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Cardiac Surgery After Heart Transplantation: Elective Operation or Last Exit Strategy?

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Background. Because of improved long-term survival after heart transplantation (HTx), late graft pathologies such as valvular disease or cardiac allograft vasculopathy (CAV) might need surgical intervention to enhance longer survival and ensure quality of life. To this date, there exist no guidelines for indication of cardiac surgery other than retransplantation after HTx. **Methods.** In this retrospective, single-center study, we evaluated patients who underwent cardiac surgery after HTx at our institution. **Results.** Between March 1984 and October 2016, 17 (1.16%) of 1466 HTx patients underwent cardiac surgery other than retransplantation after HTx. Indication were valvular disease (n = 7), CAV (n = 6), and other (n = 4). Of these, 29.4% (n = 5) were emergency procedures and 70.6% were elective cases. Median age at time of surgery was 61 years (interquartile range, 52-66 years); 82.4% (n = 14) were male. Median time to surgery after HTx was 9.3 years (2.7-11.1 years). In-hospital, mortality was 11.8% (n = 2); later need of retransplantation was 11.8% (n = 2) due to progressing CAV 3 to 9 months after surgery. One-year survival was 82.35%; overall survival was 47.1% (n = 8) with a median follow-up of 1477 days (416-2135 days). Overall survival after emergency procedures was 209 days (36-1119.5 days) whereas, for elective procedures, it was 1583.5 days (901.5-4319 days). **Conclusions.** Incidence of cardiac surgery after HTx in our cohort was low (1.16%) compared with that of other studies. In elective cases, long-term survival was good.

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Because survival after heart transplantation (HTx) is improving steadily, an increasing number of patients with late cardiac pathologies such as valvular disease or cardiac allograft vasculopathy (CAV) may arise with potential need of surgical intervention.^{1,2} Global organ shortage forces transplant centers to accept more marginal donor hearts with possible preexisting pathologies.³ There exists no guideline for indication of cardiac surgery after HTx. Chronic immunosuppression bears higher risk for infections, chronic renal insufficiency, and

wound-healing complications that are directly linked with higher postoperative mortality after cardiac surgery.

There exist single-center experiences and case reports on this topic: concerning valvular disease, severe tricuspid regurgitation (TR) refractory to medical treatment is the most common indication and surgery seems to be safe with good long-term outcome and improvement of quality of life.^{2,4-13} There are only case reports on mitral and aortic valve surgery showing that it seems to be safe in selected patients.^{2,5,14-19} New treatment options for these valves with transcatheter aortic valve implantation (TAVI) or MitraClip have been described in case reports, but the benefit of these developments in the field of HTx patients needs to be proven.^{3,20-25}

Concerning the treatment of CAV with coronary artery bypass grafting (CABG), there are single-center experiences and even a published recommendation that CABG can be performed in type A lesions even though it has limited efficacy in diffuse distal artery disease.²⁶⁻³⁰ When performed in selected patients, the operation seems to be safe.^{2,5,14} Retransplantation remains the last therapeutic option for cardiac allograft failure due to progressive CAV.³¹⁻³⁵ Unfortunately, this therapeutic option is limited mostly because of organ shortage and associated with long waiting times.³⁶ Therefore, bridge to retransplantation and bridge to destination with a ventricular assist device might be lifesaving.³⁷

The aim of this retrospective study was to evaluate our experience on short- and long-term outcomes and associated morbidity of cardiac procedures other than retransplantation after HTx.

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MATERIALS AND METHODS

This retrospective analysis was based on data obtained from the Medical University of Vienna Heart Transplant Database for consecutive patients receiving HTx between March 1984 and October 2016. HTx recipients with cardiac surgery after HTx other than retransplantation were included in our study. All data were retrospectively analyzed. The statistical analyses were performed with the Statistical Program of Social Sciences 22.0 (SPSS Inc, Chicago, Ill). Continuous variables are presented as median with interquartile ranges (IQRs). Approval for the study was obtained from the institutional review board. Graft age at time of cardiac surgery was calculated by donor age at time of HTx adding time between HTx and cardiac surgery.

Patients

Patient data were analyzed via preoperative (age, graft age, sex, HTx indication, indication for cardiac surgery, urgency, time between HTx, and cardiac surgery), intraoperative (type of intervention, surgical approach, and intraoperative complications), and postoperative (complications, length of postoperative stay, in-hospital mortality, need of retransplantation/percutaneous coronary angioplasty (PTCA), survival, and cause of death) data.

Routine transthoracic echocardiography was performed twice a year or whenever clinical symptoms were evident. CAV was monitored by coronary angiography via left heart catheterization at 1, 3, 5, 7, and 10 years posttransplant or when clinically indicated. If any intervention was carried out during angiographic procedure, angiography was repeated 6 months later.

At time of surgery, all patients but 2 received triple drug immunosuppression consisting of calcineurin inhibitor (cyclosporine [$n = 12$], tacrolimus [$n = 2$]) or target of rapamycin (mTOR) antagonist (sirolimus [$n = 1$]) in combination with antiproliferative drug (mycophenolate mofetil [$n = 6$], azathioprine [$n = 9$], and steroids [$n = 15$]). Two other patients were in a steroid-free immunosuppression combination of cyclosporine and azathioprine. All patients routinely received statins and acetylsalicylic acid therapy.

Five patients were transplanted in biatrial; 12, in bicaval transplantation technique. Demographic data are shown in Tables 1, 2, 3, and 4. Patients were stratified per the indication of cardiac surgery: valvular disease, CAV, and others as shown in Tables 2, 3, and 4.

RESULTS

Study Population

Seventeen (1.16%) of 1466 HTx patients, transplanted between March 1984 and October 2016 in the General Hospital Vienna, underwent nonretransplant cardiac surgery. Median age was 61 years (IQR, 52-66 years); 82.4% ($n = 14$) were male. Median time to surgery after HTx was 9.3 years (2.7-11.1 years); 3 patients (17.6%) underwent surgery during the first year after HTx. Indications for cardiac surgery were valvular disease ($n = 7$), CAV ($n = 6$), and infectious aortic pseudoaneurysm ($n = 1$), aortic dissection ($n = 1$), constrictive pericarditis ($n = 1$), and iatrogenic coronary artery dissection ($n = 1$).

Valvular Disease

Valvular disease was the most common indication for cardiac surgery after HTx in 41.2% ($n = 7$). Three cases comprised the

TABLE 1.

Patient characteristics

n (%)	17 (1.16)
Sex, n (%), m	14 (82.4)
Age, mean (IQR), y	60.9 (51.8-66.2)
Time to surgery, mean (IQR), y	9.3 (2.7-11.1)
Follow-up, mean (IQR), d	1477 (315.5-3181.5)
Valvular disease, n (%)	7 (41.2)
Tricuspid valve	3
Mitral valve	2
Aortic valve	2
CAV, n (%)	6 (35.3)
Other, n (%)	4 (23.5)
Infectious aortic pseudoaneurysm	1 (5.9)
Aortic dissection	1 (5.9)
Constrictive pericarditis	1 (5.9)
Iatrogenic coronary artery dissection	1 (5.9)
Return to theater (bleeding), n (%)	2 (11.8)
In-hospital mortality, n (%)	2 (11.8)
Sepsis	1 (5.9)
Bleeding	1 (5.9)
Need of retransplantation (CAV), n (%)	2 (11.8)
1-y survival	82.35%
Elective procedures, n (%)	12 (70.6)
Overall survival, mean (IQR), d	1583.5 (901.5-4319)
Emergency procedures, n (%)	5 (29.4)
Overall survival, mean (IQR), d	209 (36-1119.5)

m, men.

tricuspid valve; 2, the mitral valve; 2, the aortic valve. All patients had severe symptoms of valvular dysfunction refractory to medical treatment. At time of surgery, median recipient age and graft age were 65 years (51-75 years) and 52 years (43-68 years), respectively. Causes of valvular disease were degeneration ($n = 4$), annular distortion ($n = 2$), and endocarditis ($n = 1$). All but 1 of the patients were male (86%). Median time between HTx and surgery was 10.7 years (0.5-11.6 years). Five patients are still alive with a median follow-up of 2.5 years (2.5-4.6 years). Data for patients undergoing surgery because of valvular disease are shown in Tables 2, 3, and 4.

Tricuspid Valve

Three patients experienced severe TR. None of the TR was due to biopsy-induced iatrogenic lesions. Two patients were treated with an annuloplasty ring: One patient underwent surgery because of annular distortion (Physio Tricuspid ring, 30 mm) and a patent foramen ovale 1 month after HTx. The second patient received tricuspid reconstruction (Medtronic Contour 3D ring, 34 mm) because of ring dilation and intracardiac pacemaker wires blocking valve closure 11 years after HTx. Both are still alive with acceptable valvular function (TR grade 0-III-II). The third patient received urgent biological valve replacement because of endocarditis 6 month after the second retransplantation in 1991. The patient died because of CAV with good valvular function 4.8 years after the procedure.

Mitral Valve

One patient developed symptomatic degenerative mitral stenosis (MS) 10 years after HTx and was successfully

TABLE 2.**Valve surgery after HTx**

Pat.	Sex	Age, y	Graft age, y	Indication	Etiology	Intervention	Urgency	Access	Time to surgery, d	Follow-up, d	Alive
1	M	34	43	TR + PFO	Annular distortion	Repair (annuloplasty) + PFO closure	Elective	Standard	42	>1658	Yes
2	M	65	52	TR	Degenerative	Repair (annuloplasty)	Elective	Standard	3955	>905	Yes
3	M	51	43	TR	Endocarditis	Replacement (bio)	Urgent	Standard	183	1740	No
4	M	61	62	MS	Degenerative	Replacement (mech)	Elective	Standard	3867	>1477	Yes
5	W	66	20	MR	Annular distortion	Repair (annuloplasty)	Elective	Standard	237	>416	Yes
6	M	83	83	AS	Degenerative	Replacement (bio)	Elective	Transapical	8368	>898	Yes
7	M	75	68	AS	Degenerative	Replacement (bio)	Elective	Standard	4177	215	No

AS, aortic valve stenosis; bio, biological; M, man; mech, mechanical; Pat., patient; PFO, patent foramen ovale; W, woman.

operated with a mechanical valve (On-X valve, 25/33). In another patient, mitral regurgitation (MR) developed 4 months after HTx and was operated with an annuloplasty ring (Edwards Lifescience Annuloplasty ring, 28 mm) 6 months later. The pathology leading to MR was partial restricted leaflet motion (Carpentier Type 3b) at P3 segment most probably due to atypical scar tissue development at left atrial anastomosis site, close to the leaflet. Both patients are still alive with excellent valvular function.

Aortic Valve

Two patients developed degenerative aortic stenosis 11.6 and 23.2 years after HTx. The first patient received biological aortic valve replacement (AVR) (Medtronic Ultra, 27 mm) with a complicated postoperative course (rethoracotomy due to bleeding and cerebrovascular event). The patient died because of multiorgan failure (MOF) within the first year in another hospital. The second patient with a peak gradient of 94 mmHG underwent transapical TAVI (Edwards Sapien 3, 29 mm) after evaluation by the heart team of our institution. The patient is still alive with good valvular function 2.5 years after the procedure.

Cardiac Allograft Vasculopathy

Angiographically detected CAV with significant proximal coronary stenoses rather than diffuse vasculopathy was the reason for elective CABG in 5 patients. The decision for surgical approach was made in an interdisciplinary transplant expert team consisting of cardiologists and cardiac surgeons. Median patient age was 55 years (50-60 years) and median graft age was 39 years (30-48 years) at time of surgery. Eighty percent were male. Median time to surgery after transplantation was 10 years (6.3-11 years). None of the patients had any

previous coronary interventions. Four patients were operated via median sternotomy, one of them off pump. The last patient received a minimal invasive direct coronary artery bypass procedure via anterolateral thoracotomy. Left internal mammary artery (LIMA) was used in all; right internal mammary artery (RIMA), in 1 patient; saphenous vein grafts, in 3 patients. Median length of hospital stay was 12 days (IQR, 7-13 days). Three patients are still alive 11.7, 12.3, and 19.2 years after the procedure; 2 patients died 5.9 and 13.3 years after surgery because of heart failure as a result of progressing CAV. Two patients received further revascularization with drug-eluting stents (DES) due to progressing CAV 5 and 5.2 years after operation. Serial coronary angiograms performed after surgery showed 100% patency rate of the arterial grafts (5 LIMAs and 1 RIMA) up to 20 years after surgery whereas venous grafts (n = 4) were occluded in all but 1 patient within 5 years.

One patient underwent successful retransplantation because of progressing CAV 9 months after surgery. Data for patients undergoing CABG, including the patient with iatrogenic coronary artery dissection, are shown in Table 3.

In 2002, a 58-year-old patient received a biventricular assist device (BiVAD) (Thoratec BiVAD) because of fast-progressing CAV resulting in severe biventricular graft failure 6.1 years after HTx. After 3 months, the patient was retransplanted but died because of severe infection 4 months later.

Other Indications

Infectious aortic pseudoaneurysm (n = 1, 5.9%), aortic dissection (n = 1), iatrogenic coronary artery dissection (n = 1), and constrictive pericarditis (n = 1) were other indications for cardiac operation after HTx. Data are shown in Tables 3 (Pat 13) and 4.

TABLE 3.**Surgical revascularization after HTx**

Pat.	Sex	Age, y	Graft age, y	Lesion	Graft	Urgency	Access	Reintervention	Time to surgery, d	Follow-up, d	Alive
8	M	48	28	LAD, DG, CX, RCA	LIMA + RIMA + vein	Elective	Standard	No	4393	6920	Yes
9	W	59	39	LAD, CX	LIMA + vein	Elective	Standard	Re-HTx	3491	4228	Yes
10	M	55	53	LAD	LIMA	Elective	OPCAB	DES	3388	4410	Yes
11	M	51	43	LAD	LIMA	Elective	MIDCAB	No	1302	2135	No
12	M	60	30	LAD	LIMA	Elective	Standard	DES	3783	4795	No
13	W	62	52	LM	Vein	Urgent	Standard	No	1451	56	No

bio, M, man; CX, Circumflex artery; DG, diagonal branch; LAD, left anterior descendens; LM, left main stenosis; MIDCAB, minimal invasive direct coronary artery bypass; OPCAB, off pump coronary artery bypass; Pat., patient; RCA, right coronary artery; W, woman.

Patients 8-12, surgical revascularization due to CAV; patient 13, surgical revascularization due to iatrogenic LM-dissection.

TABLE 4.**Other cardiac surgery after HTx**

Pat.	Sex	Age, y	Graft age, y	Indication	Intervention	Urgency	Access	Time to surgery, d	Follow-up, d	Alive
14	M	61	58	Aortic pseudoaneurysm	Patch repair	Urgent	Standard	860	6	No
15	M	72	60	Aortic dissection	Gore-Tex tube graft	Urgent	Standard	6601	506	No
16	M	31	28	Constrictive Pericarditis	Pericardiectomy	Elective	Standard	1082	1531	No
17	M	58	54	Heart failure (CAV)	BIVAD	Urgent	Standard	2204	213	No

bio, M, man; Pat., patient.

Aortic dissection and infectious pseudoaneurysm were detected in computed tomography. In the patient with infectious aortic pseudoaneurysm and severe mediastinitis due to staphylococcus aureus, aortic repair with pericardial patch was performed. The patient died because of MOF after severe bleeding on day 6 after operation. The patient with aortic dissection received ascending aortic replacement (Vascutek Tubegraft, 30 mm). After an uneventful postoperative course, the patient died because of tumor progression of a colon carcinoma. Both patients were operated via circulatory arrest in deep hypothermia (18°C).

One patient developed left main stem (LM) dissection during a routine coronary angiography and received emergency double bypass surgery with 2 veins. Graft function recovered, but the patient died because of MOF 56 days after surgery.

In another patient, constrictive pericarditis was diagnosed in computed tomography and magnetic resonance imaging 3 years after HTx. The patient underwent extensive pericardiectomy and had an uneventful follow-up with good graft function. However, the patient died of severe pancreatitis 4.2 years after surgery.

Postoperative Outcome

Median follow-up of all patients was 1477 days (416–2135 days). Twelve patients were elective cases, and 5 (29.4%) were emergency procedures. Two patients (11.8%) received rethoracotomy because of bleeding; 4 patients (23.6%) developed acute perioperative kidney failure and received renal replacement therapy. One patient developed severe infection postoperatively. In-hospital mortality was 11.8% (n = 2) and affected emergency cases only. Two patients were retransplanted because of severe graft vasculopathy: 1 patient, 9 months after CABG, and another patient, 3 months after bridge to retransplant with a BiVAD. One-year survival of all patients was 82.4%. Eight patients (47.1%) are still alive at a median time of 1588 days (913–4325 days) after surgery. Elective cases had a 6-month, 1-year, and 3-year survival of 100%, 92%, 92%, respectively, whereas emergency procedures showed 60%, 40%, and 20% survival, respectively. Causes of death were graft failure due to progressive CAV (n = 3), MOF (n = 2), infection (n = 2), cancer (n = 1), and bleeding (n = 1).

DISCUSSION

This analysis reviews the experience of cardiac surgery after HTx in a high-volume center. The overall incidence of cardiac surgery was lower (1.2%) than in previous reports (Holmes et al,² 2.4%; Goerler et al,⁵ 5.5%) despite a longer follow-up in our analysis.^{2,5} However, distribution of procedures (CABG vs valves vs other) was similar between the reports, with 35% to 41% CABG procedures, 36% to 50% valve procedures, and 10% to 23% other procedures.^{2,5,14} Indications for surgery at our institution changed significantly

over time. Before 2005, 67% were CABG and 11% were valve procedures whereas 0% was CABG and 75% were valve operations after 2005. Within the valve procedure group, we observed a lower rate of tricuspid valve (3/7) surgery compared with Goerler et al's⁵ report (20/24) but similar numbers with Holmes et al's² (4/10) experience.

Because of the lack of guidelines, the decision if a patient should be operated is individual and the indication in all our patients was made by a multidisciplinary team of cardiac transplant specialists consisting of surgeons and cardiologists. A multidisciplinary team should exactly plan indication and preparation for and timing of surgery as patients can show existing morbidities in other organ system and are more prone to infection (overall immunosuppression) and wound-healing complications (corticosteroids, mTOR inhibitors) after transplantation.^{38,39} In our experience, no changes of immunosuppression were made before surgery. However, we would convert patients from mTOR-based therapy in elective surgery because of the risk of wound complications. Emergency procedures were associated with more complications and a higher early and late mortality. We assume that this finding was associated with the difficulty of optimal preparation for surgery. Nevertheless, these findings are not uncommon in this patient cohort and are comparable with others' experience.²

Valvular Disease

Indications for valvular surgery have been the same as indication for general cardiac surgery because there is a gap of evidence in transplanted patients. Urgent indications for valvular surgery are endocarditis or aortic insufficiency due to ascending aneurysm and dissection. All of them tend to have worse survival.⁵

Selection of an operative strategy, to treat valve pathologies after HTx, has been contradictory in literature. Most recommendations are based on small series of tricuspid valve surgery, and only case reports have been published on mitral and aortic valve surgery. Valve replacement has been used in 39% to 100% of the cases.^{5,7,40} Valve reconstruction has been associated with a higher risk of failure and consecutive need of valve replacement. However, new reconstructive surgical technologies (new annuloplasty rings, artificial chordae, and reconstructive techniques) have optimized outcome after reconstructive valve surgery in nontransplant patients. Nevertheless, they might be transferable into the transplant setting. In our opinion, reconstruction should be considered whenever possible, because it is not associated with lifelong anticoagulation (mechanical valve) or prosthesis degeneration (biological valve).

Median re sternotomy has been done in most surgical valve cases; however, minimally invasive access strategies might be considered in selected cases (hemisternotomy, right-sided thoracotomy).⁵

Tricuspid Valve

TR is the most common valvular heart disease after HTx.⁴⁰ Indication for surgery is present in symptomatic patients with severe TR due to primary valvular pathologies such as endocarditis, valve perforation, or rupture of chordae or flail leaflet combined with signs of right-sided heart failure refractory to medical treatment.⁴⁰ Risk-benefit ratio for operating on functional TR due to severe graft vasculopathy with reduced right ventricular function or combined with pulmonary hypertension is of uttermost importance. There exist several pathologies of TR that are typical for HTx patients: biopsy-induced injury of the chordae or leaflet, ischemic damage of papillary muscle, or structural distortion of atrial geometry due to implantation technique.^{4,7,41}

Incidence of severe TR with indication for surgery was significantly lower at our center compared with other centers (0.21% vs 1.7%-5.8%),⁵ and none of our patients showed biopsy-induced pathology. Since 1991, our center routinely performs 7 to 8 routine biopsies in the first year after HTx and thereafter only when clinically indicated. Our data suggest that lower numbers of biopsies might be associated with decreased risk of tricuspid damage. Another reason for lower incidence of TR could be due to switch from biatrial to bicaval transplantation technique in our center in 1995. This is in accordance with recent literature that has reported a higher rate of TR in biatrial implantation technique.⁴²⁻⁴⁴ Sun et al⁴³ showed a significant higher rate of TR in patients with biatrial technique, and Goerler et al⁵ reported that all but 1 case with tricuspid surgery occurred in patients transplanted in biatrial technique.

Most tricuspid valve pathologies (annular dilation or distortion, leaflet prolapse or chordae rupture, biopsy-induced injuries) besides severe destruction of the valve due to endocarditis or trauma can be repaired via advanced reconstructive strategies.⁴⁵ In case of valve replacement, biological valves might be considered first because, in case of mechanical replacement, right-sided biopsy is inaccessible.

Mitral Valve

Annular dilation as consequence of CAV and ventricular dysfunction late after HTx as described by Cavero et al⁴⁶ and myxomatous degeneration of the leaflets may be causes for MR in HTx patients.^{19,46,47} However, MS might be associated with hyperparathyroidism in HTx patients who become dialysis dependent.⁴⁸ There only exist case reports about mitral valve surgery due to MR after HTx. In most cases, cause of MR was not clearly defined. In our case, MR, showed up early after HTx most likely because of excessive scar tissue at the left atrial anastomosis, leading to restrictive motion of 1 leaflet. Until now, there has not been a report of MS after HTx in literature. Our patient with MS had been dialysis dependent because of chronic calcineurin inhibitor toxicity for 2 years before MS was diagnosed. Mitral valve replacement with a mechanical valve was performed, as accelerated calcification of a bioprosthesis was feared. Nevertheless, publications on valve replacement in dialysis-dependent patients show no clear benefit of either bioprosthesis or mechanical prosthesis.⁴⁹

New developments in interventional techniques treating MR have been published recently.²⁵ Ferraro et al²⁵ published the case of a successfully implanted MitraClip in a 72-year-old

HTx recipient with significant MR and clinical improvement after 3 months follow-up, confirmed in transesophageal echocardiography. However, the authors point out that difficulties due to the special atrial and atrioventricular anatomy after HTx may arise in these patients. In our opinion, MitraClip should only be used in patients that have a high risk for conventional surgery and an appropriate valvular pathology.

Aortic Valve

Indications for AVR in HTx patients might be severe degenerative aortic stenosis,¹⁷ aortic regurgitation in aortic aneurysm, and endocarditis.² According to case reports, AVR after HTx seems to be safe in selected patients.^{17,40,50,51} There are no long-term data on biological versus mechanical valves and on aortic valve repair after HTx so far.

In high-risk patients with symptomatic severe aortic valve stenosis, TAVI might be indicated. Case reports on TAVI performed in HTx recipients, transfemoral and transapical, show good perioperative and short-term outcome with improvement in quality of life. Our experience with transapical TAVI is in accordance with the previously mentioned case reports. However, long-term data are needed.²⁰⁻²⁴

CAV

In recent years, incidence of severe CAV has declined compared with the early phase of HTx. Moreover, survival with developed CAV has improved.³⁵ Nevertheless, CAV is still a major complication leading to significant increase of morbidity and mortality.³⁵ CABG can be successful in type A lesions (Stanford Classification) but has limited efficacy in diffuse distal artery disease (type B/C lesions).²⁷ Unfortunately, in most cases, CAV presents as a diffuse and progressive disease. Moreover, CAV might progress after surgery, and patients might need reinterventions at a later stage.²⁸ In fact, 3 (60%) of 5 patients after CABG procedures, in our cohort, needed reintervention (2 PTCA, 1 re-HTx) after surgery due to progression of CAV.

In non-HTx patients and in earlier reports in HTx patients, arterial grafts have been preferentially used because of their better long-term patency compared with vein grafts.⁵² Follow-up coronary angiograms revealed that venous grafts (n = 4) were occluded in all but 1 of our patients within 5 years whereas mammary arteries showed 100% patency rate up to 20 years after surgery. However, CABG surgery before transplantation can affect the selection of grafts in many patients. Mammary arteries and saphenous veins might have already been used before transplantation. Alternative concepts using radial artery grafts have not been reported until now.⁵³

Because of the lack of long-term benefits of CABG in our patient cohort, we have not performed surgical revascularization since 2005. Comparison of PTCA + stent versus conservative treatment in CAV with vessels with less than 70% stenosis showed significant better midterm outcome in the interventional group at our institution.⁵⁴ Therefore, coronary interventions with DES and dual antiplatelet therapy have been our first-line treatments in CAV over the past 12 years.

In severe heart failure, because of diffuse CAV not amenable for revascularization, retransplantation might be indicated because of poor prognosis of these patients.³⁰ One of our patients needed retransplantation because of progressive CAV 9 months after CABG (LIMA ad left anterior descendens, vein ad

circumflex artery). However, retransplantation remains an ethical question with worldwide organ shortness. Mechanical circulatory support as destination therapy could be a potential alternative strategy in the future. In our opinion, only patients without comorbidities should be considered for either retransplantation or mechanical bridge to retransplantation.

Limitations of the Study

The main limitations of this analysis are small patient number, retrospective nature, and no control groups with medical treatment in each category. No conclusion concerning selection criteria for surgery, risk factors for death after surgery, and long-term outcome can be drawn from this analysis. However, our experience for more than 30-year period gives a good overview on occurring cardiac problems that might affect HTx patients and can be treated via surgery.

CONCLUSIONS

In our patient cohort, the overall incidence of cardiac surgery after HTx was low. In comparison with other studies, we had a lower rate of tricuspid valve and CABG surgery. Per our results, cardiac surgery other than retransplantation after HTx is associated with low perioperative mortality and good long-term survival in selected elective patients. Emergency procedures had high in-hospital mortality. There is a strong need to collect data on cardiac surgery after HTx in a multicenter approach to evaluate strategies in a bigger collective.

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