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Outcomes and survival of patients undergoing percutaneous vegetectomy for right heart endocarditis

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ABSTRACT

Backgrounds: AngioVac is used for the percutaneous removal of vegetations and for debulking of large vegetations in patients who are not surgical candidates.This study aims to identify the demographics, echocardiographic features, indications, improvement of the tricuspid valve regurgitation, and survival outcomes of patients who have undergone AngioVac vegetectomy reported in the literature.

Methods: A systematic review was performed to identify articles reporting suction thromectomy or vegetation removal using the AngioVac system for RSIE (right sided infective endocarditis). Survival on discharge was our primary outcome. Additionally, we evaluated indications for suction thrombectomy and TR improvement. Categorical variables were expressed as percentages and ratios.

Results: A total of 49 studies were identified. The most common risk factor was intravenous drug abuse seen in 45% (20/49) and cardiovascular implantable electronic device (CIED) in 45% (20/49). Circulatory shock was seen in 35% of patients. The causative organism was gram positive cocci (86%). Moderate to severe TR was present in 74% of cases with documented echocardiograms. Indications for AngioVac were poor surgical candidacy (81%) or to reduce septic emboli risk (19%). Survival at discharge was 93%. TR improvement was reported only in 16% cases and remained unchanged/worsened in 84%.

Conclusion: AngioVac procedure is an alternative treatment for critically ill patients who cannot undergo surgery. To understand the survival, safety and candidacy of patients undergoing this procedure, further randomized control studies and literature reviews are needed. The improvement or worsening of tricuspid regurgitation in patients with TR valve involvement is another factor to be investigated.

1. Introduction

Infective endocarditis (IE) is a life-threatening condition. Diagnosis is suspected in patients with risk factors including bioprosthetic/mechanical valve, intravenous drug use, age > 60 years, cardiac implantable electronic devices (CIED), unrepaired congenital heart disease, damaged heart valves and poor dental health [1]. Management is based on severity of infection. Patients who are hemodynamically stable with normal cardiac function can be often managed with antibiotic therapy. Cardiac surgery is indicated if patients develop valvular dysfunction with acute heart failure or valvular abscess. Patients who either have surgical contraindications or are hemodynamically unstable or have massive vegetations (high risk for embolism) have been increasingly undergoing percutaneous vegetectomy as alternate treatment option.

Abbreviations: RSIE, Right sided infective endocarditis; IE, Infective Endocarditis; CIED, Cardiac implantable electronic device.

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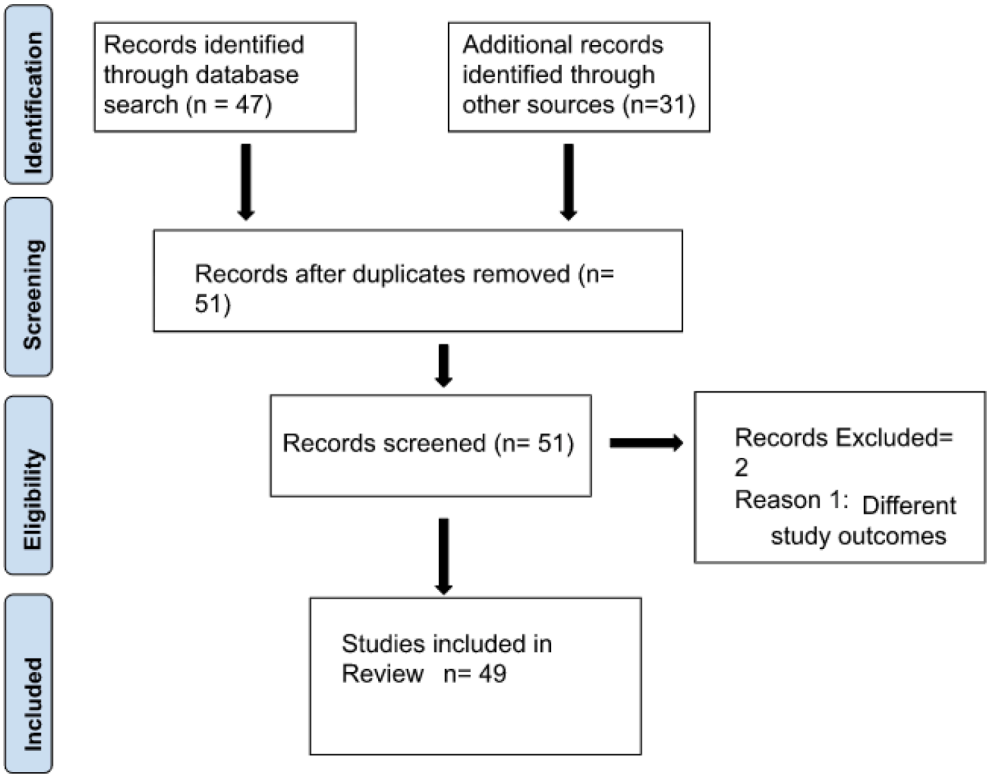

Figure 1.

AngioVac is a suction thrombectomy device that can be used to remove intravascular material from the right atrium, right ventricle, superior vena cava, inferior vena cava and iliofemoral veins. Percutaneous vegetation removal has been used for right sided valvular endocarditis and CIED lead infections. In addition to reducing infection burden, debulking vegetation may improve valvular regurgitation/RV function and reduce the risk of septic emboli.

Defining the indications and risks of suction thrombectomy is essential. We presented a case and performed a thorough literature review to study the effect of suction thrombectomy on patient's survival, right ventricular function, and improvement in tricuspid regurgitation after percutaneous vegetation removal in patients with right heart infective endocarditis.

2. Case report

We report a case of a 54-year-old-man with a past medical history of heart failure with reduced ejection fraction secondary to ischemic cardiomyopathy with CRT-D (cardiac resynchronization therapy defibrillator) implantation, insulin dependent diabetes mellitus, cocaine and intravenous drug use who presented with chest pain, fever, left flank pain and left leg weakness. Initial vital signs revealed a blood pressure of 113/70 mmHg, respiratory rate of 25 per minute, pulse of 109 beats per minute and temperature of 101.6 F. Laboratory work-up was significant for hemoglobin of 12 g/dl (13.9–16.3 g/dl), leukocytosis of 27 k/uL (4–11 k/uL), platelet count of 342 k/uL (150–450 k/uL), C-reactive protein (CRP) 190 mg/dl (<5.1 mg/dl). Blood cultures came back positive for enterococcus faecalis and methicillin sensitive staphylococcus aureus (MSSA) bacteremia. CT (computed tomography) abdomen and pelvis with contrast revealed left psoas muscle myositis and was otherwise unremarkable. The patient was subsequently started on vancomycin, ceftriaxone, and ampicillin. Transthoracic echocardiogram (TTE) revealed an ejection fraction of 20% with mild tricuspid regurgitation. Considering the patient's risk factors and clinical suspicions of endocarditis a transesophageal echocardiogram (TEE) was performed, which revealed a large vegetation approximately 2.6 cm × 2.1 cm in size, attached to the right lead of the pacemaker adjacent to the tricuspid valve, mild to moderate tricuspid regurgitation, and mild hypokinetic right ventricle. The patient's condition continued to worsen despite broad spectrum antibiotics, with an increase in white blood cell count from 30 k/uL to 59.2 k/uL and development of toxic metabolic encephalopathy. To remove the vegetation burden cardiothoracic surgery recommended AngioVac procedure. Patient underwent AngioVac procedure with complete removal of the right atrial vegetation followed by simple traction extraction of all three leads and generator. Post-procedure echocardiogram revealed unchanged moderate tricuspid regurgitation (TR) and right ventricular wall hypokinesis. The patient was discharged home with six weeks of Ampicillin 2 g every 4 hrs, Ceftriaxone 2 g every 12 hrs and with a life vest. A follow-up visit after 2 months revealed that the patient was doing well and is being considered for reimplantation of the ICD.

3. Methods

An extensive literature review was conducted initially, including Medline/Pubmed, SCOPUS, Embase, and the National Library of Medicine. Cochrane. We included literature discussing patients with right heart endocarditis who underwent percutaneous vegetectomy using the Angiovac system. Our literature search included English articles with the exclusion of any research articles done on animals. Different search strategies and MESH terms were used with words Angiovac AND thrombus AND endocarditis AND suction thrombectomy. A total of 78 articles that met our search criteria were reviewed. 27 duplicate articles were removed including one meta-analysis and one retrospective study. Fig. 1. Shows the PRISMA flow diagram. Survival on discharge was our primary outcome. Additionally, we evaluated indications for suction thrombectomy and improved tricuspid regurgitation in our literature review. For statistical analysis we expressed categorical variables as percentages and ratios.

Table 1
Results.

Total number of patients	**49**
Demographics	
Age, median	39
(IQR)	(28, 57)
Gender	27
Male	(55%)21
Female	(43%)1
Female to Male	(2%)
Risk Factors	20
Intravenous drug use	(45%)4
End Stage renal disease	(8%)4
Bioprosthetic valve	(8%)22
CIED	(45%)6
Prior Endocarditis	(12%)
Presentation	
	17
Circulatory Shock	(35%)20/24
Septic Emboli on imaging	(83%)
Microbiology	
Causative Organism	
(Identified)	14/47
MRSA	(30%)17/47
MSSA	(36%)9/47
Other Gram-positive cocci	(19%)3/47
Gram negative rods	(6%)4/47
Candida species	(9%)
Echocardiographic Findings	
Vegetation mm, median	30
(IQR)	(20, 35)
Location of Infection	45/49
Native Valve infectionNon-valvular	(92%)12/49
(catheter/SVC/IVC/RA free wall)	(24%)4/4
Bioprothetic valve infection	(100%)20/22
CIED Infection	(91%)
Ventricular Dysfunction	7/10
Right Ventricle	(70%)9/14
Left Ventricle	(64%)
Tricuspid Regurgitation severity	5/19
Mild	(26%)8/19
Moderate	(42%)6/19
Severe	(32%)
Procedural Details	
	49/49
Angiovac performed	(100%)
Indication for Angiovac	7/37
Debulking prior to CIED extraction	(19%)30/37
Poor surgical candidate	(81%)
	20/22
CIED extraction	(95%)
Outcomes	
Clinical	43/46
Survival documented on discharge	(93%)3/46
Mortality	(7%)
Echocardiographic findings	
Tricuspid Regurgitation post Angiovac	3/19
Improved	(16%)9/19
Unchanged	(47%)7/19
Worsened	(37%)

MRSA: Methicillin Resistant Staphylococcus Aureus, MSSA: Methicillin Sensitive Staphylococcus Aureus, CIED: Cardiac Implantable Electronic Devices

4. Results

As shown in Table 1, we identified 49 patients with right heart infective endocarditis (RSIE) who underwent percutaneous removal of vegetations. Table 2 summarizes the clinical characteristics of patients with right sided endocarditis.

4.1. Demographics and presentation

Median age was 39 years old, and the majority of patients were males (28/49). Most common risk factors reported were intravenous drug abuse 45% (20/49), cardiovascular implantable electronic device (CIED) 45% (20/49), and bioprosthetic valve devices 8% (4/49). One patient had fungal endophthalmitis as a risk factor. Most patients presented with signs and symptoms of sepsis and circulatory shock were seen in 35%.

4.2. Lab findings

Gram positive cocci (86%) especially staphylococcus species (66%) were isolated as the causative organism. Most reported organisms were *Methicillin-Sensitive Staphylococcus aureus (MSSA) and Methicillin-resistant Staphylococcus aureus (MRSA)*. However, five case reports mentioned Enterococcus species as well. Candida species were identified in four cases. Klebsiella, H. Influenza and Serratia marcescens were reported in one case each.

4.3. Imaging features

In Table 3, the details of different imaging procedures are summarized, including transthoracic echo (TTE) and transesophageal echo (TEE).

Median vegetation size was 30 mm (IQR 20 mm-35 mm). Most reported location was the native valve (45/49) or bioprosthetic valve (4/4) or CIED (20/22). However unusual locations including catheters/caval veins/RA free walls have also been reported (12/49). Left and right ventricular dysfunction was seen in 64% and 70% patients respectively when reported.

4.4. Survival at discharge

A survival rate of 93% (43/46) was documented at discharge. Only a few case reports provided long-term follow-up data. There were three patients who died who had multiple comorbidities with profound sepsis. One patient opted for hospice care.

4.5. Tricuspid regurgitation (TR) outcome

Tricuspid regurgitation was mentioned only in 19 cases. Moderate to severe tricuspid regurgitation was reported in 74% (14/19) patients. Improvement in TR post suction thrombectomy (Angio-vac) were reported only in 3/19 cases with worsening of the TR in 7/19 patients.

4.6. Indications for suction thrombectomy

After literature review most cases enlisted poor surgical candidacy (81%) as an indication for suction thrombectomy. The second indication was to reduce risk of emboli (19%).

5. Discussion

Patients undergoing percutaneous suction vegetectomy or AngioVac procedure are usually poor candidates for conventional therapy secondary to hemodynamic instability or multiple comorbidities. This study aims to demonstrate the survival of these patients post-AngioVac procedure. As a result of the literature review further elements came into question by the authors, namely whether any improvement was reported in studies regarding tricuspid regurgitation as well as indications for the AngioVac procedure. The available evidence on AngioVac's efficacy is limited, and further research is needed to understand its long-

Table 2
Baseline characteristics of all right sided endocarditis patient.

Author, year			Presenting symptoms	Laboratory findings
Dalia et al, 2017 [2]	26/F	IVDU	ARDS s/p intubation	MRSA
Vaidya et al, 2018 [3]	50/F	History of MRSA bacteremia, septal myectomy, ICD	Fever and chills	MRSA
Prabhudas-Stryckera et al [4]	41/M	HTN, ESRD on HD via chest tunneled catheter	Fevers, anorexia, nausea and vomiting.	Candida tropicalis.
Mercado-Alamo et al [5].	27/M	Hep C, Polysubstance abuse, IVDU	Fever, malaise and fatigue.	Neutrophilic Leukocytosis, MRSA
Koney et al, 2019 [6]	15/M	N/A	Worsening URI, temp 104F and chest pain	WBC: 22,500 mm3 and Staphylococcus hominis
Thiagaraj et al, 2017 [7]	35/M	ESRD with permacath present	Septic shock and ARDS S/p intubation	MSSA
	28/F	IVDU	AHRF s/p intubation	MRSA
	58/F	IVDU, history of TV endocarditis with TR s/p bioprosthetic valve, ICD	3 weeks of malaise and fatigue.	Enterococcus faecalis
Starck et al [8]	57/M	History of TV endocarditis	TV endocarditis in severe sepsis with hemodynamic compromise.	MSSA
Ahmed et al, 2018 [9]	56/F	NICM with ICD	Progressive dyspnoea.	MSSA
Divekar et al, 2013 [10]	17/M	Bioprosthetic Pulmonary valve, Congenital PA dilatation	septic shock	MSSA
Leso et al, 2021 [11]	34/M	IVDU	septic shock	Klebsiella oxytoca
Patel et al 2018 [12]	46/M	ICD	fungal endophthalmitis	Candida albicans
	50/M	Cardiomyopathy, CRT-D	septic shock	MSSA and E. cloacae
	68/M	PPM	Pneumonia with septic shock	H. Parainfluenza
	45/F	ICD	Respiratory failure due to right lower lobe PE.	Enterobacter faecalis.
	68/F	Complete heart block s/p PPM	septic shock and acute respiratory failure	MSSA
Patel et al 2013 [13]	59/F	ICD	septic shock	Staph aureus
	82/M	PPM	septic shock	Group B strep
	56/M	PPM	septic shock	MRSA
Tarzia et al 2020 [14]	42/M	ICD	septic shock	MSSA, elevated WBC, CRP and procalcitonin.
Talebi et al 2017 [15]	57/F	ESRD on HD	febrile, delirium	Candida parapsilosis
Bangalore et al, 2020[16]	36/M	IVDU, TV endocarditis	fever, chills, malaise, dyspnea,	MSSA
Hammad et al[17]	34/FTM	IVDU, Hx of MRSA bacteremia	Progressive shortness of breath, productive cough, pleuritic chest pain, and disabling joints pain.	MRSA
Jones et al 2017 [18]	25/F	IVDU	N/A	Candida albicans
Abubakar et al 2017[19]	33/F	IVDU	Shortness of breath	Streptococcus pyogenes.
Winkle et al 2020 [20]	27/F	IVDU	fever, chills, malaise × 1 week	WBC 16.8 × 10^9/L, Hb 6.0 g/dL, plt 47 × 10^9 /L, fibrinogen 498 mg/dL, D-dimer of 12.9 mg/L, and lactic acid 6.0 mmol/L. Serratia. marcescens and MSSA
Yoruk et al, 2020 [21]	50/M	IVDU, ICD	MSSA endocarditis	MSSA
Souka et al, 2021 [22]	27/M	IVDU, RE, TV replacement with bioprosthetic valve	septic shock	N/A
Hamilton et al, 2021[23]	35/F	IVDU, RE	Fever	MRSA
Kashyap et al 2021 [24]	39/F	IVDU	Nausea, Fever	N/A
ELJack et al, 2021 [25]	24/F	IVDU, RE	Hypotension	S. aureus.
E chang et al[26]	22/M	N/A	N/A	MSSA
	38/M	N/A	N/A	MSSA
	34/F	N/A	N/A	MRSA
Moriarty et al 2014 [27]	62/M	ICD	generalized fatigue and weakness	E Faecalis
Malviya et al 2016 [28]	35/M	N/A	septic shock	MSSA
	28/F	IVDU	septic shock	MRSA
	58/F	IVDU, Bioprosthetic TV	N/A	E Faecalis
Ayzenbart et al 2021[29]	27/F	IVDU	Lower extremity edema, palpable purpura, dyspnea, fever	MRSA
Krishnan et al 2021 [30]	66/M	PPM	Severe lumbar back pain	MSSA
	67/M	History of spinal osteomyelitis	Infected breast implant, gluteal cellulitis	MRSA
Hosoba et al 2015[31]	33/F	ICD	MRSA/ candida osteomyelitis right foot	Blood Cultures: Enterobacter cloacae
	70/M	ICD	N/A	Blood Cultures: MSSA

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Table 2 (*continued*)

Author, year			Presenting symptoms	Laboratory findings
kumar et al 2017 [32]	62/M	CRT-D	Septic shock	Blood Cultures: MSSA
Gjeka et al, 2019 [33]	45/M	IVDU	Dyspnea	Blood Cultures: MSSA
George et al 2019 [34]	24/M	IVDU	shortness of breath, mottled skin, lethargy	Blood Cultures: MRSA, Creatinine 4
Green et al 2020 [35]	55/M	ICD	Bacteremia	Blood cultures: Staph Hominis
Gaballa et al [36]	27/F	IVDU	Fever, shortness of breath, and generalized malaise	WBC-16.8, Hgb-6, Hct-19.2, and platelets 47. Fibrinogen-373.5, D-dimer-25.30.

Table 3
Echocardiographic findings, indications for suction thrombectomy and outcomes:

Author, year	TTE and TEE findings	Surgery contraindication	Outcomes of AngioVac	Hospital course and follow up
Dalia et al, 2017 [2]	Mass on TV 16x8 mm	PA aneurysm	Successful removal	Stable on d/c with no f/u
Vaidya et al, 2018 [3]	RV lead mass 3.0 cm 1.3 cm	History of surgical myomectomy.	Successful removal	Stable on d/c with no f/u
Prabhudas-Stryckera et al [4]	2 cm SVC mass and aortic root abscess	N/A	Successful removal of 75 % of SVC mass.	Stable on d/c with no f/u
Mercado-Alamo et al [5].	2.6x 1 cm TV vegetation	Multiple comorbidities	Successful removal	Patient left against medical advice
Koney et al, 2019 [6]	2 cm mass on TV	HD instability	Successful removal	Stable d/c and on f/u visit
Thiagaraj et al, 2017 [7]	TEE: 4.5 cm SVC, 1.3 × 0.9 cm MV leaflet vegetation	Prevent septic emboli	Successful removal	Stable on d/c and on f/u
	2.2 × 1.7 cm anterior and 1.2 × 0.4 cm posterior TV leaflet vegetation	HD instability, vegetation size, worsening valvular function, prevent septic emboli	Successful removal	Patient expired. Autopsy revealed TV vegetations infected with MRSA.
	3.2 cm vegetation on bioprosthetic TV.	Vegetation size, worsening TR, prevent septic emboli	25–50% extraction, TR improved from moderate to mild.	Stable on d/c, f/u revealed worsening TR again
Starck et al [8]	12 mm × 17 mm vegetation on TV.	HD instability, high operative risk	Recurrence of TV vegetation with worsening TR	TEE: vegetation recurrence. The patient underwent successful surgical TV repair
Ahmed et al, 2018 [9]	EF of 20%–25%, 2.4 × 2.1 cm ICD lead vegetation	HD instability	N/A	Stable d/c and on f/u after 8 weeks
Divekar et al, 2013 [10]	RVOT obstruction, bioprosthetic PV vegetations	HD instability	N/A	Stable d/c and on f/u
Leso et al, 2021 [11]	3.5 cm TV vegetation, flail TV leaflet and RV dilatation, PFO with right-to-left shunt.	Prevent systemic emboli	Successful removal of 75% mass	Refused further intervention on his vegetation or PFO. d/c to hospice.
Patel et al 2018 [12]	2 cm × 2 cm RA vegetation	High risk of PE during lead extraction	Successful removal	Stable on d/c
	3.2 cm × 1.3 cm RA ICD lead vegetation.	High risk of PE during lead extraction	Successful removal	Stable on d/c. PPM reimplanted on f/u.
	TV, MV and mobile masses on PPM	HD instability	Successful removal.	Stable on d/c. PPM reimplanted on f/u
	3.9 cm × 1.3 cm mass on TV and ICD lead	HD instability and multiple comorbidities.	Successful removal	Patient refused reimplantation, d/c home
	1.5 cm × 1.0 cm mass on the TV, RA and RV leads.	HD instability	Successful removal	Patient developed disseminated intravascular coagulation [DIC] and expired.
Patel et al 2013 [13]	3 2 cm mass on TV ICD lead	Prevent septic emboli	Successful removal	Stable on d/c
	1.5X 4.0 cm ICD lead, TV [0.5 × 1.1 cm] masses	Debulking prior to lead extraction	Successful removal	Stable on d/c
	3.5x1.7 cm on the pacemaker lead	Debulking prior to lead extraction	Recurrence of vegetation	Underwent TV repair and d/c home
Tarzia et al 2020 [14]	40 × 11 mm mass on ICD lead	HD instability	N/A	ICD was implanted, stable at d/c and after 1 year follow-up TTE/TEE with no recurrence of vegetations
Case 26 Talebi et al 2017[15]	(2, 3 cm) RA mass with mild TR	Multiple comorbidities	N/A	Stable on d/c
Bangalore et al, 2020[16]	2.7 × 0.8 cm TV vegetation	Vegetation debulking to prevent septic emboli	Successful removal	Stable on d/c
Hammad et al [17]	2.4 1.2 cm TV vegetation	Reinfection risk due to IVDU & patient preference	>90% removal, TV vegetation embolized to PA	No fatality reported
Jones et al 2017 [18]	6.13 cm × 3 1.65 cm SVC and RA vegetation	Vegetation size and poor surgical candidate	RA mass removed; SVC mass unsuccessful	Stable on d/c with fluconazole infusion for 8 weeks
Abubakar et al 2017[19]	3 × 1.5 cm TV vegetation	HD instability	50–60% reduction in TV vegetation.	Stable d/c and on f/u after 1 month

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Table 3 (*continued*)

Author, year	TTE and TEE findings	Surgery contraindication	Outcomes of AngioVac	Hospital course and follow up
Winkle et al 2020 [20]	3.4 × 2.0 cm vegetation on posterior & 3.2 × 1.1 cm on anterior leaflet.	HD instability	Successful removal	Stable on d/c
Yoruk et al, 2020 [21]	>2.5 cm on ICD lead	High operative risk	N/A	Stable on d/c with S-ICD implanted .
Souka et al, 2021 [22]	2.6 × 1.7 cm mass	History of previous open-heart surgery	Successful removal	Stable on d/c
Hamilton et al, 2021[23]	TV vegetation at 1.5–2 cm.	Recurrent IVDU, poor surgical candidate	Successful removal	Stable on d/c
Kashyap et al 2021[24]	0.6 cm × 0.4 cm and 1.4 cm × 0.4 cm vegetations on TV	HD instability	N/A	Stable on d/c with no f/u
ELJack et al, 2021[25]	Vegetation on annuloplasty ring and TV	high operative risk	Slightly worsening TR	No fatality reported
E chang et al[26]	TV vegetation	N/A	Significant reduction of vegetation burden	Reduction in bacteremia burden and reducing ICU stay.
	TV vegetation	N/A	Significant reduction of vegetation burden	Stable on d/c
	TV and RVOT vegetation	N/A	Significant reduction of vegetation burden	Stable on d/c
Moriarty et al 2014[27]	Vegetation 4.76 × 2.1 cm and [LVEF] of 20%.	LVEF of 20% & poor surgical candidate	Successful removal	Stable on d/c
Malviya et al 2016[28]	4.5-cm SVC mass	N/A	N/A	No fatality reported
	TEE TV vegetations on the anterior and posterior leaflets	N/A	N/A	No fatality reported
	3.2 cm TV vegetation	N/A	N/A	No fatality reported
Ayzenbart et al 2021[29]	2.4 × 1.2 cm and 1.4 × 0.7 cm TV masses	Pregnant, septic shock and MOF	Recurrence of vegetations	Preeclampsia caused c-section at 33 weeks. Healthy newborn. stable on d/c
Krishnan et al 2021[30]	0.26 × 3.6 cm on TV, pacemaker lead and PFO masses	HD instability	Successful removal of vegetation	Continuous HD instability and patient expired
	1.5 × 1.5 cm RA mass	N/A	Successful removal of vegetation	Stable on d/c and on f/u
Hosoba et al 2015[31]	2.2 × 0.6-cm vegetation	N/A	Successful removal of vegetation	Stable d/c and on f/u
	SVC and RA junction 3.4 × 1.3-cm masses	N/A	Successful removal of vegetation	Stable on d/c with no recurrence
kumar et al 2017 [32]	2 × 2 cm mass on CRT-D lead	Poor surgical candidate	Successful removal of vegetation	Stable on d/c
Gjeka et al, 2019 [33]	5.5 cm TV mass	Poor surgical candidate	75–80% reduction in TV vegetation	No fatality reported
George et al 2019 [34]	0.9 cm × 0.7 cm septal and 0.7 cm × 1 cm anterior TV mass	HD instability, MOF and RE	Significant reduction of vegetation burden	Stable on d/c. F/u TTE normal
Green et al 2020 [35]	Large 5 cm × 2 cm, mobile TV vegetation with ICD lead	N/A	CTA revealed PE. CDT unsuccessful	Stable on d/c
Gaballa et al [36]	3.4 X 2 cm TV vegetation.	N/A	Significant reduction in vegetation size	Stable on d/c with no f/u reported

Abbreviations: RA (Right atrium), MOF (multi-organ failure), MV (Mitral valve), TV (Tricuspid valve), Pulmonary valve (PV) TR (Tricuspid regurgitation), PA(Pulmonary artery), RVOT (Right ventricular outflow tract), SVC (superior vena cava), PFO (Patent foramen ovale), TTE (Transthoracic echocardiogram), TEE (Transesophageal echocardiogram), CTA (CT Angiography), CDT (Catheter Directed Thrombolysis), Recurrent endocarditis (RE), PE (pulmonary embolism), d/c (discharge), IVDU (Intravenous drug use), ESRD (end stage renal disease), AHRF (acute hypoxic respiratory failure), HD (hemodynamic) MSSA (Methicillin-Sensitive Staphylococcus aureus), MRSA (Methicillin-Resistant Staphylococcus aureus), ICD (implantable cardioverter-defibrillator), CRT-D (implantable cardiac resynchronization therapy defibrillator), PPM (permanent pacemaker), F/u (Follow-up).

term effectiveness. While previous studies have reported AngioVac's safety and outcomes [38,37], the impact on TR improvement has not been adequately investigated. Additionally, there are no specific guidelines for AngioVac use in clinical settings. This literature review aims to objectively assess the outcomes, indications, and TR outcomes post-procedure.

The results of this literature review indicate excellent outcomes for patients who underwent percutaneous suction thrombectomy. 93% of patients survived after undergoing the AngioVac procedure and were discharged in stable condition. Consequently, this procedure may be a viable alternative, especially for patients with fragile clinical status who cannot undergo open surgery.

This study also determined whether tricuspid regurgitation (TR) improved following the AngioVac procedure. Removal of tricuspid vegetation should theoretically improve TR. However, as reported in limited cases, TR deteriorated following vegetation removal post-operatively or during follow-up imaging. This observation can be attributed to a variety of factors. TR may not improve due to irreversible damage caused to the valve secondary to infective endocarditis (IE). TR may occur in patients with septic or cardiogenic shock due to confounding factors such as volume overload, ischemia, etc [39,40].

Our study has multiple limitations since there is limited data regarding outcomes, indications, and TR improvements following the AngioVac procedure. Poor outcomes post-procedure may be under-reported leading to excellent outcomes. Furthermore, several studies did not report hospital course and survival after, which limited our primary outcome. Tricuspid valve function and improvement after suction thrombectomy were only mentioned in limited case reports. Several studies failed to adequately explain the indications for AngioVac. The limitations of this study can be addressed through randomized controlled trials or by reviewing additional literature.

6. Conclusion

Percutaneous vegetectomy or AngioVac procedure is an alternative treatment for critically ill patients who cannot undergo surgery. To

understand the survival, safety and the candidacy of patients undergoing this procedure, further randomized control studies and literature reviews are needed. The improvement or worsening of tricuspid regurgitation in patients with TR valve involvement is another factor to be investigated.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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