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INTERVENTION AND SURGERY

CASE REPORT: HOW WE DID IT

Transcatheter Aspiration of Tricuspid Vegetation

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ABSTRACT

OBJECTIVE This study sought to present the endovascular approach of transcatheter aspiration using the FlowTriever (Inari Medical) aspiration system for high surgical risk patients with right-sided infective endocarditis.

KEY STEPS General anesthesia and transesophageal echocardiogram guidance; ultrasonography-guided femoral vein access, preclosure sutures, and insertion of a 24-F sheath; insertion of straight 24-F aspiration cannula over a stiff wire, parked in the superior vena cava; introduction of a 20-F curved cannula inside the 24-F cannula to create a telescopic assembly; accurate positioning using the right ventricle inflow/outflow projection in biplane mode; adjustment of the curved cannula radius by sliding the inner cannula in and out inside the mother cannula; manual aspiration of the vegetation; Postaspiration transesophageal echocardiogram assessment.

POTENTIAL PITFALLS Avoid leaflet and annular injury and account for potential embolization.

TAKE-HOME MESSAGES Endovascular aspiration using the aspiration system is an advanced therapeutic approach for high-risk patients with right-sided IE. The aggregative knowledge about transcatheter aspiration of tricuspid vegetation suggests a safe and effective procedural profile. (JACC Case Rep. 2024;29:102868) © 2024 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Right-sided infective endocarditis (IE) accounts for 5% to 10% of all IE cases. Intravenous drug use, intracardiac devices, central venous catheters, degenerative valve disease, and prosthetic valves were described as predisposing conditions. Indications for surgical intervention include persistent bacteremia despite adequate antimicrobial therapy, large residual vegetation (>20 mm), and

TAKE-HOME MESSAGES

- Endovascular aspiration is an advanced therapeutic approach for high-risk patients with right-sided infective endocarditis.
- Knowledge about the vegetation aspiration technique suggests a safe and effective procedural profile.

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ABBREVIATIONS AND ACRONYMS

ECMO = extracorporeal membrane oxygenation

IE = infective endocarditis

TEE = transesophageal echocardiogram

TR = tricuspid regurgitation

TV = tricuspid valve

recurrent pulmonary emboli. Early postoperative mortality of 11% was reported.[1]

Transcatheter treatment, with various aspiration devices, was described as an alternative to surgery in high-risk patients.[2] The first report of endovascular aspiration of vegetation on a prosthetic pulmonary valve using AngioVac (AngioDynamics, Inc) technology described vegetation debulking as a bridge to surgery.[3] Further work showed that the use of this technology combined with intravenous antibiotics was comparable to surgery in patients with right-sided IE.[4] Aspiration with this system necessitates an extracorporeal membrane oxygenation (ECMO) circuit; therefore, another large-bore access point is mandatory. Penumbra's Indigo Aspiration System for thrombus removal has the advantage of not requiring an over-the-wire setup but has limited data on pulmonary embolism removal and cardiac intervention. The largest available Penumbra device is 12-F in gauge. The smaller diameter makes is less efficient in evacuating large vegetations without disintegrating them. This device uses a suction engine, which is beneficial in pulmonary embolism thrombus aspiration; this property, however, can endanger the delicate structures, such as leaflets and subvalvular apparatus. Manual aspiration might be more sensitive to the suction power and prevent such injuries.

Other devices or techniques that involve the use of a pigtail catheter for rotation and maceration of the clot, an endovascular basket for clot trapping, snaring and cutting devices, or a saline jet to cause a vacuum effect are probably less safe for the valve leaflets in the case of a focal mobile mass and increase the risk of embolization of the vegetation.

The FlowTriever system (Inari Medical, Inc) is a transcatheter thrombus retrieval/aspiration technology approved for the treatment of high- and intermediate-high-risk pulmonary embolism. The system was also demonstrated for aspiration of a clot in transit in the right heart.[5] Several cases have described the endovascular treatment approach of right-sided IE with this system.[6-10] The main advantages of this method are the use of 1 venous access instead of 2, high suction power, the lack of need to use ECMO during the procedure, and a lower risk of blood loss and seeding of microfragments. The large-bore venous access of 24-F (Figure 1) and aspiration catheter of 20-F help to minimize the number of manipulations required to aspirate the vegetation.

FIGURE 1 A 24-F Introducer Sheath That Allows Large-Bore Venous Access Via the Femoral Vein

Here, we present a case of right-sided endocarditis treated by using the aspiration system and discuss the principles of the procedure, advantages, and pitfalls. In Table 1, we summarized data on relevant similar cases.

CASE SUMMARY

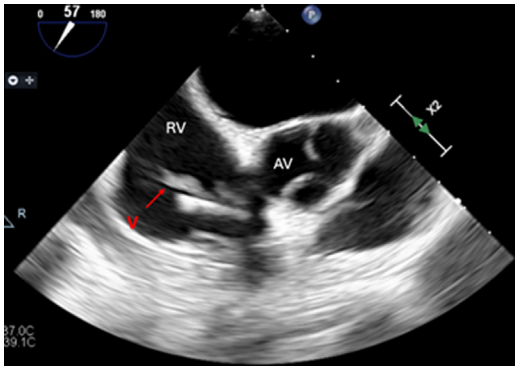
A 35-year-old woman was admitted to our hospital after 2 weeks of fever, dry cough, and weakness. Her blood pressure was 85/50 mm Hg, heart rate was 82 beats/min, temperature was 36.6 °C, and oxygen saturation was 97% on room air. She had unremarkable physical examination findings. Her medical history included systemic lupus erythematosus and

TABLE 1 Right-Sided Native Valve IE Debulking Using the Aspiration System

Number	First Author, Year	Sex	Age, y	Number of Vegetations	Size of Vegetation, cm	Pathogen	Number of Suctions	TR Grade Before Procedure	TR Grade Outcome	Length of Follow-Up, mo	Bridge to Surgery/ Definitive
1	Becker et al, 2022[6]	F	32	2	3.2 × 1.4 2.6 × 1.2	MRSA	3	Severe	Severe	5	Definitive
2	Almanfi and Nabous, 2022[7]	M	35	1	2.1 × 2.3	MSSA	4	Severe	Mild	7	Definitive
3	Morton et al, 2023[8]	F	48	1	N/A	*Candida albicans*	N/A	N/A	N/A	–	Bridge
4		M	39	2	1.4 × 1.1 2.1 × 1.3	PA	N/A	Moderate to severe	Severe	2	Definitive
5	Rozenbaum, 2023[9]	F	30	1	3	MSSA	Multiple	Severe	Severe	–	Bridge
6	Khalil et al, 2024[10]	M	68	1	3.7 × 0.5	MSSA	5	N/A	N/A	N/A	Definitive
7	Current case	F	35	1	2.3 × 0.7	MSSA	2	Mild	Mild	4	Definitive

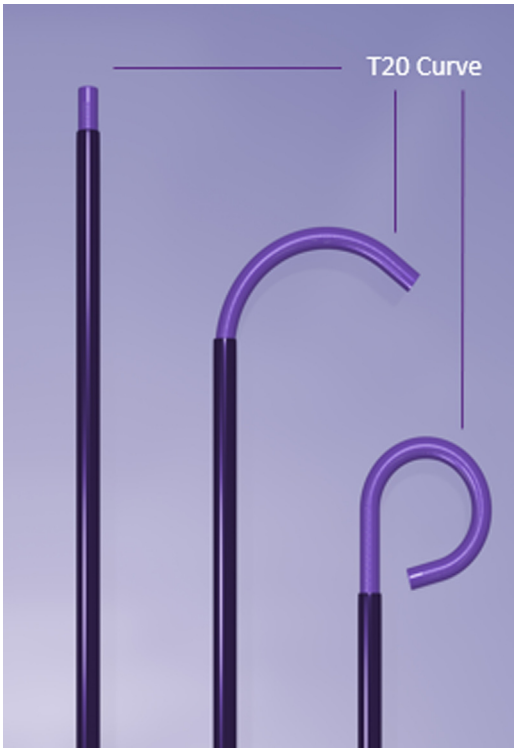
MRSA = methicillin-resistant *Staphylococcus aureus*; MSSA = methicillin-sensitive *Staphylococcus aureus*; N/A = not applicable; PA = *Pseudomonas aeruginosa*; TR = tricuspid regurgitation.

FIGURE 2 Transesophageal Echocardiogram Showing a Mass on the Tricuspid Valve



AV = aortic valve; RV = right ventricle; V = vegetation.

FIGURE 3 Triever20 Curve



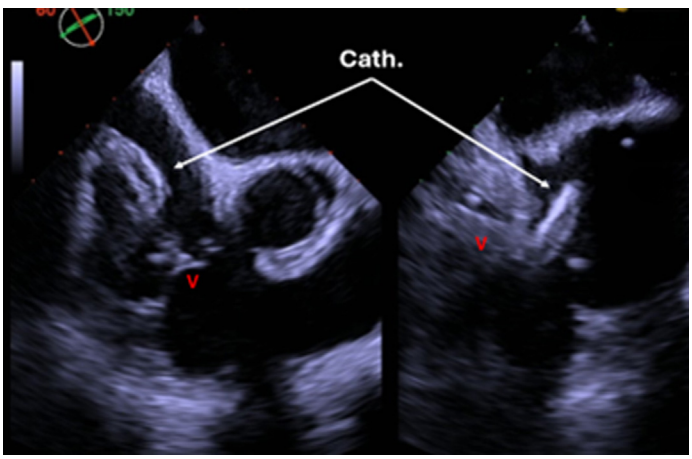
The Triever20 Curve (Inari Medical) is a catheter with a customizable angled tip for precise catheter placement by telescoping through the Triever24 (Inari Medical). The catheter has working length of 105 cm and an aspiration flow rate of 104 cm^3/s.

antiphospholipid syndrome, for which she was being treated with warfarin and hydroxychloroquine.

Thirteen years before her current admission, the patient had severe perimyocarditis that was attributed to her underlying systemic lupus erythematosus. During the event, she developed cardiogenic shock, which necessitated venous-arterial ECMO support. An atrial septal defect with left-to-right shunting was noted, as were moderate to severe tricuspid regurgitation (TR) secondary to right ventricle dilation and tricuspid annulus expansion. During surgical separation from ECMO, a tricuspid valve (TV) repair was performed with purse string annuloplasty using Prolene suture and Teflon pledgets. A 1-cm-diameter atrial septal defect was approximated with 2 mattress sutures of Prolene backed with Teflon pledgets. She was discharged with moderate to severe left ventricular dysfunction, with an ejection fraction of 30% to 35%, and was treated with a β-blocker, mineralocorticoid antagonist, angiotensin receptor, and neprilysin inhibitor. Under chronic treatment, she was stable in NYHA functional class II. Her last echocardiogram demonstrated severe left ventricular dysfunction, preserved right ventricle function, and minimal TR.

On admission, laboratory examination revealed elevated C-reactive protein (11.98 mg/dL), lactate dehydrogenase (228 IU/L) and white blood cells ($18.6 \times 10^3/\mu L$ with 84.6% neutrophils). She had a normal creatinine level (1.0 mg/dL) and normal liver enzyme levels. Her first international normalized ratio was 6.63 because of chronic warfarin therapy. Six blood culture results were positive for methicillin-sensitive *Staphylococcus aureus*. On transesophageal

FIGURE 4 Biplane Guidance of the Aspiration System Position Above the Vegetation



Cath. = aspiration catheter; V = vegetation.

FIGURE 5 A Mass Aspirated From the Tricuspid Valve

echocardiogram (TEE), she had a large mobile mass (2.3 cm in length) on the septal leaflet of the TV with mild TR (**Figure 2**, Video 1). Positron emission tomography-computed tomography showed pulmonary septic emboli.

Considering the patient risk factors (immunodeficiency and repaired TV) and the findings described, the patient was diagnosed with definite IE and treated with intravenous cephazolin for 12 days and gentamicin for 8 days. Blood culture results were positive for 4 days, and the bacteremia resolved after 2 days of treatment. However, she remained febrile, and the tricuspid vegetation persisted at similar dimensions. Given her high surgical risk (post-, adherent and scarred pericardium, and poor LV function), surgical treatment was declined.

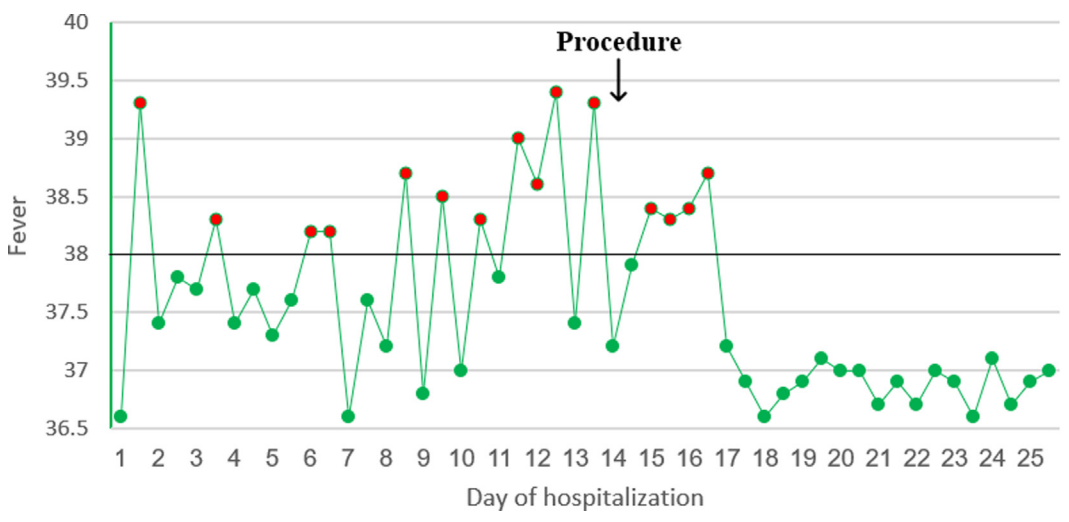
Because of persistent infection, distal embolization, and the stable large vegetation, a decision was made to proceed with endovascular aspiration of the vegetation using the FlowTriever system.

PROCEDURAL STEPS

The procedure was performed under general anesthesia and TEE guidance. The right femoral vein was cannulated under ultrasound, and a 24-F sheath was inserted. A telescopic assembly of a straight 24-F aspiration cannula and 20-F curved cannula (**Figure 3**) were inserted over a stiff wire to the superior vena cava. The vegetation was demonstrated using the right ventricle inflow/outflow projection in biplane mode (**Figure 4**). The relative position of the 2 cannulas enabled control over the inner cannula curve and accurate manipulation. Two manual aspirations were performed, resulting in retrieval of a large soft mass (**Figure 5**). The aspirated blood was considered infected and was not returned to the patient. TEE postaspiration showed mass elimination. No injury to the tricuspid leaflets or the subvalvular apparatus was demonstrated, nor was there an increase in the TR grade. Pathologic examination of the aspirated mass was consistent with thrombotic vegetation, and microbiologic culture results were negative.

The course of the procedure and recovery were uneventful. The estimated blood loss was minimal.

FIGURE 6 Fever Charts During the Patient's Hospital Stay



However, because of persistent anemia, the patient was treated with 2 units of packed red blood cells. Fever persisted for 3 days after the procedure (**Figure 6**), presumably secondary to residual emboli, and the patient reported a significant improvement in her general feeling of weakness and improved mobility, including walking without help. She was discharged from the hospital 11 days after the procedure and completed 6 weeks of intravenous antibiotic treatment uneventfully.

POTENTIAL PITFALLS

To minimize the risk of mechanical damage to the TV during this procedure, TEE guidance is highly recommended. The 20-F curved cannula aids in safe navigation and positioning and increases stabilization during the suction of vegetation.

Another possible complication of this approach is an embolism caused by the procedure itself.

CONCLUSIONS

Our case is the first, to our knowledge, to describe vegetation debulking on a repaired valve in a patient who has had previous chest surgery. Although only a few isolated cases, including ours, have been reported, major complications to the valve, such as leaflet perforation, annular injury, and damage to the subvalvular apparatus, have not been reported, nor has the need for redo procedure. The pathogens listed in **Table 1** are consistent with the typical microorganisms causing right-sided IE.[1]

Endovascular debulking of tricuspid vegetation using the aspiration system offers an advanced therapeutic approach for patients with right-sided IE who require mechanical removal of a vegetation but are considered at high risk for open heart surgery.

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Dr Dvir has served as a consultant for Inari Medical, Inc. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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REFERENCES

1. Shmueli H, Thomas F, Flint N, Setia G, Janjic A, Siegel RJ. Right-sided infective endocarditis 2020: Challenges and updates in diagnosis and treatment. *J Am Heart Assoc*. 2020;9:1-12.

2. Delgado V, Ajmone Marsan N, De Waha S, et al. 2023 ESC guidelines for the management of endocarditis. *Eur Heart J*. 2023;44:3948-4042.

3. Divekar AA, Scholz T, Fernandez JD. Novel percutaneous transcatheter intervention for refractory active endocarditis as a bridge to surgery—AngioVac aspiration system. *Catheter Cardiovasc Interv*. 2013;81:1008-1012.

4. Veve MP, Akhtar Y, McKeown PP, Morelli MK, Shorman MA. Percutaneous mechanical aspiration vs valve surgery for tricuspid valve endocarditis in people who inject drugs. *Ann Thorac Surg*. 2021;111:1451-1457.

5. Kim KW, Wheeler M, Schneider F, Carino G. Mechanical thrombectomy for a clot in transit with adherence to the tricuspid valve. *Cureus*. 2023;15(10):e46636. https://doi.org/10.7759/cureus.46636

6. Becker MC, Reddy S, Miccio B, Pappas O. A novel technique for the percutaneous removal of tricuspid valve vegetations utilizing the Inari FlowTriever System. *Catheter Cardiovasc Interv*. 2022;100:261-265.

7. Almanfi A, Nabous I. Percutaneous aspiration of vegetation in tricuspid valve infective endocarditis: a possible novel treatment option. *JACC Case Rep*. 2022;4:1151-1155.

8. Morton K, Heindl B, Mcelwee SK, Litovsky S, Ahmed MI, Clarkson S. Percutaneous debulking of tricuspid valve endocarditis in severe COVID-19 pneumonia after prolonged venovenous extracorporeal membrane oxygenation with right-ventricular support: a case series. *Eur Heart J Case Rep*. 2023;7:1-8.

9. Rozenbaum Z. Percutneous aspiration of tricuspid infective endocarditis vegetation using Inari FlowTriever. *Isr Med Assoc J*. 2023;25:702-703.

10. Khalil MH, Wong A, Shih T, Garg A, Elias Y. Endovascular aspiration of native tricuspid valve vegetation using INARI catheter in a patient with methicillin-sensitive *Staphylococcus aureus* endocarditis. *Radiol Case Rep*. 2024;19:387-392.

KEY WORDS endocarditis, right-sided catheterization, tricuspid valve

APPENDIX For a supplemental video, please see the online version of this paper.