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Outcome and determinants of prognosis in patients undergoing isolated tricuspid valve surgery: Retrospective single center analysis

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ABSTRACT

Aims: Although tricuspid valve (TV) surgery has become more popular, isolated TV surgery is infrequently performed. The aims of this study were (1) to evaluate the postoperative and long-term mortality of patients undergoing isolated TV surgery, (2) to compare the outcomes of patients undergoing their first TV surgery or TV reoperation, and (3) to assess the additive value of echocardiographic and invasive hemodynamic evaluations for predicting postoperative outcome.
Methods: We followed a contemporary cohort of patients undergoing isolated TV surgery from January 1, 1995, through December 31, 2011. Preoperative demographic, echocardiographic, hemodynamic, and operative data were included. Outcome was all-cause mortality.
Results: Ninety-two patients (38% male; mean age: 56 ± 14 years) were included. Kaplan-Meier survival analyses showed that 30-day, 3-month, 5-year, and 10-year mortality were 7.9%, 15.2%, 25.7%, and 53.7%, respectively. No difference in outcome was found between patients undergoing first TV surgery ($n = 61$) and TV reoperation ($n = 31$) ($p = 0.669$). Univariable Cox analysis identified age ($p < 0.0001$), extracardiac vascular disease ($p = 0.001$), glomerular filtration rate ($p = 0.022$), NYHA classification ($p = 0.010$), and mean pulmonary artery pressure ($p = 0.005$) as predictors of mortality. Multivariable analysis identified significant associations with outcome, only for age ($p = 0.010$) and NYHA functional class ($p = 0.044$). In younger patients (<59 years), mean pulmonary artery pressure was associated with the worse outcome ($p = 0.024$).
Conclusions: Isolated TV surgery is still associated with important postoperative and long-term mortality, both for first TV surgery and TV reoperation. Pre-operative NYHA functional class and, in younger patients, pulmonary hypertension appear to determine prognosis.

1. Introduction

In recent years, interventions involving the tricuspid valve (TV) have become increasingly popular. European Society of Cardiology guidelines have recently been updated and now advocate a more liberal approach towards TV surgery, especially in combination with operations on left-sided valves [1]. On the other hand, AHA/ACC guidelines are largely silent on tricuspid valve surgery [2]. However, a registry describing hospital admissions for TV surgery in the United States showed that the number of tricuspid procedures more than doubled from 1999 to 2008 [3].

TV disease affects morbidity and mortality as well as functional capacity in different types of heart disease [4–10]. The great majority of TV interventions are performed due to tricuspid regurgitation, most often secondary to left-sided valvular disease. Although a low threshold to perform TV surgery in conjunction with mitral valve surgery is currently advocated, isolated TV surgery is still infrequently performed [3]. ESC guidelines advise isolated TV intervention if patients are symptomatic and tricuspid regurgitation is severe. TV surgery can be considered if tricuspid regurgitation is severe and signs of right ventricular dilatation or dysfunction are present [1]. However, if tricuspid regurgitation is severe and surgery is postponed, right ventricular failure can develop, increasing morbidity and mortality dramatically [11,12].

Determining when to perform isolated TV surgery remains difficult. Registries and small studies have shown that isolated TV surgery is still associated with significant perioperative morbidity and mortality, especially when compared to left-sided valve surgery [13–17]. However, studies on the postoperative and long-term outcomes of isolated TV surgery are scarce and often include patient cohorts operated decades ago, making application to present-day patient care difficult.

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Therefore, the aims of the present study were (1) to evaluate the postoperative and long-term mortality of patients undergoing isolated TV surgery, (2) to compare the outcomes of patients undergoing first TV surgery or TV reoperation, and (3) to assess the additive value of pre-operative echocardiographic and invasive hemodynamic evaluations for predicting outcome after surgery.

2. Methods

2.1. Population and Data Collection

We followed a contemporary cohort of consecutive patients undergoing isolated TV surgery at the University Hospitals Leuven in Leuven, Belgium between January 1, 1995, and December 31, 2011. Data were collected at the time of surgery and stored in the database of cardiac surgery. A search from the database of cardiac surgery was performed and data were exported for analysis after review of each patient file for completeness of the data studied. Follow-up of patients for all-cause mortality ended January 1, 2012. Echocardiography and invasive hemodynamic assessment via cardiac catheterization were performed within 2 months before surgery. Patients had to be older than 18 years of age at the time of surgery to be included in our study. All patients underwent isolated TV surgery (first TV surgery or TV reoperation), during which the TV was repaired or replaced with a biological or mechanical prosthesis.

The local ethics committee approved the selection process and the review of the data.

2.2. Variables

Preoperative demographic, echocardiographic and hemodynamic data as well as operative data were included in the analysis. Thirty-day, 3-month postoperative, and long-term follow-up of all-cause mortality were considered as outcomes.

Preoperative demographic variables included age; gender; body mass index; cardiac risk profile (including currently smoking, presence of diabetes mellitus, high blood pressure, hypercholesterolemia, family history of coronary artery disease); extracardiac vascular disease (carotid endarterectomy, carotid disease defined as total occlusion or >50% stenosis of the carotid arteries, clinical claudication, amputation due to peripheral vascular disease); previous cardiac surgery; recent myocardial infarction (<90 days preoperatively); angina; chronic lung disease; renal function (glomerular filtration rate as calculated using Cockcroft-Gault formula); cardiac rhythm (sinus rhythm, atrial fibrillation, or pacemaker dependent); New York Heart Association (NYHA) functional class; cause of valvular disease (primary TV disease defined as disease of the TV leaflets and secondary annular dilatation defined as dilatation of the tricuspid annulus causing tricuspid regurgitation (TR) but with intact leaflets); urgency grade of TV surgery; and type of TV surgery (annuloplasty, valve replacement with a bioprosthetic or mechanical valve). The use of loop diuretics, potassium sparing diuretics, ACE-inhibitor or angiotensin receptor blocker and beta-blockade was included. The EuroScore II was calculated for each patient [18].

Echocardiographic variables included the grade of TR as assessed by colour Doppler imaging, right ventricular (RV) end-diastolic diameter, right atrial (RA) end-systolic diameter, right ventricular function assessed by eyeballing, tricuspid regurgitant gradient, calculated from the CW Doppler velocity of the tricuspid regurgitant jet and left ventricular ejection fraction. The RV diameter was measured at end-diastole at the mid-ventricular level in the apical 4-chamber view. The RA long-axis dimensions were measured at end-systole in the apical 4-chamber view. [19,20] Right ventricular function was graded by eyeballing and was graded as normal, mild, moderate or severe impairment. Furthermore, digitally available echocardiographic images were reanalyzed for tricuspid annular plane systolic excursion (TAPSE).

Hemodynamic variables included right atrial pressure; systolic and diastolic right ventricular pressure; and systolic, diastolic, and mean pulmonary artery pressure (PAP), determined invasively by right heart catheterization. Postoperative, in-hospital (<3 months) complications were reoperation due to bleeding; cardiac tamponade; valve dysfunction or postoperative myocardial infarction; infection (sternal infection, sepsis); cerebrovascular accident or transient ischemic stroke; pulmonary events (pulmonary embolism or pneumonia) and the need for artificial ventilation; renal failure and the need for renal dialysis; postoperative heart block; postoperative arrhythmias; and pleural effusion.

2.3. Statistical Analysis

Data are presented as means ± standard deviations or as numbers and proportions where appropriate. Firstly, the Kaplan-Meier method was used to estimate survival probabilities in the total population. Secondly, the patient population was divided into two groups based on prior TV surgery: one group consisted of patients undergoing their first TV surgery; another group consisted of patients undergoing TV reoperation. Baseline characteristics of both groups were compared by using unpaired t-test, Pearson's chi-square, or Fishers' exact test where appropriate. Multivariable analysis was performed to evaluate the effect of TV reoperation on post-operative survival. Thirdly, on the total population, we performed univariable and multivariable analyses using the Cox proportional hazards model to identify predictors of outcome in the total population. Kaplan Meier and log rank analysis was performed for comparison of survival in patients presenting in NYHA 1-2 compared to NYHA 3-4. Because PAP is age-dependent, we split the study-population according to median age and we checked for interactions between age and mean PAP [21]. $P < 0.1$ was considered significant for interactions. Cox proportional hazards were recalculated for mean PAP in both age groups. Pulmonary hypertension (PH) was defined as a mean PAP ≥ 25 mmHg on right heart catheterization. Kaplan Meier analysis was performed for both age groups, followed by a log-rank test after stratification into "no PH" and "PH".

Data were analyzed using SPSS® (version 20, SPSS, Chicago). All tests were two-tailed, and $p < 0.05$ was considered significant.

3. Results

3.1. Population Characteristics, Postoperative Events, and Outcome Mortality

We included 92 patients (38% male; mean age: 56 ± 14 years) in the analysis. Demographic data and indication for TV operation are summarized in Tables 1 and 2, respectively. All but one of the patients underwent sternotomy as opposed to lateral thoracotomy. Detailed information regarding postoperative (in hospital and <3 months) complications is listed in Table 3. The 30-day in-hospital mortality for the total population was 7.9%, 3-month mortality was 15.2%, 5-year mortality was 25.7%, and 10-year mortality was 53.7% (Fig. 1).

3.2. Comparison of First Intervention and TV Reoperation

Sixty-one patients (66%) underwent their first TV intervention, while 31 patients (34%) underwent TV reoperation. Of the 61 patients undergoing their first intervention on the TV, 26 (42.6%) already underwent prior cardiovascular surgery by median sternotomy. Baseline characteristics and comparison between the two groups are listed in Tables 1 and 2. The EuroScore II was significantly higher in patients who underwent reoperation on the TV. Patients who underwent first TV intervention had significantly more TR and had more dilated right ventricles. Significantly more TV reoperation patients experienced postoperative high-grade atrioventricular block and needed implantation of a definitive pacemaker (Table 3). On multivariable analysis, including TV reoperation, previous cardiac surgery by median sternotomy, age and the EuroScore II, no significant association of TV reoperation on outcome was observed (HR 1.273 (0.420-3.860); $p = 0.669$).

3.3. Identification of Predictors of Outcome after TV Surgery

For the entire cohort, univariable Cox proportional hazards analysis revealed that age ($p < 0.0001$), extracardiac vascular disease ($p = 0.001$), renal function ($p = 0.022$), NYHA functional class 1-2 compared to NYHA 3-4 ($p = 0.010$), and use of loop diuretics ($p = 0.017$) or potassium-sparing diuretics ($p = 0.002$) were significantly associated with outcome. Whether valve repair or valve replacement was performed did not influence outcome (HR = 0.722 (0.346-1.510); $p = 0.387$). Similarly, whether valve replacement was performed with a bioprosthesis compared to a mechanical valve did not influence outcome (HR = 0.691 (0.301-1.587); $p = 0.384$). Hemodynamic parameters associated with outcome were right atrial pressure ($p = 0.004$); right ventricular systolic and diastolic pressure ($p = 0.038$ and $p = 0.043$ respectively); and systolic, diastolic, and mean PAP ($p = 0.003$; $p = 0.015$; $p = 0.005$, respectively). (Table 4) The only echocardiographic parameter that was associated with outcome was the tricuspid regurgitant gradient ($p = 0.027$). Multivariable Cox proportional hazards analysis identified age (HR = 1.089 (1.054-1.165); $p = 0.015$) and NYHA functional class 1-2 vs 3-4 (HR 6.671 (1.154-38.551); $p = 0.034$) as factors significantly associated with outcome. (Table 5)

When patients presented in NYHA functional class 3 or 4, survival was significantly worse compared to patients presenting in NYHA functional class 1 or 2. Thirty-day, 90-day and 5 year survival was 100%, 100%, 94.7% respectively for NYHA class I and II whereas survival was 88.8%, 79.1% and 66.9% respectively for NYHA class III and IV (log-rank test, $p = 0.005$). (Fig. 2)