventricular failure was not observed. In the series of 53 cases by Merino-Ingelmo et al. (19) it was reported that pulmonary failure developed in all patients in the long-term, 58.2% of them were grade 2 and 31.2% were grade 3. Pulmonary valve insufficiency may seem innocent in the early period after the procedure, but careful follow-up is required in the long term.

The incidence of aortic coarctation is 5-7% of all congenital heart diseases (20). Emergency balloon angioplasty can be life-saving in neonatal coarctations with cardiovascular collapse (20). Surgery is recommended primarily in the neonatal period due to the high rate of recoarctation

after balloon angioplasty and the accompanying isthmus hypoplasia in most cases (20). Although not as high as stated in the literature, recoarctation developed in 9 of 17 patients in our center. These patients were referred to surgery instead of repeated balloon angioplasty. Considering the low rate of recoarctation in centers with an experienced pediatric cardiovascular surgery team, surgery should be preferred instead of angioplasty, balloon angioplasty should be preferred only in patients who are not suitable for surgery and who have developed cardiogenic shock. After the neonatal period, the success rate of balloon angioplasty and stenting is higher and the risk of recoarctation is low (21). In our center, after the newborn period, balloon angioplasty was applied to 4 children, one of them was middle aortic syndrome, and stenting was applied to 4 patients. Stenting to coarctation can be applied in native coarctations, recoarctations, as well as complications such as aneurysm developing after surgery or balloon angioplasty (21). However, the requirement for the patient to be over 20 kg for stenting is an important limitation. It should be kept in mind that the success rate of balloon angioplasty alone is high in pediatric patients (22).

Balloon atrial septostomy provides a mixture of systemic and pulmonary blood flow in cyanotic congenital heart diseases, thus saving time until surgery. The success rate of the procedure is high and the complication rate is low. Complications such as balloon rupture and embolization of its parts, stroke or cardiac rupture may occur during the procedure (23). We did not encounter any complications in balloon septostomy procedures performed in our center, but the procedure was unsuccessful in one hypoplastic left heart patient because the balloon could not be passed into the left atrium. The success rate of the procedure is lower in hypoplastic left heart syndrome. This is because the left atrium is also hypoplasic and the interatrial septum has an unusual configuration (24).

Ductus arteriosus stenting is an alternative to shunt operations in CHDs. It can be applied to provide pulmonary blood flow in diseases such as pulmonary atresia, as well as to provide systemic blood flow in diseases such as hypoplastic left heart, interrupted aortic arch. It has advantages such as lower complication rate, not requiring thoracotomy and cardiopulmonary bypass compared to shunt operations (25). McMullan et al. (25) reported a lower complication rate and peripheral pulmonary artery stenosis in the stent group in their study comparing 42 shunt operations and 13 ductal stent applications. In our center, ductus arteriosus stent implantation was successfully performed in 4 patients. In 1 patient, the stent embolized into the descending aorta and died after surgery. In 1 patient, the duct could not be located and the procedure was unsuccessful. We could not reach the number of cases to compare with surgical shunt operation.

Cardiac tamponade is the decrement of diastolic and systolic functions of the heart due to increased fluid in the pericardium, and it is a condition that requires urgent intervention. Pericardiocentesis can be performed under the guidance of fluoroscopy and transthoracic echocardiography. The procedure has a high success rate and a low complication rate (26). Pericardial tamponade may develop due to percutaneous central long catheter in premature neonates and pericardiocentesis should be performed carefully in these cases (27). Pericardiocentesis was performed with a 20-gauge (pink) intraket in a premature baby weighing 700 grams. The short, plastic tip of the intraket helped prevent myocardial damage (28).

With the advancement in the technology of the devices and the increase in the experience of the physicians in transthoracic echocardiography examination, diagnostic angiography is no longer needed in the diagnosis of many CHDs. Computed tomography angiography and cardiac magnetic resonance examination also play a role in reducing this need (29). However, conventional diagnostic angiography is still needed, especially in the surgical decision-making of patients with left-right shunts or in the identification of complex cardiac pathologies. Although angiography is mostly performed for therapeutic purposes in our center, it has also been applied for diagnostic purposes.

CONCLUSION

The rate of interventional methods in the treatment of CHDs has been increasing over the years. Compared to surgery, less length of hospital stay, less complication rate, and the absence of the need for thoracotomy make interventional methods more preferable. In addition, considering the birth rate and the incidence of these diseases in Turkey, more pediatric heart centers are needed. However, the missing equipment should be completed and the team should gain more experience in this field, especially in the newly opened centers that have just started to make these interventions.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Kayseri City Hospital Clinical Researches Ethics Committee (Date: 17.06.2021, Decision No: 409).

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients for the study. However, written informed consent was obtained from the parents before the all procedures.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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