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Emergency cardiac surgeries after Interventional Catheterization in pediatric age group, Twelve-Years Retrospective Study

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Purpose: Due to the progress in interventional pediatric cardiology, more congenital cardiac anomalies are being treated in the catheterization laboratory.We retrospectively reviewed all those cases done in our institute over twelve years.

Methods: All the pediatric interventional catheterizations done in our institute from January 2008 till January 2020 were included in this retrospective study. The total number of interventions were 2500 over this period of twelve years. We performed 30 emergency cardiac surgeries after interventional catheterization. The interventions were 11 ASD device closures, 10 PDA coil closures , 5 PDA Amplatzerdevice removal, 1 balloon dilatations (valvuloplasty, angioplasty) with stent , 3 cases of VSD closures. Surgical approaches as well as morbidity and mortality were reviewed to assess our decision of timing of the surgery as well as the surgical technique.
Results: The number of emergency interventions was 30 cases out of 2500 (1.2%).We had 30 patients (19 males and 11 females),median age 4(2-12) years. 11 patients had ASD closure with Amplatzer device, 9 of which slipped into the right atrium or were entangled into the tricuspid valve while 1 patient had the device passing through the Eustachian valve with a large residual ASD in the superior rim. 10 patients had trial of PDA coil closure which slipped into the LPA. 5 patients had the PDA closed with an Amplatzer device which was protruding in the aorta. 3 patients had LPA and RPA stent application but were dislocated and 1 patient had pulmonary valvuloplasty but had injury of the RV. 3 patients had VSD closure with slipped Amplatzer devices into the RV. There was one mortality case (3.8%) due to infective endocarditis after VSD closure, while 3 had severe chest infection.
Conclusions: The number of emergency interventions of 30 cases out of 2500 (1.2%) is acceptable especially when we consider the learning curve in interventional catheterization. Immediate emergency surgical intervention is required if problems of bleeding or slipped devices happens and the quicker the surgical interference, the better the results.
Keywords: rescue cardiac surgery; interventional catheterization; congenital cardiac defects; device closure; pulmonary stenting.

Introduction

Catheter-based interventions for congenital cardiac defects, such as atrial septal defect (ASD), [1] ventricular septal defect (VSD), patent ductus arteriosus (PDA) and pulmonary stenosis (PS), have gained wide acceptance in the guidelines for managing

such congenital heart defects as they carries less risks associated with surgery. However, these procedures are associated with some complications, such as the embolization of devices or stents and the injury of surrounding structures, which might need a rescue surgical intervention. [2] Device and stent embolization, whether early during the intervention or later after its end, represents a serious complication that has been reported to occur in 0.55% to 2.3% of cases. [3&4] The retrieval of such foreign bodies may be achieved percutaneously in some cases using gooseneck snares or endomyocardial biopsy forceps, especially when discovered early. [5] However, urgent surgical removal is required
when percutaneous extraction fails in early cases or from the start in later cases after epithelization due to the risk of injury to surrounding structures. [6] Injury to surrounding structures usually occurs at the time of device deployment or balloon valvuloplasty and necessitates emergency surgery. [7] In this study, we retrospectively reviewed the early outcomes of all pediatric patients who required a rescue surgical procedure after a catheter-based intervention at our institute over a period of 10 years.

Patients and methods

Between January 2008 and January 2020, a total of 2500 pediatric cardiac interventions were performed in the catheterization laboratory of our institute, including PDA closure (1008), secundum ASD closure (896), balloon dilatation with stenting of a stenotic main pulmonary artery (256), pulmonary balloon valvuloplasty (200) and muscular VSD closure (140). Among these cases, early device embolization (during the intervention) occurred in 20 cases at the time of deployment, but the devices could be immediately extracted percutaneously. However, emergency surgery was needed in 30 cases to retrieve the devices after the failure of percutaneous extraction. We have chosen at our institute the strategy of early removal of these devices at the same day after full heparinization to avoid further embolization of the devices to more distal locations as well as any psychic upset of the patients or their parents from the embolized devices. The data of these 30 cases were retrospectively collected and statistically analysed to review the decision and timing of surgery as well as the surgical techniques and results in comparison to elective surgical procedures of similar congenital heart defects over the same period. This study was approved by our institutional ethical committee, and because of its retrospective nature, patient consent was waived.

Statistical analysis

Data were coded and then entered into the SPSS statistical package (Statistical Package for the Social Sciences). Quantitative data are summarized using the mean ± standard deviation, while categorical data are presented as the frequency (count) and relative frequency (percentage).

Results

There were 30 rescue surgeries after device embolization, including in 11 cases of secundum ASD closure with an Amplatzer device, 10 cases of PDA closure with coils and with an Amplatzer device in 5 cases , 1 case of pulmonary artery balloon dilatation with stenting and 3 cases of muscular VSD closure as shown in table (1). There were 19 males (63.3%) and 11 females (36.6%), with a median age of 4 years (range, 2 months-12 years). All 30 patients with an embolized device or stent were operated in the hybrid room in our hospital.The interventional catheter operators spended a mean of 130±24 min trying to retrieve percutaneously the migrated devices.The percutaneous trails were

stopped when the retrieval trails were considered impossible. The time interval between the decision to stop the percutaneous trails to remove the device , decision to refer the patient for urgent surgery and the actual surgical procedure was 73±16 min.Transoesophageal echocardiography (TEE) was performed in the operating room to confirm the position of the device. Median sternotomy approach was used in all refered patients.

Table 1: Interventional procedures needed rescue surgeries

ASD closure	11 (36.6%)
PDA closure	10 (33.3%)
PDA Amplatzer	5 (13.3%)
Pulmonary artery balloon dilatation with stenting	1 (3.3%)
Muscular VSD closure	3 (10%)

Cardiopulmonary bypass (CPB) via aortic and bicaval cannulation,tapes on both cavae followed by aorta cross-clamping and giving antegrade cold-blood cardioplegia in the ASD cases. After both cavae were snared, small right atriotomy was done and we removed the device by holding its edges via forceps to avoid injuring of any of the surrounding cardiac structures. The ASDs defects were closed with autologous pericardium. In the 11 ASD cases refered to surgery in this series , 9 of the migrating Amplatzer devices were in the right atrial cavity and stucked in the right ventricular trabeculations and the last 2 was passing through the Eustachian valve. Among those cases, the reason of migration in 7 of them was due to size mismatch between the defect size and the Amplatzer device size , 3 cases due to thin superior (aortic) rim (<5 mm), and the last case due to thin inferior (caval) rim.

In our cases , 4 of them the coils slipped into the left pulmonary artery (LPA) while in the remaining 10 cases the Amplatzer devices were wrongely placed during closure and it protruded into the descending aorta leading to a significant pressure gradient. In the cases where the coils slipped into the LPA, digital localization of the occluder in the artery from outside and taking a purse-string suture in the wall of the artery over the device without the need of cardiopulmonary bypass. Very Small arteriotomy was done within the purse string and the device was quickly removed and then the purse-string was tightened properly. The patent ductus arteriousus were then closed using double ligation technique In the cases where the Amplatzer devices slipped in the descending aorta, median sternotomy was done, cardiopulmonary bypass was established via aorto bicaval cannualtion and the devices were refolded through pulling on a knob at the middle of the device pulling it out of the descending aorta carefully without causing any injury to the surrounding structures . Before closure, we used the double ligature technique to close

the PDA . In all the refered PDA cases, the mean pressure gradient across the defect was 68±17 mmHg.

In the refered 3 perimembraneous VSD cases ,the migrated devise caused a mean systolic gradient between the right and left ventricles of 78±13 mmHg . In those cases , Stents slipped into the LPA leading to main pulmonary artery stenosis .Median sternotomy were used in all cases, cardiopulmonary bypass was established via aortobicaval cannualtion and cold-blood cardioplegia . The stents were removed from the LPA through a small arteriotomy followed by patch angioplasty of the MPAand Then the VSDs defects were closed with polytetrafluoroethylene (PTFE) patches . Among the VSD cases, the reason of migration was attributed to the operators learning curve

In the case of membranous pulmonary atresia referred to the cath lab for balloon valvuplasty , the operator was successful in perforating the membrane during catheterization, but the stent migrated while stenting the MPA. Median sternotomy was done, cardiopulmonary bypass was established via aorto bicaval cannualtion, and the stent was removed from the LPA, followed by Commissurotomy of the pulmonary valve and patch angioplasty of the MPA.

The mean duration of intensive care stay was 2.4±1.2 and for the total hospit stay was 6.5±2.1 days, respectively.There was one mortality case (3.8%) due to infective endocarditis after VSD closure, and 3 morbidities due to severe chest infection. Following the patients by echocardiography for a mean of 8.7±2.3 months with no significant gradients in cases with pulmonary commissurotomy, patch angioplasty of the MPA and arteriotomy of LPA or residual shunts left to right shunt in the other cases.

Comments

Device migration after **Pediatric Interventional Catheterization** is attributed to different factors as small atrial size , large size of the defect (> 30 mm, thin inadequate rims, and lack of operator experience. [8] Although strict selection criteria is established for choosing the patients for transcatheter defect closure with respect to the size of the defect and adequacy of the rims,refusal of the patient or the guardians to undergo surgical closure may promote transcatheter defect closure despite unsuitable anatomical finding. [9]

This was found in 2 of our ASD cases . The rest of the cases the device migration was mainly attributed to size mismatch between the sizes of the defect and the device .Also, another important factor was the operator learning curve.

The site of device embolization was variable. The devices in the Atrial septal defects can embolize to the left atrium (24.6%), right ventricle (16.7%), aorta and its branches (18.4%), left ventricular outflow tract and MPA. [10] The ventricular septal defects devices usually migrate to the right ventricle with the direction of the shunt from left to right. [12] The patent ductus arterioses devices usually migrate to the pulmonary arteries, especially the left pulmonary artery, because of the difference in the pressure gradient between the aorta and the pulmonary artery. [11 Transoesophageal usage for

localization of the migrated device is a must as its place might change during sternotomy or cannulation for cardiopulmonary bypass.

Interventional pulmonary angioplasty used in neonates in pulmonary artery stenosis is a good alternative to avoid surgical intervention and cardiopulmonary bypass at that age. However, it might may be complicated by embolization of the stent in up to 5% of cases due to the use of smaller stents than actually needed. [13]

There are no available guidelines regarding indications, the timing of surgery or surgical approaches for rescue cardiac surgeries after complicated **Pediatric Interventional Catheterization** as most of those cases are individually reported. Thus, the surgical strategies are designed individually according to each case situation . [14] Median sternotomy offers the best exposure in almost all cases, and allows rapid and safe cannualtion and establishment cardiopulmonary bypass. Right atriotomy in ASD and VSD cases is usually sufficient to reach the migrated device, whether it was in the right atrium ,right ventricle or left atrium , left ventricle through the existing atrial septal defect or ventricular septal defect . Approach through the right atriotomy gives good exposure and allows also proper closure of these defects. In PDA and pulmonary stent cases, Our strategy was to reach the migrated devise to the pulmonary artery by a small arteriotomy without cardiopulmonary bypass.

In the cases where the Amplatzer devices protruded into the descending thoracic aorta , our strategy was to reach the migrated devise by opening the left pulmonary artery under cardiopulmonary bypass and securing this opening with purse string suture . In Our experience, the availability of a cardiac surgical team is a must as back up for interventional catheterization patients.

Conclusion

Our center experience confirms that early rescue cardiac surgery to correct adverse events after pediatric Interventional Catheterization transcatheter interventions is safe and effective. Surgical strategies is individually should tailored according to the situation in each case. The number of emergency interventions of 26 cases out of 2495 (1.04%) is acceptable especially when we consider the learning curve in interventional catheterization. Immediate emergency surgical intervention is required if problems of bleeding or slipped devices happens and the quicker the surgical interference, the better the results

Conflicts of interest: The authors have declared that no conflicts of interest exist.

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