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Pulmonary valve and right ventricular outflow tract surgery in adults: 23-year experience

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Abstract

Background: Surgery of the pulmonary valve, right ventricular outflow tract, and pulmonary artery falls under the domain of paediatric cardiac surgery. However, 97 adult patients underwent such operations in our institution from 1993 to 2016.

Aim: This study aims to analyse preoperative risk factors, intraoperative data, postoperative outcomes, and long-term survival to identify the potential predictors of mortality and high-risk patients.

Methods: We divided our patient cohort into three groups in accordance with surgical indications: 17 patients with pulmonary valve endocarditis (group A), 70 patients with congenital defects involving the pulmonary valve (group B), and 10 patients who underwent pulmonary valve surgery for other indications, such as tumour or other acquired valvular disease (group C).

Results: Gender distribution was comparable in all the three groups, with about 40% of the total number of patients being female. The mean age was 35.9 ± 15.7 years. Sixty (61.9%) patients had a history of cardiac surgery. Various concomitant cardiac surgical procedures were necessary in 49 (50.5%) cases. There were two (11.8%) in-hospital deaths in group A, two (2.9%) in group B, and none in group C. Within the mean follow-up time of 6.6 ±7.2 years, three (17.7%) patients in group A, two (2.9%) in group B, and four (40%) in group C died.

Conclusions: Adult patients with pulmonary valve disease are often previously heart-operated and often need concomitant procedures. The operative risk in patients with pulmonary valve endocarditis is high. Surgery of congenital defects of the pulmonary valve is safe and can be performed with excellent outcomes.

Key words: tetralogy of Fallot, endocarditis, pulmonary valve, Ross procedure, surgery

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INTRODUCTION

The right ventricular outflow tract (RVOT), pulmonary valve (PV), and pulmonary artery (PA) develop together and make up one anatomical unit; therefore, congenital malformations of one of these structures can affect the others [1]. Operations in this area of the heart principally fall under the domain of paediatric cardiac surgery. However, of late, the survival of patients after surgical treatment for congenital heart disease (CHD) has remarkably improved, while the number of adults undergoing such procedures is always increasing, forming the so-called 'grown-up with CHD (GUCH)' population [2]. Some of these patients must undergo a redo heart surgery. The most frequent reasons are new haemodynamic complications occurring after the initial surgery, change of the therapeutic option from palliation to correction, and no prior correction [2]. Congenital malformations affecting the RVOT, PV, and PA are relatively frequent among GUCH patients [3].

The above-mentioned heart structures can also be affected by acquired diseases in adult patients. Some of them must be treated surgically. Infective endocarditis (IE) of right-sided heart valves accounts for as much as 5–10% of all cases of IE. In most patients, the tricuspid valve is involved, while isolated infection of the PV is infrequent. Intravenous antibiotics are the therapy of choice, but surgery must be

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considered in cases of right-sided heart failure, failed antimicrobial therapy, large vegetation, or when other surgical indications are present [4].

Patients after implantation of the prosthetic or homograft PV can develop a graft failure. This special group consists partially of patients who received the Ross procedure due to either congenital or acquired aortic valve disease. Some of them must undergo redo surgery. However, failure of the pulmonary homograft is a rare indication [5].

Structural pathologies of the PA, such as aneurysms or stenosis, are infrequent in the adult population and are often associated with CHD [6, 7]. Cardiac tumours in this location are extremely uncommon and mostly malignant [8].

To our knowledge, no study has so far compared the risk factors and outcomes after PV surgery in adults for various indications. We report 97 patients undergoing PV surgery in our institution over a 23-year period with a follow-up time of up to 23.4 years. Our study shows distinct differences in the postoperative outcomes in accordance with operative indications.

METHODS

Patient population

We included 97 consecutive patients who underwent surgery of the PV, RVOT, and PA in the Department of Cardiac Surgery, Heart and Marfan Centre — University of Heidelberg from 1993 to 2016. Overall, the mean age was 35.9 ±15.7 years, and 40 (41.2%) of them were female. We divided our patient cohort into three groups. Group A consisted of 17 patients undergoing surgery for PV endocarditis. The other two groups included patients with non-infective pathologies: 70 patients who were initially diagnosed with CHD affecting the PA, PV, or RVOT (group B) and 10 patients who were operated on because of various other PA, PV, or RVOT pathologies (group C). We analysed the preoperative data including a type of the RVOT, PV, or PA disease, previous cardiac procedures, presence of cardiogenic shock, coronary artery disease, hypertension, or diabetes. We also took into consideration the surgical data, such as procedures performed on the above-mentioned heart structures, concomitant procedures, and duration of the surgery, of the cardiopulmonary bypass, and of the aortic cross-clamp. Additionally, we analysed patients' clinical outcomes, and long-term survival.

Surgical procedures

Median sternotomy was the approach of choice in all cases. All the patients were operated with use of cardiopulmonary bypass. One patient underwent a hybrid-procedure because of severely calcified PV-prosthesis. In this case, there was no possibility to replace the valve conventionally and we implanted a transcatheter aortic valve implantation-valve (Sapien) through a right ventricle puncture.

Definitions

Postoperative respiratory insufficiency was defined as the need for reintubation or total mechanical ventilation for longer than 72 h. Postoperative renal failure was defined as a new start of dialysis or elevation of creatinine level > 1 mg/dL over the preoperative level. Postoperative stroke was defined as new neurological deficit. In-hospital mortality was defined as any death occurring after surgery until hospital discharge.

Statistical analysis

We used SPSS software version 24 (IBM Corp.) for statistical analysis. Categorical variables were described as absolute values and percentages, while continuous variables were reported using mean ± standard deviation. Survival rates were expressed using a Kaplan-Meier curve. The differences of survival in the analysed subgroups were assessed with the Log Rank and Breslow test. We used Cox regression analysis to assess the predictors of mortality. The hazard ratio (HR) and 95% confidence intervals (CI) were calculated in relation to each analysed variable. The mean values were compared with the Mann-Whitney U test because of the small cohort and lack of normal distribution of values in small subgroups.

RESULTS

The preoperative and intraoperative data are presented in Tables 1–4.

In group A, endocarditis patients (n = 17) were 44.2 ± 20.1 years old and seven (41.2%) of them were female. Seven (41.2%) patients had a history of cardiac surgery performed, on average, 7.3 ± 6.3 years earlier. In five (29.4%) of them, the previous surgical procedures involved the PV and RVOT. Of these five patients, four had CHD. Three (17.7%) patients were diagnosed with a prosthetic PV endocarditis. Eight (47%) patients presented with cardiogenic shock. Three (17.7%) patients were intravenous drug users, and one (5.9%) of them had HIV infection.

Simple removal of the vegetation was performed in four (23.6%) cases. In two (11.8%) cases of multiple valve endocarditis, the PV was inspected and IE of the valve was intraoperatively ruled out. In two (11.8%) patients, the infection was limited to the native PV in an otherwise anatomically normal heart. In six endocarditis patients, the RVOT was augmented with a patch. Concomitant operations of other valves were performed because of multiple valve infections in 11 patients. Three (17.7%) patients received aortic root replacement due to extensive infection. Aortic valve replacement (AVR) as the only concomitant procedure was necessary in one case. AVR combined with explantation of an infected pacemaker and tricuspid valve reconstruction was carried out in one patient, AVR with coronary artery bypass grafting (CABG) in another one, and AVR with mitral valve replacement (MVR) in two others. MVR as the only concomitant

Table 1. Preoperative patient characteristics

Characteristics	Endocarditis	Congenital	Others
Demographic data			
Number of patients	17	70	10
Age [years]	44.2 ± 20.1	31 ± 11.4	55.8 ± 12.7
Female	7 (41.2%)	29 (41.4%)	4 (40%)
Body mass index [kg/m^2]	24.4 ± 6.29	23.6 ± 4.5	26.7 ± 3.5
Cardiogenic shock	8 (47%)	2 (2.9%)	1 (10%)
Preoperative diagnosis			
Native PV endocarditis	12 (70.6%)		
Endocarditis of prosthetic PV	3 (17.7%)		
Other valve endocarditis with intact PV	2 (11.7%)		
PV stenosis		7 (10%)	
PV regurgitation		27 (38.6%)	2 (20%)
PV stenosis and regurgitation		5 (7.1%)	
Homograft degeneration after Ross procedure			2 (20%)
Bioprosthetic PV degeneration		11 (5.7%)	
Dysfunction of mechanical prosthetic PV		1 (1.4%)	
PV thrombus			1 (10%)
RVOT obstruction		4 (5.7%)	
RVOT and LVOT obstruction with hypertrophic cardiomyopathy			1 (10%)
Suspected RVOT		1 (1.4%)	
Insufficiency of RV–PA shunt		1 (1.4%)	
Complex congenital defect		13 (18.6%)	
PV tumour			1 (10%)
PA tumour			3 (30%)
Recent heart operation (also, as performed in various combinations)	7 (41.2%)	50 (71.4%)	3 (30%)
AV conduit implantation	1 (5.9%)	2 (2.9%)	
AV replacement	1 (5.9%)		
PV conduit implantation		1 (1.4%)	
PV prosthesis implantation	3 (17.7%)	1 (1.4%)	
PV commissurotomy	1 (5.9%)	11 (15.7%)	
Correction of TOF	2 (11.8%)	34 (48.6%)	
Correction of double outlet right ventricle		1 (1.4%)	
Balloon-valvuloplasty of homograft PV		1 (1.4%)	
RVOT enlargement		5 (7.1%)	
Ross operation			2 (20%)
Central shunt implantation		1 (1.4%)	
Closure of VSD	1 (5.9%)		
TV replacement		1 (1.4%)	
Coronary artery bypass grafting	1 (5.9%)		
PA tumour resection			1 (10%)
The most recent heart surgery before [years]	7.3 ± 6.3	19.1 ± 9.1	6.4 ± 2.5

Data are shown as mean ± standard deviation or number (percentage). AV — aortic valve; LVOT — left ventricular outflow tract; PA — pulmonary artery; PV — pulmonary valve; RV — right ventricle; RVOT — right ventricular outflow tract; TOF — tetralogy of Fallot; TV — tricuspid valve; VSD — ventricular septal defect

Table 2. Performed procedures

Surgical procedures (also, as performed in various combinations)	Endocarditis	Congenital	Others
PV surgery	17 (100%)	63 (90%)	8 (80%)
Implantation of mechanical conduit	2 (11.7%)	1 (1.4%)	1 (10%)
Implantation of biological conduit	3 (17.7%)	2 (2.9%)	1 (10%)
Homograft valve implantation	1 (5.9%)	24 (34.3%)	2 (20%)
Implantation of mechanical valve prosthesis	4 (23.6%)	6 (8.6%)	
Implantation of biological valve prosthesis	1 (11.7%)	18 (25.7%)	2 (20%)
Hybrid transcatheter valve implantation		1 (1.4%)	
Rotation of mechanical PV prosthesis		1 (1.4%)	
Commissurotomy		7 (10%)	
Other types of valve repair		3 (4.2%)	
Removal of vegetation	4 (23.6%)		
Resection of valve tumour			1 (10%)
Inspection	2 (11.7%)		
RVOT surgery	6 (35.3%)	39 (55.7%)	2 (20%)
Muscle bundle resection		5 (7.1%)	
Patch implantation	6 (35.3%)	17 (24.3%)	1 (10%)
Muscle bundle resection and patch implantation		17 (24.3%)	1 (10%)
PA surgery	1 (5.9%)	15 (21.4%)	4 (40%)
Enlargement of main PA	1 (5.9%)	7 (10%)	
Enlargement of left or right PA		7 (10%)	
Reduction		5 (7.1%)	1 (10%)
Tumour resection			3 (30%)
Concomitant surgery	12 (70.6%)	31 (44.3%)	6 (60%)
Coronary artery bypass grafting	1 (5.9%)	2 (2.9%)	4 (40%)
AV conduit implantation	3 (17.7%)	1 (1.4%)	
AV replacement	5 (29.4%)	1 (1.4%)	
MV replacement	3 (17.7%)		
TV reconstruction	2 (11.7%)	5 (7.1%)	1 (10%)
Pacemaker explantation	1 (5.9%)		
Closure of recurrent VSD	1 (5.9%)	8 (11.4%)	
Closure of primary VSD		7 (10%)	
Closure of atrial septal defect		8 (11.4%)	
LVOT muscle resection			1 (10%)
Closure of patent ductus arteriosus		1 (1.4%)	
Closure of coronary fistula		1 (1.4%)	
TV replacement	2 (5.9%)	2 (2.9%)	
Aortic arch enlargement		2 (2.9%)	
TV tumour resection		1 (1.4%)	
Lung lobar resection because of complicated tuberculosis		1 (1.4%)	
Central shunt removal		1 (1.4%)	
Reduction of aorta ascendens		1 (1.4%)	

Data are shown as number (percentage). AV — aortic valve; LVOT — left ventricular outflow tract; MV — mitral valve; PA — pulmonary artery; PV — pulmonary valve; RV — right ventricle; RVOT — right ventricular outflow tract; TV — tricuspid valve; VSD — ventricular septal defect

Table 3. Intraoperative data

Characteristics	Endocarditis	Congenital	Others
Surgical data			
Beating-heart surgery	4 (23.6%)	44 (62.9%)	2 (20%)
Operation time [min]	33 ± 149	269 ± 83	278 ± 70
Cardiopulmonary bypass time [min]	192 ± 98	125 ± 51	147 ± 54
Aortic clamp time [min]	99 ± 57	73 ± 27	78 ± 46
Intraoperative body temperature [°C]	30.7 ± 4.9	31.2 ± 2.7	31.2 ± 2.2
Intraoperative transfusions			
Autotranfusion [mL]	290 ± 608	407 ± 405	437 ± 326
Packed red blood cells [mL]	2435 ± 2012	550 ± 913	980 ± 1221
Platelets [mL]	487 ± 393	491 ± 188	248 ± 271
Fresh frozen plasma [mL]	965 ± 1008	328 ± 569	420 ± 569

Data are shown as mean ± standard deviation or number (percentage)

Table 4. Initial diagnoses of the patients who were operated due to congenital heart disease

Characteristics	Value
Tetralogy of Fallot	34 (48.6%)
PV stenosis (valvular or subvalvular)	17 (24.3%)
Double-chambered right ventricle	5 (7.1%)
PV atresia	4 (5.7%)
VSD with subvalvular PV stenosis	2 (2.9%)
DORV	2 (2.9%)
DORV with levo-TGA	1 (1.4%)
Ebstein anomaly with DORV	1 (1.4%)
Ebstein anomaly with PV stenosis	1 (1.4%)
Dextro-TGA	1 (1.4%)
VSD with valvular PV stenosis	1 (1.4%)

Data are shown as number (percentage). DORV — double outlet right ventricle; PV — pulmonary valve; TGA — transposition of the great arteries: VSD — ventricular septal defect

Table 5. Microbiological findings of patients with preoperative diagnosis of pulmonary valve endocarditis

Characteristics	Value
Negative	6 (35.3%)
Staphylococcus species	4 (23.6%)
Enterococcus faecalis	2 (11.8%)
Streptococcus species	1 (5.9%)
Coxiella burnetti	1 (5.9%)
Candida albicans	1 (5.9%)
Not performed	2 (11.8%)

Data are shown as number (percentage).

surgery was performed in one patient and tricuspid valve replacement in two patients.

Patients with endocarditis received significantly more blood product transfusions than the other, including packed red blood cells ($p < 0.001$), blood platelets ($p = 0.012$), and fresh frozen plasma ($p = 0.004$). In all cases of intraoperatively confirmed IE, material for microbiological examination was obtained (Table 5). *Staphylococcus* was the most common pathogen.

Group B comprised 70 patients aged 31 ± 11.4 years and they were significantly younger than the patients in the two other groups ($p < 0.001$). As many as 29 (41.4%) of them were female, while 50 (71.4%) had already experienced heart operations, on average, 19 ± 9.1 years previously. The time interval between the most recent surgical intervention and reoperation considered in this study was significantly longer than that in the two other groups ($p < 0.001$). The most common previous cardiac procedures were correction of tetralogy of Fallot (TOF; n = 34, 48.6%) and PV commissurotomy (n = 11, 15.7%). Patients with previous TOF correction had been surgery-free for 19.3 ± 9.2 years. The most frequent preoperative diagnoses in this subgroup were native PV regurgitation (n = 27, 38.6%), complex congenital diseases affecting the PV or RVOT (n = 13, 18.6%), and bioprosthetic PV degeneration (n = 11, 5.7%). Two (2.9%) patients of this group presented with cardiogenic shock. PV surgery was performed in 63 (90%) cases. The most frequent procedure was homograft (n = 24, 34.4%) or bioprosthetic valve (n = 18, 25.7%) implantation. Concomitant procedures were carried out in 31 (44.3%) cases, mostly because of accompanying congenital malformations such as atrial septal defect, ventricular septal defect, or recurrent ventricular septal defect.

Group C was heterogenic, with 10 patients being 55.8 ± 12.7 years old, and significantly older than those in the two other subgroups ($p < 0.001$). Four (40%) of them were female. Three had already undergone heart operations: two patients had undergone the Ross procedure because of acquired aortic valve disease 7.3 and 8.4 years before (already

Table 6. Postoperative outcomes and adverse events

Characteristics	Endocarditis	Congenital	Others
Postoperative outcomes			
Intensive care unit — length of stay [days]	8.1 ± 9.8	1.8 ± 2.8	1.9 ± 1.3
Total hospital length of stay [days]	32.1 ± 25.6	17.2 ± 13.5	11.9 ± 6.6
Mechanical ventilation [h]	147 ± 185	27 ± 43	14 ± 8
In-hospital death	2 (11.8%)	2 (2.9%)	
Death after hospital discharge	3 (17.7%)	2 (2.9%)	4 (40%)
Follow up time [years]	3.4 ± 5.5	7.4 ± 7.5	4.6 ± 6.8
Postoperative adverse events			
Extracorporeal membrane oxygenation	1 (5.9%)		
Intra-aortic balloon pump	3 (17.7%)		
Revision due to bleeding	2 (11.8%)	3 (4.3%)	
Drainage due to pericardial tamponade	1 (5.9%)		1 (10%)
Revision due to wound infection			
Cardiopulmonary resuscitation	3 (17.7%)	1 (1.4%)	
Stroke			
Acute renal failure treated with dialysis	8 (47.1%)	2 (2.9%)	1 (10%)

Data are shown as mean ± standard deviation or number (percentage).

in adulthood, at the age of 26 and 56 years, respectively), whereas one patient had undergone the resection of a PA fibrosarcoma and came back after 3.5 years with tumour recurrence. There were also two cases of primary angiosarcoma of the PA in this group. One (10%) patient presented with cardiogenic shock. Eight (80%) patients received various types of PV surgery, while CABG was the most frequent additional surgery in this group.

Early outcomes

Postoperative data and outcomes are presented in Table 6. Patients with endocarditis stayed significantly longer in the intensive care unit than those of the two other groups (8.1 ± 9.8 days vs. 1.8 ± 2.8 days for congenital defects and 1.9 ± 1.3 days for various pathologies, $p = 0.001$). During the postoperative course, two (11.8%) IE patients died in the hospital because of low cardiac output syndrome. There were two (2.9%) in-hospital deaths in group B, both because of right ventricular failure, and none in group C.

Follow-up

The survival curve of the entire cohort is presented in Figure 1. The follow-up time of the entire cohort varied from 0 (cases of in-hospital death) to 23.36 years (Table 6). The survival curves differed significantly between the three subgroups; Log Rank, $p < 0.001$, Breslow, $p = 0.001$ (Fig. 2).

Predictors of mortality

Older patients had slightly worse prognosis than the younger ones (HR 1.1; 95% CI 1.046–1.128; $p < 0.001$). The concomitant procedures did not significantly affect the long-term outcome ($p = 0.149$). The time since the most recent surgery ($p = 0.151$) and gender ($p = 0.372$) also had no influence on survival. The presence of preoperative cardiogenic shock (HR 4.9; 95% CI 1.6–15.2; $p = 0.006$) and postoperative acute renal failure requiring dialysis (HR 31.6; 95% CI 8–125; $p < 0.001$) could be defined as independent risk factors of mortality. The transfusion of blood products could be defined as a surrogate parameter.

DISCUSSION

Our study presents and compares the outcomes of PV, RVOT, and PA surgery for various indications, based on 23-year experience with a relatively large patient cohort.

Preoperative haemodynamic instability is distinctly associated with high mortality, which is intuitively comprehensible and has been ascertained many times by various studies [9]. Also, in our patient cohort the presence of preoperative cardiogenic shock was found to be an independent risk factor of mortality. It is important to note that most of these patients suffered from endocarditis, and thus we suppose that the septic component of shock was present in these cases as well.

Infective endocarditis of the PV is rare and mostly occurs in combination with IE of other valves. The risk factors include intravenous drug use, presence of cardiac implantable electronic devices or prosthetic valves, intracardiac shunts, and residual defects after surgical correction of CHD [10–12]. Surgical indications in cases of isolated infection of the PV have not been clearly established yet. However, surgery should be carried out for patients who do not adequately respond to

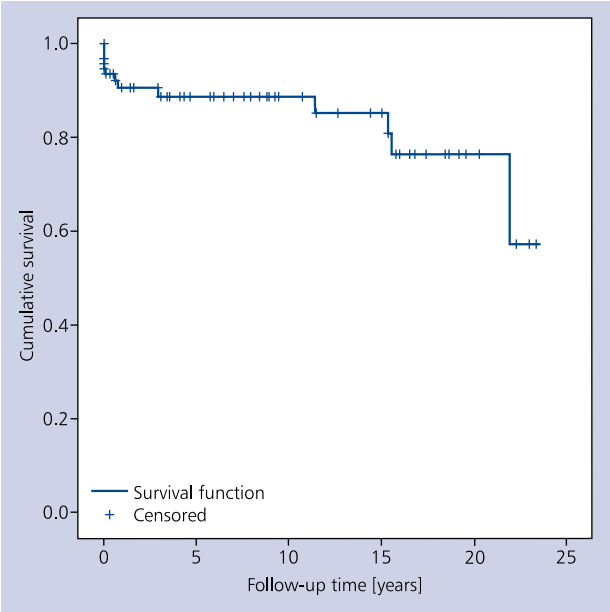

Figure 1. Overall cumulative survival of the whole patient cohort

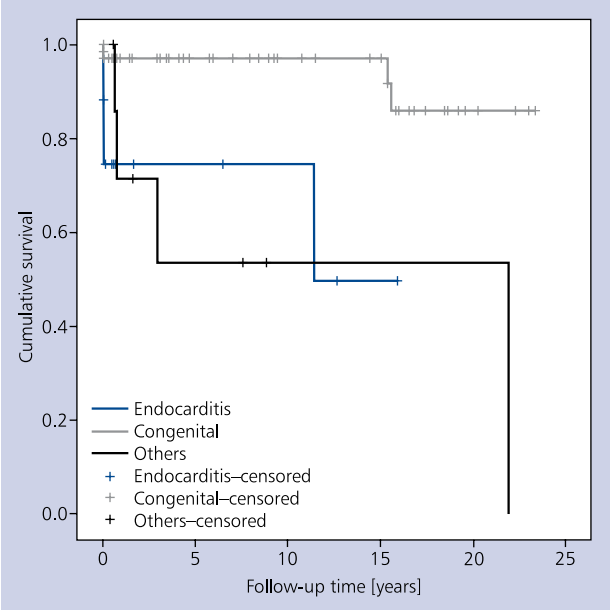

Figure 2. Cumulative survival of all three analysed cohorts. The difference between groups is statistically highly significant (Log Rank, $p < 0.0001$, Breslow, $p = 0.001$)

the antimicrobial therapy, who are haemodynamically compromised, when large vegetation is present, and in cases of prosthetic PV endocarditis [4, 13]. In our record, there was no data of genetic conditions like microdeletion 22q11, which are believed to be often associated with CHD and affect the immune system, making the patient vulnerable to various infections [14]. The outcome of our IE cohort was comparable to the literature [15].

Redo cardiac surgery is technically more complex than the first operation, but the surgical risk and survival of these patients are quite similar to those of other patients not previously operated upon [16]. Also, previous surgery did not affect the outcome in our study. Furthermore, the concomitant procedures seemed to have no relevant effect on the outcome.

Patients with congenital disease of the PV or RVOT live to reach adulthood more frequently than at any time in the past [3]. Some of them require redo surgery or other cardiovascular interventions. Transcatheter PV replacement has recently gained recognition and can be performed with good outcomes in selected patients. The surgical option is still recommended for patients with complex anatomy [17].

Pulmonary valve regurgitation, residual septal defect, RVOT patch aneurysm, and PA stenosis are the most frequent surgical indications found in the literature as well as in our case series. The outcomes are usually satisfying despite common impairment of the right ventricular function in this population [18].

Pulmonary valve regurgitation or stenosis after TOF correction is usually well tolerated, but reliable quantification is very difficult. Therefore, the timing of redo surgery is not clearly defined. Echocardiographic examination should be performed in every case. Surgery should be considered for symptomatic patients. The presence of other surgical indications should incline the strategy towards redo surgery [19].

There are no studies in the literature that assess adult patient series with recurrent RVOT obstruction. In our study, 22 (31.4%) patients received excisions of RVOT muscle bundles, while enlargement of the RVOT with a patch was performed in 17 (24.3%) patients. Patch implantation in the RVOT is part of PV replacement when valvular ring enlargement is needed. In patients suffering from congenital anomalies with a reduced pulmonary flow, such as TOF, the PV ring can be initially small and thus the valve implanted in a child must be explanted after several years to prevent the development of a valve–patient mismatch. Hence, RVOT patch enlargement is mostly required in these cases [20]. This could be observed in 17 (24.3%) more patients in our cohort.

Pulmonary artery stenosis is rare in the adult population and can be treated either surgically or in an endovascular manner [21]. The history of CHD is often present in these cases, and individual surgical indications depend on patient characteristics [22]. Aneurysms of the PA are often related to right ventricular congenital lesions, and surgery remains the strategy of choice [6]. Tumours of the PA, which are rare and mostly malignant, have limited survival [8].

The Ross procedure is one of the surgical strategies in both congenital and acquired aortic valve disease [23]. In

the literature, the outcomes are good, with about 85% of the patients having no need to undergo surgery even 10 years after the operation. Following surgery, not only the aortic valve pathology is present, but also the PV, which is replaced with conduit that is prone to degeneration. However, it is a rare surgical indication. On the other hand, degeneration of the pulmonary autograft in the aortic position is more frequent [5].

Gender can influence the outcomes of various cardiac surgical procedures, and worse outcomes were reported in female patients [24]. Our analysis does not support this hypothesis.

Postoperative acute renal failure can lead to electrolytes imbalance, metabolic disturbances, persistent impairment of kidney functions, and reduced survival [25]. We could confirm such statistically significant associations in our study. Patients receiving massive transfusions were in a worse clinical condition than the others, and this factor has no predictive value.

Limitations of the study

The study is limited by its retrospective nature. The analysed subgroups are small and unequal. Therefore, the distribution of some variables does not necessarily meet the criteria for normality. This issue needs further prospective analysis to confirm the presented hypotheses.

CONCLUSIONS

In conclusion, adult patients with indications for PV surgery are mostly in the third to sixth decade of life. Many of them have previously undergone heart operations. Concomitant procedures are necessary in most cases of PV endocarditis and in numerous cases of congenital disease affecting the PV. Patients with endocarditis involving the native or prosthetic PV face a high risk of mortality and morbidity. Adult patients with congenital anomalies affecting the PV can undergo redo cardiac surgery with excellent outcomes. Preoperative cardiogenic shock and postoperative acute renal failure requiring dialysis are strong independent risk factors of mortality. Gender and concomitant procedures do not influence the outcome after PV surgery.

Conflict of interest: *none declared*

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