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THROMBUS MANAGEMENT

HOW WE DID IT

Removal of Massive Left Atrial Appendage Closure Device–Related Thrombus With Complete Embolic Protection

Step-by-Step Technique

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ABSTRACT

OBJECTIVE Device-related thrombus (DRT) is a life-threatening complication of left atrial appendage closure devices. Transcatheter vacuum-assisted thrombectomy has recently been described as a novel strategy for removal of large DRT, but it is associated with increased risk of systemic embolism. We describe a step-by-step technique of a complete embolic protection strategy in patients undergoing vacuum-assisted thrombectomy.

KEY STEPS First, bilateral cerebral embolic protection devices are deployed. Next, systemic embolic protection is achieved by positioning an ONO retrieval device (Onocor) within the proximal aortic arch. An arterial return cannula is inserted. Then, transseptal crossing is performed with positioning of a suction catheter within the left atrium for aspiration thrombectomy.

POTENTIAL PITFALLS Aspiration should be performed meticulously, avoiding traumatic dislodgment of thrombotic material. The ONO basket must be assessed for embolic debris before its removal using transesophageal echocardiography. Long-term oral anticoagulation should be considered if tolerated.

TAKE-HOME MESSAGE Transseptal transcatheter vacuum-assisted thrombectomy with complete embolic protection is a viable and effective strategy to prevent thromboembolic complications for life-threatening DRT. (JACC Case Rep. 2026;31:106928) © 2026 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Left atrial appendage closure (LAAC) has become a routine procedure for stroke prevention in patients with atrial fibrillation where long-term oral anticoagulation (OAC) is contraindicated.[1-3] Postimplantation, short-term OAC is required to prevent device-related thrombus (DRT), however DRT may still occur, posing significant challenges in clinical management and increasing the risk of serious embolic complications. Large, multicenter, international registries have indicated that DRTs

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ABBREVIATIONS AND ACRONYMS

DRT = device-related thrombus

LA = left atrium

LAAC = left atrial appendage closure

OAC = oral anticoagulation

TEE = transesophageal echocardiography

often lead to increased risk of death, ischemic stroke, and systemic embolization.[4] The 2023 Society for Cardiovascular Angiography & Interventions and Heart Rhythm Society joint expert consensus statement regarding DRTs recommends treatment with OACs, with repeat imaging at 45- to 90-day intervals until resolution.[5] No formal guideline recommendations currently exist regarding optimal treatment of DRTs in patients in whom OAC is high risk or contraindicated. Surgical thrombectomy can be considered but may be prohibitive in some patients.

Recently, transcatheter vacuum-assisted mass extraction devices have emerged as a viable alternative in high-risk surgical patients.[6-8] Concomitant use of neuroprotection devices is advised, however the risk of systemic embolization of thrombotic debris remains. Therefore, we propose a novel technique with step-by-step instructions of a complete embolic protection strategy to mitigate the risk of both cerebrovascular and systemic thromboembolic phenomena during vacuum-assisted mechanical thrombectomy.

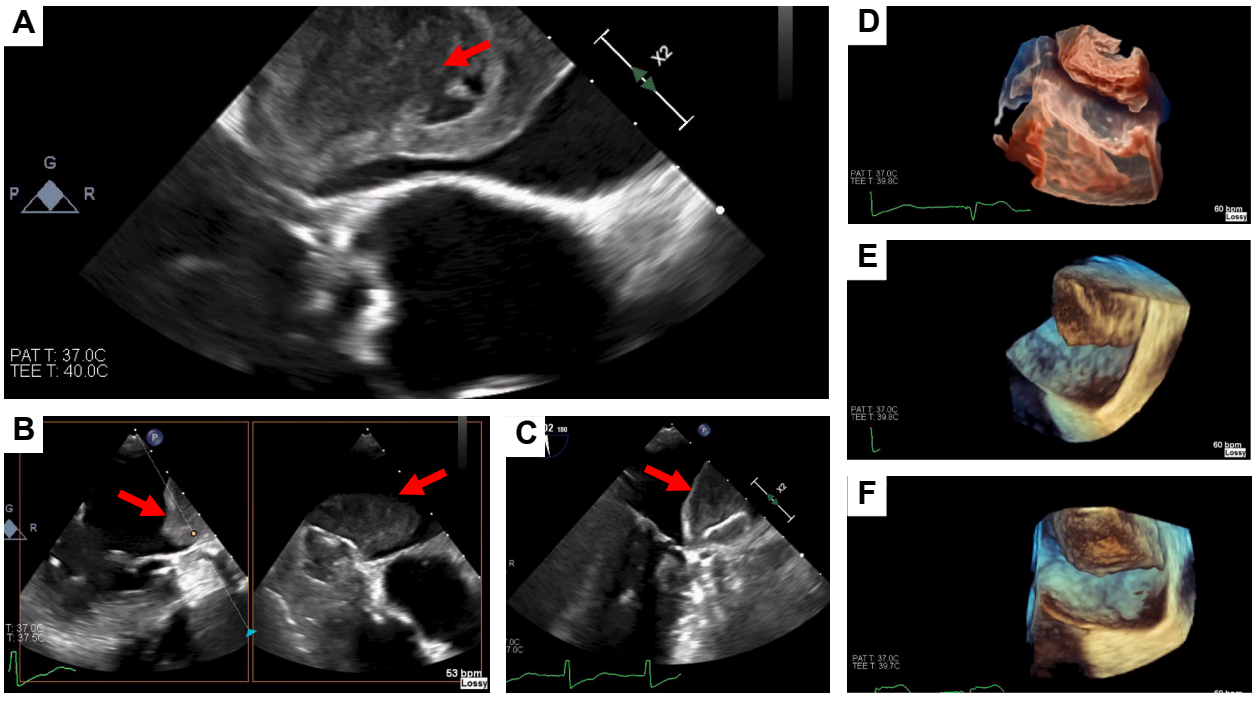
TAKE-HOME MESSAGES

- Device-related thrombus is a life-threatening complication of left atrial appendage closure devices.
- Transseptal transcatheter vacuum-assisted thrombectomy is an effective alternative to surgery or anticoagulation for device-related thrombus.
- Complete embolic protection is a viable and effective strategy to prevent cerebral and systemic thromboembolic complications.

CASE SUMMARY

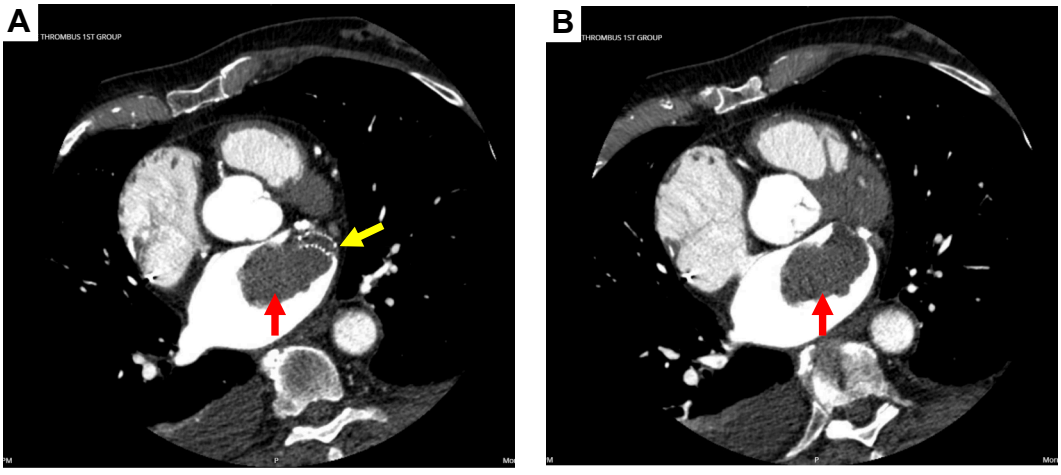
An 81-year-old man presented to the hospital after sustaining a fall, with a prolonged downtime of 3 days owing to an acute ischemic stroke. The patient's medical history included type 2 diabetes mellitus, hypertension, hyperlipidemia, obstructive sleep apnea, moderate aortic stenosis, sick sinus syndrome with prior insertion of a single-lead implantable cardioverter defibrillator, and persistent atrial fibrillation. Because of his history of

FIGURE 1 Initial Evaluation of a Massive Left Atrial Appendage Closure Device-Related Thrombus on Transesophageal Echocardiography



(A to C) Visualization of a massive device-related thrombus (red arrows) in the left atrium on 2D TEE. (D to F) TEE 3D imaging of a massive device-related thrombus. 2D = two-dimensional; 3D = three-dimensional; TEE = transesophageal echocardiography.

FIGURE 2 **Initial Cardiac CT Angiography Demonstrating a Massive Left Atrial Appendage Closure Device-Related Thrombus**



(A) Visualization of left atrial appendage device (yellow arrow) with attached massive thrombus (red arrow). (B) Massive thrombus within the left atrium (red arrow). CT = computed tomography.

multiple falls with high risk of intracranial hemorrhage, the patient had undergone LAAC with a Watchman device 2 months prior. His anticoagulation was discontinued after LAAC. He was maintained on dual-antiplatelet therapy with aspirin and clopidogrel.

The initial computed tomography of the head demonstrated a linear area of increased attenuation

TABLE 1 **Equipment List**

Procedural Step	Item and Description
Vascular access	Initial RFA access with 4-F sheath (VSI Micro introducer 4-F 7 cm; Teleflex), exchanged to 8-F sheath (Pinnacle 8-F 0.038-inch × 10 cm; Terumo Medical), then exchanged to 16-F sheath (DrySeal Flex introducer 16-F; 5.3 × 6.1 mm, 33 cm; Gore Medical) used to deploy the ONO retrieval system. Secondary LFA access with 4-F sheath (VSI Micro introducer 4-F 7 cm; Teleflex), exchanged to 8-F sheath (Pinnacle 8-F 0.038-inch × 10 cm; Terumo Medical), then exchanged to 15-F sheath (DrySeal Flex introducer 17-F; 5.0 × 5.6 mm, 33 cm; Gore Medical) for arterial cannula placement for blood return. Tertiary RFV access with 4-F sheath (VSI Micro introducer 4-F 7 cm; Teleflex), exchanged to 8-F sheath (Pinnacle 8-F 0.038-inch × 10 cm; Terumo Medical), then exchanged to 26-F sheath (DrySeal Flex introducer 26-F; 8.7 × 9.5 mm, 33 cm; Gore Medical).
Complete embolic protection	Cor Runthrough guidewire 0.014-inch × 300 cm (Terumo Medical) or Hi-Torque Whisper ES STR guidewire 0.035-inch × 190 cm (Abbott) Catheter filter Sentinel cerebral protection system ×2 (Boston Scientific) 17-F TruSteer access system (Boston Scientific) or 14-F DrySeal sheath (Gore Medical) ONO retrieval (Onocor)
Transseptal crossing	Cor Runthrough guidewire 0.014-inch × 300 cm (Terumo Medical) or Hi-Torque Whisper guidewire 0.035-inch × 190 cm (Abbott) VersaCross large access solution (Boston Scientific) Confida Brecker guidewire CRV 0.035-inch × 260 cm (Medtronic) Armada balloon 35 OTW 12 mm × 40 mm × 135 cm (Abbott)
Suction catheter	Cannula with dilator AngioVac 180° (AngioDynamics) ECMO system ECMO oxygenator module[a] AngioVac reservoir filter 15-F or 17-F arterial return cannula (Medtronic)
ASD closure (optional)	Ampltazer cribriform occluder (Abbott) (or other ASD closure device)
Closure device	Perclose ProGlide ×7 (Abbott) (or other closure device)

[a]Optional equipment.

ASD = atrial septal defect; ECMO = extracorporeal membrane oxygenation; LFA = left femoral artery; RFA = right femoral artery; RFV = right femoral vein.

TABLE 2 Step-by-Step Protocol for Transseptal Transcatheter Vacuum-Assisted Thrombectomy With Complete Embolic Protection

1. Obtain vascular access (right and left femoral arteries of 15-F and 17-F; either right or left femoral vein, 26-F) per the usual standard.
2. Deploy bilateral cerebral protection devices.
3. Advance the 17-F TruSteer access system into the proximal ascending aortic arch.
4. Advance the ONO retrieval system through the steerable sheath and deploy it within the proximal ascending aortic arch (substitute with a 14-F DrySeal sheath delivered via transaxillary access).[9]
5. Confirm ONO retrieval system position on fluoroscopy and TEE.
6. Insert 15-F or 17-F arterial return ECMO cannula into a peripheral artery.
7. Perform transseptal cross per the usual standard.
8. Advance a stiff guidewire transeptally (we use a Versacross wire) and perform balloon septostomy (we use a 12-mm Armada balloon).
9. Advance the suction catheter into the LA (we used AngioVac 180°).
10. Inflate a large balloon (we use a 12-mm Armada balloon) at the distal tip of the suction catheter to deploy the basket.
11. Connect suction catheter circuit (AngioVac) with an extracorporeal pump ensuring connection with a reservoir filter to capture the thrombotic material.
12. Perform transseptal transcatheter vacuum-assisted thrombectomy.
13. Assess ONO retrieval system for embolic tissue using TEE prior to removal.
14. Remove the complete embolic protection devices (ONO retrieval system, Sentinel cerebral protection system ×2).
15. Option to use an ASO device if right-to-left or bidirectional shunting leading to hypoxemia, or left-to-right shunting leading to RV dysfunction is observed.
16. Remove all sheaths and close vascular access with closure device of choice (we use the Abbott Perclose ProGlide).

ASO = atrial septal occluder; ECMO = extracorporeal membrane oxygenation; LA = left atrium; RV = right ventricle; TEE = transesophageal echocardiography.

in the right occipitoparietal region concerning for subarachnoid hemorrhage. Subsequent work-up including magnetic resonance imaging of the brain reveled an acute infarct involving the right paramedian parieto-occipital lobe with an area of evolving hemorrhagic transformation and laminar necrosis. Transesophageal echocardiography (TEE) revealed a very large (4.8 × 3 cm) mobile thrombus attached to the prior Watchman with concomitant mild left atrial (LA) enlargement (**Figure 1**, Video 1). Biventricular systolic function was preserved. After discussion with the neurology and neurosurgery teams, the patient was initiated on full-dose anticoagulation.

The patient was evaluated by both the cardiac surgery and structural heart teams, who determined that he was at prohibitive risk for open heart surgery given the high risk of hemorrhagic conversion of the acute stroke. Subsequent imaging with transthoracic echocardiography and computed tomography demonstrated elimination of the LAA thrombus with no signs of resolution or reduction in size despite anticoagulation (**Figure 2**, Video 2). After multidisciplinary discussion, the DRT was considered at an unacceptable risk for repeat embolic events if treated with OACs alone given high-risk features including size, mobility, attachment to the atrial surface involving the central screw hub of the device, extension into the left atrial cavity, and patient's presentation of acute ischemic stroke.

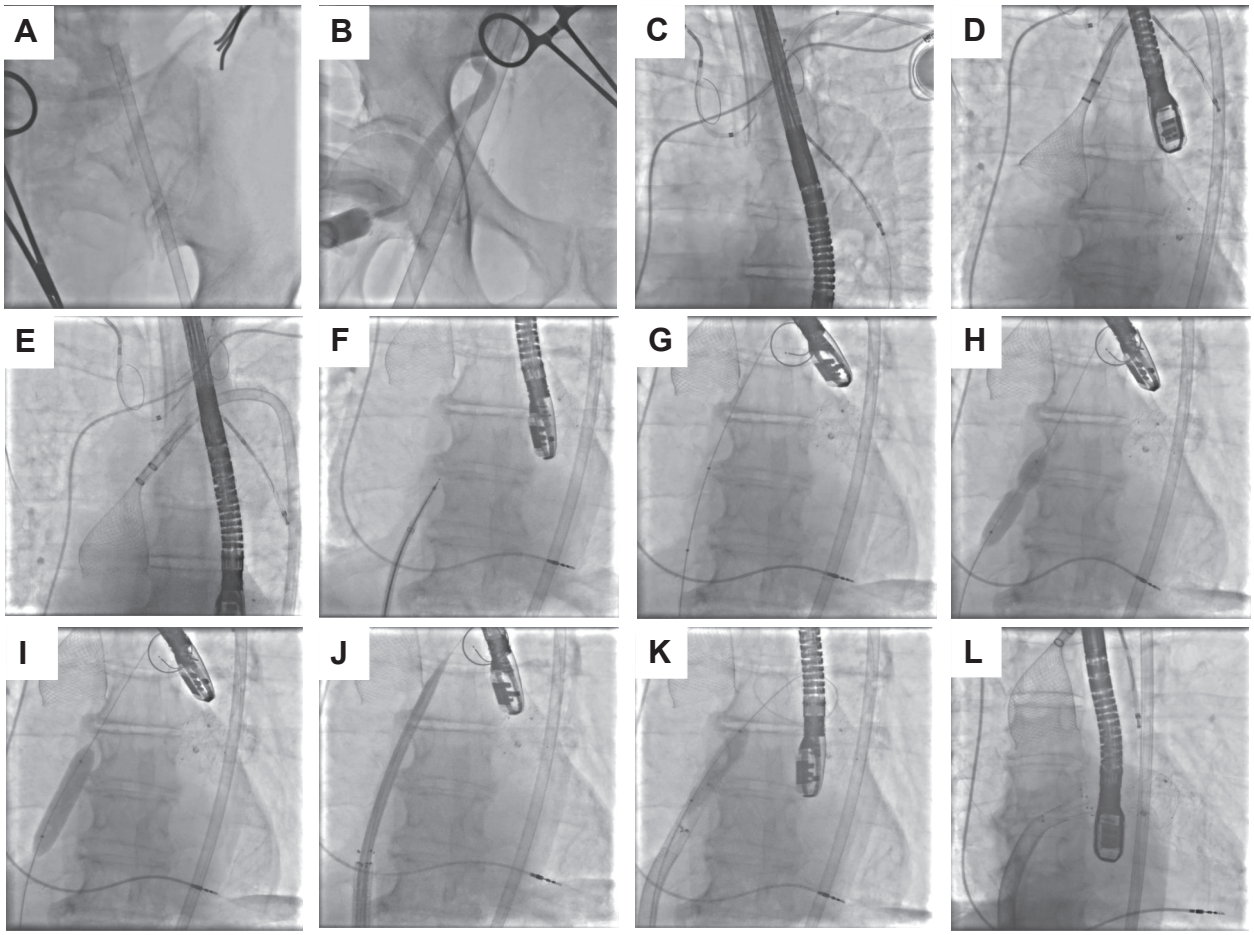
Therefore, the patient underwent percutaneous vacuumed-assisted mechanical thrombectomy with a complete embolic protection strategy including bilateral cerebral embolic protection and systemic embolic protection with the ONO retrieval device (Onocor). After multiple runs of aspiration, the thrombus was successfully removed. Total fluoroscopic time was 32 minutes. Repeat transthoracic echocardiography demonstrated elimination of the LA thrombus. A discrete 3-mm leak around the device was newly identified; its role in the original thrombus formation as compared with persistent atrial fibrillation is unknown at the present time, however other risk factors for thrombus formation were excluded. The patient's neurological status improved after the procedure, and there were no neurological deficits. He was discharged to an acute rehabilitation facility on OAC therapy with planned repeat TEE in 6 to 8 weeks to ensure no new thrombus formation.

PROCEDURAL STEPS

EQUIPMENT. The equipment used for the vacuum-assisted mechanical thrombectomy with complete embolic protection is listed in **Table 1**, and the step-by-step instructions for the procedure are described in **Table 2**.

COMPLETE EMBOLIC PROTECTION. We developed a novel concept of a complete embolic protection

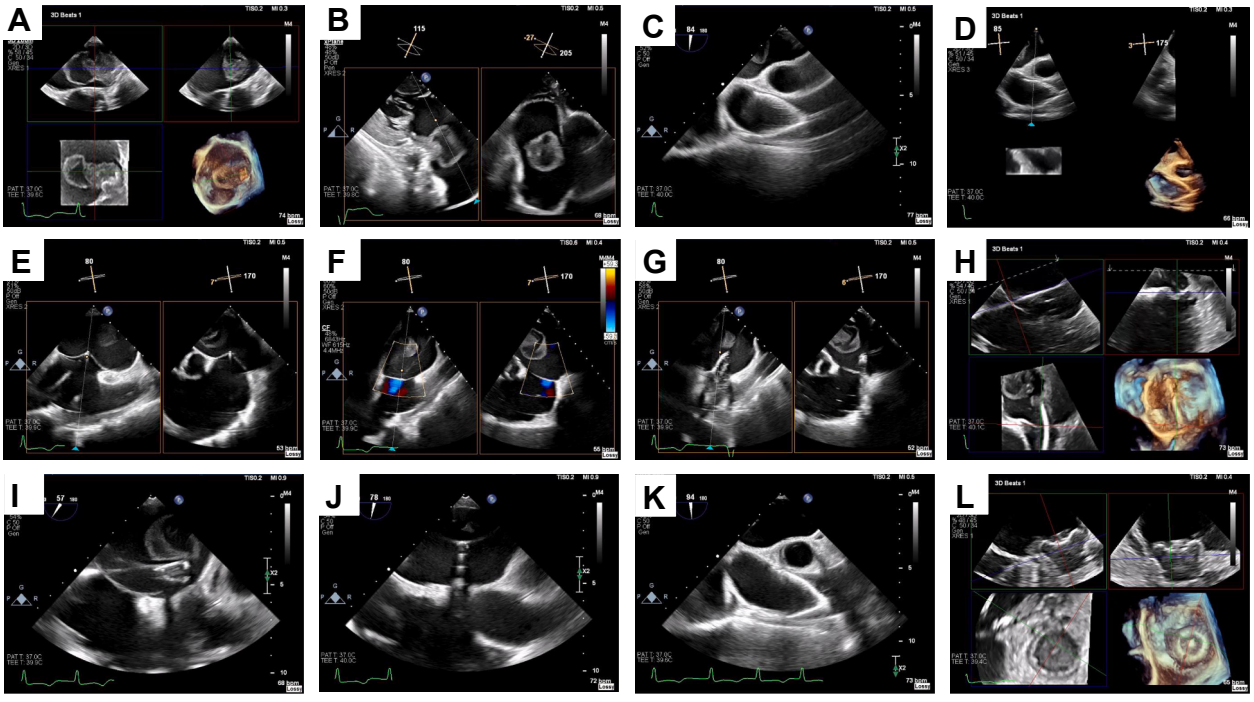
FIGURE 3 **Step-by-Step Technique of Transseptal Transcatheter Vacuum-Assisted Thrombectomy With Complete Embolic Protection Under Fluoroscopic Guidance**



(A) Insertion of an arterial return cannula in the left femoral artery. (B) Secondary vascular access of right femoral artery for insertion of the TruSteer with the Ono device in the ascending aorta. (C) Deployment of bilateral cerebral protection devices. (D) Deployment of ONO retrieval device in the proximal aortic arch distal to the brachiocephalic trunk. (E) Complete embolic protection. (F) Transseptal puncture. (G) Transseptal crossing with a Versacross guidewire in the left atrium. (H) Partial inflation of 12-mm Armada balloon. (I) Septostomy with 12-mm Armada balloon. (J) Advancement of suction catheter transseptally. (K) Suction catheter basket deployment in the left atrium using a 12-mm Armada balloon using balloon-tracking technique. (L) Vacuum-assisted mechanical thrombectomy under complete embolic protection.

strategy that can be used in cases where an extra-large intracardiac mobile thrombus requires vacuum-assisted mechanical thrombectomy given an elevated risk of both cerebral and systemic thromboembolization, which could otherwise be a devastating and a potentially life-threatening complication of the procedure. The first step of this technique requires large-bore vascular access, which should be appropriately assessed prior to the procedure using contrast computed tomography. Next, a bilateral cerebral embolic protection device (Sentinel cerebral protection system, Boston Scientific) should be deployed per the usual standard to prevent microembolic phenomena from causing acute cerebrovascular infarcts. This is followed by deployment of a systemic embolic protection device such as the ONO retrieval device. A 17-F TruSteer sheath (Boston Scientific), which can be advanced over a standard 0.035-inch stiff guidewire and positioned within the aortic arch proximal to the brachiocephalic trunk is utilized as access for the ONO retrieval system. The ONO retrieval device may be advanced through the steerable sheath and opened in the proximal aortic arch. Device positioning should be assessed

FIGURE 4 Step-by-Step Technique of Transseptal Transcatheter Vacuum-Assisted Thrombectomy With Complete Embolic Protection Under TEE Guidance



(A and B) Assessment of massive left atrial appendage closure device thrombus. (C) Deployment of the ONO retrieval device in the proximal aortic arch distal to the brachiocephalic trunk. (D) Assessment of ONO retrieval device position. (E) Transseptal puncture. (F) Transseptal crossing with a Confida guidewire in the left atrium. (G) Septostomy with 12-mm Armada balloon. (H to J) Vacuum-assisted mechanical thrombectomy under complete embolic protection. (K) Post-thrombectomy assessment of the ONO retrieval device basket with absence of embolic debris. (L) Visualization of the left atrial appendage closure device with notable absence of thrombus. TEE = transesophageal echocardiography.

intraprocedurally on fluoroscopy and TEE (**Figures 3E, 4C, and 4D**). As the ONO basket has open cells, it does not cause hemodynamic instability or obstruction to flow, while protecting from embolisms of large thrombotic masses.

VACUUM-ASSISTED MECHANICAL THROMBECTOMY. A transseptal approach for removal of left-sided intracardiac masses using a vacuum-assisted mass extraction device has been previously described.[6] First, a 15-F or 17-F arterial return cannula is inserted and is preclosed with 2 ProGlide (Abbott) in the right or left common femoral artery. Insertion of a return cannula in the arterial system will prevent hypotension during aspiration and reduction in preload in the left-side cardiac chambers. Placement of the return cannula within the arterial system should be considered in patients that require prolonged aspirations in the left-side chambers which can result in hypotension due to reduction in cardiac pre-load. Then, transseptal crossing may be performed with a dedicated device such as the VersaCross large access solution system (Boston Scientific) and confirmed using a combination of imaging modalities (fluoroscopy, TEE, or intracardiac echocardiography). A stiff 0.035-inch wire (eg, Confida guidewire; Medtronic) is positioned within the LA to facilitate delivery of a noncompliant ballon (12-mm Armada balloon; Abbott) for septostomy. A suction catheter (AngioVac C180; AngioDynamics) is then advanced into the LA, and vacuum-assisted mechanical thrombectomy is performed as previously described.[6] Suction power can be increased during the procedure by augmenting the flow on the extracorporeal pump connected to the reservoir filter. Transition of the thrombectomy cannula across the septum can be facilitated using the balloon-tracking technique.[6] A summary of the step-by-step technique under fluoroscopic and TEE guidance is represented in **Figure 3** (Video 3) and **Figure 4**, respectively.

POTENTIAL PITFALLS

There are potential pitfalls of this technique that need to be mentioned. First, deployment of a complete embolic protection strategy requires familiarity with the ONO retrieval device as well as cerebral protection devices. The ONO retrieval device must be advanced through a large-bore 17-F steerable sheath inserted in a peripheral artery, which can increase the risk of vascular and bleeding complications. Once the basket is opened, an echocardiographer must confirm its position as well as assess the basket for embolic debris before its removal (Video 4). If this basket is not adequately assessed before its removal, peripheral or visceral ischemia may ensue. If embolic debris is identified within the basket, the basket should be pulled back into the descending thoracic aorta before device recapture. This should be performed with cerebral embolic protection devices in situ. Second, the ONO retrieval device is a novel technology, with only a few reports of its use; it therefore may be associated with a more unpredictable pattern of use.[10-12] Thirdly, the operator should have access to multiple transcatheter vacuum-assisted devices (eg, Inari, AlphaVac, AngioVac) for extra-large thrombus removal, as a combination of devices may be required. Finally, this procedure does not guarantee complete thrombus removal, as small microthrombotic particles may still be adherent to the LAAC device, nor does it prevent reoccurrence of DRTs. Therefore, consideration for long-term OAC should be discussed on a case-by-case basis after the procedure.

CONCLUSIONS

To our knowledge, this is the first description of a complete embolic protection strategy during transseptal vacuum-based thrombectomy for a massive life-threatening DRT. The ONO device was demonstrated to be useful for securing systemic embolic protection, avoiding peripheral or visceral infarction. In high- or extreme-risk patients, this technique should be considered in case of massive DRT as an alternative to open heart surgery or OAC alone.

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KEY WORDS complete embolic protection, device related thrombus, left atrial appendage closure device, vacuum-assisted mechanical thrombectomy

APPENDIX For supplemental videos, please see the online version of this paper.