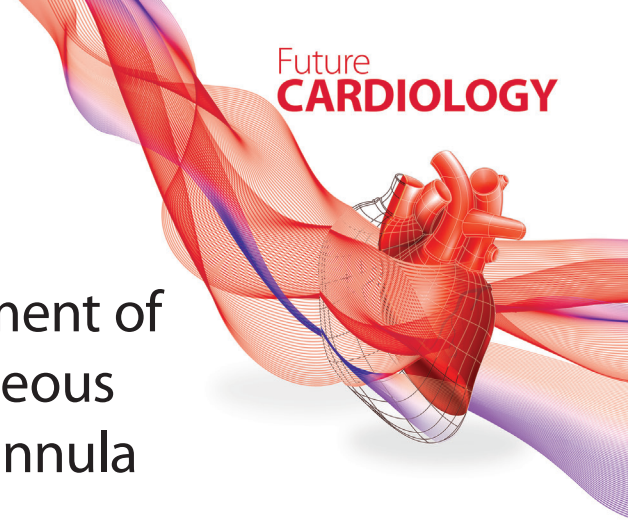
Future CARDIOLOGY



CASE SERIES

A novel approach in the management of right-sided endocarditis: percutaneous vegectomy using the AngioVac cannula

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The AngioVac is a vacuum-based device introduced in 2012 to percutaneously remove undesirable material from the intravascular system. In scattered reports, the AngioVac has been used for removal of device-led vegetations and right-sided thrombi. In this article, we describe three cases of right-sided endocarditis treated with AngioVac: a mobile mass extending from the vena cava into the right atrium, large native tricuspid vegetations, and bioprosthetic tricuspid vegetations. This device shows benefit in reducing vegetation load, decreasing septic lung embolization, and reducing reinfection in active intravenous drug users. These cases exhibit the AngioVac's arrival as a new and exciting tool in endocarditis treatment, providing an alternative to open surgery and accessorizing antimicrobial treatment.

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KEYWORDS: AngioVac • cardiac surgery • endocarditis • interventional • minimally invasive • percutaneous • tricuspid valve • valvular disease • vegectomy

The AngioVac cannula (AngioDynamics, NY, USA) is a venous drainage device introduced in 2012 to remove clots, emboli, tumors or other undesirable foreign material in the intravascular system. It gained momentum as a novel way to remove debris intact from the superior vena cava (SVC), the inferior vena cava, the iliac vein, the right atrium (RA) and the pulmonary artery. It consists of a 22-French coil-based cannula with an expandable funnel-shaped distal tip that permits *en bloc* suction of undesirable material **(Figure 1)** [1]. Blood and debris encounter an extracorporeal filter (part of the veno–veno bypass circuit), and the patient's own blood without the debris is reinfused via a smaller sized reinfusion central venous cannula established elsewhere in the body **(Figure 2)** [1,2].

On the heels of the AngioVac's success, interventional cardiologists have expanded its use to treating infective endocarditis. Specifically, the AngioVac is gaining popularity for removal of device-lead vegetations and right-sided vegetations (RA, tricuspid valve [TV], and pulmonic valve). The AngioVac is not yet studied for endocarditis vegectomy and is being used off-label for this indication. Nevertheless, its benefit is appealing on multiple fronts: as a minimally invasive alternative to surgical vegectomy – especially valuable in critically ill patients, to reduce vegetation load and minimize septic-lung embolization; often as a bridge to surgery; and to reduce vegetation burden in intravenous drug users (IVDU) and other select groups that are at a higher risk for recurrent endocarditis.

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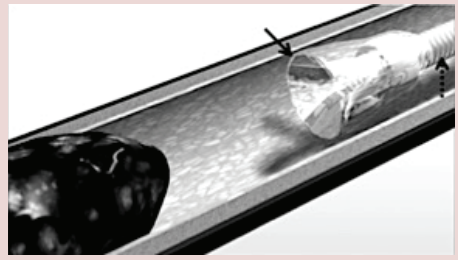

Figure 1. AngioVac cannula.

In this article, we describe three cases of right-sided endocarditis successfully treated with AngioVac at our medical center. Each case presents a variety of indications for employing AngioVac, and accentuates its diverse potential as a cutting-edge approach to endocarditis treatment. All three cases were treated in 2015, at the Heart Hospital of the Detroit Medical Center, the principal hospital affiliate of the Wayne State University School of Medicine. Cardiothoracic surgeons were initially consulted for these patients, and open-heart surgery was declined as a feasible option either due to high surgical risk or risk for recurrence (as in case 3). The patients or their families were educated about the reasons for AngioVac consideration. They were informed that AngioVac was a new device that has shown success but not yet undergone formal study for vegectomy. Consent was obtained after risks, benefits and the novelty of this percutaneous intervention were fully explained. It is our belief that given the criticality of disease, opinion of the surgeons, and grim prognosis without aggressive treatment, the patients and their next-of-kin took a well-educated leap of faith and consented for AngioVac intervention. The age range of our patients spanned from 28 to 58 years old. In two of the cases, the patients were active IVDU. In both of these cases, the target vegetation was located on the TV – in one case a bioprosthetic valve placed 15 months prior. All three patients presented with positive blood

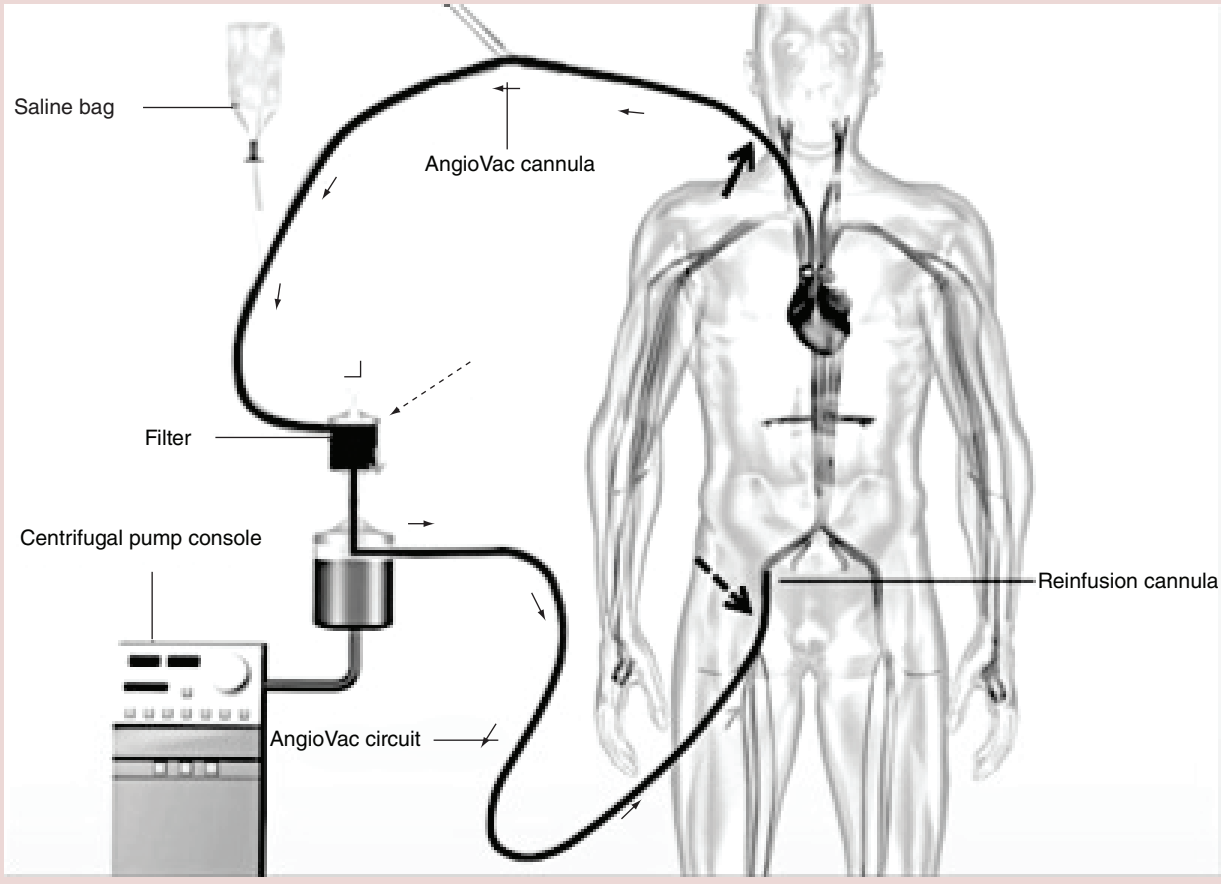

Figure 2. AngioVac circuit.

cultures. After being removed by AngioVac, the material removed was confirmed as vegetation by pathology.

• Case 1

A 35-year-old man with a history of hypertension and end-stage renal disease (on hemodialysis) was admitted to an outside facility after having missed dialysis sessions. He was noted to be in sepsis that quickly progressed to septic shock and acute respiratory distress syndrome (ARDS), leading to ventilator requirement for nearly 13 days. A dialysis permacath was suspected to be the source of the bacteremia and was removed shortly after admission to the outside facility. No other infectious source or local lesions were identified. Nonetheless, blood cultures consistently yielded methicillin-sensitive *Staphylococcus aureus*. He was started on intravenous (iv.) nafcillin, but due to persistent bacteremia for 8 days and concern for resistance to nafcillin, his antibiotic was changed to iv. vancomycin. Oral rifampin was added because a replacement dialysis catheter was necessary and concern existed for catheter reinfection. He improved and was weaned off the ventilator, but abruptly relapsed days before a planned discharge. A repeat transesophageal echo (TEE) revealed larger echodensities compared with the prior TEE 3 weeks earlier. Cardiothoracic surgeons deemed that he was a poor surgical candidate. At this point, he was transferred to our facility for a percutaneous approach.

A TEE performed upon transfer to our facility noted echodensities in the RA and on the mitral valve. Specifically, a 4.5-cm elongated and mobile echodensity (later confirmed as vegetation) was noted attached to the SVC, extending into the RA and protruding across the TV during diastole **(Figure 3A)**. A 1.3 × 0.9 cm echodensity was also noted attached to the anterior mitral leaflet, albeit without significant valvular disruption. Blood cultures were negative since admission to our hospital. Less than 24 h after his arrival, AngioVac extraction of the elongated SVC/RA mass was undertaken without complication, and with near 100% mass retrieval **(Figure 3B)**. Mass pathology revealed fibrin with focal microabscesses consistent with vegetation **(Figure 4A)**. Postvegectomy, blood cultures were redrawn and remained negative.

In this particular case, the indications for employing AngioVac were to decrease the vegetation burden, avoid disruption of the TV, and prevent further septic emboli. The patient had an uncomplicated postoperative course and was discharged with a plan for 6 weeks of vancomycin and rifampin therapy. He chose to follow-up with physicians closer to his residence. At time of this manuscript (nearly 14 months post-AngioVac), attempts to reach the patient have been unsuccessful; however, a family member who we reached, informed us that the patient was doing well.

• Case 2

A 28-year-old woman with a history of hepatitis C, bipolar disorder, and active iv. heroin use was transferred to our medical center from a smaller outside facility, where she had been hospitalized for a week and intubated for hypoxic respiratory failure due to numerous septic pulmonary emboli. A TEE at the outside facility had noted tricuspid vegetation, and this was confirmed 7 days later (hospital day 8) at our center as a mobile 2.1 × 1.0 cm multilobulated echodensity on the TV. Blood cultures at the outside facility had yielded methicillin-resistant *S. aureus* (MRSA) on the day of admission. The patient was initially treated with daptomycin (10 mg/kg daily, minimal inhibitory concentration of 1 mg/l), since she had a reported allergy to vancomycin. Ceftaroline 600 mg iv. twice-daily was added for synergism, given her extensive septic pulmonary emboli [3]. Bacteremia persisted for 9 days despite treatment with this antimicrobial regimen. No source other than iv. drug use was implicated. Blood cultures eventually cleared, but MRSA bacteremia recurred 10 days later.

A repeat TEE performed 2 days after our original study (hospital day 10) revealed that the initial vegetation had grown to 2.2 × 1.7 cm on the anterior TV leaflet, and a new mobile vegetation 1.2 × 0.4 cm was now present on the posterior TV leaflet **(Figure 5A)**. Moderate tricuspid regurgitation was now noted. 2 days later, AngioVac aspiration was attempted, but was unsuccessful owing to difficulty in engaging the catheter to the TV. The patient's condition worsened, requiring vasopressor support. Medical therapy was aggressively continued and 1 week later, another TEE revealed further enlargement of the anterior tricuspid leaflet vegetation. A decision was made to reattempt AngioVac, which was successful in removing nearly 100% of the vegetations as confirmed by intraoperative TEE **(Figure 5B)**.

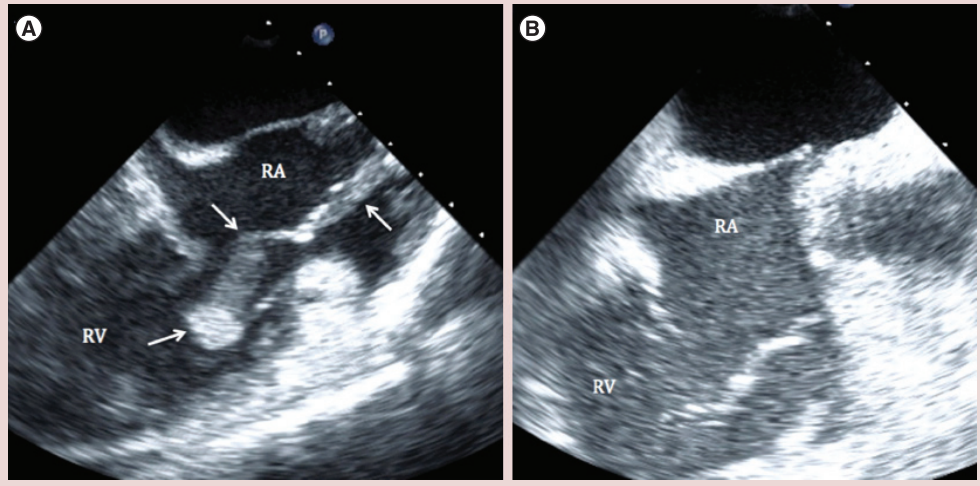

Figure 3. Case 1.

The indications for AngioVac in this case were persistent bacteremia, large vegetations, worsening valvular function, concern for further showering of septic emboli to the lungs, and septic shock despite targeted and synergistic antibiotic therapy. The procedure itself was successful and the patient's condition temporarily improved; she was taken off vasopressor support for 2.5 days after the vegectomy – during which, blood cultures were redrawn and were negative. Regrettably, her condition abruptly deteriorated with re-emergence of MRSA in her blood culture, and increase in ventilator dependence over the next 2 days. Nearly 5 days post-AngioVac treatment, and 24 days after her ordeal began, she entered cardiopulmonary arrest and expired. Autopsy was performed, and pathology demonstrated TV vegetations infected with MRSA (Figure 4B).

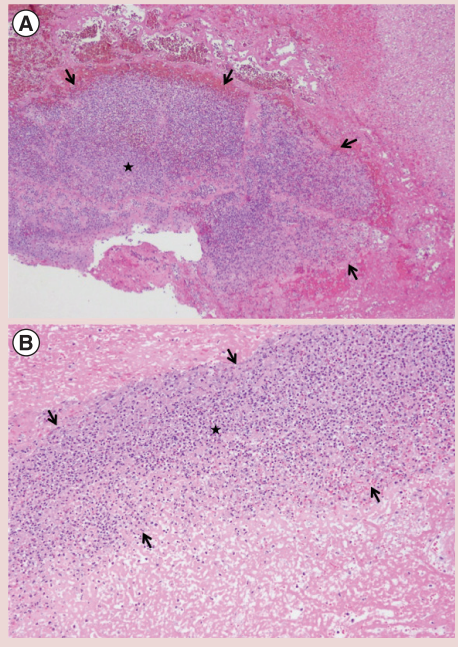

Figure 4. Histopathology of aspirated specimens.

• Case 3

A 58-year-old woman with a history of hypertension, chronic hepatitis B and C, iv. heroin abuse, chronic deep vein thrombosis, pulmonary embolism and vena cava filter due to a past gastrointestinal hemorrhage was admitted to the hospital with 3 weeks of generalized malaise and fatigue. Importantly, this patient had had an episode of TV endocarditis a year previously. During that admission, her TV had been replaced with a bioprosthetic valve (31 mm; St Jude, MN, USA) owing to severe tricuspid regurgitation. Furthermore, in the postoperative period, she had sustained complete heart block and brief asystole, warranting placement of a permanent dual-chamber pacemaker.

Her primary care practitioner sent her to our medical center after suspecting recurrence of endocarditis given her symptoms and ongoing heroin use. Her blood cultures yielded *Enterococcus faecalis* on the day of admission, with repeat cultures demonstrating the same organism for 3 consecutive days. No source other than iv. drug

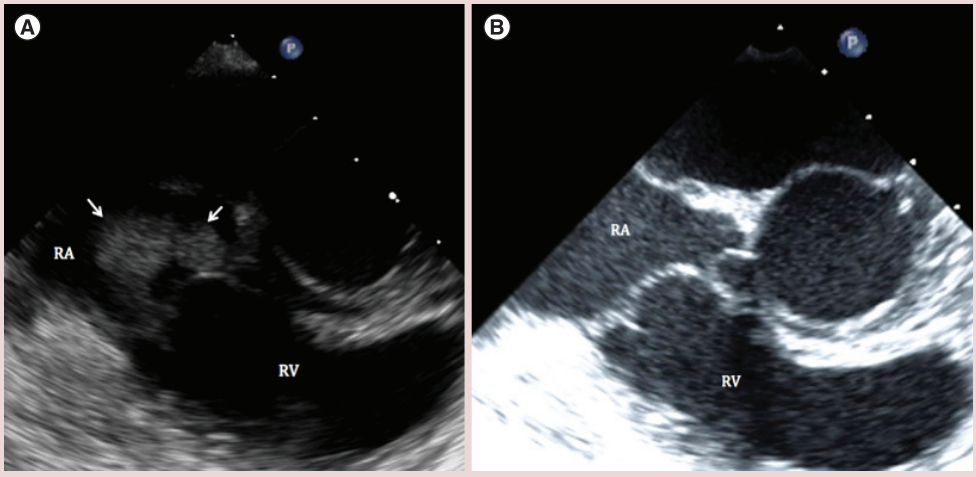

Figure 5. Case 2.

use was implicated for the bacteremia. Based on susceptibility, ampicillin (minimal inhibitory concentration of 1 mg/l) and ceftriaxone were administered for synergistic effect – resulting in clearance of cultures within 3 days of treatment. A TEE revealed a 3.2 cm mobile vegetation on the bioprosthetic TV (Figure 6A), with moderate tricuspid regurgitation. No vegetation was noted on the pacemaker leads. Cardiothoracic surgery was consulted, but refused operation owing to her ongoing heroin use. Eight days after admission, our interventional cardiologists attempted to remove the vegetation with AngioVac. The procedure was partially successful, with only 25–50% of the mass being extracted (Figure 6B). However, her tricuspid regurgitation improved from moderate to mild.

The patient was observed for a few more days, and was eventually discharged to a rehabilitation facility to complete 6 weeks of therapy with ampicillin and ceftriaxone. Mass pathology confirmed vegetation. Postintervention blood cultures remained negative. In this case, the indications for attempting AngioVac were the size of the vegetation, concern for worsening tricuspid

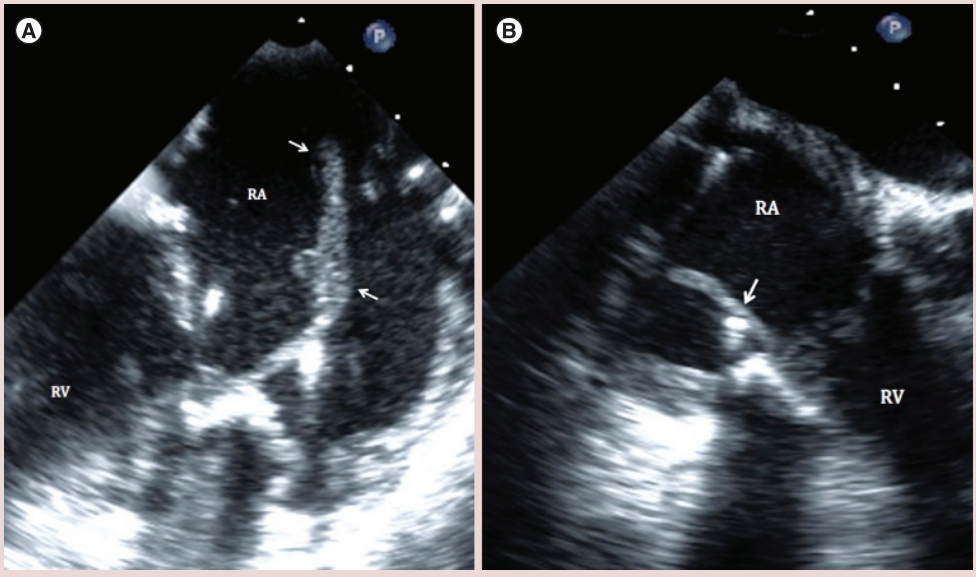

Figure 6. Case 3.

regurgitation, prevention of septic pulmonary emboli, and reduction of vegetation burden to minimize risk of reinfection. During follow-up appointments at 1.5 and 3.5 months post-AngioVac, the patient was noted to be in good health with no recurrence of endocarditis or hospitalization for any reason. A transthoracic ECG done 2.5 months post-AngioVac revealed absence of any vegetation, but trace worsening of tricuspid regurgitation. The patient was asymptomatic.

Discussion

Most of the cases in the literature regarding AngioVac pertain to device-lead vegectomies, specifically to debulk lead vegetations before removal of the leads and device [4]. Debulking of large valvular vegetations as a bridge to surgery has been noted as another indication [5,6]. Extraction of nonvalvular right-sided vegetations has also been reported, with excellent patient follow-up months later [7].

However, for right-sided endocarditis, there is a paucity of evidence that clearly delineates optimal timing and indications for surgery. Current guidelines from the American Heart Association (AHA) and Infectious Diseases Society of America (IDSA) have stronger evidence for surgery in left-sided endocarditis [8]. However, they do suggest that surgery can be reasonable in the following settings with right-sided endocarditis: severe tricuspid regurgitation causing right heart failure poorly responsive to medical therapy, sustained infections caused by difficult-to-treat organisms, lack of response to appropriate antimicrobial therapy, TV vegetations larger than 20 mm in diameter, and recurrent pulmonary embolism despite appropriate antimicrobial therapy. When feasible, valve repair is suggested rather than replacement. Specifically, the article advises against valve replacement in IVDU, to avoid risk for prosthetic valve infection [8].

The patients in cases 1 and 2 were deemed nonsurgical candidates owing to the critical nature of their condition: acute history of ARDS/shock in case 1 and ongoing ARDS/shock in case 2. AngioVac afforded an intervention previously unavailable. Case 3 is especially important, because it involves an infected bioprosthetic valve. Not only was this patient a high-risk surgical candidate, she was also an active iv. drug user, which gave further reason for the cardiothoracic surgeon to refuse open surgery. Percutaneous intervention presented a ready alternative that has precluded surgery thus far.

With the AHA/IDSA guidelines in mind, the steadily gaining popularity of AngioVac is enticing. Percutaneous debulking or vegectomy could accommodate cases that may have previously had high thresholds for surgery. In addition to the AHA/IDSA indications, we propose a few more to be considered for further study: bridge to percutaneous-lead extractions in cases of large vegetations (>40 mm) [9]; bridge to open surgical repair of TV or pulmonic valve – debulking of vegetation and potential for recurrence – such as in IVDU dialysis patients and chemotherapy patients. By reducing vegetation burden, the AngioVac may decrease the 'inoculum effect' – which refers to the negative effect of high bacterial densities on antimicrobial activity. Specifically, β-lactams, glycopeptides, and lipopeptides (such as daptomycin) are rendered less effective due to this effect of large and dense vegetations, suggesting that antibiotic penetration may be enhanced in smaller vegetations [10,11]. Moreover, antibiotic resistance is more likely to arise in large inocula [12,13]. Dense vegetations could promote stationary growth phase conditions that make it less likely for bacterial cell wall-active antibiotics (β-lactams and glycopeptides) to be effective [12–14].

Conclusion

The cases described in our article underscore a novel mode of management in right-sided endocarditis. Percutaneous aspiration could be especially useful in critically ill patients, patients with artificial valves, active iv. drug users, patients with indwelling catheters (chemotherapy and dialysis) and many more. The technology being relatively new, there is scant literature on recurrence and mortality. Moreover, as previously mentioned, AngioVac is presently approved only for removal of thrombi and emboli. Vegectomies have been strictly off-label, but the benefits are compelling: reducing the vegetation load may permit greater antimicrobial penetration, reduction in septic pulmonary emboli, and quicker clearance of bacteremia. If used as a bridge, the improved hemodynamics post-AngioVac may reduce lag time to surgery, reduce operative complications, and enhance outcome. Given its early success, the AngioVac merits closer study as an exciting new force in right-sided endocarditis management.

Financial & competing interests disclosure

The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials

discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

No writing assistance was utilized in the production of this manuscript.

Informed consent disclosure

The authors state that they have obtained verbal and written informed consent from the patient/patients for the inclusion of their medical and treatment history within this case report.

EXECUTIVE SUMMARY

- The AngioVac cannula (AngioDynamics, NY, USA) is a venous drainage device originally introduced to remove clots, emboli, tumors or other undesirable foreign material in the intravascular system.
- The AngioVac is not only useful to remove intravascular thrombi and device-lead vegetations, but is gaining traction in percutaneous right-sided infectious vegetation debulking and removal.
- Critically ill patients, patients at the risk for recurrent endocarditis (such as intravenous drug abusers, dialysis patients and chemotherapy patients) and patients who are otherwise poor open surgical candidates may benefit from the minimally invasive AngioVac treatment.
- The AngioVac can be used as a bridge to lead extractions in cases of large vegetations, and as a bridge to open surgical repair of the tricuspid valve or pulmonic valve.
- Percutaneous debulking may enhance antimicrobial penetration, possibly shortening time to treatment completion, reducing risk for resistance development, and decreasing adverse effects from prolonged antimicrobial therapy.
- Indications for surgical intervention in right-sided endocarditis are sparsely delineated by the American Heart Association and the Infectious Diseases Society of America, making the AngioVac an enticing option that could lead to a change in the guidelines.

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