



Percutaneous mechanical aspiration in tricuspid valve infective endocarditis

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Tricuspid valve infective endocarditis (TVIE) is increasing, largely driven by rising injection drug use and the expanding use of cardiac implantable electronic devices (CIEDs). Percutaneous mechanical aspiration (PMA) has emerged as a viable catheter-based therapy to achieve source control through vegetation debulking in patients with a suboptimal response to antimicrobial therapy or those deemed at high risk for surgery. An expanding literature has demonstrated favorable feasibility and promising outcomes, and recent societal guidelines recognized PMA as a therapeutic option for carefully selected cases. Optimal results rely on multidisciplinary evaluation, rigorous patient selection, appropriate device choice, and meticulous procedural technique. This review summarizes the growing evidence base, outlines patient selection and technical considerations, and highlights future directions for PMA in the management of TVIE.

Keywords: Percutaneous mechanical aspiration (PMA); infective endocarditis; tricuspid valve (TV); indications



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Introduction

The incidence of tricuspid valve infective endocarditis (TVIE) has risen, driven primarily by people who inject drugs (PWID) and patients with cardiac implantable electronic devices (CIEDs) (1). These evolving demographics expose the limitations of traditional management with prolonged antimicrobial therapy with or without surgery, as PWID remain prone to sepsis, recurrent embolic events, infection relapse, recurrence and early mortality (2), while CIED-related cases often involve older, medically frail patients with high operative risk (3,4). Together, these challenges underscore the need for less invasive, catheter-based approaches that can achieve source control, bridge selected patients to surgery, or serve as definitive therapy.

Percutaneous mechanical thrombectomy was originally

developed for the management of acute pulmonary embolism, employing aspiration systems to remove thrombotic material from the vasculature. More recently, this technology has been adapted for off-label use in TVIE as percutaneous mechanical aspiration (PMA) (5). In this setting, PMA offers a catheter-based means of aspirating and debulking large, friable vegetations from valve surfaces or infected CIED leads, providing a potential therapeutic option for patients in whom surgery is not optimal (6).

PMA has emerged as a potential adjunct in the contemporary multidisciplinary management of infective endocarditis (IE). Recent consensus documents, including the American Heart Association Scientific Statement (7) and the European Heart Rhythm Association (8) statement on right-sided IE, have acknowledged PMA as a therapeutic consideration, and the 2023 European Society of Cardiology

guidelines assigned it a class IIb recommendation (9). In this review, we appraise the evolving evidence base, discuss patient selection and technical aspects, and consider future directions for PMA in the management of TVIE.

Gaps in contemporary care of TVIE

Right-sided infective endocarditis (RSIE) accounts for approximately 10% of all cases, most commonly involving the tricuspid valve (TV), and carries a distinct clinical course with complex therapeutic challenges (10). Outcomes remain poor in the two highest-risk populations, PWID and patients with CIEDs, despite advances in antimicrobial therapy and surgical technique (2,3).

In PWID, relapsing and recurrent infection, refractory sepsis, embolic-related pulmonary complications, and limited adherence to care contribute to high long-term mortality, exceeding 20% at one year and 65% at five years (2,11-13). While initial surgery may offer favorable early survival in this young cohort, reoperation is both common and high risk; in the Society of Thoracic Surgeons registry, 16.1% required reoperation with worse outcomes than that of non-PWID (14). Surgical decision-making is further hampered by incomplete risk models and the complex resource demands these patients require from institutions (7).

CIED-related TVIE presents additional challenges, particularly when large vegetations (>20 mm) are attached to leads. Despite guideline recommendations, complete lead extraction is achieved in only a minority of patients, and those with retained or abandoned leads face higher infection relapse rates and excess mortality (3,4,15). Extraction in the presence of bulky vegetations carries the risk of massive pulmonary embolism, and even technically successful procedures may leave residual infected casts or “ghosts”, which predispose to infection relapse after new device reimplantation (16).

Timing of intervention is another critical limitation. Current guidelines generally defer surgery until recurrent embolization, progressive valve destruction, or persistent sepsis, often at an advanced stage when physiologic reserve is diminished and operative risk escalates (9,17). Persistent *Staphylococcus aureus* bacteremia beyond 24 hours, common in both PWID and CIED-IE, is independently associated with increased mortality, while septic embolism also predicts adverse outcomes (18,19). In contrast, several studies suggest that earlier surgical intervention improved survival and reduced recurrence (20).

The rationale behind PMA in IE

IE develops when bacteria adhere to damaged endocardial surfaces or prosthetic material, initiating an inflammatory thrombotic cascade that produces vegetations. These structures, composed of bacterial aggregates within fibrin and biofilm, shield pathogens from host defenses and limit antimicrobial penetration, allowing infection to persist and enlarge, with consequent valve injury and embolic risk (21). From a surgical perspective, the guiding principle in endocarditis management is removal or debridement of vegetative material to achieve durable source control, and remains the standard of care for patients who are appropriate operative candidates. PMA follows this same rationale: by physically disrupting and debulking the vegetation, PMA aims to reduce bacterial burden, enhance antibiotic efficacy and mitigate embolic potential (6). In doing so, PMA may address gaps in the management of TVIE, serving as a bridge to surgery or, in selected patients, as a potential stand-alone therapy.

Approach to patient and device selection

The principal objective of PMA in appropriately selected patients with TVIE is to align the catheter and aspirate the vegetation as maximum as feasible, while minimizing adverse events such as distal embolization (6). Optimal outcomes with PMA are contingent not only on optimal procedural execution but also on familiarity with the existing literature, which has yielded valuable insight into our approach to patient selection, device choice, and procedural technique.

Insights from the literature

Outcomes of PMA in RSIE

Initial experience with PMA in RSIE was largely confined to salvage cases in patients without viable medical or surgical options (22,23). Since its first reported application in 2013 (24), adoption has steadily expanded (5), supported by case reports, small series, and early registries demonstrating feasibility and procedural success in carefully selected patients (16,22,23,25-33). Success, commonly defined as $\geq 70\%$ reduction in vegetation size or a residual ≤ 1 cm, has been consistently reported in 80–90% of early series, accompanied by high rates of culture clearance in those with persistent sepsis (16,22,23,25,27,29-31,33-35). Treated patients most often had large vegetations (>20 mm)

on the TV, typically caused by *Staphylococcus aureus* (16,22,23,25,27,29-31,33-35). Common indications included persistent bloodstream infection, recurrent septic pulmonary emboli, and lead-associated vegetations in patients with CIED infections or in PWID (16,22,23,25,27,29-31,33-35).

A recent meta-analysis showed an associated higher short-term mortality observed with PMA compared with surgery, while 1-year mortality, and endocarditis readmission rates were similar between strategies. These findings likely reflect patient selection, as PMA was often used as salvage therapy in critically ill or high-risk patients, which may have contributed to the early mortality (36). With broader adoption, PMA has evolved from a salvage measure to a therapeutic alternative in select populations. Propensity-matched analyses of PMA in TVIE have shown associated outcomes comparable to surgery, including short- and mid-term mortality and heart failure (32,34,37), while other studies have reported hospital cost savings with PMA, particularly among PWID (30). Additional reported potential benefits have included diagnostic yield from microbiologic analysis of aspirated material, particularly in culture-negative or polymicrobial cases, and the ability to perform transvenous lead extraction more safely after vegetation debulking (6,16,27,31).

Registry data have reinforced these findings. The CLEAR-IE multicenter registry, the largest dataset to date, reported procedural success in 89.4% of patients, most of whom presented with persistent bloodstream infection, recurrent embolization, or large vegetations. Among patients with positive blood cultures prior to intervention, 93.6% achieved clearance at a median of one day post-procedure (26). Administrative datasets have further suggested shorter hospitalizations and potentially lower mortality compared with TV surgery, though these observations are limited by inherent bias, retrospective design and lack of procedural detail (5,38). The current evidence base for PMA remains predominantly retrospective and non-randomized, and its frequent use in critically ill or high-risk patients introduces inherent selection bias that must be considered when interpreting reported procedural success and mortality outcomes. Taken together, available evidence suggests that PMA is associated with high rates of procedural success and may represent a viable option for patients at elevated surgical risk, while underscoring the need for prospective, controlled studies to define its risks and benefits more clearly.

Complications of PMA

Despite encouraging outcomes, complications associated with PMA have been reported. Early series described vascular injury, access-site complications, and rare but serious events such as cardiac perforation and tamponade (16,22,23,29,31,33,35). Embolic events remain a concern, including septic pulmonary emboli or paradoxical embolization in the presence of a patent foramen ovale (PFO) (6). Another early observation was transient or sustained worsening of sepsis following vegetation disruption, likely reflecting bacterial translocation, particularly in unstable patients presenting in shock (16,25).

In the CLEAR-IE registry, reported adverse events included pulmonary embolism (8.3%), stroke (2.5%), pericardial tamponade (2.5%), vascular complications (3.8%), and emergency surgery (3.2%). In-hospital mortality occurred in 9.8% of patients, occurring at a median of one week after the procedure. No intraprocedural deaths were reported. Baseline septic shock and hypoxia were the strongest predictors of adverse events, suggesting that the latter was likely driven by the severity of TVIE rather than the procedure itself (26). Meta-analyses and pooled datasets have consistently demonstrated acceptable safety, though interpretation remains constrained by retrospective design and publication bias (28,39-41).

Worsening tricuspid regurgitation (TR) is a recognized complication of PMA, reported in approximately 15% of patients in the CLEAR-IE registry (26). The mechanisms appear multifactorial, including unmasking of pre-existing leaflet perforations obscured by vegetations or trauma to valvular and chordal structures during device manipulation. George *et al.* reported TR progression in 43.5% of patients, three of whom required valve replacement after infection clearance (22), while Scantland *et al.* observed 15.6% of patients requiring subsequent TV surgery (23). In contrast, Akhtar *et al.* found no valve tissue in aspirated specimens, suggesting that leaflet aspiration is unlikely to be a mechanism (25). Clinically, worsening TR is often tolerated in the short term and was not associated with excess mortality (26), providing an interval in which PWID may undergo addiction rehabilitation before definitive valve intervention.

These findings demonstrate that PMA in TVIE is associated with high rates of procedural success. However, adverse events from the severity of the underlying infection and procedure risk should be considered. To mitigate

Table 1 Summary of main case series of percutaneous mechanical aspiration in right-sided infective endocarditis (including tricuspid valve infective endocarditis)

Author	Study years	Sample size	Patient population	Vegetation size (mm)	Device	Follow-up	Procedural success	Adverse events
Zhang (33)	2020–2022	29	PWID	24±7.6	AngioVac	Mid-term	96.6%	No intraprocedural death; no tricuspid surgery; death at f/u 6.9%
Stantland (23)	2014–2020	32	PWID	32	AngioVac	Early-term	90.6%	No death; tricuspid surgery 16.5%; major bleeding 3%
George (22)	2017	33	PWID	21.2±7	AngioVac	In-hospital	100%	No intraprocedural death; in-hospital death 9%; tricuspid surgery 9%; major bleeding 3%
Akhtar (25)	2017–2019	25	PWID	24	Penumbra	Early-term	88%	No intraprocedural death; death 12% (worsening septic shock); blood transfusion (blood loss) 28%
Schaerf (31)	2016	20	CIED	36	AngioVac	In-hospital	100%	No intraprocedural death; iliac vein injury 5%
Godara (27)	2015–2016	8	CIED	22–41	AngioVac	In-hospital	88%	No death; no adverse events related to PMA; open surgery due to extraction complication; blood transfusion 50%
Tarzia (35)	2016–2022	13	CIED	37.2	AngioVac	In-hospital	92.3%	No death; 1 cardiac perforation
Modi (34)	2010–2022	16	PWID and CIED	25.2	AngioVac	Long-term	–	No in-hospital death; death at f/u 12.5%; blood transfusion 37.5%; recurrence of IE 37.5%

Early-term, within 30 days; mid-term, 30 days–1 year; long-term, >1 year. CIED, cardiovascular implantable electronic device; f/u, follow-up; IE, infective endocarditis; PMA, percutaneous mechanical aspiration; PWID, people who inject drugs.

these risks and optimize outcomes, meticulous procedural planning is key, encompassing familiarity with the device armamentarium, careful patient selection, and optimal technical execution.

The main series, registry data, meta-analyses, and administrative datasets are summarized in *Tables 1–3*.

Knowledge of the armamentarium

A variety of aspiration platforms have been employed off-label, distinguished by catheter size, length, shape, aspiration mechanism, and capacity for blood reinfusion. Broadly, these devices fall into continuous-flow (CF) and non-continuous-flow (NCF) systems (*Figure 1*). CF aspiration systems operate through a veno-venous bypass circuit connected to a perfusion pump, enabling uninterrupted aspiration with simultaneous blood filtration and reinfusion, thus requiring two large bore venous accesses. By contrast, non-continuous flow devices are

single access systems that generate aspiration in a more intermittent fashion, which results in interrupted flow (6).

Continuous flow aspiration devices

The AngioVac system (AngioDynamics, Latham, NY, USA) is the only CF device currently in use. Now in its third generation, it employs an extracorporeal circuit with an outer cannula through which a funnel-tipped inner cannula advances telescopically for directional aspiration. Two configurations are available: a 22 Fr system (25 Fr outer cannula, 20° or 180° orientation, 77 cm length) and an 18 Fr system (22 Fr outer cannula, 85° bend, 105 cm length). Blood is aspirated, filtered, and reinfused via a dedicated return sheath. Strong, adjustable suction reduces reliance on direct catheter-lesion contact, potentially lowering risk of distal embolization, while the closed circuit minimizes blood loss. These features have made AngioVac the most widely used device reported in TVIE (26).

Table 2 Summary of main registry data of percutaneous mechanical aspiration in right-sided infective endocarditis

First author	Study period	Sample size	Patient population	Vegetation size	Devices used	Follow-up	Procedural success	Complications
Moriarty (29)	2016–2019	59	PWID + CIED	–	AngioVac	In-hospital	75%	Death 1.3%; distal embolization 3%; major bleeding 2.6%
Starck (16)	2014–2018	101	CIED	30.7±13.5 mm	AngioVac	Short-term	94%	No intraprocedural death; death at f/u 3%; distal embolization 1%
Reddy (30)	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 (26)	2014–2024	256	PWID and CIED	24 mm	AngioVac; AlphaVac; Penumbra; Inari	Mid-term	89.4%	No intraprocedural death; composite of in-hospital mortality, new PE, emergency surgery 18%; worsening TR 15%; tamponade 2.5%; vascular complications 3.8%; stroke 2.5%

Short-term, <30 days; mid-term, 30 days–1 year. CIED, cardiovascular implantable electronic device; f/u, follow up; PE, pulmonary embolism; PWID, people who inject drugs; TR, tricuspid regurgitation.

Limitations include the need for a perfusionist and availability of an extracorporeal perfusion circuit, which may limit widespread adoption, large-bore venous access with its attendant vascular risks, potential TV injury, and technical challenges in advancing into the pulmonary arteries in the event of embolization (6).

Noncontinuous flow aspiration devices

The AlphaVac system resembles AngioVac in design but generates suction by rapid plunger pulls (10–30 cc per plunge), without reinfusion. It avoids the need for a perfusionist and offers strong suction when the cannula funnel is sealed against the vegetation. Its main limitations are the intermittent nature of aspiration with associated embolic risk, the need for direct cannula-vegetation contact, and blood loss due to the absence of a return mechanism.

The Inari FlowTriever generates suction via a 60-cc syringe, with aspirated material emptied into a FlowSaver reservoir for filtration and reinfusion. It is available in 20 and 24 Fr sizes, the latter accommodating a T20 curve catheter with a 260° bend for improved reach. Key advantages include simplified setup and reduced blood loss; however, suction force declines as the syringe fills, and catheter manipulation often necessitates upfront wires, which may increase the risk of malalignment, vegetation dislodgement, or chamber injury. To facilitate delivery,

some operators have adapted large nondedicated steerable sheaths from structural procedures, thereby reducing wire dependence.

The Penumbra Lightning system (Penumbra, Alameda, CA, USA) is another NCF device, most commonly used with the PL12 catheter (12 Fr, 115 cm, atraumatic tip) powered by an engine that generates intermittent suction with real-time audio-visual feedback. Delivered through a 12 Fr steerable sheath, it offers straightforward setup and navigability. A newer 16 Fr version provides larger flow capacity but lacks a dedicated steerable sheath. Limitations include modest suction strength, the need for direct vegetation contact, and absence of blood reinfusion, with blood loss more pronounced in the larger system.

Patient selection and procedural planning

Role of endocarditis teams

Candidacy for PMA should be determined through multidisciplinary discussion within dedicated endocarditis teams (*Figure 2*). These typically include cardiology, infectious diseases, imaging, cardiac surgery, interventional cardiology, electrophysiology (for CIED-related IE), addiction medicine, psychiatry, social work, and case management. Such teams address both clinical and psychosocial complexities, and their implementation has

Table 3 Summary of published meta-analyses and administrative database analyses of percutaneous mechanical aspiration in right-sided infective endocarditis

Study author	Study type	Sample size	Study period	Patient population	Vegetation size	Device	Main findings	Adverse events
Rusia (41)	Meta-analysis	88	2013–2018	CIED	27.8 mm	AngioVac	Procedural success 97.7%	Rate 4.5%; related to extraction and not aspiration; 2 vascular injuries, 1 coronary sinus injury and 1 tricuspid valve injury
Mhanna (28)	Meta-analysis	301	2013–2022	PWID and CIED	28 mm	AngioVac	Procedural success 89.2%; overall survival 89.7%	2 cardiac tamponade; 1 coronary sinus ostium tear (from extraction); 1 hemothorax; 2 access site bleeding; 1 retroperitoneal bleed; 2 femoral vein injuries
Gill (39)	Meta-analysis	232	2013–2022	PWID and CIED		AngioVac; Penumbra	Procedural success PWID: 97%; CIED: 100%	In-hospital mortality 14%; worsening TR 14%; blood transfusion 37%; tricuspid surgery 3%
Kim (40)	Meta-analysis	431	2012–2023	PWID and CIED		AngioVac; Penumbra		PMA vs. surgery: similar procedural, 30-day and 1-year mortality; shorter hospital stay; reduced costs
Suruagy-Motta (36)	Meta-analysis	974	2019–2025	PWID		AngioVac; Penumbra		PMA vs. surgery; similar in-hospital, 1 year mortality, IE readmission; PMA higher 30-day mortality; PMA shorter hospital stay
Malik (38)	Administrative database	1,085 hospital admissions	2016–2020	PWID and CIED			Increasing trend of PMA use; procedural success: 91%	In-hospital mortality 4.6%; readmission for IE 18%
Haddad (5)	Administrative database	1,675 hospital admissions	2016–2020	PWID and CIED			Increasing trend of PMA use	In-hospital mortality 6%

CIED, cardiovascular implantable electronic device; IE, infective endocarditis; PMA, percutaneous mechanical aspiration; PWID, people who inject drugs; TR, tricuspid regurgitation.

been shown to improve adherence, reduce reinfection and readmission, and enhance surgical and long-term outcomes (42).

Risk-benefit determination

PMA should be pursued when the anticipated benefit is likely to alter the natural course of infection and outweigh

procedural risks. For example, PMA may not be beneficial in patients with refractory septic shock or severe hypoxemia from recurrent emboli, for whom procedural success is unlikely to improve outcomes (26).

Indications for PMA

PMA is generally reserved for high-risk patients for whom

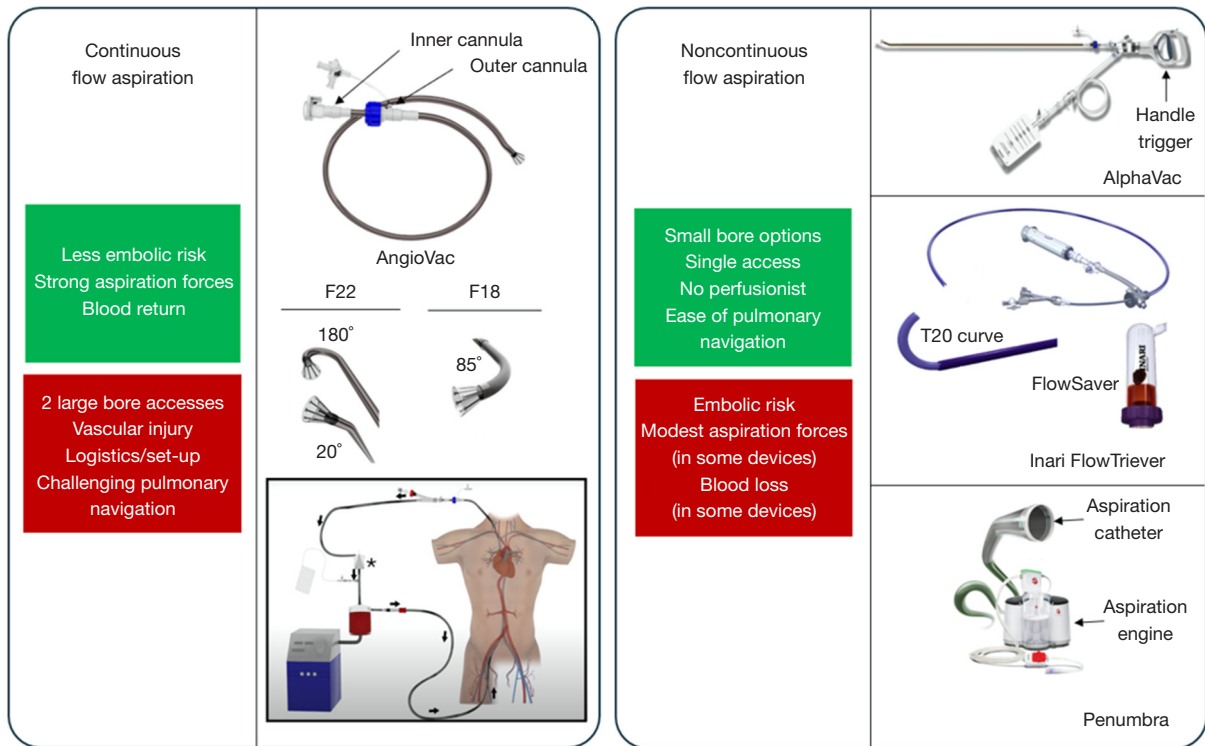


Figure 1 Armamentarium of percutaneous mechanical aspiration for tricuspid valve endocarditis. Continuous- and non-continuous-flow aspiration devices are shown, highlighting the respective advantages (green) and limitations (red) of each category.

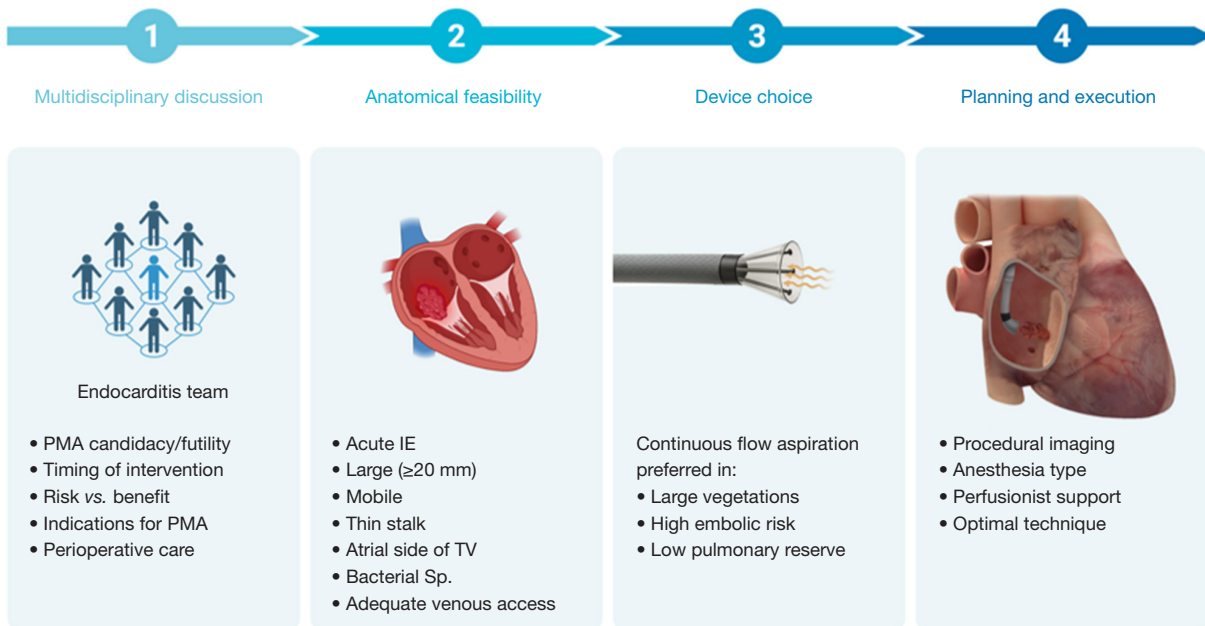


Figure 2 Patient selection for percutaneous mechanical aspiration requires multidisciplinary discussion within an endocarditis team, evaluation of anatomical feasibility, device choice tailored to anatomical and patient-specific factors, and meticulous procedural planning and execution. IE, infective endocarditis; PMA, percutaneous mechanical aspiration; TV, tricuspid valve.

conventional medical or surgical therapy is not feasible. Indications and timing remain largely guided by institutional expertise and are areas of ongoing investigation. Indications include:

- ❖ Large vegetations (>20 mm), recurrent septic pulmonary emboli, or persistent sepsis despite appropriate antimicrobial therapy.
- ❖ Definitive therapy in PWID with refractory infection, given the high likelihood of reinfection and poor surgical outcomes in this population.
- ❖ Bridge to surgery in PWID with worsening TR. This approach provides initial source control and subsequently allows time for engagement in addiction medicine treatment and rehabilitation, potentially reducing prosthetic reinfection risk.
- ❖ CIED-related IE, where PMA can reduce embolic burden and facilitate safer lead extraction, particularly with vegetations ≥ 20 or ≥ 10 mm in the presence of a PFO. By lowering infected material burden, PMA decreases the risk of septic pulmonary embolization and may reduce the chance of reinfection after device re-implantation.
- ❖ Diagnostic uncertainty, where aspiration provides material for histopathologic or microbiologic confirmation.

Timing of intervention

Timing should be individualized. Standard practice involves 5–7 days of intravenous antibiotics to allow stabilization and assessment of response (9,17). However, in aggressive infections such as *S. aureus*, earlier intervention within the first 5 days may be advantageous to prevent progression and irreversible valve injury.

Anatomical feasibility

Anatomic suitability is essential for procedural success. Favorable targets include large, friable, and mobile vegetations on the atrial surface of the TV. Less favorable substrates include ventricular-side or subvalvular vegetations, as well as dense or chronic morphologies that are more resistant to aspiration.

Procedural planning

Three domains should be addressed before PMA: imaging, anesthesia, and device choice.

Imaging

Pre-procedural transesophageal echocardiography (TEE) is recommended to define vegetation size, mobility, attachment, and baseline regurgitation and its mechanism. Cardiac computed tomography (CT) can help evaluate venous access for large-bore cannulation. The choice of intraprocedural imaging to guide the intervention should be based on which modality provides all sets of imaging to assist in catheter assembly, alignment, visualization of device-vegetation interaction, and avoidance of iatrogenic injury or embolization. TEE remains standard, while intracardiac echocardiogram (ICE) may be an alternative in selected cases. All patients should be screened for PFO, with cerebral embolic protection considered when right-to-left shunting is present.

Anesthesia

Most procedures are performed under general anesthesia, particularly when TEE is required, large-bore internal jugular (IJ) cannulation is planned, or respiratory compromise is anticipated. This provides airway control in the event of septic pulmonary embolism or pulmonary edema following reinfusion. Hemodynamic optimization is critical, as aspiration devices rely on adequate preload to avoid hypotension.

Device choice

Device selection should reflect vegetation characteristics, embolic risk, and institutional resources. CF systems are favored for large (>2 cm), mobile vegetations, offering strong suction and reduced reliance on direct contact. This is especially relevant in patients with compromised pulmonary reserve from prior septic emboli, who may not tolerate an additional embolic event. NCF systems may be considered in select anatomies or centers without perfusion support, though they carry higher risks of blood loss and embolization. Regardless of system, procedural success depends on high-quality imaging, precise catheter manipulation, and consistent aspiration technique.

PMA of TVIE: step-by-step approach

Although device platforms vary, the fundamental steps of PMA in TVIE are consistent and should be executed in a systematic manner (*Figure 3*).

Venous access

Access with appropriately sized sheath should be selected to

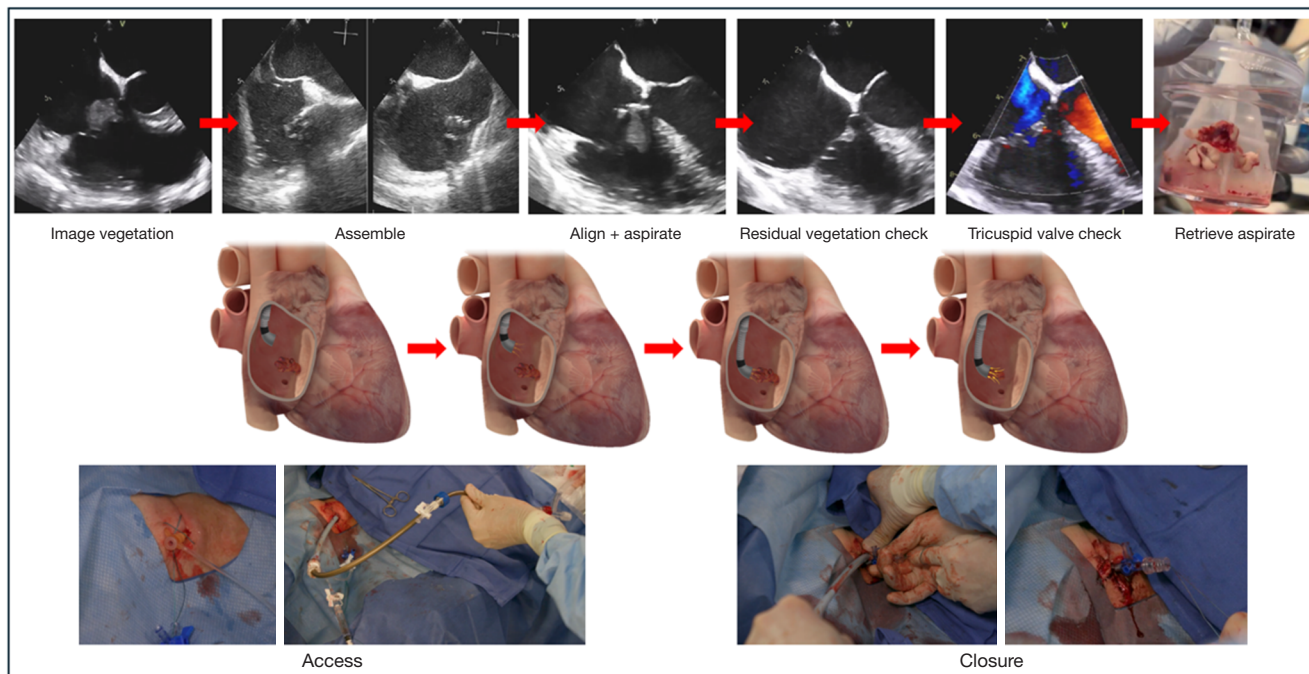


Figure 3 Percutaneous mechanical aspiration of tricuspid valve infective endocarditis. Venous access is obtained with pre-closure using a figure-of-eight suture, followed by upsizing to a large-bore sheath for introduction of the aspiration catheter. After baseline assessment of the vegetation, the aspiration system is assembled, and the catheter is advanced and aligned with the target. Aspiration is performed under active flow, after which residual vegetation burden and tricuspid valve competence are reassessed. Retrieved material is sent for microbiological and pathological evaluation. The large-bore sheath is then removed, and hemostasis is achieved by tightening the preplaced figure-of-eight suture.

allow optimal trajectory towards the vegetation:

- ❖ Atrial surface, posterior leaflet: IJ approach.
- ❖ Atrial surface, anterior/septal leaflets: IJ or femoral approach.
- ❖ Ventricular vegetations: IJ is preferred; femoral feasible for basal or mid-right ventricle (RV) sites.

System preparation

Prime, de-air, and verify the aspiration system prior to sheath insertion. Assemble all catheter components away from the target vegetation to minimize inadvertent contact.

Navigation and alignment

Under imaging guidance, advance the aspiration catheter to the right-sided target and achieve coaxial alignment with

the vegetation.

Initiation of aspiration

Activate aspiration flow before engaging the vegetation to establish a protective inflow field and reduce embolic risk.

Controlled engagement and debulking

Carefully engage the vegetation while maintaining coaxiality and continuous aspiration. Perform incremental passes as needed, reassessing alignment after each maneuver.

Specimen handling

Retrieve all aspirated material under sterile conditions and submit promptly for microbiologic evaluation and pathology review.

Final assessment

Perform post-procedural imaging to evaluate residual vegetation burden and valve function. Withdraw the system and secure hemostasis.

Our preferred platform for PMA in TVIE is the AngioVac CF aspiration system. The following describes the stepwise technique with this device.

Setup

- ❖ Anesthesia: general;
- ❖ Intraprocedural imaging: TEE;
- ❖ Circuit: centrifugal pump managed by a perfusionist.

Stepwise technique

- (I) Venous access: two punctures (femoral-femoral or IJ-femoral) under ultrasound/fluoroscopy.
- (II) Anticoagulation: unfractionated heparin, maintain activated clotting time >250 s.
- (III) Pre-closure: figure-of-eight sutures; insert 7 Fr sheaths.
- (IV) Sheath insertion: dilate over SuperStiff wires; place 26 Fr (F22) or 22 Fr (F18) aspiration sheath + 16–18 Fr return cannula. Lock sheaths by tightening figure-of-eight sutures.
- (V) Cannula preparation: lubricate outer cannula-flush with fat emulsion (propofol, Rotaglide), exercise outer and inner cannulas telescopically.
- (VI) Circuit connection: aspiration cannula to one limb, return cannula to pump (wet-to-wet to avoid air).
- (VII) Advancement: advance outer cannula over wire; insert inner cannula.
- (VIII) Positioning: extrude inner cannula funnel under imaging, maintain safe distance from vegetation.
- (IX) Engagement: achieve coaxial alignment; angle of approach determined by sheath-outer-inner cannula relationship. Initiate low flow (~1 m/s), then increase to 3–4 m/s once stable.
- (X) Aspiration: debulk vegetation to maximum feasible extent. Aspiration may occur from a proximal position or by direct contact at higher flow. Continuously monitor for “suck-down” events (thump, arrhythmia, reduced flow). Keep aspiration runs brief, as the circuit lacks a heater.
- (XI) Assessment: re-image; success defined as $\geq 70\%$ reduction or residual <1 cm.
- (XII) Circuit shutdown: stop flow, retract inner cannula, withdraw system; reinfuse blood gradually [slower in

low ejection fraction].

- (XIII) Hemostasis: remove sheaths, secure sutures, reverse anticoagulation if indicated.
- (XIV) Specimen handling: measure and send aspirated material for microbiology and pathology.

Postprocedural management

Figure-of-eight sutures are typically removed within four hours of sheath removal. Intravenous antimicrobial therapy is continued for approximately six weeks, with close hemodynamic monitoring and serial blood cultures to ensure clearance of infection. Transient hypotension and low-grade fever are common but usually self-limited. The development of new or worsening respiratory symptoms should prompt chest CT to assess for pulmonary embolism. Discharge planning should prioritize coordination of outpatient antibiotic therapy and, in PWID, integration of addiction support services. Follow-up blood cultures and repeat imaging performed after completion of therapy are recommended to confirm durable infection resolution.

Future directions

The role of PMA in TVIE is evolving. Randomized trials across key phenotypes, including PWID, CIED-related infections, and *S. aureus* endocarditis, are needed to establish its safety and efficacy. Trial design is challenging given the heterogeneity of TVIE: PWID are prone to early discharge and limited follow-up, while CIED patients often have higher comorbidity and require complex extraction strategies. Surgical data suggest improved outcomes with early intervention for large vegetations, raising the possibility that pre-emptive PMA could reduce embolic events, preserve valve integrity, and shorten antimicrobial therapy. Rigorous prospective evaluation will be essential to define the optimal timing, patient selection, and long-term role of PMA in RSIE.

Conclusions

PMA is an emerging option for TVIE, with outcomes dependent on multidisciplinary evaluation, patient selection, device choice, and procedural execution. While early experience suggests feasibility, further prospective studies are needed to define optimal timing, safety, and long-term efficacy of this catheter-based option.

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