Right-sided infective endocarditis (IE) accounts for 5% to 10% of cases of endocarditis, and it is most often seen on the tricuspid valve (TV) of patients with intracardiac devices (central lines, pacemaker wires) or with histories of intravenous drug use (IDU). Among these cases, 70% to 85% will resolve with conservative treatment. The most common surgical intervention in the IDU population is radical debridement with TV repair. Insertion of prosthetic material is usually avoided because of the risk for reinfection related to drug use relapse; if the TV repair fails, tricuspid valvectomy is an option when the patient is otherwise healthy. Following a period of recovery and abstinence from drugs, a bioprosthesis can be implanted after valvectomy once the patient has achieved sobriety. This case report describes the perioperative care of a young patient with IDU and tricuspid endocarditis on a bioprosthesis who underwent a tricuspid valvectomy.

CASE PRESENTATION

A 27-year-old woman with a medical history of IDU, depression, and fibromyalgia initially presented at our institution with severe sepsis secondary to *Staphylococcus aureus* bacteremia and TV endocarditis. She successfully underwent emergent TV replacement, with good postoperative recovery. However, the patient left the hospital against medical advice before completing the intravenous antibiotic treatment and continued to abuse intravenous drugs. She presented to our institution again 7.5 months later with fever, headache, and chest pain, and she was diagnosed with endocarditis of her prosthetic TV. Initially, because she was a high-risk surgical candidate, she was admitted for conservative management with intravenous antibiotics. Five days after admission, she started to deteriorate, and following discussion with the patient and her family, a tricuspid valvectomy was proposed. A bioprosthesis would be implanted at a later date once the patient had achieved long-term sobriety. Nine days after her admission, the patient was brought to the operating room for removal of her infected TV bioprosthesis. Intraoperative transesophageal echocardiography showed normal left ventricular function, a moderately dilated right ventricle with moderately reduced systolic function, and a large 5.2 × 3.1 cm vegetation on the ventricular side of the TV bioprosthesis (Figures 1A and 2A). A mean transtricuspid gradient of 15 mm Hg was measured, consistent with severe tricuspid stenosis (Figure 1B). Tricuspid valvectomy was performed, and the patient was separated from cardiopulmonary bypass with infusions of epinephrine 0.08 µg/kg/min, norepinephrine 0.04 µg/kg/min, and inhaled epoprostenol. Intraoperative post–cardiopulmonary bypass transesophageal echocardiography showed an underfilled left ventricle with preserved systolic function and a severely dilated right ventricle with mild systolic dysfunction (Figure 2B). The intraoperative cultures diagnosed fungal IE with *Candida albicans* and *Abiotrophia* spp. Soon after surgery, the patient was started on continuous venovenous hemofiltration to manage fluid overload and elevated right-sided pressure in the context of her acute preoperative renal failure. By postoperative day 3, she was weaned off inotropes, vasopressors, and epoprostenol and was successfully extubated. Hemofiltration was stopped on postoperative day 6, and she was transferred to the cardiac progressive care unit the next day. The patient remained hospitalized to allow the completion of a 7-week intravenous course of antibiotics and antifungal agents. She was then discharged home with follow-up appointments at an outpatient addiction clinic and the possibility to be scheduled for implantation of a bioprosthetic TV if she could remain sober for ≥6 months. At this time, 16 months later, the patient is still working on achieving long-term sobriety. She is followed as an outpatient for her chronic heart failure and her substance abuse problem. Recent transthoracic echocardiography showed normal left ventricular function, a severely dilated right ventricle with mildly reduced systolic function, and free tricuspid regurgitation (TR) secondary to the absence of TV (Video 1).

DISCUSSION

Right-sided endocarditis accounts for only a fraction of IE. IDU is one of the major risk factors, and most often it involves the TV (90%). It is estimated that 76% of cases of endocarditis in patients with IDU occur on the right side, compared with only 9% in patients without IDU.

IDU is also a risk factor for fungal endocarditis, though it remains uncommon. It accounts for 4% to 13% of cases of IE in the IDU population. Other risk factors for fungal endocarditis are underlying cardiac abnormality, the presence of a prosthetic valve, and the presence of a central venous catheter. Fungal endocarditis has an extremely high mortality rate (approximately 50%) with combined aggressive medical and surgical treatment and a 100% mortality rate.
**VIDEO HIGHLIGHTS**

**Video 1:** Prebypass imaging prior to tricuspid valvectomy (0:00–0:58): Most pertinent transesophageal images acquired intraoperatively prior to tricuspid valvectomy, starting with the midesophageal aortic valve short-axis view, with the asterisk identifying the vegetation seen on the tricuspid bioprosthesis. Midesophageal aortic valve long-axis view, with asterisk identifying the vegetation that extends in the RV outflow tract. Midesophageal RV inflow view, with asterisk identifying the large vegetation that occupies the majority of the RV cavity. Midesophageal RV inflow view with color flow Doppler (CFD) demonstrating tricuspid stenosis with inflow acceleration across the tricuspid bioprosthesis. Midesophageal four-chamber view, with asterisk identifying the tricuspid vegetation. With the addition of CFD, tricuspid stenosis with inflow acceleration across the tricuspid bioprosthesis can once again be seen. Postbypass imaging tricuspid valvectomy (0:59–1:40): Most pertinent transesophageal images acquired intraoperatively after separation from bypass and tricuspid valvectomy, starting with the midesophageal four-chamber view, acquired immediately after separation from bypass, showing a severely dilated right ventricle, an underfilled left ventricle, and the interatrial septum bowed to the left throughout the cardiac cycle, which is a sign of increased right-sided filling pressure and volume overload. The asterisk indicates the tricuspid annulus. With the addition of CFD, total TR is seen after surgical removal of the tricuspid valve. RV inflow view demonstrates RV function without TV. Similarly, when adding CFD on this view, total TR is seen. Transgastric LV short-axis view showing an underfilled left ventricle with preserved systolic function. One-year follow-up imaging after tricuspid valvectomy (1:41–2:51): Most pertinent thoracic images acquired during an outpatient follow-up exam 1 year after tricuspid valvectomy, starting with the parasternal long-axis view, showing normal LV systolic function. Parasternal RV inflow showing the absence of tricuspid valve and, when adding CFD, total TR. Parasternal RV inflow-outflow showing a dilated right ventricle with some degree of systolic dysfunction that is difficult to quantify in the context of free TR. The asterisk indicates the tricuspid annulus and absent tricuspid valve. Parasternal LV short-axis view showing normal LV systolic function. Apical four-chamber view showing severe RV dilatation, absence of TV, total TR when adding CFD, and preserved LV systolic function. Continuous-wave Doppler across the tricuspid annulus demonstrates a triangular wave pattern that is classic in severe TR. Subcostal view of the inferior vena cava (IVC) shows a dilated IVC without any inspiratory variation, which indicates high right atrial pressure.

**View the video content online at www.cvcasejournal.com.**

Reinfec tion after surgical repair is a concern with fungal IE, and many patients will need to remain on lifelong oral antifungal therapy. 

The diagnosis of right-sided IE can be challenging, and a high index of suspicion should be maintained in the presence of unexplained fever or bacteremia in a patient with a history of IDU. Unlike left-sided IE, no clear diagnostic criteria have been established for right-sided infection. The Duke criteria are commonly used to diagnose left-sided IE, but they do not fully apply to right-sided disease. The clinical presentation of right-sided IE often combines fever and respiratory symptoms: cough, dyspnea, or hemoptysis, as septic pulmonary emboli occurs in 75% to 100% of patients with right-sided IE. The sensitivity and specificity of the Duke criteria have not been studied in the context of isolated right-sided endocarditis.

Most patients with right-sided IE can be successfully treated conservatively with intravenous antibiotics. The duration of treatment depends on the type and sensitivity of the pathogen and will vary between 2 and 6 weeks. In-hospital mortality is lower in patients with right-sided IE (<5%) than in those with left-sided endocarditis (18%).

The indications for surgery in right-sided IE are not as well defined as for left-sided infection, and one of the most common indications for surgical intervention is persistent infection that does not respond to antibiotic therapy. Some microorganisms, particularly *S. aureus* and fungi, are aggressive, and surgical intervention must be considered early in the course of the disease. Other indications for surgical intervention are recurrent septic pulmonary emboli, massive or worsening TR, septic shock, new-onset or worsening renal or hepatic failure, and multivascular involvement.

Surgical management of tricuspid endocarditis in patients with IDU can be challenging because of a higher rate of noncompliance with anticoagulant therapy, drug abuse relapse, and a higher rate of loss to follow-up. When surgical intervention is needed, the most common approach is radical debridement of the vegetation of the infected tissue, especially if a fungal infection is suspected, followed by valve repair with avoidance, when possible, of the implantation of any prosthetic material. When repair is not an option, mostly in cases with extensive damage to more than one leaflet, a bioprosthesis is often preferred over a mechanical valve. Another surgical option is complete removal of the TV. Tricuspid valvectomy was first described >45 years ago by Arbulu and is generally well tolerated, as long as pulmonary pressures are normal. In the presence of pulmonary hypertension, patients often develop refractory right heart failure. Studies have reported that patients have survived with minimal inconvenience up to 20 years without a TV. However, one quarter to one third of patients will develop ascites, peripheral edema, and low cardiac output secondary to right ventricular (RV) dysfunction and will require the early implantation of a bioprothetic valve. Most often, achievement of sobriety from drug use is the limiting factor to that second stage of the procedure (reimplantation of a prosthetic TV).

Echocardiographic assessment of RV systolic function is challenging with severe, total TR after tricuspid valvectomy. The American Society of Echocardiography’s recommended methods of assessing RV systolic function are tricuspid annular plane systolic excursion, two-dimensional RV fractional area change, tissue Doppler–derived tricuspid lateral annular systolic velocity, and RV index of myocardial performance. Unfortunately, all these parameters are unreliable in the setting of severe TR and will tend to overestimate RV function. For example, in our patient, on intraoperative transesophageal echocardiography, RV systolic function was deemed to be mildly reduced by visual assessment of tricuspid annular plane systolic excursion and...
Figure 1 TV vegetation causing severe tricuspid stenosis. (A) Midesophageal RV inflow view. Arrows indicate a large $5.2 \times 3.1$ cm fungal vegetation on the ventricular side on the tricuspid bioprosthesis. (B) Transtricuspid gradient measured using continuous-wave Doppler. Mean gradient was 15 mm Hg, which was compatible with severe tricuspid stenosis.

Figure 2 Midesophageal four-chamber view of the right ventricle before and after the tricuspid valvectomy. *Intra-atrial septum bowing to the left in end-diastole, which is a marker of increased right-sided filling pressure. (A) Prebypass view of the right ventricle showing the tricuspid bioprosthesis and large vegetation (arrow). (B) Postbypass view of the right ventricle without the TV (arrow).
RV fractional area change, but the presence of a severely dilated right ventricle and an underfilled left ventricle is the hallmark of acute RV failure.

**CONCLUSION**

Tricuspid valvectomy is a radical surgical alternative in patients with IDU with right-sided endocarditis when valve repair is not an option, especially if there is doubt about the patients’ future sobriety. The severe TR that follows renders the assessment of RV systolic function very challenging, but it is generally well tolerated by patients, as long as they have normal pulmonary pressure. Once sobriety has been achieved, a bioprosthetic valve can be implanted with reduced risk for reinfection.

**SUPPLEMENTARY DATA**

Supplementary data related to this article can be found at https://doi.org/10.1016/j.case.2019.07.002.

**REFERENCES**

1. Akinosoglou K, Apostolakis E, Koutsogiannis N, Leivaditise V, Gogos CA. Right-sided infective endocarditis: surgical management. Eur J Cardiothorac Surg 2012;42:470-9.
2. Frontera JA, Gradon JD. Right-side endocarditis in injection drug users: review of proposed mechanisms of pathogenesis. Clin Infect Dis 2000;30:374-9.
3. Pierrotti LC, Baddour LM. Fungal endocarditis 1995–2000. Chest 2002;122:302-10.
4. Muehrcke DD, Lytle BW, Cosgrove DM. Surgical and long-term antifungal therapy for fungal prosthetic valve endocarditis. Ann Thorac Surg 1995;60:538-43.
5. Moss R, Munt B. Injection drug use and right side endocarditis. Heart 2003;89:577-81.
6. Wallace SM, Walton BJ, Kharbanda RK, Hardy R, Wilson AP, Swanton RH. Mortality from infective endocarditis: clinical predictors of outcome. Heart 2002;88:53-60.
7. Arbulo A, Thoms NW, Chiscano A, Wilson RF. Total tricuspid valvulotomy without replacement in the treatment of Pseudomonas endocarditis. Surg Forum 1971;22:162-4.
8. Gaca JC, Sheng S, Daneshmand M, Rankin JS, Williams ML, O’Brien SM, et al. Current outcomes for tricuspid valve infective endocarditis surgery in North America. Ann Thorac Surg 2013;96:1374-81.
9. Lang RM, Badano LP, Mor-Avi V, Afilalo J, Armstrong A, Ernande L, et al. Recommendations for cardiac chamber quantification by echocardiography in adults: an update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. J Am Soc Echocardiogr 2015;16:233-71.
10. Hsiao S, Lin S, Wang W, Yang S, Gin P, Liu C. Severe tricuspid regurgitation shows significant impact in the relationship among peak systolic tricuspid annular velocity, tricuspid annular plane systolic excursion, and right ventricular ejection fraction. J Am Soc Echocardiogr 2006;19:902-10.