

AHA SCIENCE ADVISORY

Percutaneous Mechanical Aspiration in Patients With Right-Sided Infective Endocarditis: A Science Advisory From the American Heart Association

Abdallah El Sabbagh, MD, Vice Chair; Evin Yucel, MD; Sanjum S. Sethi, MD, MPH; Mikhael F. El-Chami, MD, FAHA; Sandra S. Mattos, MD, FAHA; Bailey Ann Estes, AGNP-C, MSN, RN-BC, RCIS; Brittany A. Zwischenberger, MD, MHSc, FAHA; John M. Moriarty, MD; Andrew SP Sharp, MD; Larry M. Baddour, MD, Chair; on behalf of the American Heart Association Council on Lifelong Congenital Heart Disease and Heart Health in the Young; and Council on Clinical Cardiology

Abstract: Percutaneous mechanical aspiration has emerged as a novel, catheter-based strategy for the management of right-sided infective endocarditis, particularly in patients with a suboptimal response to antimicrobials or in those considered high risk for surgery. Initially developed for thrombus extraction, percutaneous mechanical aspiration has been increasingly used to achieve source control by debulking large vegetations. Despite growing clinical adoption and support from societal statements and guidelines, there have been no randomized controlled trials evaluating its safety or efficacy in right-sided infective endocarditis. Current evidence is derived from retrospective case series, registries, and administrative data sets, all limited by heterogeneity in patient populations, procedural techniques, and outcome definitions. Nevertheless, recent data from multicenter registries demonstrate promising procedural success and feasibility in select patients. In response to expanding use and persistent knowledge gaps, this American Heart Association Science Advisory aimed to (1) define the rationale and evolving indications for percutaneous mechanical aspiration in right-sided infective endocarditis, (2) summarize the available clinical evidence and technical considerations, (3) provide expert consensus on patient selection and procedural planning, and (4) identify priorities for future prospective investigation.

Key Words: AHA Scientific Statements ■ aspiration, mechanical ■ infective endocarditis ■ injection drug use ■ people who inject drugs ■ tricuspid valve

The incidence of right-sided infective endocarditis (RSIE) has markedly increased, largely driven by an escalating number of people who inject drugs (PWID) and an aging population with prior cardiovascular implantable electronic device (CIED) placement.¹ This shifting epidemiology presents new challenges to the traditional management paradigm, which has long centered on prolonged antimicrobial therapy and surgical intervention when indicated.² PWID with RSIE are typically younger and have fewer comorbidities but face high rates of recurrent infection, early prosthetic valve infection due to ongoing substance use, and premature mortality.³ Conversely, older adults with

CIED-related infections frequently present with significant frailty and comorbid conditions that limit surgical options.⁴ These 2 patient populations underscore the limitations of existing strategies and highlight the urgent need for alternative, nonsurgical therapies.

Percutaneous mechanical thrombectomy, originally designed for treatment of pulmonary embolism, uses aspiration systems to extract thrombotic material. This technique has been adapted for off-label use in RSIE as percutaneous mechanical aspiration (PMA), particularly to debulk large, friable vegetations on damaged endocardial surfaces or intracardiac devices.⁵ These vegetations arise through a cascade of platelet and

Supplemental material is available with this article at <https://www.ahajournals.org/doi/suppl/10.1161/jaha.126.050115>

© 2026 The Author(s). Published on behalf of the American Heart Association, Inc., by Wiley. This is an open access article under the terms of the [Creative Commons Attribution-NonCommercial-NoDerivs](#) License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

JAHA is available at: www.ahajournals.org/journal/jaha

fibrin deposition, forming biofilms that protect pathogens from immune clearance and hinder antimicrobial penetration, often resulting in persistent infection.⁶ The rationale for PMA is rooted in the principle of source control. By mechanically reducing and disrupting the architecture of a vegetation, PMA aims to enhance antimicrobial efficacy and reduce the risk of septic and pulmonary embolization.⁵ Although current evidence is limited to case reports, small series, and registry data, the 2023 European Society of Cardiology guidelines provide a class IIb recommendation for PMA in select high-risk patients with right-sided intra-atrial septic masses.⁷

Despite increasing clinical adoption and recent inclusion in society guidelines, PMA remains variably implemented. Significant heterogeneity exists across medical, surgical, and procedural specialties on awareness, patient selection, timing of intervention, device choice, procedural technique, and perioperative management. Critical knowledge gaps persist, including limited data on procedural outcomes, microbiologic clearance, and postprocedural care. No professional society has yet issued a formal advisory on PMA use in RSIE. The United States leads in clinical experience with PMA; therefore, it is both timely and appropriate for the American Heart Association to provide a formal perspective on the role of PMA in select patients with RSIE.

Accordingly, this American Heart Association Science Advisory aims to: (1) clarify the rationale and evolving indications for PMA in RSIE; (2) review the current evidence and procedural considerations; (3) provide expert consensus on patient selection, device use, and procedural safety; and (4) identify ongoing uncertainties and research priorities. This Science Advisory is intended to guide clinicians, interventionalists, infectious disease specialists, and multidisciplinary endocarditis teams as they navigate the expanding role of PMA in contemporary RSIE management.

CURRENT UNDERSTANDING OF RSIE

RSIE accounts for approximately 10% of all endocarditis cases and presents with distinct pathophysiologic and clinical features.⁸ Despite advancements in antimicrobial therapy and surgical techniques, outcomes remain poor in high-risk populations. In PWID, RSIE is associated with recurrent infection, pulmonary complications, and poor long-term survival. Although in-hospital mortality may be low ($\approx 1.8\%$), 1-year mortality approaches 21%, and 5-year mortality exceeds 65%, often driven by reinfection, accumulated complications from recurrent illness, relapse and overdose of substance use, and poor follow-up adherence.⁹ Similarly, CIED-related RSIE poses substantial challenges; transvenous lead

extraction, a cornerstone of effective management, is performed in only a minority of cases, and mortality is significantly higher among patients who do not undergo device removal (10.6% versus 6.8%).¹⁰

These poor outcomes have prompted a reassessment of conventional RSIE management. Emerging data support earlier intervention in patients with high-risk features, such as persistent bloodstream infection, despite appropriate antimicrobial therapy,¹¹ vegetation size >20 mm,¹² recurrent septic pulmonary emboli,^{13,14} and heart failure due to valvular damage.⁸ Although current guidelines recommend surgery when feasible,^{2,7} recent studies, including a randomized trial in younger patients, suggest that early surgical intervention may improve outcomes if performed before complications develop.¹⁵ Notably, persistent *Staphylococcus aureus* bacteremia beyond 24 hours, common in both PWID and CIED-infective endocarditis has been independently associated with increased mortality.¹¹ Septic embolism has been a strong predictor of adverse outcomes.⁷ These findings reinforce the clinical imperative for timely intervention and effective source control, whether through surgical management, the most established option for patients with RSIE who meet operative criteria, or through PMA in suboptimal surgical candidates or as a bridge to surgery in select cases.

CURRENT UNDERSTANDING OF PMA IN RSIE

PMA Technique and Devices

PMA for RSIE is typically performed under combined fluoroscopic and echocardiographic guidance, allowing real-time visualization to optimize catheter positioning, maximize vegetation debulking, and minimize procedural complications (Figure 1). A variety of aspiration systems have been used off-label, each differing in catheter size, aspiration force, blood reinfusion capability, and overall procedural complexity, which significantly influences preprocedural planning, operator familiarity, and institutional feasibility.⁵ Understanding the advantages and limitations of each platform is essential for tailoring PMA to individual patient needs and institutional capabilities in the management of RSIE.

PMA platforms are broadly categorized into continuous-flow and noncontinuous-flow systems. The AngioVac system (AngioDynamics, Latham, NY), the only commercially available continuous-flow device, has been the most widely studied in RSIE.⁵ It uses a veno-venous extracorporeal bypass circuit with 2 large-bore venous access sites: 1 for aspiration and 1 for reinfusion, and a filter. This design enables high-volume, uninterrupted aspiration of blood and vegetation while minimizing blood loss. Given a similar setup to extracorporeal membrane oxygenation, its use necessitates a perfusionist and a

more complex setup, which may limit implementation in centers without dedicated support teams.

In contrast, noncontinuous-flow systems, such as AlphaVac (AngioDynamics), FlowTriever (Inari Medical), and Lightning (Penumbra), use single-access designs without extracorporeal circulation, offering logistical simplicity. These devices require direct catheter contact with the vegetations and deliver intermittent suction, factors that may increase the risk of embolization. Additionally, some systems lack a mechanism for blood reinfusion, contributing to procedural blood loss.⁵

Continuous-flow systems offer sustained aspiration and better control of suction forces, potentially reducing embolization, but at the cost of procedural complexity, large-bore access, and theoretical risks such as tricuspid valve injury or difficulty navigating into the pulmonary arteries in case of embolization. In contrast, non-continuous-flow systems simplify access and navigation into the pulmonary arteries but may sacrifice suction consistency, blood conservation, and embolic protection.

PMA IN RSIE: CURRENT EVIDENCE, LIMITATIONS, AND EVOLVING OF ROLE

Early Data and Clinical Applications

Early use of PMA was limited to salvage scenarios for high-risk patients lacking viable medical or surgical alternatives.^{16,17} Since its first reported use in

2013,¹⁸ adoption of PMA has spread across the United States,¹⁹ supported by early data from case reports, small series, and limited registries demonstrating technical feasibility and procedural success in carefully selected patients (Supplementary Figure 1).^{16,17,20–28} These early applications largely mirrored surgical indications, including persistent bloodstream infection, septic pulmonary emboli, and large vegetations (>20mm), particularly in patients with CIED infections or PWID-associated infective endocarditis.^{16,17,20–28} Throughout these early reports, PMA has consistently achieved procedural success, typically defined as $\geq 70\%$ reduction in vegetation size or a residual size ≤ 1 cm.^{16,17,20–28}

With broader adoption, PMA has transitioned from salvage to a therapeutic alternative. A recent propensity-matched analysis in PWID with tricuspid valve endocarditis demonstrated outcomes comparable with surgery, including similar 1-month mortality and 1-year rates of heart failure and tricuspid regurgitation.²⁹ These findings support the use of PMA in lieu of surgery or as a staged approach preceding valve surgery in case of valve damage or persistent infection.^{16,17} In PWID-associated RSIE, tricuspid valve damage is often hemodynamically tolerated. In this context, PMA may offer timely source control, facilitate clinical stabilization, allow for addiction treatment initiation, and potentially reduce the risk of prosthetic valve reinfection by deferring surgery until after addiction rehabilitation.⁵

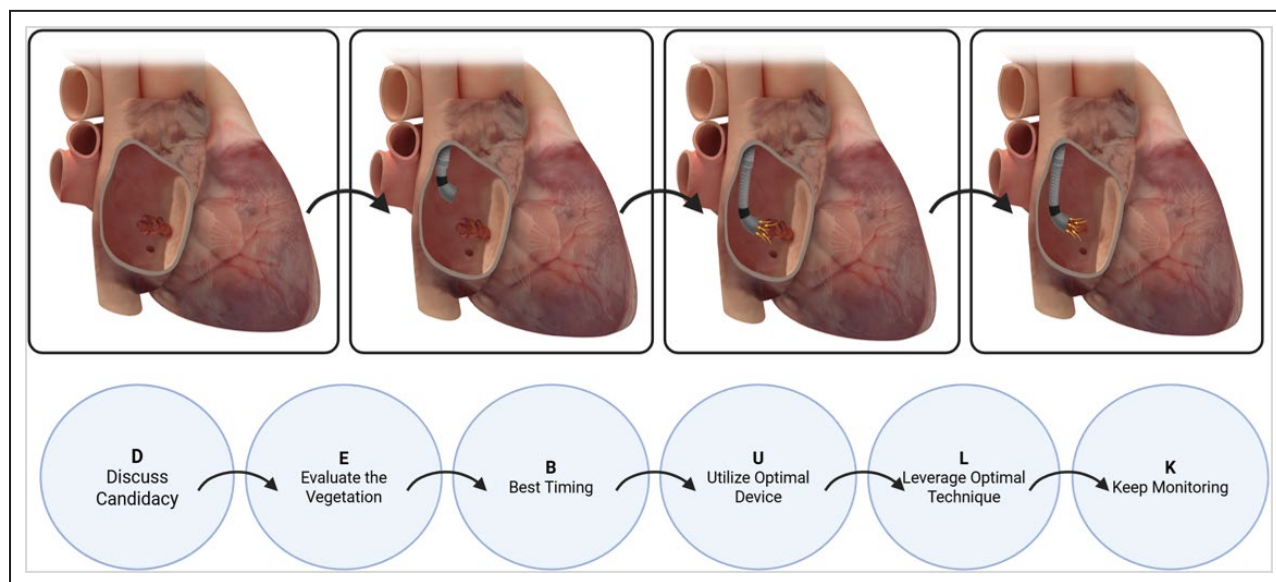


Figure 1. Percutaneous mechanical aspiration in right-sided infective endocarditis.

Upper panel: The procedure involves careful imaging-guided alignment of the aspiration catheter with the target vegetation, followed by initiation of aspiration flow to achieve maximal debulking. Lower panel: Structured approach to percutaneous mechanical aspiration in right-sided infective endocarditis: The DEBULK (Discuss candidacy, Evaluate the vegetation, Best timing, Utilize optimal device, Leverage optimal technique, Keep monitoring) Framework.

Beyond debulking, PMA has provided diagnostic usefulness through microbiologic analysis of aspirated material, especially in cases of blood culture-negative or polymicrobial endocarditis, to guide antimicrobial therapy.⁵ Additionally, PMA may facilitate source control in patients with persistent bloodstream infection or recurrent embolization despite appropriate antimicrobial treatment. It has also been used in cases of CIED infection with large lead-associated vegetations, where pre-extraction debulking may reduce embolic risk and facilitate safer transvenous lead removal.^{21,25,26}

Early experience has highlighted several procedural risks, including vascular injury, access site complications, and rare instances of cardiac perforation.^{16,17,20–28} Worsening tricuspid regurgitation has been observed, potentially reflecting an unmasking of underlying leaflet or chordal injury or direct device-related trauma.^{16,17,20–28} Dislodgement of infected material has posed a risk for distal embolization, including septic pulmonary emboli and paradoxical embolism in patients with patent foramen ovale.^{5,26} Another important concern has been the potential for transient or sustained worsening of sepsis due

to vegetation disruption, particularly in patients presenting with baseline shock, highlighting the critical need for initiating appropriate antimicrobial therapy before intervention.^{20,26} Early series and registry data are summarized in [Tables 1 and 2](#).

Meta-Analyses and Administrative Data Set Analyses

Four meta-analyses have attempted to synthesize the available data on PMA in RSIE, consistently reporting high procedural success rates and acceptable safety profiles.^{30–33} However, their interpretability has been constrained by significant methodological limitations. The included studies are predominantly retrospective, heterogeneous in design, and frequently unpublished or available only in abstract form. For example, in the analysis by Kim et al, 4 of 5 studies were available in abstract form, raising concerns about data completeness, quality, and reproducibility.³¹ Many of these meta-analyses included case reports and small series, which are inherently prone to selection and publication bias and often omit procedural failures. Additional limitations include

Table 1. Summary of Published Case Series of PMA in RSIE

First author	Center/country	Study period	N	Predominant patient population	Vegetation size	Devices used	Follow-up	Procedural success	Complications
Zhang et al ²⁸	New York University/USA	2020–2022	29	PWID	24±7.6mm	AngioVac	181 d	96.6%	Death: 6.9% TVR: 0%
Stantland et al ¹⁷	Indiana University/USA	2014–2020	32	PWID	32 mm	AngioVac	60 d	90.6%	TVR: 16.5% Bleeding: 3%
George et al ¹⁶	University of Kentucky/USA	2017	33	PWID	21.2±7 mm	AngioVac	In-hospital	100%	Death: 9% TVR: 9% Major bleeding: 3%
Akhtar et al ²⁰	Tennova Heart Institute/USA	2017–2019	25	PWID	24 mm	Penumbra	1 mo	88%	Death: 12% (worsening septic shock) Transfusion: 28%
Schaerf et al ²⁵	Providence St. Joseph Medical Center/USA	2016	20	CIED	36 mm	AngioVac	In-hospital	100% 100% lead extraction	Iliac vein injury: 5%
Godara et al ²¹	Ohio State University/USA	2015–2016	8	CIED	22–41 mm	AngioVac	In-hospital	88% 100% lead extraction	None related to PMA, open surgery due to extraction complication, blood transfusion: 50%
Tarzia et al ²⁷	University of Padua/Italy	2016–2022	13	CIED	37.2 mm	AngioVac	In-hospital	92.3% 100% lead extraction	1 cardiac perforation
Modi et al ²²	Emory University/USA	2010–2022	16	PWID and CIED	25.2 mm	AngioVac	473±604		0 In-hospital death 12.5% at F/U Transfusion: 37.5% Recurrence of IE: 37.5%

CIED indicates cardiovascular implantable electronic device; F/U, follow up; IE, infective endocarditis; PMA, percutaneous mechanical aspiration; PWID, people who inject drugs; and TVR, tricuspid valve replacement.

Table 2. Summary of Published Registries of PMA in RSIE

First author	Center/country	Study period	N	Predominant patient population	Vegetation size	Devices used	Follow-up	Procedural success	Complications
Moriarty et al ²³	Multicenter registry	2016–2019	59	All RSIE	...	AngioVac	In-hospital	75%	Death: 1.3% Distal embolization: 3% Major bleeding: 2.6%
Starck et al ²⁶	Multicenter registry	2014–2018	101	CIED	30.7±13.5 mm	AngioVac	30 d	Successful PMA: 94% Lead extraction: 99.2%	Death: 3% Distal embolization: 1%
Reddy et al ²⁴	Multicenter registry	2017–2022	177	PWID	21.5±9.1 mm	AngioVac	In-hospital	...	Postop surgery: 1.6% Tamponade: 0.5% New PE: 0.5% Mortality 1.1% Worsening TR: 21.4%
El Sabbagh et al ³⁵	Multicenter registry	2014–2024	256	PWID and CIED	24 mm	AngioVac, AlphaVac, Penumbra, Inari	6 wk	89.4%	Composite of in-hospital mortality, new PE, emergency surgery: 18% Worsening tricuspid regurgitation: 15%

CIED indicates cardiovascular implantable electronic device; PE, pulmonary embolism; PMA, percutaneous mechanical aspiration; PWID, people who inject drugs; RSIE, right-sided infective endocarditis; and TR, tricuspid regurgitation.

variability in pathogens, procedural techniques, and operator experience; inconsistent definitions of success and adverse events; and sparse reporting of long-term outcomes. Collectively, these findings underscore a growing interest in PMA but highlight the urgent need for prospective, standardized studies to more rigorously define its safety, efficacy, and clinical role.

Complementary analyses using administrative databases have provided additional, albeit indirect, insights. Two such studies reported shorter hospital stays and potentially lower mortality in patients undergoing PMA compared with tricuspid valve surgery.^{19,34} Nonetheless, the absence of clinical detail, susceptibility to miscoding, and inability to capture procedural nuances limit the usefulness of these data in informing patient selection or procedural strategy. Published meta-analyses and administrative database registry studies are summarized in Table 3.

Contemporary Multicenter Registry Data

The CLEAR-IE (Cardiac Lesion Extraction and Aspiration Registry for Infective Endocarditis) study represents the largest multicenter registry to date, capturing real-world PMA use across 19 US centers. The cohort included patients with large vegetations, persistent *S aureus* bacteremia, septic pulmonary embolism, and high rates of injection drug use and CIED-related infections.

PMA achieved a high procedural success rate (89.4%), defined as a ≥70% reduction in vegetation size or a residual size ≤1 cm.³⁵ Most cases were performed

for persistent sepsis or recurrent embolization. In-hospital adverse events included death (9.8%), new pulmonary embolism (8.3%), worsening tricuspid regurgitation (15%), emergency surgery (3.2%), pericardial tamponade (2.5%), and vascular complications (3.8%).³⁵ Despite these risks, 86.9% of patients experienced no major procedural complications, and no intraprocedural deaths occurred. Most deaths occurred approximately 1 week postprocedure and were attributed to progression of the underlying infection. Hypoxia and septic shock at baseline were associated with increased risk, whereas worsening tricuspid regurgitation was not linked to mortality.³⁵

These findings support the feasibility of PMA in select patients with RSIE and underscore the need for prospective controlled studies. Limitations of the registry include its observational design, lack of a comparator group, absence of core event adjudication, and procedural heterogeneity across sites.

Guideline Statements

Despite increasing use, PMA remains underrepresented in major societal guidelines. The 2015 American Heart Association Scientific Statement addressing diagnosis and treatment of infective endocarditis did not mention PMA²; however, a 2022 American Heart Association Scientific Statement on PWID-related infective endocarditis³ and a 2024 Scientific Statement on CIED infection⁴ both acknowledged its potential role and emphasized the need for prospective trial data.

Table 3. Summary of Published Systematic Reviews, Meta-Analyses, and Administrative Database Analyses of PMA in RSIE

Study author	Study type	N	Study period	Predominant population	Vegetation size	Device	Main findings	Complications	Comments
Rusia et al ³³	Systematic review and meta-analysis	88	2013–2018	CIED	27.8 mm	AngioVac	Procedural success: 97.7% Lead extraction: 98.9%	Rate: 4.5% None attributed to AngioVac2 vascular injuries, 1 coronary sinus injury, and 1 tricuspid valve injury	Included case reports
Mhanna et al ³²	Systematic review and meta-analysis	301	2013–2022	PWID and CIED	28 cm	AngioVac	Procedural success: 89.2% Overall survival: 89.7%	2 cardiac tamponade 1 coronary sinus ostium tear (extraction) 1 hemothorax 2 access site bleeding 1 RP bleed 2 femoral vein injuries	Included case reports
Gill et al ³⁰	Systematic review and meta-analysis	232	2013–2022	PWID and CIED	...	AngioVac and Penumbra	Procedural success PWID: 97% and CIED: 100%	In-hospital mortality: 14% Worsening TR: 14%; Blood transfusion, 37% TV surgery, 3%	...
Kim et al ³¹	Systematic review and meta-analysis	431	2012–2023	PWID and CIED	...	AngioVac and Penumbra	...	Procedural mortality, 30 d and 1 y similar to surgery, shorter hospital stay, reduced costs	Included abstracts
Malik et al ³⁴	Administrative database	1085 hospitalizations with PMA	2016–2020	PWID and CIED	...	...	Increasing trend of PMA use Procedural success: 91%	In-hospital mortality: 4.6%; Readmission for IE: 18%	Administration database
Haddad et al ¹⁹	Administrative database	1675 Hospitalizations with PMA	2016–2020	PWID and CIED	...	...	Increasing trend of PMA use	In-hospital mortality: 6%	Administration database

CIED indicates cardiovascular implantable electronic device; IE, Infective endocarditis; PMA, percutaneous mechanical aspiration; PWID, people who inject drugs; RSIE, right-sided infective endocarditis; RP, retroperitoneal; TR, tricuspid regurgitation; and TV, tricuspid valve.

As cited previously, the 2023 European Society of Cardiology guidelines assigned PMA a class IIb recommendation (level C) for right-sided PMA in high-surgical-risk patients.⁷

CURRENT POSITION

Structured Approach to PMA in RSIE

The optimal role of PMA in RSIE remains to be established through prospective studies; however, growing clinical experience, encouraging outcomes from contemporary

multicenter registries, and emerging support in professional guidelines warrant the development of a structured framework for its safe and effective integration of PMA into clinical practice with sponsorship by the American Heart Association (Figure 1 and Figure 2). The writing group proposes the DEBULK (Discuss candidacy, Evaluate the vegetation, Best timing, Utilize optimal device, Leverage optimal technique, Keep monitoring) framework, informed by the collective experience and findings from emerging data, as a pragmatic, expert-derived construct to assist in considerations of patient selection, procedural planning, and postprocedural care. This framework reflects current

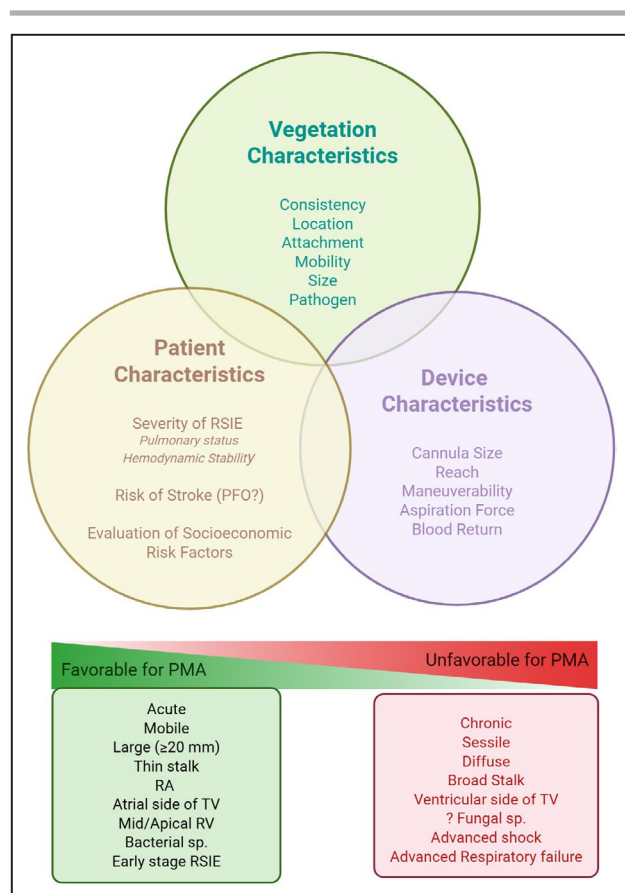


Figure 2. Patient selection for percutaneous mechanical aspiration in RSIE.

Precise patient selection depends on anatomical, clinical, and device-related characteristics. PFO indicates patent foramen ovale; PMA, percutaneous mechanical aspiration; RA, right atrium; RSIE, right-sided infective endocarditis; RV, right ventricle; and TV, tricuspid valve.

practice patterns rather than evidence from prospective observational studies or randomized trials and is intended to provide context and structure for clinical decision-making until additional data and formal consensus methodologies become available.

D: Discuss Candidacy

Decisions on PMA candidacy rest on robust multidisciplinary discussions. The implementation of dedicated endocarditis teams, typically available at tertiary care centers, is encouraged, regardless of institutional PMA volume.³⁶ These teams often include cardiology, infectious diseases, cardiac surgery, electrophysiology (for CIED-related infective endocarditis), addiction medicine, psychiatry, social work, and case management to address the complex clinical and psychosocial dimensions of RSIE. The team evaluates clinical indications, assesses procedural futility, and ensures holistic care. This discussion also considers the appropriateness of

PMA, surgery, or a staged approach, integrating clinical, anatomical, and psychosocial factors to individualize management decisions. Typical indications to proceed with PMA include large vegetation (>20 mm) at risk of embolization, persistent sepsis, or recurrent pulmonary emboli despite appropriate antibiotics. In addition, PMA may also serve as a bridge to definitive therapy, providing a window for infection control, clinical stabilization, and in PWID, engagement in addiction rehabilitation before proceeding with valve intervention. PMA is unlikely to confer benefit in patients with refractory septic shock or severe hypoxemia due to recurrent septic emboli. Appropriately targeted intravenous antibiotic therapy should be initiated before the procedure.

E: Evaluate the Vegetation

Anatomic feasibility is critical to procedural success. Vegetation assessment includes size, location, mobility, attachment, and consistency. Optimal targets for PMA are large, soft, mobile vegetations located on the atrial surface of the tricuspid valve or in the middle right ventricle. In contrast, subvalvular vegetations or those with diffuse, chronic morphology are less favorable.

B: Best Timing

Timely intervention is essential to maximize benefit, particularly in patients with high-risk features such as large vegetations (>20 mm), septic pulmonary emboli, or persistent bloodstream infection. In infections caused by aggressive pathogens such as *S aureus*, earlier intervention (within 5 days) with PMA before significant endocarditis complications occur, may be beneficial, because delays are associated with adverse outcomes in observational studies.¹¹

U: Utilize Optimal Device

Device selection is typically tailored to optimize debulking and minimize embolic risk. For vegetations ≥ 2 cm with thin stalks and high mobility, continuous-flow aspiration systems may be preferred due to their large lumen and capacity for flow-mediated capture from a distance. Operator experience and local resources may also influence device choice. In centers without perfusion support, experienced operators may consider noncontinuous-flow systems for select anatomies, though caution is warranted when treating large or complex vegetations.

L: Leverage Optimal Technique

Intraprocedural success depends on adequate imaging, catheter control, and aspiration technique. The imaging modality should provide optimal visualization of vegetation and tricuspid valve pre- and postprocedure, most commonly transesophageal echocardiography, although intracardiac echocardiography may be used

when appropriate. Patent foramen ovale screening is advised in all patients, with consideration of cerebral embolic protection when shunting is present. Anesthesia type can be individualized based on patient stability, access site, and imaging modality, for example, general anesthesia may be considered for patients with respiratory compromise or anticipated transesophageal echocardiography use. PMA procedures are best performed by operators with expertise in endovascular or structural heart catheter-based interventions. Venous access (femoral versus internal jugular) can be chosen based on trajectory and ability to achieve coaxial alignment of the aspiration catheter with the vegetation. Assembling catheters away from a vegetation and initiating aspiration flow before vegetation engagement may help reduce embolic risk. Procedural targets generally include $\geq 70\%$ debulking or residual vegetation < 1 cm, with operators aiming to achieve as complete a removal as safely possible based on anatomic and procedural considerations. All retrieved specimens should be handled under sterile conditions and submitted for culture.

K: Keep Monitoring

Postprocedural management includes ongoing intravenous antimicrobials (typically for 6 weeks), hemodynamic monitoring, and serial blood cultures to confirm clearance. Transient hypotension or low-grade fever is common and generally self-limited. In patients with new or worsening respiratory symptoms, imaging such as cardiac computed tomography may be considered to evaluate for procedure-related pulmonary embolism. Discharge planning often involves coordination of outpatient parenteral antibiotic therapy and consideration of addiction support services for PWID. Repeat imaging and blood cultures following completion of antimicrobial therapy may help confirm resolution.

FUTURE DIRECTIONS

PMA's precise position within the treatment algorithm remains to be fully delineated. In some cases, PMA may serve as a bridge to surgery; in others, it may offer definitive therapy for patients with persistent bloodstream infection despite appropriate antimicrobial therapy.

Although conventional guidelines advocate for intervention following 5 to 7 days of persistent bacteremia or the development of complications such as embolization or valvular destruction, the concept of preemptive aspiration, guided by vegetation size, mobility, or high-risk clinical features, seeks to reduce the pathogen burden and avert structural and systemic complications before they occur with

clinical deterioration. This strategy remains investigational, and the optimal timing, selection criteria, and outcomes of early intervention warrant prospective evaluation.

To advance the field, a pragmatic, prospective, single-arm observational trial is warranted to evaluate the safety, feasibility, and to further refine the definition of procedural success of PMA in a well-defined patient population. Although randomized controlled trials remain the ultimate objective, an initial focused study could provide essential groundwork. An appropriate early cohort would include patients who are not surgical candidates and who have bloodstream infection for ≥ 72 hours despite appropriate antimicrobial therapy or present with septic pulmonary embolism. Clinically meaningful surrogate end points including time to blood culture clearance or resolution of systemic manifestations of ongoing infection could be considered. Procedural success has typically been defined as $\geq 70\%$ reduction in vegetation size or a residual vegetation < 1 cm; however, these are empirically derived thresholds from an early experience that provide practical procedural guidance yet need prospective validation against clinical outcomes. Establishing safety and feasibility in this high-risk group would provide the necessary rationale for future RCTs powered to assess definitive clinical outcomes.

Prospective studies should also stratify by clinical phenotype. PWID and patients with CIED present 2 distinct challenges. PWID often have more aggressive infection and are prone to early discharge, whereas patients with CIED carry higher comorbidity burdens and require complex extraction strategies. Similarly, patients with aggressive pathogens such as *S aureus* may warrant separate consideration, because their risk profile and therapeutic response may differ from patients with more indolent infection. Although this advisory is limited to RSIE, future investigation may explore whether PMA has a role in left-sided endocarditis. At present, current data should not be extrapolated, because left-sided aspiration carries unique procedural challenges and risks, including systemic embolization and hemodynamic consequences. Dedicated studies will be necessary to determine the safety, feasibility, and potential role of PMA in left-sided disease.

In summary, PMA represents a promising therapeutic strategy for the management of RSIE. We propose that there is sufficient evidence and growing support from professional societies and clinical guidelines for continued integration into clinical practice in select cases where conventional therapies are limited. Ultimately, rigorous prospective trials will be essential in defining its role within a therapeutic algorithm.

ARTICLE INFORMATION

The American Heart Association makes every effort to avoid any actual or potential conflicts of interest that may arise as a result of an outside relationship or a personal, professional, or business interest of a member of the writing panel. Specifically, all members of the writing group are required to complete and submit a Disclosure Questionnaire showing all such relationships that might be perceived as real or potential conflicts of interest.

This statement was approved by the American Heart Association Science Advisory and Coordinating Committee on December 3, 2025, and the American Heart Association Executive Committee on March 2, 2026. A copy of the document is available at <https://professional.heart.org/statements> by using either "Search for Guidelines & Statements" or the "Browse by Topic" area.

The American Heart Association requests that this document be cited as follows: El Sabbagh A, Yucel E, Sethi SS, El-Chami MF, Mattos SS, Estes BA, Zwischenberger BA, Moriarty JM, Andrew SP. Sharp ASP, Baddour LM; on behalf of the American Heart Association Council on Lifelong Congenital Heart Disease and Heart Health in the Young; and Council on Clinical Cardiology. Percutaneous mechanical aspiration in patients with right-sided infective endocarditis: a science advisory from the American Heart Association. *J Am Heart Assoc.* 2026;15:e050115. doi:10.1161/jaha.126.050115

The expert peer review of AHA-commissioned documents (eg, scientific statements, clinical practice guidelines, systematic reviews) is conducted by the AHA Office of Science Operations. For more on AHA statements and guidelines development, visit <https://professional.heart.org/statements>. Select the "Guidelines & Statements" drop-down menu, then click "Publication Development."

Writing Group Disclosures

Writing group member	Employment	Research grant	Other research support	Speakers' bureau/honoraria	Expert witness	Ownership interest	Consultant/advisory board	Other
Larry M. Baddour	Mayo Clinic	None	None	None	None	None	None	None
Abdallah El Sabbagh	Mayo Clinic	None	None	None	None	None	None	None
Mikhael F. El-Chami	Emory University	None	None	None	None	None	Medtronic [†] ; Boston Scientific*	None
Bailey Ann Estes	Hendrick Medical Center	None	None	Shockwave Medical*	None	None	Shockwave Medical*	Alleviant Medical (Site Manager, Clinical Liaison) [†]
Sandra S. Mattos	Real Hospital Portugues (Brazil)	None	None	None	None	None	None	None
John M. Moriarty	UCLA Health	None	Penumbra, Inc. [†]	None	None	None	Angiodynamics, Inc. [†] ; Abiomed [†] ; Stryker [†] ; Imperative Care [†] ; Innova Vascular [†] ; Penumbra, Inc. [†] ; Siemens Medical Solutions USA, Inc. [†] ; Imperative Care, Inc. [†] ; Inari Medical, Inc.*	None
Sanjum S. Sethi	Columbia University. Irving Medical Center	None	AngioDynamics, Inc. [†] ; Penumbra, Inc. [†] ; Boston Scientific Corp. [†] ; Inari Medical, Inc. [†]	None	None	None	Inari [†] ; Angiodynamics [†] ; Penumbra [†] ; Boston Scientific [†]	None
Andrew S. P. Sharp	University College Dublin College of Health and Agricultural Sciences School of Medicine (Ireland)	None	None	Medtronic [†] ; Boston Scientific [†] ; Philips [†] ; Recor Medical [†] ; Penumbra [†] ; Angiodynamics [†]	None	Althea Medical [†]	Boston Scientific [†] ; Medtronic [†] ; Recor Medical [†] ; Philips [†] ; Angiodynamics [†] ; Penumbra [†]	Boston Scientific (Senior Medical Director) [†]
Evin Yucel	Massachusetts General Hospital	None	None	None	None	None	None	None
Brittany A. Zwischenberger	Duke University	None	None	None	None	None	None	None

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives \$5000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns \$5000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

[†]Significant.

Reviewer Disclosures

Reviewer	Employment	Research grant	Other research support	Speakers' bureau/ honoraria	Expert witness	Ownership interest	Consultant/ advisory board	Other
Andrew Fagan	University of Manitoba (Canada)	None	None	None	None	None	None	None
Maisha Maliha	University of Oklahoma	None	None	None	None	None	None	None
J. Hunter Mehaffey	West Virginia University	None	None	None	None	None	None	None
Matthew McAuliffe	Baystate Health	None	None	None	None	None	None	None
Mohammed Qintar	Henry Ford Hospital	None	None	None	None	None	None	None

This table represents the relationships of reviewers that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all reviewers are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives \$5000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns \$5000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

REFERENCES

- 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:e017293. doi: [10.1161/JAHA.120.017293](https://doi.org/10.1161/JAHA.120.017293)
- Baddour LM, Wilson WR, Bayer AS, Fowler VG Jr, Tleyjeh IM, Rybak MJ, Barsic B, Lockhart PB, Gewitz MH, Levison ME, et al. Infective endocarditis in adults: diagnosis, antimicrobial therapy, and management of complications: a scientific statement for healthcare professionals from the American Heart Association. *Circulation.* 2015;132:1435–1486. doi: [10.1161/CIR.0000000000000296](https://doi.org/10.1161/CIR.0000000000000296)
- Baddour LM, Weimer MB, Wurcel AG, McElhinney DB, Marks LR, Fanucchi LC, Esquer Garrigos Z, Pettersson GB, DeSimone DC; on behalf of the American Heart Association Rheumatic Fever, Endocarditis and Kawasaki Disease Committee of the Council on Lifelong Congenital Heart Disease and Heart Health in the Young; Council on Cardiovascular Surgery and Anesthesia; Council on Cardiovascular and Stroke Nursing; Council on Clinical Cardiology; and Council on Peripheral Vascular Disease. Management of Infective Endocarditis in people who inject drugs: a scientific statement from the American Heart Association. *Circulation.* 2022;146:e187–e201. doi: [10.1161/CIR.0000000000001090](https://doi.org/10.1161/CIR.0000000000001090)
- Agarwal S, Qamar U, Patel HP, Abideen Asad ZU, Munir MB, Kowligi GN, Lee JZ, Tan NY, Sugrue A, Mulpuru SK, et al. Association of frailty with outcomes of patients undergoing transvenous lead removal for cardiac implantable electronic device infections in the United States. *Heart Rhythm.* 2025;22:3107–3112. doi: [10.1016/j.hrthm.2025.03.1973](https://doi.org/10.1016/j.hrthm.2025.03.1973)
- El Sabbagh A, Yucel E, Zlotnick D, Moriarty JM, Younes S, Hamid N, Akhtar Y, Baddour LM, O'Gara P, Starck C, et al. Percutaneous mechanical aspiration in infective endocarditis: applications, technical considerations, and future directions. *J Soc Cardiovasc Angiogr Interv.* 2024;3:101269. doi: [10.1016/j.jscvi.2023.101269](https://doi.org/10.1016/j.jscvi.2023.101269)
- Werdan K, Dietz S, Löffler B, Niemann S, Bushnaq H, Silber RE, Peters G, Müller-Werdan U. Mechanisms of infective endocarditis: pathogen-host interaction and risk states. *Nat Rev Cardiol.* 2014;11:35–50. doi: [10.1038/nrcardio.2013.174](https://doi.org/10.1038/nrcardio.2013.174)
- Delgado V, Ajmone Marsan N, de Waha S, Bonaros N, Brida M, Burri H, Caselli S, Doenst T, Ederhy S, Erba PA, et al. 2023 ESC guidelines for the management of endocarditis. *Eur Heart J.* 2023;44:3948–4042. doi: [10.1093/eurheartj/ehad193](https://doi.org/10.1093/eurheartj/ehad193)
- Akinosoglou K, Apostolakis E, Marangos M, Pasvol G. Native valve right sided infective endocarditis. *Eur J Intern Med.* 2013;24:510–519. doi: [10.1016/j.ejim.2013.01.010](https://doi.org/10.1016/j.ejim.2013.01.010)
- Javorski MJ, Rosinski BF, Shah S, Thompson MA, Streem D, Gordon SM, Insler S, Houghtaling PL, Griffin B, Blackstone EH, et al. Infective endocarditis in patients addicted to injected opioid drugs. *J Am Coll Cardiol.* 2024;83:811–823. doi: [10.1016/j.jacc.2023.12.016](https://doi.org/10.1016/j.jacc.2023.12.016)
- Sciria CT, Kogan EV, Mandler AG, Yeo I, Simon MS, Kim LK, Ip JE, Liu CF, Markowitz SM, Lerman BB, et al. Low utilization of Lead extraction among patients with infective endocarditis and implanted cardiac electronic devices. *J Am Coll Cardiol.* 2023;81:1714–1725. doi: [10.1016/j.jacc.2023.02.042](https://doi.org/10.1016/j.jacc.2023.02.042)
- Minejima E, Mai N, Bui N, Mert M, Mack WJ, She RC, Nieberg P, Spellberg B, Wong-Beringer A. Defining the breakpoint duration of *Staphylococcus aureus* bacteremia predictive of poor outcomes. *Clin Infect Dis.* 2020;70:566–573. doi: [10.1093/cid/ciz257](https://doi.org/10.1093/cid/ciz257)
- Martin-Davila P, Navas E, Fortun J, Moya JL, Cobo J, Pintado V, Quereda C, Jimenez-Mena M, Moreno S. Analysis of mortality and risk factors associated with native valve endocarditis in drug users: the importance of vegetation size. *Am Heart J.* 2005;150:1099–1106. doi: [10.1016/j.ahj.2005.02.009](https://doi.org/10.1016/j.ahj.2005.02.009)
- Durante-Mangoni E, Ursi MP, Andini R, Mattucci I, Della Ratta EE, Iossa D, Bertolino L, De Vivo S, Manduca S, Torella M, et al. Long-term outcome of infective endocarditis involving cardiac implantable electronic devices: impact of comorbidities and Lead extraction. *J Clin Med.* 2022;11:7357. doi: [10.3390/jcm11247357](https://doi.org/10.3390/jcm11247357)
- Siddiqui E, Alviar CL, Ramachandran A, Flattery E, Bernard S, Xia Y, Nayar A, Keller N, Bangalore S. Outcomes after tricuspid valve operations in patients with drug-use infective endocarditis. *Am J Cardiol.* 2022;185:80–86. doi: [10.1016/j.amjcard.2022.08.033](https://doi.org/10.1016/j.amjcard.2022.08.033)
- Kang DH, Kim YJ, Kim SH, Sun BJ, Kim DH, Yun SC, Song JM, Choo SJ, Chung CH, Song JK, et al. Early surgery versus conventional treatment for infective endocarditis. *N Engl J Med.* 2012;366:2466–2473. doi: [10.1056/NEJMoa1112843](https://doi.org/10.1056/NEJMoa1112843)
- George B, Voelkel A, Kotter J, Leventhal A, Gurley J. A novel approach to percutaneous removal of large tricuspid valve vegetations using suction filtration and veno-venous bypass: a single center experience. *Catheter Cardiovasc Interv.* 2017;90:1009–1015. doi: [10.1002/ccd.27097](https://doi.org/10.1002/ccd.27097)
- Scantland J, Hendrix J, Schmitz A, Casciani T, Butty S. Clinical efficacy of percutaneous Vegetectomy in tricuspid and right-heart indwelling device infective endocarditis. *Angiology.* 2022;74:33197221121009. doi: [10.1177/00033197221121009](https://doi.org/10.1177/00033197221121009)
- Divekar AA, Scholz T, Fernandez JD. Novel percutaneous transcatheter intervention for refractory active endocarditis as a bridge to surgery-angiogram aspiration system. *Catheter Cardiovasc Interv.* 2013;81:1008–1012. doi: [10.1002/ccd.24593](https://doi.org/10.1002/ccd.24593)
- Haddad SF, Lahr BD, El Sabbagh A, Wilson WR, Chesdachai S, DeSimone DC, Baddour LM. Percutaneous mechanical aspiration in patients with right-sided infective endocarditis: an analysis of the national inpatient sample database-2016-2020. *Catheter Cardiovasc Interv.* 2024;103:464–471. doi: [10.1002/ccd.30958](https://doi.org/10.1002/ccd.30958)
- Akhtar YN, Walker WA, Shakur U, Smith G, Husnain SS, Adigun SF. Clinical outcomes of percutaneous debulking of tricuspid valve endocarditis in intravenous drug users. *Catheter Cardiovasc Interv.* 2021;97:1290–1295. doi: [10.1002/ccd.29584](https://doi.org/10.1002/ccd.29584)
- Godara H, Jia KQ, Augostini RS, Houmsse M, Okabe T, Hummel JD, Weiss R, Kalbfleisch SJ, Afzal MR, Badin A, et al. Feasibility of concomitant vacuum-assisted removal of lead-related vegetations and cardiac implantable electronic device extraction. *J Cardiovasc Electrophysiol.* 2018;29:1460–1466. doi: [10.1111/jce.13692](https://doi.org/10.1111/jce.13692)
- Modi RD, Ueyama HA, Tully A, Byku I, Greenbaum AB, Xie JX, Gleason PT, Daneshmand M, Babaliaros VC, Keeling B. Outcomes of suction debulking and surgery in patients with isolated tricuspid valve endocarditis. *Innovations (Phila).* 2025;20:39–47. doi: [10.1177/15569845241298283](https://doi.org/10.1177/15569845241298283)

23. Moriarty JM, Rueda V, Liao M, Kim GHJ, Rochon PJ, Zayed MA, Lasorda D, Golowa YS, Shavelle DM, Dexter DJ. Endovascular removal of thrombus and right heart masses using the AngioVac system: results of 234 patients from the prospective, multicenter registry of AngioVac procedures in detail (RAPID). *J Vasc Interv Radiol*. 2021;32:549–557 e543. doi: [10.1016/j.jvir.2020.09.012](https://doi.org/10.1016/j.jvir.2020.09.012)
24. Reddy VS, Zwischenberger BA, Williams AR, Rowe JF 3rd, Subramanian S, Kingeter A, Wright J, Joseph M. Percutaneous Thromboectomy as an alternative to surgery for tricuspid valve endocarditis. *Ann Thorac Surg Short Rep*. 2024;2:748–753. doi: [10.1016/j.atssr.2024.03.012](https://doi.org/10.1016/j.atssr.2024.03.012)
25. Schaerf RHM, Najibi S, Conrad J. Percutaneous vacuum-assisted thrombectomy device used for removal of large vegetations on infected pacemaker and defibrillator leads as an adjunct to Lead extraction. *J Atr Fibrillation*. 2016;9:1455. doi: [10.4022/jafb.1455](https://doi.org/10.4022/jafb.1455)
26. Starck CT, Schaerf RHM, Breitenstein A, Najibi S, Conrad J, Berendt J, Esmailian F, Eulert-Grehn J, Dreizler T, Falk V. Transcatheter aspiration of large pacemaker and implantable cardioverter-defibrillator lead vegetations facilitating safe transvenous lead extraction. *Europace*. 2020;22:133–138. doi: [10.1093/europace/euz283](https://doi.org/10.1093/europace/euz283)
27. Tarzia V, Ponzoni M, Evangelista G, Tessari C, Bertaglia E, De Lazzari M, Zanella F, Pittarello D, Migliore F, Gerosa G. Vacuum-implemented removal of Lead vegetations in cardiac device-related infective endocarditis. *J Clin Med*. 2022;11:11. doi: [10.3390/jcm11154600](https://doi.org/10.3390/jcm11154600)
28. Zhang RS, Alam U, Maqsood MH, Xia Y, Harari R, Keller N, Elbaum L, Rao SV, Alviar CL, Bangalore S. Outcomes with percutaneous debulking of tricuspid valve endocarditis. *Circ Cardiovasc Interv*. 2023;16:e012991. doi: [10.1161/CIRCINTERVENTIONS.123.012991](https://doi.org/10.1161/CIRCINTERVENTIONS.123.012991)
29. Purcell M, Gnilyopyat S, Makwana B, Narayanan S. Comparison of outcomes of percutaneous mechanical aspiration vs tricuspid valve surgery in drug use-associated endocarditis of the tricuspid valve. *Open Forum Infect Dis*. 2025;12:ofaf259. doi: [10.1093/ofid/ofaf259](https://doi.org/10.1093/ofid/ofaf259)
30. Gill GS, Shailly S, Chakralla T, Palicherla A, Ponna PK, Alla VM, Kanmanthareddy A. Adverse outcomes with left atrial appendage occlusion device implantation in chronic and end stage kidney disease: a systematic review and meta-analysis. *Cardiovasc Revasc Med*. 2025;75:56–63. doi: [10.1016/j.carrev.2024.08.016](https://doi.org/10.1016/j.carrev.2024.08.016)
31. Kim AG, Salazar AM, Panama G, Saeed M, Sabanci R, Al-Asad KS, Yavari M, Prasad RM, Rayamajhi S, Abela GS. Transcatheter vacuum-assisted mass extraction versus surgical debridement for vegetations in tricuspid valve infective endocarditis: a meta-analysis of observational studies. *Am J Cardiol*. 2024;210:69–75. doi: [10.1016/j.amjcard.2023.10.021](https://doi.org/10.1016/j.amjcard.2023.10.021)
32. Mhanna M, Beran A, Al-Abdoun A, Jabri A, Sajdeya O, Al-Aaraj A, Alharbi A, Khuder SA, Eltahawy EA. AngioVac for vegetation debulking in right-sided infective endocarditis: a systematic review and meta-analysis. *Curr Probl Cardiol*. 2022;47:101353. doi: [10.1016/j.cpcardiol.2022.101353](https://doi.org/10.1016/j.cpcardiol.2022.101353)
33. Rusia A, Shi AJ, Doshi RN. Vacuum-assisted vegetation removal with percutaneous lead extraction: a systematic review of the literature. *J Interv Card Electrophysiol*. 2019;55:129–135. doi: [10.1007/s10840-019-00555-6](https://doi.org/10.1007/s10840-019-00555-6)
34. Malik AH, Bandyopadhyay D, Krishnan S, Goel A, Hajra A, Gupta R, Goldberg J, Haidry SA, Ahmad H. Percutaneous tricuspid valve vegetation debulking in infective endocarditis: 2016 to 2020 National Database Analysis. *JACC Adv*. 2023;2:100373. doi: [10.1016/j.jacadv.2023.100373](https://doi.org/10.1016/j.jacadv.2023.100373)
35. El Sabbagh A, Hibbert B, Bangalore S, Fong P, Zlotnick D, El-Sabawi B, Zhang R, Zwischenberger B, Mourad A, Palatnic L, et al. Outcomes of percutaneous mechanical aspiration in right-sided infective endocarditis: a multicenter registry. *J Am Coll Cardiol*. 2025;86:846–856. doi: [10.1016/j.jacc.2025.06.054](https://doi.org/10.1016/j.jacc.2025.06.054)
36. Yucel E, Bearnot B, Paras ML, Zern EK, Dudzinski DM, Soong CP, Jassar AS, Rosenfield K, Lira J, Lambert E, et al. Diagnosis and Management of Infective Endocarditis in people who inject drugs: JACC state-of-the-art review. *J Am Coll Cardiol*. 2022;79:2037–2057. doi: [10.1016/j.jacc.2022.03.349](https://doi.org/10.1016/j.jacc.2022.03.349)