Surgical Treatment for Isolated Tricuspid Valve Endocarditis
– Long-Term Follow-up at a Single Institution –

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Background: Systematic long-term data on tricuspid valve (TV) endocarditis are limited. The aim of this study was to investigate the outcome of surgery for isolated TV endocarditis.

Methods and Results: A total of 637 patients who underwent TV surgery between June 1996 and September 2012 at Hannover Medical School were retrospectively investigated. Of the 637 patients, 33 (14 female, mean age, 49±21 years) underwent isolated TV surgery for endocarditis: biological TV replacement, n=14; mechanical TV replacement, n=4; TV reconstruction, n=15. A total of 28 cases were associated with i.v. drug abuse (n=14) or pacemaker infection (n=14). Staphylococcus (S.) aureus was the most common microorganism detected on preoperative blood culture. Mean follow-up was 6.0±4.1 years (83% completed). Three patients (9%) died during the first 30 postoperative days. Survival at 1, 5 and 10 years was 88%, 73%, and 73%, respectively. Freedom from reoperation was 100%, 95%, and 88%, respectively. During follow-up New York Heart Association class improved significantly, and echocardiography identified remaining TV insufficiency grade ≥II only in 2 patients. Statistical analysis identified advanced age, logistic EuroSCORE and positive blood culture for S. aureus as significant risk factors for long-term mortality.

Conclusions: Isolated TV endocarditis is strongly associated with i.v. drug abuse or pacemaker infection. Long-term outcome is acceptable, independent of the surgical procedure. (Circ J 2013; 77: 2032–2037)

Key Words: Cardiac surgery; Endocarditis; Isolated tricuspid valve surgery; Tricuspid valve
Isolated Tricuspid Valve Endocarditis

Surgically in redo procedures. In these cases cardiopulmonary bypass was established by peripheral cannulation of the femoral artery and the femoral and jugular vein. Depending on surgeon preference and the underlying pathology, the operative procedures were performed on the beating (n=14, 42%) or arrested (n=19, 58%) heart. Cardiac arrest was achieved with ante-grade cold blood cardioplegia with a mean cross-clamp time of $46\pm28$ min and a mean bypass time of $81\pm43$ min. The detailed procedures are listed in Table 2. In patients with pacemaker lead infection, complete removal of all foreign material and extensive debridement at the site of the device pocket were done as previously described.\textsuperscript{11,12} In brief, after establishing the cardiopulmonary bypass, the leads were cut in the superior vena cava, and the distal portion was explanted. The device pocket and proximal lead segments were explanted at the end after closure of the sternotomy. Extraction sheaths were used as required to free the lead remnant from adhesions under the clavicle. Temporary pacing was achieved via epicardial temporary pacing wires. Permanent epicardial pacemaker was implanted.

### Table 1. Patient Characteristics and Perioperative Data

<table>
<thead>
<tr>
<th></th>
<th>Total cohort (n=33)</th>
<th>Death ≤30 days (n=3)</th>
<th>Late death (n=4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (years)</td>
<td>49±21</td>
<td>59±11</td>
<td>62±17</td>
</tr>
<tr>
<td>Female (%)</td>
<td>14 (42.4)</td>
<td>2 (66.7)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Preoperative NYHA functional class</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>9 (27.3)</td>
<td>0 (0)</td>
<td>1 (25.0)</td>
</tr>
<tr>
<td>III</td>
<td>16 (48.5)</td>
<td>1 (33.3)</td>
<td>3 (75.0)</td>
</tr>
<tr>
<td>IV</td>
<td>8 (24.2)</td>
<td>2 (66.7)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Heart rhythm (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sinus</td>
<td>19 (57.6)</td>
<td>2 (66.7)</td>
<td>1 (25.0)</td>
</tr>
<tr>
<td>Paced</td>
<td>14 (42.4)</td>
<td>1 (66.7)</td>
<td>3 (75.0)</td>
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<tr>
<td>Preoperative NYHA functional class</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COPD</td>
<td>2 (6.1)</td>
<td>0 (0)</td>
<td>2 (50.0)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>2 (6.1)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Renal impairment (serum Cr &gt;200μmol/L)</td>
<td>11 (33.3)</td>
<td>3 (100)</td>
<td>1 (25.0)</td>
</tr>
<tr>
<td>Hemodialysis</td>
<td>1 (3.0)</td>
<td>1 (33.3)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Clinical signs of right heart insufficiency (edema, pleural effusion, ascites, hepatomegaly)</td>
<td>11 (33.3)</td>
<td>1 (100)</td>
<td>1 (25.0)</td>
</tr>
<tr>
<td>PH (mean &gt;40mmHg)</td>
<td>7 (21.2)</td>
<td>1 (33.3)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>LVEF &gt;50%</td>
<td>29 (87.9)</td>
<td>1 (33.3)</td>
<td>4 (100)</td>
</tr>
<tr>
<td>30–50%</td>
<td>4 (12.1)</td>
<td>2 (66.7)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>RVEF &gt;50%</td>
<td>16 (48.5)</td>
<td>0 (0.0)</td>
<td>2 (50.0)</td>
</tr>
<tr>
<td>30–50%</td>
<td>14 (42.4)</td>
<td>3 (100)</td>
<td>2 (50.0)</td>
</tr>
<tr>
<td>&lt;30%</td>
<td>3 (9.1)</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
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<tr>
<td>I.v. drug abuse (%)</td>
<td>14 (42.4)</td>
<td>1 (33.3)</td>
<td>1 (25.0)</td>
</tr>
<tr>
<td>Logistic EuroSCORE (%)</td>
<td>10±13</td>
<td>39±26</td>
<td>10±6</td>
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<tr>
<td>Urgent/Emergency operation</td>
<td>7 (21.2)</td>
<td>1 (33.3)</td>
<td>1 (25.0)</td>
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<tr>
<td>Lateral thoracotomy</td>
<td>7 (21.2)</td>
<td>2 (66.7)</td>
<td>1 (25.0)</td>
</tr>
<tr>
<td>CPB time (min)</td>
<td>81±43</td>
<td>94±51</td>
<td>65±27</td>
</tr>
<tr>
<td>Cardiopulic clamp arrest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>19 (57.6)</td>
<td>1 (33.3)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>No</td>
<td>14 (42.4)</td>
<td>2 (66.7)</td>
<td>4 (100)</td>
</tr>
<tr>
<td>ICU stay (days)</td>
<td>3±5</td>
<td>11±11</td>
<td>1±1</td>
</tr>
<tr>
<td>Hospital stay (days)</td>
<td>18±12</td>
<td>18±12</td>
<td>19±7</td>
</tr>
</tbody>
</table>

Data given as mean±SD or n (%). COPD, chronic obstructive pulmonary disease; CPB, cardiopulmonary bypass; Cr, creatinine; EuroSCORE, European System for Cardiac Operative Risk Evaluation; ICU, intensive care unit; LVEF, left ventricular ejection fraction; NYHA, New York Heart Association; PH, pulmonary hypertension; RVEF, right ventricular ejection fraction.

The standard surgical approach was a median sternotomy and central cannulation (bicaval and ascending aorta). A right anterolateral thoracotomy was performed in 7 cases (21%), exclusively in redo procedures. In these cases cardiopulmonary bypass was established by peripheral cannulation of the femoral artery and the femoral and jugular vein. Depending on surgeon preference and the underlying pathology, the operative procedures were performed on the beating (n=14, 42%) or arrested (n=19, 58%) heart. Cardiac arrest was achieved with ante-grade cold blood cardioplegia with a mean cross-clamp time of $46\pm28$ min and a mean bypass time of $81\pm43$ min. The detailed procedures are listed in Table 2. In patients with pacemaker lead infection, complete removal of all foreign material and extensive debridement at the site of the device pocket were done as previously described.\textsuperscript{11,12} In brief, after establishing the cardiopulmonary bypass, the leads were cut in the superior vena cava, and the distal portion was explanted. The device pocket and proximal lead segments were explanted at the end after closure of the sternotomy. Extraction sheaths were used as required to free the lead remnant from adhesions under the clavicle. Temporary pacing was achieved via epicardial temporary pacing wires. Permanent epicardial pacemaker was implanted.
after 2 weeks of i.v. antibiotic therapy via an anterolateral mini-
thoracotomy or a subxiphoidal approach. In the case of drug
addiction there was no standardized protocol. Valve repair was
the major priority in these patients, accepting an insufficiency
up to grade II. Of the 14 patients with drug abuse, tricuspid re-
pair was done in 9 patients and replacement with bio- and me-
chanical prosthesis were done in 2 and 3 patients, respectively.
All patients received antibiotics for 6 weeks and anticoagula-
tion with warfarin for at least 3 months postoperatively. Pa-
ients with additional indications for long-term anticoagulation
such as mechanical prostheses and atrial fibrillation were con-
tinued on anticoagulation based on individual decisions.

Data Follow-up
Follow-up was performed by telephone interviews with pa-
tients, their family members and with general practitioners.
Patients were asked about their activity level, current symp-
toms, cardiac reoperations, thromboembolic events and anti-
coagulation. Echocardiography was performed in all survivors
and the data were analyzed with regard to new or persisting TV
dysfunction. Valve-related complications were documented
according to the guidelines for reporting morbidity and mortality
after cardiac valvular operation.13

Statistical Analysis
Statistical analysis were performed using SPSS 19 (SPSS,
Chicago, IL, USA). Continuous variables are expressed as
mean±SD. Chi-square test was used for categorical data and
the Mann-Whitney U-test for continuous variables. Intrain-
dividual differences in NYHA functional class were compared
using the paired t-test. Significance was defined as P≤0.05.
The small number of cases did not allow for multivariate risk
analysis of mortality. Survival and freedom from reoperation
were analyzed using the Kaplan-Meier method.

<table>
<thead>
<tr>
<th>Table 2. Rate of Mortality and Reoperation vs. Operative Procedure</th>
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<tbody>
<tr>
<td>Procedure</td>
</tr>
<tr>
<td>Replacement</td>
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<tr>
<td>Biological valve</td>
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<tr>
<td>Mechanical valve</td>
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<tr>
<td>Repair</td>
</tr>
<tr>
<td>De Vega</td>
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<tr>
<td>Ring annuloplasty</td>
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<tr>
<td>Leaflet repair</td>
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</table>

Results

Etiologic Infective Organisms
Preoperative blood culture allowed identification of the etiologic
agent in 25/33 patients (75.8%). Staphylococci were the
most common microorganism in those with positive blood cul-
ture (21/25, 84.0%). Fifteen of these patients had Staphylococc-
us (S.) aureus, one of whom had methicillin-resistant S. aureus.
Of the 14 patients with i.v. drug abuse, 10 had positive preop-
erative blood culture with S. aureus (Table 3).

Perioperative Results
Three patients (9%) died during the first 30 postoperative days
due to cardiac failure (n=2), and acute respiratory distress syn-
drome based on pneumonia (n=1). They were older than aver-
age (59±11 years) and had a higher mean EuroSCORE of
39±26%. All these 3 patients had reduced heart EF and clinical
signs of right heart insufficiency preoperatively. Two of the 3 patients had left ventricu-
lar EF (Table 1). One patient needed a re-thoracotomy for ex-
cessive postoperative bleeding and 2 patients required a perma-
nent pacemaker implantation due to persistent atrioventricular
block grade III postoperatively. Mean intensive care unit (ICU)
and hospital stay were 3±5 days and 18±12 days, respectively.

Long-Term Results
Follow-up was completed in 25 (83.3%) out of 30 survivors.
Five patients were lost for evaluation. Mean time of follow-up
was 6.0±4.1 years. During this time a total of 7 patients died
(Table 2). Late death was related to cardiac causes in 3 cases.
One patient died due to bronchial cancer. Overall survival at 1,
5 and 10 years was 88%, 73%, 73%, respectively (Figure 1). Of
the 14 patients with drug abuse, 1 patient with tricuspid repair
and 1 with replacement (mechanical) died due to heart failure.
NYHA class improved significantly from 3.0±0.8 preoper-
tively to 1.9±0.7 at follow-up (P=0.002). Echocardiography
identified a remaining TV insufficiency grade III° in 2 patients,
1 following De Vega procedure and 1 patient after leaflet re-
pair. Echocardiography of all other patients showed a remain-
ing TV insufficiency grade 0–I°.

During follow-up, 3 patients required TV reoperation. One
patient with previous De Vega procedure needed a mechanical
prosthesis due to recurrent insufficiency 3 years after the pri-
mary operation. Two drug-addicted patients with TV prosthe-
ses (mechanical n=1, biological n=1) had to undergo reopera-
tion after 3 years and 5 years due to re-endocarditis caused by
continued drug abuse. Overall freedom from reoperation was
100%, 95%, and 88%, respectively (Figure 2). During follow-
up, there were no reports of valve-related thromboembolic
events or other anticoagulation related complications.

<table>
<thead>
<tr>
<th>Table 3. Microorganism Responsible for Endocarditis vs. Cause of Infection</th>
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<tbody>
<tr>
<td>I.v. drug abuse (n=14)</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
</tr>
<tr>
<td>MRSA</td>
</tr>
<tr>
<td>Coagulase-negative staphylococci</td>
</tr>
<tr>
<td>Streptococcus mitis</td>
</tr>
<tr>
<td>Enterococcus</td>
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<tr>
<td>Lactobacillus ramosus</td>
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<tr>
<td>Culture-negative</td>
</tr>
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</table>

MRSA, methicillin-resistant Staphylococcus aureus.
Figure 1. Kaplan-Meier survival curve in patients after tricuspid valve (TV) surgery due to TV endocarditis.

Figure 2. Kaplan-Meier curve of freedom from reoperation after tricuspid valve surgery.
The following preoperative risk factors were associated with mortality on univariate analysis: older age (P=0.046) and logistic EuroSCORE (P=0.011), and positive blood culture for S. aureus (P=0.043).

**Discussion**

This study describes the clinical characteristics of patients with severe isolated TV endocarditis who required TV surgery, and analyzes the outcome of these patients. The data showed that surgical treatment of TV endocarditis can be performed with an acceptable operative mortality, reasonable long-term survival and low reoperation rate. Recurrent infection, however, proved to be a significant risk especially in patients with drug abuse.

In the present series, >70% of the patients were in NYHA functional class III or IV, one-third of patients presented with renal impairment, and approximately half of the patients had reduced left and/or right ventricular function (Table 1). Three patients died during the first 30 days postoperatively due to heart failure and pneumonia. Overall long-term outcome, however, was acceptable, with 1-, 5-, and 10-year survival being 88%, 73%, and 73%, respectively. This result is at least comparable with or even better than shown in previous studies. The overall surgical outcome of isolated TV endocarditis is better than those of left-sided acute endocarditis. Reported early mortality of left-sided acute endocarditis is as high as 26–27%, 15,16 Musci et al compared the survival rates of patients who underwent surgery for isolated right-sided endocarditis and those who underwent surgery for combined right- and left-sided endocarditis. They found a significant difference in the survival of the 2 groups: the 1-, 5-, and 10-year survival rate in the isolated right-sided endocarditis group was 88.4%, 73.5%, and 70.4%, respectively, and in the combined right- and left-sided endocarditis group it was 67.8%, 50.8%, and 35.6%, respectively (P=0.0093). Even an isolated acute TV endocarditis, however, might have fatal outcome if consequent treatment is delayed. Capoun et al reported in their series of 13 patients with isolated TV endocarditis that actuarial survival was only 63.1% at 3 years and 50.4% at 5 years after surgery. In the present study, all 3 patients who died early postoperatively had renal impairment and right heart failure and 2 of them also had reduced left ventricular function. We also found that older age, high EuroSCORE and positive blood culture for S. aureus were risk factors for mortality. These results are in accordance with those reported by Musci et al and with the data from the Euro heart survey published in 2005. Factors such as renal impairment, reduced left and/or right heart function, and high EuroSCORE reflect an advanced morbidity at the time point of the operation, leading to high mortality rates postoperatively. Therefore, we strongly recommend early surgery in these patients before concomitant heart failure or secondary organ failures occur.

While the overall incidence of IE has remained static over the past 2 decades, there has been a change in the cause of right-sided IE. The new groups of individuals at risk of right-sided IE include patients with intracardiac devices (pacemakers, defibrillators, and prosthetic valves) and i.v. drug abusers. Of the 33 patients reported in the present study, 14 (42.4%) presented with infected pacemaker leads and another 14 (42.4%) had i.v. drug abuse. The widespread and liberal use of device therapy in cardiac rhythm disorders has led to an absolute as well as relative increase of TV endocarditis mediated by descending lead infection. The pathogenesis usually involves skin contamination and wound infection at the time of implantation and progresses from the generator site over the pacing leads to the TV. Treatment usually requires complete extraction of the device and the leads. Del Rio et al have reported a mortality rate of surgical treatment of pacemaker and defibrillator-induced IE as high as 12.5%. 20

History of i.v. drug abuse is the other most common predisposing factor for TV endocarditis. Patients are usually of young age and present with systemic symptoms of infection. S. aureus is the most common pathogen in these patients. It is associated with high morbidity and mortality compared with IE caused by other pathogens. In the present report, 10 out of 14 patients with i.v. drug abuse had blood cultures positive for S. aureus, which proved to be a significant risk factor for mortality. Disease management in these patients is challenging, often due to poor compliance. Continued i.v. drug use after discharge from hospital increases the risk of recurrent infection. We observed that 2 out of 3 patients who required TV reoperation for recurrent endocarditis were persistent drug abusers.

The management of TV endocarditis is dictated by the pathogens and the clinical condition of the patient. In many cases, TV endocarditis resolves with medical treatment. The indications for surgery of right-sided IE, however, are: (1) uncontrolled septicemia, or fever that persists longer than 3 weeks despite antibiotic therapy; (2) intractable right-sided heart failure despite appropriate medical therapy; (3) perivascular abscess formation; (4) fungal IE; (5) repeated occurrence of pulmonary embolism; (6) concomitant left-sided IE; and (7) vegetation diameter >20 mm. When surgery is indicated, prognosis is better when the operation is performed before cardiac function deteriorates and before the function of other organs is affected by the long-term and intense antibiotic therapy. Appropriate surgical treatment of right-sided IE includes the following basic principles for left-sided IE: (1) aggressive and extensive debridement (if the infection is localized on the valve leaflets without relevant destruction, removal of vegetation should be performed); (2) reconstruction of structural defects, such as fistulas or abscess cavities, with homologous or autologous pericardial patches; and (3) valve repair with homologous or autologous pericardium. TV replacement remains the second-best choice due to inferior hemodynamics and long-term prognosis as well as potential reinfection of the implanted prosthesis. In the present series, however, we found no difference in patient survival or in reoperation rates between TV repair and TV replacement, probably due to the small number of patients. When repair is impossible, it is still a controversial decision as to whether a mechanical or a tissue valve should be used in patients with active IE. Rizzoli et al and Carrier et al demonstrated comparable results in long-term survival and reoperation-free survival for mechanical and bioprosthetic valves in the TV position. Because we observed only 4 patients who received mechanical valves compared to 14 patients with biological prostheses, we were not able to analyze this issue.

**Study Limitations**

Limitations of this study include the nature of retrospective analysis and the urgent situation at the time of operation. Therefore, detailed preoperative hemodynamic variables such as right ventricular stroke work (RVSW) and RVSW index, both significant indicators of right heart failure, were not available for risk analysis. Additionally, the follow-up rate was low at 83%. Due to the small number of patients, we could not perform multivariate risk factor analysis for mortality and we did not find significant effects on clinical outcome with regard to operative procedure, such as repair or replacement or the type of procedure.
of prosthesis. Because we have concerns regarding compliance issues with oral anticoagulation in drug addicts, clinical policy is to prefer biological valves in tricuspid position, which resulted in only 4 patients with mechanical valve replacement.

Conclusions

Isolated TV endocarditis is strongly associated with pacemaker lead infection and i.v. drug abuse. *S. aureus* is the most common etiologic pathogen, especially in patients with i.v. drug abuse. Although overall outcome is acceptable, surgery should be performed early, before the onset of concomitant heart failure or secondary organ dysfunction. The rareness of the disease will make prospective randomized studies very difficult and protracted. To provide more detailed and statistically proven answers for this patient type, we should include all endocarditis patients in multicenter study registers, which would allow for proper subgroup analysis.

Acknowledgment

We gratefully acknowledge the assistance of Mrs Pia Piekemohr for data acquisition and follow-up of patients.

References


Circulation Journal Vol.77, August 2013