

Outcomes in patients with solid organ transplants undergoing cardiac surgery



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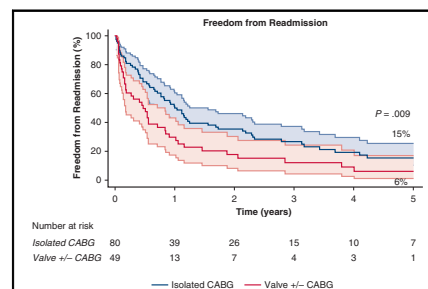
ABSTRACT

Objective: Long-term outcomes after cardiac surgery in solid organ transplant recipients are limited in the contemporary literature. The objective of this study is to evaluate postoperative outcomes in these patients, including variables associated with mortality and readmissions.

Methods: All adults undergoing isolated coronary artery bypass grafting, isolated valve, or coronary artery bypass grafting + valve cardiac surgical procedures from 2011 to 2018 were included in this study. Patients with solid organ transplants undergoing cardiac surgery were studied. Primary outcomes included operative (30-day) and 5-year mortality.

Results: A total of 11,190 patients underwent isolated coronary artery bypass grafting, isolated valve, or coronary artery bypass grafting + valve operations at our institution from 2011 to 2018. Of these, 129 patients (1%) had solid organ transplants and underwent isolated coronary artery bypass grafting (n = 84), isolated valve (n = 30), or coronary artery bypass grafting + valve (n = 15). Type of organ transplant included 84 patients (65%) with kidney, 27 patients (21%) with liver, 9 patients (7%) with heart, and 9 patients (7%) with lung transplants. The median Society of Thoracic Surgeons Predicted Risk Of Mortality for the cohort was 2.73 (Q1-Q3: 1.67-6.33). Three patients (2%) had an operative (30-day) mortality. Significant variables associated with 5-year mortality on multivariable Cox regression analysis included chronic obstructive pulmonary disease (hazard ratio, 2.44; 1.01-5.90; $P = .048$) and congestive heart failure (hazard ratio, 4.45; 1.81-10.9; $P = .001$). Significant variables associated with 5-year readmissions included chronic obstructive pulmonary disease, dialysis dependence, and concomitant valve surgery with coronary artery bypass grafting. Five-year readmission rate was 88%, and patients with valve operations (\pm coronary artery bypass grafting) had significantly lower ($P = .009$) freedom from readmission (6%).

Conclusions: Cardiac surgery can be performed with low operative mortality and good long-term survival in patients with solid organ transplants. Five-year hospital readmissions are common, with significantly more readmissions in patients who had valve procedures. (*J Thorac Cardiovasc Surg* 2020;160:701-7)



Freedom from hospital readmission in organ transplant recipients postcardiac surgery.

Central Message

Cardiac surgery can be performed with acceptable operative and long-term mortality in patients with prior solid organ transplants, although with a higher rate of unplanned readmissions.

Perspective

Cardiac surgery can be performed safely and effectively with low operative mortality and reasonable long-term survival in patients with solid organ transplants. Rates of unplanned 5-year readmission are high, and patients who undergo valve operations have significantly lower freedom from readmission.

See Commentaries on pages 708 and 710.

Over the past 2 decades, surgical and medical advancements in transplantation have led to successful solid organ transplants in patients of increasing age.¹ Moreover,

advancements in perioperative management and immunosuppression have led to an increase in long-term survival in transplant recipients. With this success has come an aging population of patients with prior transplants who have a heightened propensity for cardiac comorbidities, including coronary artery disease (CAD).² Both renal and liver transplant recipients are predisposed to high rates of cardiac disease. Orthotopic liver transplant recipients have been shown to have an approximately 3-fold increased rate of cardiac ischemic events and cardiovascular death, with more than 70% of patients having cardiovascular complications that affect long-term survival.^{3,4} Likewise, the majority of

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Abbreviations and Acronyms

AV	= aortic valve
AVR	= aortic valve replacement
CABG	= coronary artery bypass grafting
CAD	= coronary artery disease
COPD	= chronic obstructive pulmonary disease
HR	= hazard ratio
MV	= mitral valve
PCI	= percutaneous coronary intervention
STS-PROM	= Society of Thoracic Surgeons Predicted Risk of Mortality
UPMC	= University of Pittsburgh Medical Center

renal transplant recipients have cardiovascular disease, and approximately 50% of deaths after transplant are a result of cardiovascular etiologies.^{5,6}

Several single-center studies with limited sample size and length of outcomes have reported higher operative mortality for patients who underwent cardiac operations with a history of solid organ transplant.^{1,7-10} An analysis of large national inpatient sample data corroborates these findings of higher operative risk for the transplant population undergoing heart surgery, with transplant recipients being at increased risk for postoperative renal failure and blood transfusions.¹¹

Our institution has made historic contributions in the field of solid organ transplant and continues to be a leader in the field of solid organ transplantation with several thousand transplants since the 1980s.¹ We present one of the largest single-center studies on patients with solid organ transplants who underwent cardiac surgery. The primary aim of this study is to provide postoperative and long-term outcomes for survival and readmission in this high-risk patient population.

MATERIALS AND METHODS

Study Population

The institutional Society of Thoracic Surgeons (STS) database revealed 11,190 cardiac surgical procedures performed at the University of Pittsburgh Medical Center (UPMC) from 2011 to 2018, from which 129 patients were identified to have had a prior solid organ transplant. The 7 index operations included isolated coronary artery bypass grafting (CABG), isolated aortic valve replacement (AVR), isolated mitral valve (MV) replacement, isolated MV repair, CABG + AVR, CABG + MV replacement, and CABG + MV repair. Elective, urgent, and emergency cases were included. Patients who had prior solid organ transplants at outside centers and then presented to UPMC for cardiac surgery and patients who underwent any concomitant valve operation (valve repair or replacement) were included. Preoperative criteria for deeming a patient an acceptable candidate for cardiac surgery included thorough evaluation by a multidisciplinary team, including transplant medicine, cardiology, and cardiac surgery. Patients' current rejection status and

immunosuppression regimen were taken into consideration during preoperative evaluation. All patients in this series were selected for surgery following standard indications for percutaneous coronary intervention (PCI) and transcatheter aortic valve replacement, at which time it was decided that catheter-based therapies were not indicated. Perioperative data and long-term outcomes up to 5 years were retrospectively gathered from a prospectively maintained cardiac surgical database. The institutional review board approved use and analysis of the database.

Data Analysis

The primary outcomes were all-cause 30-day and 5-year survival. Secondary outcomes included operative morbidity and readmissions at 5 years. Descriptive statistics are recorded as mean \pm standard deviation for continuous variables and percentage (frequency) for categorical variables. Kaplan-Meier curves for 5-year overall survival and 5-year readmissions were generated and compared using the log-rank test. All-cause mortality was obtained from a review of the medical records using the clinical data warehouse at UPMC for all patients who died during and after index hospitalization or during readmissions. Physical chart review, phone calls, and Social Security Death Index were used to doubly verify and supplement from that information. All unplanned inpatient readmissions were captured because these data are collected for all postoperative patients presenting to our healthcare system, which includes 40 hospitals with a total of approximately 8000 inpatient hospital beds. Less than 2% of variables were missing, but this was supplemented by detailed chart review because of the small nature of the cohort.

Risk adjustment was performed using separate multivariable Cox proportional hazard regression models to evaluate the impact of baseline characteristics and comorbidities on 5-year mortality and hospital readmissions. We also applied the Total Time-Restricted model to identify the risk factors for readmission,^{12,13} which is an extension of the Cox proportional hazards model and is ideal for analyzing multiple events data. Univariate analysis was performed to identify significant associations with 5-year survival. Multivariable analysis was performed.¹⁴ Multivariable proportional hazard Cox regression model was used with censoring follow-up at the different landmark times. Proportional hazard assumption was tested using methodology developed by Grambsch and Therneau,¹⁵ and the proportional hazard was met.¹⁶ Variables that were evaluated in univariable analysis for potential inclusion in the multivariable model included patient demographics (age, sex, race, height, weight, body mass index, body surface area), presentation acuity variables (cardiogenic shock, New York Heart Association class, operative urgency), comorbidities (liver disease, sleep apnea, pneumonia, cerebrovascular disease, diabetes, hypertension, hyperlipidemia, smoking, chronic obstructive pulmonary disease, alcohol use, dialysis-dependence, kidney failure, immunosuppression, intravenous drug use, family history of coronary disease, peripheral arterial disease, endocarditis, mediastinal radiation, congestive heart failure, arrhythmia, prior myocardial infarction, and CAD), laboratory data (creatinine, albumin, bilirubin, white blood cell count, hemoglobin, platelet count), hemodynamic parameters (ejection fraction, left ventricular dimensions, mitral, tricuspid, or aortic valvular insufficiency or stenosis), and operative variables (operative approach, number of prior open operations, concomitant procedures). All statistical analyses were performed with STATA statistical software (StataCorp LLC, College Station, Tex).

RESULTS

Baseline Characteristics

The total population consisted of 11,190 STS index cardiac surgical procedures, of which 129 patients were identified with a history of solid organ transplant who underwent isolated CABG (n = 84), isolated valve

(n = 30), or CABG + valve (n = 15). Type of organ transplant included 84 patients (65%) with kidney transplant, 27 patients (21%) with liver transplants, 9 patients (7%) with heart transplants, and 9 patients (7%) with lung transplants (Table 1). The mean age of the patients was 60 ± 10.4 years, and the majority were white (82%) and male (74%) with a mean body mass index of 28.8 ± 5.6 kg/m². The majority of patients had baseline hypertension (95%), diabetes mellitus (62%), and dyslipidemia (80%). Other significant comorbidities included chronic obstructive pulmonary disease (COPD) (21%), smoking history (28%), dialysis dependence (40%), peripheral artery disease (31%), cerebrovascular disease (22%), and congestive heart failure (33%). Forty-seven (52%) of the patients with renal transplants had preoperative dialysis requirements compared with only 4 nonrenal transplant recipients (11%) (*P* < .0001). Ninety-nine patients (77%) were on immunosuppression medication at the time of surgery. Nine patients (7%) had prior cardiac surgery, 32 patients (25%) had previous PCI, and 56 patients (43%) had previous myocardial infarction. The 9 previous cardiac surgeries were performed in the 9 patients (7%) with heart transplants. The mean left ventricular ejection fraction and pulmonary artery systolic pressure for the patient cohort were 54% ± 11.2% and 42 ± 16.5 mm Hg, respectively. Three patients (2%) required preoperative intra-aortic balloon pump placement.

Operative Characteristics

The majority of patients underwent isolated CABG (n = 84, 65%) (Table 2). Other operations included isolated AVR (n = 20, 16%), isolated MV replacement (n = 2, 2%), MV repair (n = 8, 6%), CABG + AVR (n = 10, 8%), CABG + MV repair (n = 3, 2%), and CABG + MV repair (n = 2, 2%). Operative status included 55 patients (43%) who underwent elective operations, 71 patients (55%) who had urgent operations, and 3 patients (2%) who had emergency operations. The median STS PROM for the total transplant cohort was 2.73 (Q1-Q3: 1.67-6.33). Cardiopulmonary bypass time and ischemic time were 120 ± 43.8 minutes and 85.5 ± 34.4 minutes, respectively.

Operative Mortality and Morbidity

Three patients (2%) had an operative (30-day) mortality (Table 3). The majority (58%) of patients required at least 1 postoperative packed red blood cell transfusion, and 12 patients (9%) returned to the operating room for bleeding. Prolonged ventilator support (>24 hours) was observed in 19 patients (15%), and 8 patients (6%) developed postoperative pneumonia. There was no difference in prolonged ventilatory requirements between lung transplant recipients and nonrecipients. Two patients (2%) had postoperative sepsis, although there were no deep sternal wound infections (0%). Two patients (2%) had stroke with permanent deficits. New-onset atrial fibrillation occurred in 40 patients

TABLE 1. Baseline characteristics of solid organ transplant recipients undergoing cardiac surgery

Variable	n = 129
Age, mean ± SD	60.0 ± 10.4
Female, n (%)	33 (26%)
White race	106 (82%)
BMI (kg/m ²), mean ± SD	28.8 ± 5.6
Dyslipidemia, n (%)	103 (80%)
Diabetes mellitus	80 (62%)
Hypertension	123 (95%)
COPD	27 (21%)
Smoker	21 (28%)
Dialysis dependence	51 (40%)
Immunosuppression	99 (77%)
Peripheral arterial disease	40 (31%)
Cerebrovascular disease	29 (22%)
Previous PCI	32 (25%)
Previous cardiac surgery	9 (7%)
Family history of CAD	30 (23%)
Previous MI	56 (43%)
Congestive heart failure	42 (33%)
Left ventricular ejection fraction (mean % ± SD)	54% ± 11.2
Pulmonary artery systolic pressure (mm Hg), mean ± SD	42 ± 16.5
Preoperative intra-aortic balloon pump, n (%)	3 (2%)
Type of transplant	
Kidney, n (%)	84 (65%)
Liver	27 (21%)
Heart	9 (7%)
Lung	9 (7%)

SD, Standard deviation; BMI, body mass index; COPD, chronic obstructive pulmonary disease; PCI, percutaneous coronary intervention; CAD, coronary artery disease; MI, myocardial infarction.

(31%), and no patients required permanent pacemakers. Acute kidney injury occurred in 13 patients (10%), 5 (4%) of whom required dialysis. The total intensive care unit length of stay was a median of 2 days (interquartile range, 1-4), and hospital length of stay was 10 days (interquartile range, 7-15). The most common cause of cardiac (71%) and overall readmission was congestive heart failure (28%) (Table 4). Kaplan–Meier survival estimate revealed a 5-year survival of 75% (Figure 1). For the total patient cohort with solid organ transplants, the majority (88%) of patients had hospital readmissions over the follow-up period (Figure 2). Freedom from unplanned readmission at 5 years was significantly lower for patients who underwent valve (± CABG) operations (6%) compared with patients who underwent isolated CABG (15%) (*P* = .009) (Figure 3).

TABLE 2. Operative characteristics of solid organ transplant recipients undergoing cardiac surgery

Variable	n = 129
Operation type	
Isolated CABG, n (%)	84 (65%)
AVR	20 (16%)
CABG AVR	10 (8%)
MV repair	8 (6%)
MV repair CABG	3 (2%)
MV replacement	2 (2%)
MV replacement CABG	2 (2%)
Operative times	
CPB time (min) ± SD	120 ± 43.8
Ischemic time (min)	85.5 ± 34.4
Status	
Elective, n (%)	55 (43%)
Urgent	71 (55%)
Emergency	3 (2%)
STS PROM%, mean ± SD	5.0 ± 6.1
STS PROM%, Median (IQR)	2.73 (1.67, 6.33)

CABG, Coronary artery bypass grafting; AVR, aortic valve replacement; MV, mitral valve; CPB, cardiopulmonary bypass; SD, standard deviation; STS PROM, Society of Thoracic Surgeons Predicted Risk of Mortality; IQR, interquartile range.

Multivariable Analysis for 5-Year Mortality and Readmission

Significant variables associated with 5-year mortality on multivariable Cox regression analysis included COPD (hazard ratio [HR], 2.44; 1.01-5.90; $P = .048$) and congestive heart failure (HR, 4.45; 1.81-10.9; $P = .001$) (Table 5). Peripheral vascular disease (HR, 2.19; 0.97-4.93; $P = .059$) demonstrated a trend toward being associated with 5-year mortality, although this was not statistically significant. With the use of the Total Time-Restricted model for repeat readmissions (Table 6), COPD, dialysis dependence, and

TABLE 3. Postoperative outcomes of solid organ transplant recipients undergoing cardiac surgery

Variable	n = 129
30-d mortality, n (%)	3 (2%)
Blood product transfusion	75 (58%)
Prolonged ventilation >24 h	19 (15%)
Deep sternal wound infection	0 (0%)
Sepsis	2 (2%)
Pneumonia	8 (6%)
Permanent stroke	2 (2%)
Reoperation for bleeding	12 (9%)
New-onset atrial fibrillation	40 (31%)
Acute kidney injury	13 (10%)
Acute kidney injury requiring dialysis	5 (4%)
New onset pacemaker	0 (0%)

TABLE 4. Hospital readmissions for solid organ transplant recipients undergoing cardiac surgery

Cardiac (N = 58)	
CHF	41 (28%)
Arrhythmia	9 (6%)
Endocarditis	2 (1%)
Other*	6 (6%)
Noncardiac (N = 86)	
GI	17 (12%)
Stroke	4 (3%)
CNS	7 (5%)
Infectious	10 (7%)
PAD	2 (1%)
Orthopedic	6 (4%)
Renal failure	27 (19%)
Anemia	5 (3%)
Other	8 (6%)

CHF, Congestive heart failure; GI, gastrointestinal; CNS, central nervous system; PAD, peripheral arterial disease. *Cardiac other includes chest pain and coronary reintervention.

valve ± CABG were found to be associated with repeat hospital readmission. The type of organ transplant was not significantly associated with mortality or readmission on univariate or multivariable analysis.

DISCUSSION

Transplant recipients undergoing cardiac surgery constitute a small but important cohort of patients because of the scrutiny they face by accrediting organizations. In one of the largest single-center studies to date for patients undergoing cardiac surgery who received solid organ transplants, we present a detailed analysis of postoperative outcomes and risk factors for both long-term mortality and readmission. We found that heart surgery can be performed safely and effectively in the transplant population, although the majority of these patients will have unplanned hospital readmissions within 5 years. Our operative mortality (2%) was significantly less than the STS PROM mean of 5% and comparatively low relative to prior literature, which reports a range from 0% to 14%.^{1,7-9,17-22}

In addition to low short-term mortality, the long-term survival (75%) in our current study was acceptable at 5 years. However, our data show that 88% of transplant recipients who undergo cardiac surgery will be readmitted within 5 years. A significant proportion of 5-year readmissions was for cardiac etiologies, including a large percentage of patients who returned for a heart failure diagnosis. This is different than what we have reported in nontransplant recipients undergoing cardiac surgery.^{23,24} Moreover, the risk of long-term readmission was dependent on the type of cardiac surgery that the patient underwent. The percentage of patients (6%) with freedom from readmission at 5 years who had valve (± CABG) operations was significantly worse in comparison with freedom from readmission in

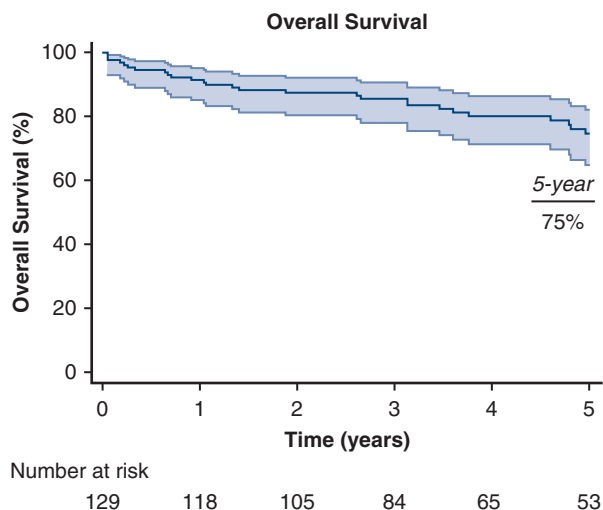


FIGURE 1. Overall survival of solid organ transplant recipients undergoing cardiac surgery. The total cohort had good survival at 75% on 5-year follow-up.

patients who had isolated CABG (15%). Variables associated with elevated risk of 5-year readmission estimates on multivariable Cox regression analysis included aortic valve replacement and MV repair. Elevated body mass index was associated with a lower likelihood of 5-year mortality, which may be reflective of select patients with better general health in the transplant population, who are prone to poor nutrition and a lower body mass index than seen in the nontransplant cohort.²⁵ Variables associated with increased 5-year mortality estimates included COPD and congestive heart failure. Likewise, the most common cause of long-term cardiac readmissions was heart failure.

The general population of solid organ transplant recipients requires close follow-up and supervision by a number of

medical professionals, which can result in planned readmissions for additional necessary procedures, including biopsy. Because of a heightened awareness for increased use of hospital resources during readmission, efforts have been made to limit readmission for Endoscopic Retrograde Cholangiopancreatography/biopsy by having liver transplant recipients undergo same-day procedures or by being placed in observation status after procedures.²⁶ In the current study, we have captured long-term unplanned hospital readmissions in transplant recipients who underwent cardiac surgery, which was higher than we anticipated. A history of heart disease has been shown to be independently associated with early hospital readmission in kidney transplant recipients.²⁷ Moreover, fluid overload has been identified as a factor contributing to cardiovascular disease after renal transplant,⁶ and right ventricular failure has been associated with liver transplantation.²⁸ This may at least partially explain the increased rate of readmissions for cardiac etiologies, including congestive heart failure, in our current study.

Solid organ transplant recipients assume a higher operative risk because of associated baseline comorbidities. The effects of immunosuppression can predispose transplant recipients to infection,^{11,29} impaired wound healing, and nephrotoxicity.³⁰⁻³² Postoperative renal failure is common in transplant recipients who undergo cardiac operations, has been identified as an independent predictor of in-hospital mortality,¹¹ and is associated with long-term allograft failure.³³ Low perioperative perfusion pressures are avoided to ensure minimal risk of acute tubular necrosis in this susceptible patient population. In addition, because patients with chronic kidney disease or on dialysis tend to calcify their valves at a rate that is faster than the average population, mechanical prostheses are recommended unless contraindicated. In the current study, renal impairment was the most common cause of noncardiac long-term readmission, and both dialysis dependence and elevated creatinine were associated with 5-year readmissions on univariate analysis. Dialysis dependence alone has been shown to be an independent predictor of mortality in patients undergoing CABG.³⁴⁻³⁶ Transplant recipients are also prone to anemia, and post-transplant anemia is a predictor of cardiovascular morbidity and mortality in patients who undergo kidney transplants.³⁷ Potential explanations include iron deficiency, acute rejection, and inflammation. Large national inpatient sample data have shown that patients with a history of solid organ transplant who underwent cardiac surgery are more likely to require blood transfusions.¹¹ In our study, the proportion of patients requiring blood transfusions (58%) was significantly higher than in our reported overall cohort, and 12 patients (9%) returned to the operating room for postoperative bleeding.³⁸ Moreover, the need for intraoperative blood transfusion has been identified as a risk factor for both early and overall mortality in this patient population.³⁹

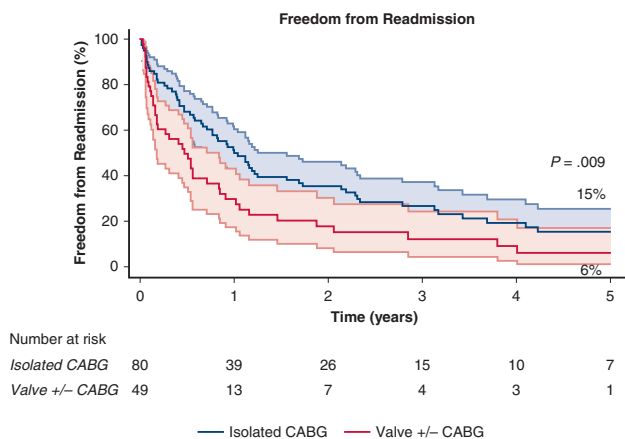


FIGURE 2. All-cause freedom from readmission for solid organ transplant recipients undergoing cardiac surgery. The majority ($\geq 85\%$) of the total transplant cohort was readmitted within 5 years after cardiac surgery. Freedom from readmission was significantly worse for patients who had CABG + valve procedures.

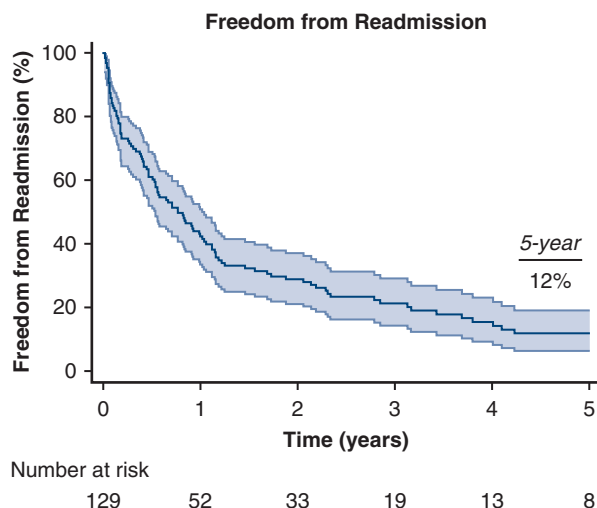


FIGURE 3. Freedom from hospital readmission in organ transplant recipients postcardiac surgery.

Despite the numerous factors that heighten the operative risk of patients with prior transplants, we have demonstrated that cardiac surgery can still be performed with low operative mortality (2%) and good 5-year survival (75%). Yet, the rate of readmission at 5 years (88%) for this high-risk patient population is higher than we would expect from the general cardiac surgery population, with prior series having less than 50% of patients readmitted at 5 years.²³ It is our practice to have transplant recipients who may require cardiac surgery to be thoroughly vetted by a physician team that takes into consideration both the status of the patient's health regarding their solid organ transplant and the potential risks versus benefits of undergoing cardiac surgery. Because of the potential operative risks, all efforts are made to perform catheter-based/nonsurgical therapies such as PCI or transcatheter aortic valve replacement before considering operative intervention. If contraindications to catheter-based therapies exist, then a thorough risk assessment by the multidisciplinary team determines the patient's potential operative candidacy. Careful preoperative assessment and close postoperative follow-up by a multidisciplinary team, including cardiac and transplant surgeons, cardiologists, and transplant physicians, are essential to improving long-term cardiac surgery outcomes for patients with solid organ transplants.

Study Limitations

This study is limited by the typical constraints of retrospective study design, including selection bias. The patient data set comes from a mixed population with numerous operative procedures and types of prior organ transplants; given this, we acknowledge the potential for confounding factors. Multivariable analysis was performed to overcome some of the variability in baseline patient risk. A percentage

TABLE 5. Cox regression analysis: Variables associated with 5-year mortality estimates

Variable	HR (95% CI)	P value
White	2.19 (0.46-10.47)	.328
BMI	0.90 (0.83-0.99)	.025
Recent smoking history	1.36 (0.53-3.48)	.521
COPD	2.44 (1.01-5.90)	.048
Creatinine	0.90 (0.75-1.09)	.287
Ejection fraction	0.99 (0.95-1.02)	.395
Elective status	1.56 (0.61-4.02)	.354
Congestive heart failure	4.45 (1.81-10.87)	.001
Peripheral vascular disease	2.19 (0.97-4.93)	.059
Redo operation	1.40 (0.40-4.90)	.594

HR, Hazard ratio; CI, confidence interval; BMI, body mass index; COPD, chronic obstructive pulmonary disease.

of the patient data on prior transplantations was limited by what could be gathered from outside records because some were performed at outside centers and then the patients presented for the cardiac surgery to the University of Pittsburgh. Our hospital system has numerous locations within the state of Pennsylvania with an extremely high likelihood for capture of readmissions, but there was the possibility that some patients were lost to follow-up and readmitted at outside centers. Despite the available resources, we believe that it is impossible to capture all readmission data in our hospital system and a small percentage of the readmission data may be unknown to us. Another study limitation is that the initial number of all-comers with solid organ transplants and cardiac disease, from which some patients were excluded from surgical candidacy for prohibitive risk, is unknown. The decision to exclude patients from cardiac surgery was both patient and surgeon specific.

CONCLUSIONS

In the current largest single-center study with both long-term survival and readmission outcomes, our results demonstrate that cardiac surgery can be performed safely

TABLE 6. Significant variables associated with repeat hospital readmissions identified by the Total Time-Restricted model

Variables	HR (95% CI)	P value
COPD	1.55 (1.082-2.221)	.02
Dialysis	1.94 (1.221-3.097)	.007
Operation type		
Isolated CAB	ref (ref)	ref
Valve ± CABG	1.68 (1.161-2.253)	.004
Heart failure	2.79 (0.948-1.946)	.09
Creatinine (increasing)	0.99 (0.939-1.049)	.99

HR, Hazard ratio; CI, confidence interval; COPD, chronic obstructive pulmonary disease; CAB, coronary artery bypass; CABG, coronary artery bypass grafting.

and effectively with low operative mortality and good long-term survival in patients with solid organ transplants. Rates of 5-year readmission are high in this patient population, and patients who undergo valve operations have significantly worse freedom from readmission. Close follow-up with a multidisciplinary team is necessary to mitigate the long-term effects of associated comorbidities in transplant recipients.

Conflict of Interest Statement

Authors have nothing to disclose with regard to commercial support.

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