Staged sternal opening for sternal-adhering aneurysm repair and mitral valve replacement

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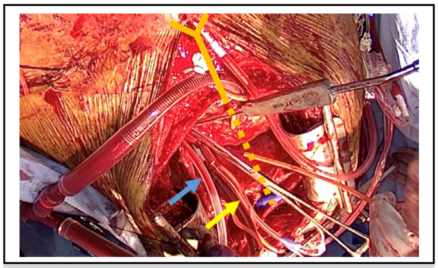


Left ventricular vent and retrograde cardioplegia cannula via a lower hemisternotomy.

CENTRAL MESSAGE

Staged sternal opening allows for safe re-entry, left ventricular decompression, and cardiac protection in complex redo aortic aneurysm repair and mitral valve surgery.

Video clip is available online.

The incidence of re-entry injury is low: 2.7% in redo cardiac surgery, but it is associated with a significant increase in in-hospital mortality up to 26%.[1] These cases often receive cardiopulmonary bypass (CPB) support before resternotomy and hypothermic circulatory arrest (HCA) to facilitate safe re-entry.[2] Left ventricular (LV) venting during cooling and protecting the myocardium after circulatory arrest attenuate the risk of adverse cardiac events related to prolonged CPB time and HCA. Herein, we describe a staged sternotomy strategy, facilitating insertion of an LV vent and retrograde cardioplegia cannula via a lower hemisternotomy, followed by upper sternotomy with circulatory arrest in complex redo aortic aneurysm repair and mitral valve replacement (MVR). This report was approved by the Columbia University Institutional Review Board (AAAR2949; approved September 21, 2023) with waiver of patient consent.

CASE SUMMARY

Patient 1

The first case was a 42-year-old man who had undergone 4 prior open cardiac operations (Table 1). The most recent surgery was a hemiarch and aortic root replacement with hemi-Commando technique by homograft, and MVR with mechanical valve for infective endocarditis 3 years prior. The latest echocardiogram showed severe paravalvular leak of the mitral valve (Figure 1, *A*), mild aortic insufficiency (AI), and reduced right ventricular function with a left ventricular ejection fraction of 55%. Computed tomography showed a proximal arch pseudoaneurysm with severe adhesions to the sternum (Figure 1, *B* and *C*). The patient was taken to the operating room for a planned MVR and proximal aortic repair.

Patient 2

Patient 2 was a 69-year-old man who had also undergone 4 prior cardiac and aortic operations and was admitted for progressive dyspnea during minimal exertion (Table 1). The most recent open surgery was an aortic valve replacement and bioprosthetic MVR 11 years ago, followed by a transcatheter intervention for bioprosthetic mitral stenosis 2 years ago. Preoperative workup showed moderate mitral paravalvular leak (Figure 1, *D*), severe LV dilatation with LV dysfunction (LV ejection fraction, 45%), and aortic root ectasia (Figure 1, *E* and *F*) with trace AI. The paravalvular leak was also causing hemolysis. Thus, MVR and aortic root replacement (ARR) were indicated.

Surgical Technique

In patient 1, the right axillary artery was cannulated before sternotomy. A lower partial sternotomy was performed by transecting the sternum at the second intercostal

TABLE 1. The surgical history in patient 1 and 2

Operation	Indication for surgery	Procedures
Patient 1		
1	BAV with infective endocarditis	AVR
2	VSD caused by persistent endocarditis	VSD closure
3	Pseudo aortic aneurysm with aorto-ventricular fistula	Bentall, HAR, and CABG
4	Prosthetic graft infection, and infective endocarditis	HAR, Bentall (hemi-Commando procedure) and MVR
Current	Severe mitral paravalvular leak and proximal arch pseudoaneurysm	Bentall (Commando), HAR, and MVR
Patient 2		
1	Acute type A aortic dissection	Ascending aortic repair
2	Severe AI and MR	AVR and MVR with mechanical valve
3	Coumadin intolerance	AVR and MVR with bioprosthetic valve
4	Bioprosthetic mitral stenosis	Valve-in-valve MVR
Current	Symptomatic mitral paravalvular leak and aortic root ectasia	Bentall procedure, MVR, and CABG

BAV, Bicuspid aortic valve; *AVR*, aortic valve replacement; *VSD*, ventricular septal defect; *HAR*, hemi arch replacement; *CABG*, coronary artery bypass grafting; *MVR*, mitral valve replacement; *AI*, aortic insufficiency; *MR*, mitral regurgitation.

space. The middle and lower mediastinum were exposed and CPB was started with bicaval central venous cannulation. The patient was cooled to 24 °C. The retrograde cardioplegia cannula was inserted into the coronary sinus and the LV vent was placed in the right upper pulmonary vein. During opening of the manubrium, as expected, arterial bleeding occurred. Once the target temperature was reached, the rest of the sternum was quickly opened during circulatory arrest with cardioplegia given retrograde. After sternotomy, antegrade selective cerebral perfusion was initiated. The pseudoaneurysm was removed with the previous homograft, and the aortic arch was anastomosed to a prosthetic graft. After the distal anastomosis was completed, systemic perfusion was resumed through side branch of the prosthetic graft. Next, the mitral valve was addressed. The patient had a prior mechanical valve sewn into the anterior mitral leaflet of the homograft tissue with a hemi-Commando technique because the native anterior

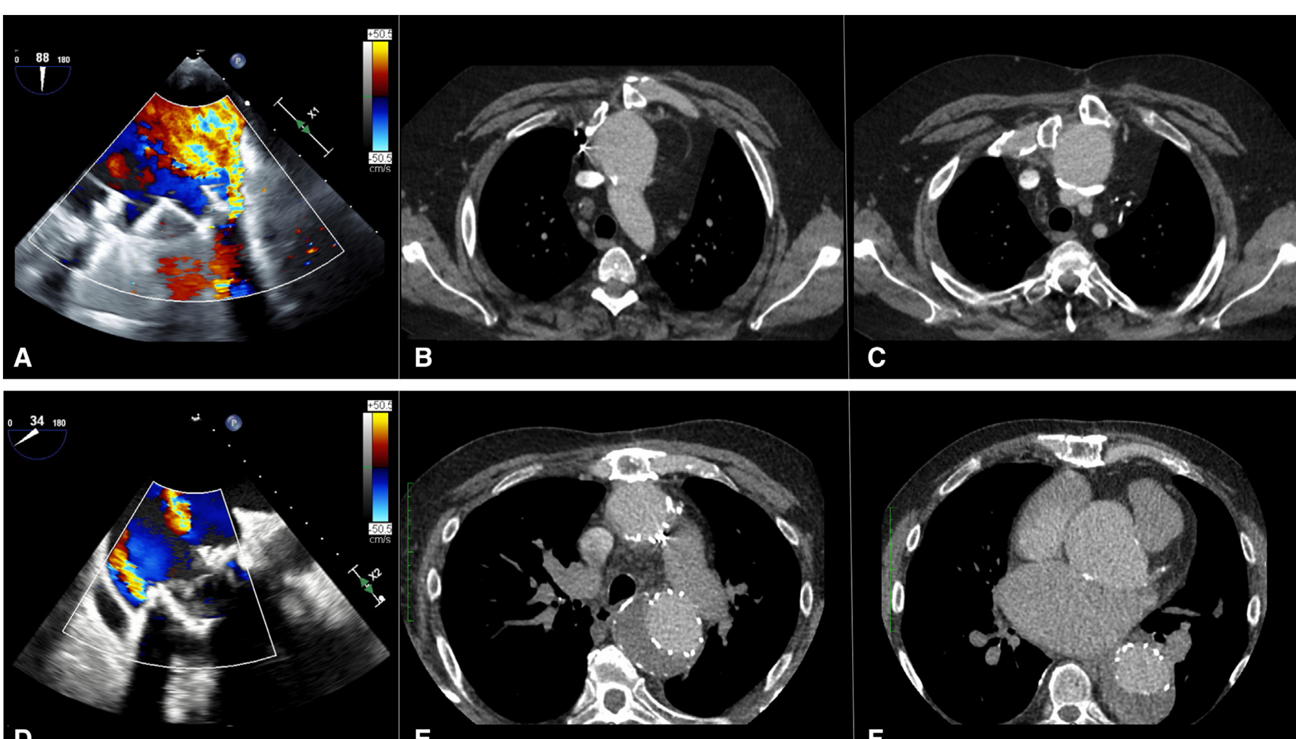
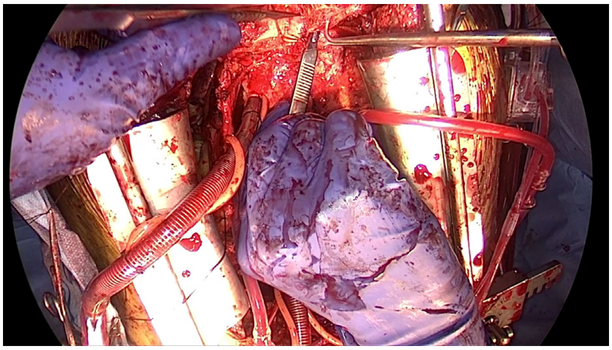


FIGURE 1. Transoesophageal echocardiography and contrast-enhanced computed tomography in patient 1 (A-C) and patient 2 (D-F). A, Color Doppler imaging. Multiple paravalvular leaks occurred after mitral valve replacement (*MVR*). B, Pseudoaneurysm at proximal aortic arch, heavily adherent to the sternum. C, Pseudoaneurysm at proximal aortic arch (axial view above supra-aortic vessels). D, Color Doppler imaging. Moderate paravalvular leakage after valve-in-valve MVR. E, Ascending aorta, adherent to the sternum. F, Aortic root ectasia.



VIDEO 1. Bentall (Commando), hemiarch replacement, and mitral valve replacement with staged sternal opening. Video available at: https://www.jtcvs.org/article/S2666-2507(24)00041-5/fulltext.

mitral annulus was debrided in a previous surgery due to an infected mitral-aortic intervalvular fibrosa. The mitral valve was removed via a right-side left atriotomy. Considering the significant degeneration of the homograft, an ARR and Commando procedure were pursued. An incision was made in the right atrium and was extended to the aortic annulus, which was divided from the middle of the noncoronary sinus to the mitral annulus. A bovine pericardial membrane was sewn to the anterior side of sewing ring of the 31-mm bioprosthetic valve and it was seated on the mitral annulus. Finally, ARR was performed without difficulty. The CPB time and aortic crossclamp times were 367 and 266 minutes, respectively, with no blood product (Video 1). In patient 2, the chest was re-entered similarly using the staged sternotomy approach. ARR, MVR, and coronary artery bypass grafting were completed; however, a large amount of blood products and extracorporeal membrane oxygenation were required due to postcardiotomy mixed shock with cardiogenic, vasoplegic, and hemorrhagic components after prolonged bypass (CPB time, 447 minutes; crossclamp time, 297 minutes). The postoperative courses are described in Table E1.

DISCUSSION

In cases of complex redo aortic aneurysm repair and MVR, in which aortic injury is highly anticipated at sternal re-entry, CPB support is often initiated before sternotomy to allow immediate initiation of HCA, followed by dissection from the heart to the transverse aorta for exposure of the mitral valve and aortic repair. Therefore, our technique allows standard LV decompression and myocardial protection, which can attenuate the risk of adverse events related to prolonged CPB time and HCA even in the absence of significant AI.

Previously, transapical LV venting via lateral thoracotomy has been described.[3] However, some complications have been reported, including LV ischemia, false aneurysm formation, and mural thrombus formation resulting in stroke.[4] Additionally, a percutaneous method has been reported.[5] Because these procedures add no preparation for mitral valve surgery, we chose a staged sternal opening to allow dissection of the heart and insertion of the LV vent and retrograde cardioplegia cannula. The site of transverse sternotomy was determined based careful review of the preoperative computed tomography image.

CONCLUSIONS

We report 2 cases of complex redo aortic aneurysm repair and MVR for which staged sternal opening was used. In redo cases where there is concern for aortic injury upon sternotomy and adverse cardiac events with prolonged CPB time, a staged sternal opening facilitates heart dissection, LV venting, and coronary sinus cannulation before circulatory arrest.

Conflict of Interest Statement

Dr Takayama has received a research grant from Rudin Foundation and consulting fees from Artivion and Edwards. All other authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

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TABLE E1. Postoperative courses for patients 1 and 2

Postoperative date	Event
Patient 1	
Day 1	Extubation
Day 5	Transferred to SDU
Day 15	Discharged (without any complications)
Patient 2	
Day 0	VA ECMO and open chest management for vasoplegic, hemorrhagic, and cardiogenic shock with prolonged bypass and significant coagulopathy
Day 3	Sternal closure
Day 11	VA ECMO decannulation with recovery of biventricular function
POD 23	Suspected mediastinitis by vancomycin-resistant enterococcus faecium
Day 30	Sternal wound debridement with pectoralis muscle and omental flap, complicated by sudden lethal tachyarrhythmia and cardiac arrest

SDU, Step-down unit; *VA ECMO*, venoarterial extracorporeal membrane oxygenation.