Radiology Case Reports 19 (2024) 387–392

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/radcr

Case Report

Endovascular aspiration of native tricuspid valve vegetation using INARI catheter in a patient with methicillin-sensitive *Staphylococcus aureus* endocarditis ☆

Muhammad Hasib Khalil, MBBS[a], *Anthony Wong*[b], *Timothy Shih, DO, MS*[a], *Anuj Garg, MD*[a], *Youssef Elias, MD, PhD*[a,b,*]

[a] *Carle Foundation Hospital, 611 W Park St, Urbana, IL 61801, USA*
[b] *Carle Illinois College of Medicine, 807 S Wright St, Champaign, IL 61820, USA*

ARTICLE INFO

Article history:
Received 15 June 2023
Revised 2 October 2023
Accepted 5 October 2023

Keywords:
Inari FlowTriever
Percutaneous debulking
Tricuspid valve endocarditis

ABSTRACT

A middle-aged man presented to the hospital with chief complaint of worsening chest pain and shortness of breath. He was found to have methicillin-sensitive *Staphylococcus aureus* (MSSA) bacteremia, acute hypoxic respiratory failure secondary to MSSA pneumonia and septic emboli. The patient underwent a transesophageal echocardiogram which revealed a large, mobile tricuspid valve vegetation secondary to endocarditis. The patient was initially managed conservatively with intravenous antibiotics and supportive measures. However, his respiratory status worsened due to persistence of a large tricuspid valve vegetation which progressed to bilateral septic pulmonary emboli with peripheral cavitary lesions identified on follow-up CT of the chest. In order to debulk the large tricuspid vegetation, the patient successfully underwent endovascular mechanical aspiration of tricuspid valve vegetation utilizing the 20-Fr INARI curved Flowtriever (INARI Medical, CA) catheter. This case highlights a new, minimally invasive technique and device employed in treating native valve vegetations caused by endocarditis as an alternative approach to surgery.

Introduction

Infective endocarditis (IE) is a potentially fatal condition characterized by an infection of the heart valves or endocardium that globally affects 2.6-7 individuals per 100,000 annually [1]. IE can manifest as a valvular or endocardial vegetation leading to complications including septic emboli, valvular incompetence, or abscess formation [2]. Only 5%-10% of cases involve the pulmonic or tricuspid valves. Most of right-sighted IE are associated with intravenous (IV) drug use [2]. Nearly 60% of IE patients have a predisposing condition such as degenerative

☆ Competing Interests: The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Dr Anuj Garg is a speaker for Cook Medical.

* Corresponding author.
E-mail address: Youssef.Elias@carle.com (Y. Elias).

https://doi.org/10.1016/j.radcr.2023.10.013

valve disease, congenital heart disease, indwelling catheters and implanted cardiac devices. These associated conditions may increase the degree of complexity in managing IE [3].

Patients with IE have an increased risk of in-hospital mortality by 15%-20% and an overall 1-year mortality of 40% [4]. Long-term antibiotic therapy for 4-6 weeks is recommended [5,6]. Surgical interventions are often required to reduce the aforementioned complication risks with more than 50% of patients with IE requiring valve surgery [7]. Debulking procedures including surgical resection of valvular vegetation is indicated when conservative management fails to control the bacteremia, presence of septic pulmonary embolism (PE), and for large vegetations (>20 mm) [4]. For patients with multiple comorbidities and who are poor surgical candidates, early data of percutaneous endovascular interventions have shown excellent short-term outcomes. Previous studies have demonstrated that large-bore, catheter-based aspiration debulking techniques using devices such as the AngioVac (AngioDynamics, Latham, NY, USA) have achieved success in debulking valvular vegetations [8,9]. Recently, the INARI FlowTriever aspiration catheter (INARI Medical, CA) has been utilized as an alternative, less invasive endovascular option for removing tricuspid valve vegetation in select patients [10]. In this case report, we describe the use of the INARI FlowTriever device in treating a patient with tricuspid valve endocarditis that had progressed to bilateral pulmonary septic emboli despite receiving intravenous (IV) antibiotics.

Case report

A 68-year-old male with past medical history significant for type 2 diabetes mellitus, hypertension and alcohol use presented to the emergency department with a 1-week history of worsening chest pain and shortness of breath. The patient also complained of low back pain and right foot pain. He denied recent viral infections or sick contacts. The patient was fully vaccinated for COVID-19. He denied any history of intravenous drug use and family history was noncontributory.

In the emergency department, the patient was hypertensive, tachycardic and tachypneic. He was hypoxic, requiring supplemental oxygen via nasal canula. Chest auscultation revealed bibasilar rales. Cardiac auscultation did not reveal any murmurs. Initial workup showed an elevated serum procalcitonin (5.9 ng/mL), thrombocytopenia (platelets 91/nL), and mild anemia (hemoglobin 10.5 g/dL). To evaluate for PE, CT pulmonary angiogram (CTPA) was performed. CTPA was negative for pulmonary embolism but showed bilateral, peripheral ground-glass opacities thought to be secondary to atypical pneumonia (Figs. 1A-C). Arterial blood gas analysis showed respiratory alkalosis (pH 7.50, pO2 178.1 mmHg, pCO2 27.4 mmHg, bicarbonate 21.2). Serum lactic acid was elevated at 2.44 mmol/L. The patient was admitted and started on IV ceftriaxone and oral azithromycin for empirical treatment of community acquired pneumonia.

In the ensuing 3 days, the patient's respiratory status continued to decline despite treatment with antibiotics. Blood cultures were positive for MSSA. Repeat CTPA demonstrated worsening bilateral ground-glass opacities, with several lesions demonstrating central cavitation, consistent with septic emboli (Figs. 1D-F). A transesophageal echocardiogram (TEE) was performed revealing a large, highly mobile and elongated vegetation attached to the atrial side of the septal tricuspid valve leaflet oscillating between the right atrium and right ventricle, measuring approximately 37 mm lengthwise and 5 mm in width (Fig. 2). The ejection fraction was preserved, and the exam was negative for tricuspid regurgitation.

The constellation of clinical, microbiology and image findings were consistent with tricuspid valve *Staphylococcus aureus* endocarditis according to modified Duke criteria [13]. In the absence of valvular dysfunction, cardiothoracic surgery recommended conservative management with repeat echocardiogram after completion of antibiotic course. However, in light of worsening respiratory status and increasing septic emboli, cardiology recommended endovascular aspiration and debulking of the tricuspid vegetation.

After informed consent was obtained, the patient underwent endovascular mechanical aspiration and removal of tricuspid valve vegetation using the INARI 20-French (Fr) curved FlowTriever catheter (Fig. 3). After induction of general anesthesia and with the patient in a supine position, the right inguinal region was prepped and draped with chlorohexidine in standard sterile fashion. A TEE was introduced into the esophagus and operated by a cardiologist. The right common femoral vein was accessed under ultrasound (US) guidance using a micro-puncture set. A super stiff Amplatz wire (Boston Scientific, MA) was advanced into the superior vena cava (SVC) under fluoroscopic guidance through a 5-Fr transitional dilator. Serial dilations over the wire were performed to accept a 40 cm 24-Fr DrySeal sheath (Gore, DE) which was advanced over the Amplatz wire and positioned in the inferior vena cava (IVC). A 24-Fr INARI FlowTriever catheter was advanced to the level of the right atrium under fluoroscopic guidance. Through the 24-Fr catheter, a curved INARI 20-Fr FlowTriever catheter was positioned close to the tricuspid valve vegetation guided by transesophageal echocardiogram (TEE) and fluoroscopy (Fig. 3).

Five aspirations were performed, and the aspirate was returned to the patient after filtering through the INARI FlowSaver filter. The final 2 aspirations removed the vegetation (Fig. 3F). This was confirmed by TEE which demonstrated less than 10 mm vegetation residual along the atrial aspect of the tricuspid valve. A portion of the vegetation was sent for analysis and aerobic culture of the specimen yielded MSSA. The patient's respiratory status improved in the 72 hours following the procedure. Repeat blood cultures were negative. The patient was switched to IV cefazolin for a 4-week course of antibiotic therapy and scheduled for follow-up with pulmonology, infectious disease and cardiology. He was discharged to short-term rehabilitation and continued to improve clinically.

Discussion

Infective endocarditis refers to the infection of the endocardial surface of the heart. It usually involves cardiac valves but can also involve an implantable cardiac device. The most common

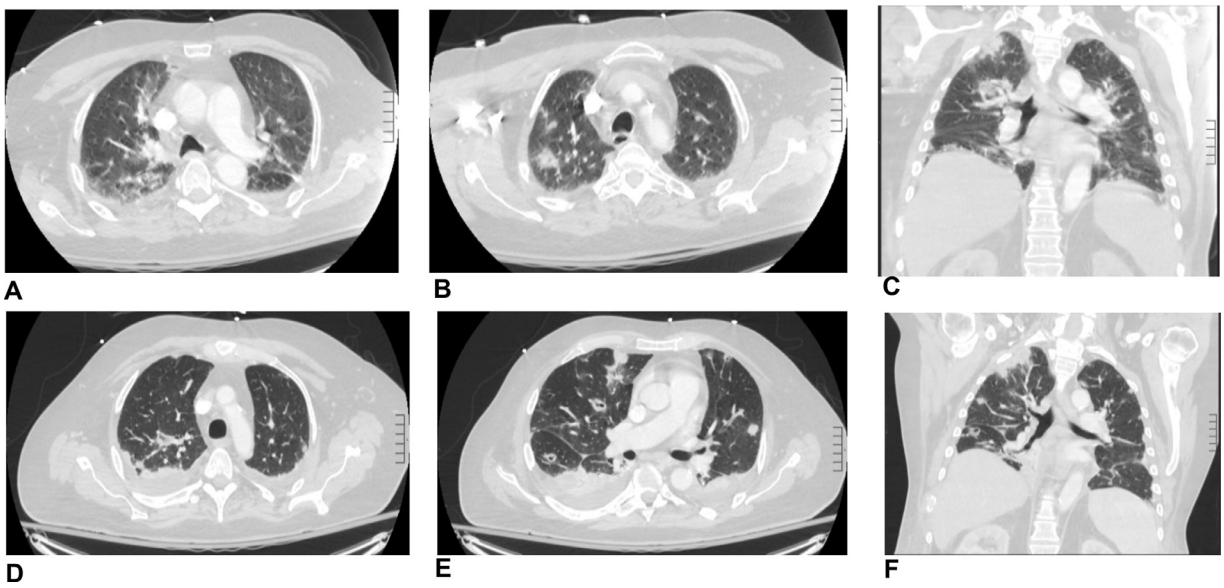

Fig. 1 – (A-C) Axial contrast-enhanced CT images of the chest obtained day of admission showing bilateral patchy opacities in the lungs concerning for atypical pneumonia. (D-F) Contrast-enhanced CT of the chest (PE protocol) showing progression of bilateral opacities with new cavitary lesions most consistent with septic emboli in the context of methicillin-sensitive *S. aureus* (MSSA) bacteremia.

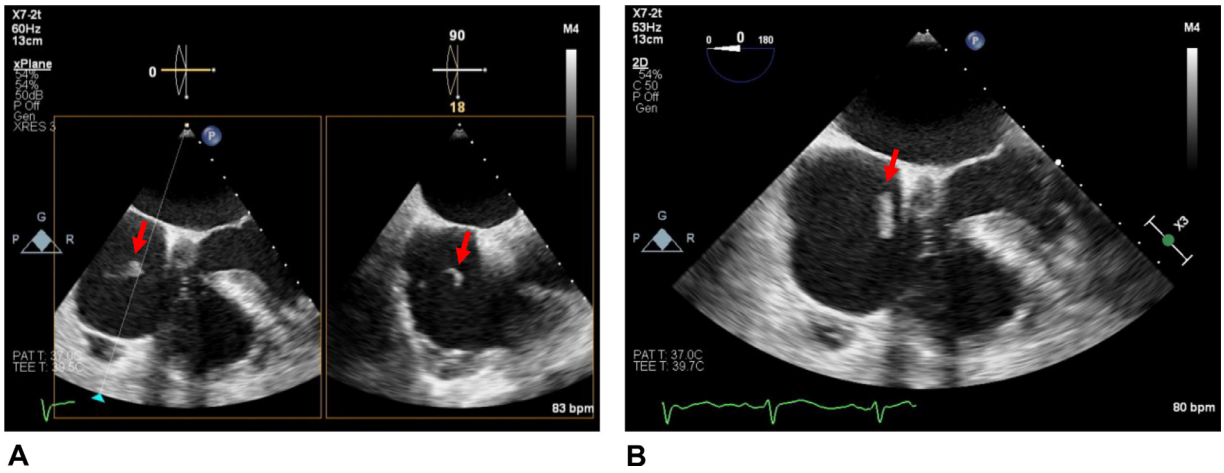

Fig. 2 – Transesophageal echocardiogram (TEE) with different probe orientation showing mobile, elongated vegetation (red arrow) arising from the atrial side of the tricuspid valve.

organisms are *S. aureus, Viridans streptococci* and enterococci [11]. Common symptoms include fever, malaise, nightsweats, arthralgias, and dyspnea. Signs of endocarditis include a new cardiac murmur, splinter hemorrhages, Janeway lesions and splenomegaly [12]. Establishing a diagnosis of infective endocarditis requires positive blood cultures of a causative organism plus evidence of endocardial involvement based on the modified Duke Criteria [13], which according to the 2016 American Association of Thoracic Surgery (AATS) includes patients with valve dysfunction leading to heart failure, heart block or aortic abscess, persistent bacteremia or fever lasting longer than 5-7 days, recurrent emboli, and patients with vegetation size greater than 10 mm in length.

Right-sided endocarditis accounts for about 5%-10% of total cases of infective endocarditis [14]. The risk factors include intravenous drug use, presence of cardiac devices including pacemaker leads and right sided cardiac anomaly [15,16]. Various mechanisms for right sided endocarditis have been proposed; these are mostly in patients who inject intravenous drugs. IE is believed to occur by direct inoculation of bacteria, other skin microorganisms or contaminants in illicit drugs that become systemic. The use of saliva as a dilutional agent for patients who repeatedly inject drugs contributes to bacteremia which can ultimately lead to IE [17,18]. In contrast to left sided IE, patients with right-sided IE are at high risk for septic pulmonary emboli, usually from tricuspid valve in-

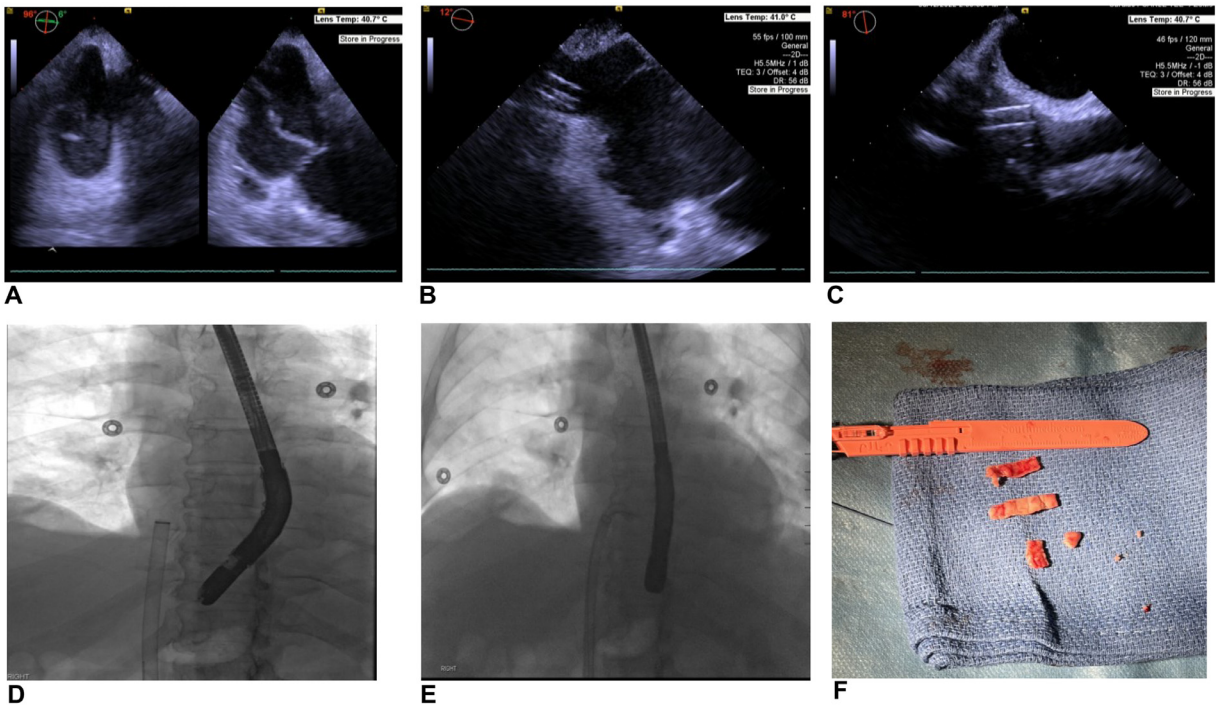

Fig. 3 – (A) Intraprocedural TEE images showing elongated vegetation arising from the atrial side of the tricuspid valve. (B and C) Intraprocedural TEE images showing tip of INARI 20-Fr curved FlowTriever catheter approximating the tricuspid valve. (D-E) Fluoroscopic images showing TEE, base 24-Fr INARI FlowTriever catheter, and curved 20-Fr INARI FlowTriever telescoped through the 24-Fr catheter. (F) Fragments of the aspirated tricuspid valve vegetation after filtration through INARI FlowSaver device.

volvement and subsequent embolization into the lungs [25]. This can lead to chest pain, hemoptysis and dyspnea. Presumably due to a lower flow, tricuspid valve endocarditis does not usually produce an audible murmur [17]. Patients with right-sided IE are at risk for stroke if a patent foramen ovale is present. The primary treatment for IE is antibiotic therapy tailored to the causative organism. All attempts should be made to eliminate risk factors (eg, intravenous drug use) or remove infected, implanted devices. As previously mentioned, patients with large valvular or endocardial vegetations (20 mm or larger) or patients with valve dysfunction may require surgical or endovascular intervention.

In the case described here, the patient did not report any of the aforementioned risk factors that would predispose him to right-sided endocarditis. He denied intravenous drug use, did not have any implanted cardiac devices and did not have a congenital cardiac abnormality. MSSA was isolated from blood cultures, and he was started on the appropriate antibiotic therapy. However, he clinically declined and his respiratory status worsened. Repeat chest imaging revealed increasing, bilateral septic pulmonary emboli. Despite adding a broad spectrum antibiotic with ertapenem, he had persistent bacteremia with TEE showing a large tricuspid valve vegetation. Given the worsening respiratory status, it was decided to perform endovascular debulking of the tricuspid valve vegetation with the INARI catheter. Nearly the entire vegetation was aspirated, achieving improved source control. Percutaneous, endovascular catheter-based aspiration of tricuspid valve vegetations has recently been described in multiple case reports [19,20]. The Angiovac system for aspiration and removal of vegetation has been reported. This device employs a large bore continuous aspiration system in combination with a venous-venous bypass and therefore requires a perfusionist. One study speculates that the rigid cannula causes difficulty in maneuvering the cannula into the right ventricle and increase the risk for tricuspid valve injury [21]. Although data is limited, the INARI systems has demonstrated success in aspirating right-sided valvular vegetation in patients with IE [10]. The large bore 24-Fr INARI FlowTriever and 20-Fr curved FlowTriever catheters were recently released on the market in January 2020 and March 2021, respectively. The FlowTriever INARI catheter system received FDA approval for pulmonary embolectomy and atrial clot in transit embolectomy in May of 2018 and January 2021, respectively. A right common femoral approach was chosen in case the tricuspid vegetation embolizes to the pulmonary circulation and pulmonary artery embolectomy becomes necessary. Placement of the 24-Fr FlowTriever INARI catheter into the lower lobar pulmonary arteries is much more challenging from an internal jugular approach as there are 2 reverse curves that would have to be navigated compared to one with common femoral vein approach. Additionally, the exchange length working wires are more manageable from common femoral vein approach as the wires can be placed along the patient's legs. Fluoroscopy was used for initial insertion and positioning of the INARI catheter into the right atrium and, in combination with TEE, the INARI

catheter was guided toward the vegetation with real time US imaging.

Conclusion

Utilization of endovascular, catheter-based aspiration devices and techniques for treatment of tricuspid valve vegetation endocarditis has recently been described. There is lack of data describing the indication, benefits and risks of removing tricuspid valve vegetation with large-bore endovascular aspiration devices. The available data is mostly comprised of case reports. Complication profiles including venous injury, hemorrhage, valvular injury, technical failure, and embolization of valve vegetation into the pulmonary circulation are yet to be determined. This case report, in combination with other published reports [8–10,19–24] demonstrate the effectiveness of minimally invasive endovascular techniques in removing or debulking large tricuspid valve vegetation. A larger body of comparative data is needed to decipher the long term-effectiveness, role and appropriateness of endovascular large bore aspiration devices in treating right heart infective endocarditis, particularly in cases unresponsive to conservative management and for patients that are poor surgical candidates.

Patient consent

Informed consent for this case report was obtained from the patient's next of kin (who was also power of attorney) as the patient is deceased. Consent was initially taken over the phone. The consent form and accompanying manuscript was then sent to the next of kin for review. The POA then signed the consent form and emailed the signed consent form back. The signed consent form can be provided if required.

REFERENCES

[1] Williams ML, Doyle MP, McNamara N, Tardo D, Mathew M, Robinson B. Epidemiology of infective endocarditis before versus after change of international guidelines: a systematic review. Ther Adv Cardiovasc Dis 2021;15:17539447211002687. doi:10.1177/17539447211002687.

[2] 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(15):e017293. doi:10.1161/JAHA.120.017293.

[3] Hubers SA, DeSimone DC, Gersh BJ, Anavekar NS. Infective endocarditis: a contemporary review. Mayo Clin Proc 2020;95(5):982–97. doi:10.1016/j.mayocp.2019.12.008.

[4] Pettersson GB, Hussain ST. Current AATS guidelines on surgical treatment of infective endocarditis. Ann Cardiothorac Surg 2019;8(6):630–44. doi:10.21037/acs.2019.10.05.

[5] Cuervo G, Escrihuela-Vidal F, Gudiol C, Carratala J. Current challenges in the management of infective endocarditis. Front Med (Lausanne) 2021;8:641243. doi:10.3389/fmed.2021.641243.

[6] Ribera E, Gomez-Jimenez J, Cortes E, del Valle O, Planes A, Gonzalez-Alujas T, et al. Effectiveness of cloxacillin with and without gentamicin in short-term therapy for right-sided *Staphylococcus aureus* endocarditis. A randomized, controlled trial. Ann Intern Med 1996;125(12):969–74. doi:10.7326/0003-4819-125-12-199612150-00005.

[7] Gaca JG, 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(4):1374–81. doi:10.1016/j.athoracsur.2013.05.046.

[8] Memon S, Goldman S, Hawthorne KM, Gnall EM. Percutaneous transeptal mitral valve endocarditis debulking with AngioVac aspiration system. Catheter Cardiovasc Interv. 2022;100(4):667–73. doi:10.1002/ccd.30319.

[9] Kelschenbach K, Patel P, Mamone M. Catheter-directed vegetation aspiration in tricuspid valve bacterial endocarditis: a potential treatment for poor surgical candidates. Cureus 2022;14(4):e24417. doi:10.7759/cureus.24417.

[10] Almanfi A, Nabous I. Percutaneous aspiration of vegetation in tricuspid valve infective endocarditis: a possible novel treatment option. JACC: Case Rep 2022;4(18):1151–5. doi:10.1016/j.jaccas.2022.03.032.

[11] Murdoch DR, Corey GR, Hoen B, Miro JM, Fowler VG Jr, Bayer AS, et al. Clinical presentation, etiology, and outcome of infective endocarditis in the 21st century: the International Collaboration on Endocarditis-Prospective Cohort Study. Arch Intern Med 2009;169(5):463–73. doi:10.1001/archinternmed.2008.603.

[12] Cahill TJ, Prendergast BD. Infective endocarditis. Lancet 2016;387(10021):882–93. doi:10.1016/S0140-6736(15)00067-7.

[13] Li JS, Sexton DJ, Mick N, Nettles R, Fowler VG Jr, Ryan T, et al. Proposed modifications to the Duke criteria for the diagnosis of infective endocarditis. Clin Infect Dis 2000;30(4):633–8. doi:10.1086/313753.

[14] Chan P, Ogilby JD, Segal B. Tricuspid valve endocarditis. Am Heart J 1989;117(5):1140–6. doi:10.1016/0002-8703(89)90874-0.

[15] Uslan DZ, Sohail MR, St Sauver JL, Friedman PA, Hayes DL, Stoner SM, et al. Permanent pacemaker and implantable cardioverter defibrillator infection: a population-based study. Arch Intern Med 2007;167(7):669–75. doi:10.1001/archinte.167.7.669.

[16] Hussey HH, Katz S. Infections resulting from narcotic addiction; report of 102 cases. Am J Med 1950;9(2):186–93. doi:10.1016/0002-9343(50)90021-0.

[17] Sande MA, Lee BL, Mills J, Chambers HF. Endocarditis in intravenous drug users. 2nd ed. New York, NY: Raven Press; 1992.

[18] Tuazon CU, Sheagren JN. Increased rate of carriage of *Staphylococcus aureus* among narcotic addicts. J Infect Dis 1974;129(6):725–7. doi:10.1093/infdis/129.6.725.

[19] Hammad TA, Abu-Omar Y, Shishehbor MH. Novel intracardiac echocardiography-guided catheter-based removal of inoperable tricuspid valve vegetation. Catheter Cardiovasc Interv 2022;99(2):508–11. doi:10.1002/ccd.29999.

[20] Bangalore S, Alviar CL, Vlahakis S, Keller N. Tricuspid valve vegetation debulking using the AngioVac system. Catheter Cardiovasc Interv 2021;98(3):E475–7. doi:10.1002/ccd.29519.

[21] Khosla A, Mojibian H, Assi R, Tantawy H, Singh I, Pollak J. Right heart thrombi (RHT) and clot in transit with concomitant PE management: approach and considerations. Pulm Circ 2022;12(2):e12080. doi:10.1002/pul2.12080.

[22] Whitbeck MG, Chambers JW. Treatment of cardiac device-related infective endocarditis utilizing the new T20 curve catheter and flow saver with the Inari mechanical aspiration system. Catheter Cardiovasc Interv 2022;100(3):476–9. doi:10.1002/ccd.30350.

[23] 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(2):261–5. doi:10.1002/ccd.30294.
[24] 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(2):ytac409. doi:10.1093/ehjcr/ytac409.
[25] Yuan SM. Right-sided infective endocarditis: recent epidemiologic changes. Int J Clin Exp Med 2014;7(1):199–218.