A strategy for safe sternal reentry in patients with pseudoaneurysms of the ascending aorta using the PORT-ACCESS EndoCPB system

Karl G. Reyes, Gosta B. Pettersson*, Tomislav Mihaljevic, Eric E. Roselli
Departments of Thoracic and Cardiovascular Surgery, Cleveland Clinic, Cleveland, OH, USA
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Abstract
Pseudoaneurysms of the ascending aorta developing after previous aortic or aortic valve surgery pose a high risk of exsanguination upon sternal reentry. In the past, femorofemoral bypass and hypothermic circulatory arrest before sternotomy was the preferred approach. Today, however, availability of the PORT-ACCESS EndoCPB system (Edwards Lifesciences, Irvine, CA, USA) allows for endovascular clamping and cardioplegia before sternotomy, avoiding circulatory arrest.

Keywords: Aorta; Aortic valve; Aortic root; Aneurysm; Reoperation

1. Introduction
The main challenge of managing aortic pseudoaneurysms is sternal reentry, where the risk of exsanguination and air embolization is high using standard techniques. Currently, femorofemoral bypass and hypothermic circulatory arrest before sternotomy is most frequently used [1, 2]. However, arrest time required for sternal reentry, dissection, and controlling the aorta is unpredictable, and even more so after multiple operations. To address this, we present a strategy of cannulation and cardioplegia that can eliminate the need for circulatory arrest during reentry.

2. Scenario
A 48-year-old male was referred 10 months after a Bentall procedure. His medical history was significant for bicuspid aortic valve, for which he underwent valvuloplasty at the age of 8 years. At age 45, he underwent aortic valve replacement with a mechanical valve and supracoronary ascending aorta replacement with a Hemashield graft. Two years later, he developed prosthetic valve endocarditis and underwent debridement of the aortic root and left ventricular outflow tract, root reconstruction with Peri-Guard, and replacement of the root and ascending aorta using a St Jude mechanical prosthesis extended with a Vascutek graft. He presented with progressive dyspnea. Echocardiography demonstrated dehiscence of the aortic valve prosthesis, pseudoaneurysm around the root and ascending aorta with systolic compression of the graft, and turbulent flow around the left coronary button into the pseudoaneurysm, creating suspicion of a possible second source leak. Computed tomography confirmed the pseudoaneurysm around the graft. The upper 4 cm of the pseudoaneurysm was lying in immediate contact with the sternum (Fig. 1). Additional findings noted included an ejection fraction of 30%, moderately decreased right ventricular function, mild pulmonary hypertension, and moderate mitral and tricuspid regurgitation. Standard reentry into the chest without catastrophic rupture was deemed impossible. Hence, our choice of the PORT-ACCESS EndoCPB system (Edwards Lifesciences, Irvine, CA, USA).

After anesthesia induction and placement of right- and left-sided arterial lines, an EndoPlege coronary sinus catheter was inserted through the right internal jugular vein under transesophageal echocardiogram guidance. The right axillary artery and right femoral vessels were exposed. The lower half of the sternum was opened to define the pericardial plane of dissection and expose the right atrium. The patient was heparinized and right axillary artery, right femoral artery, and right atrium cannulated. An EndoClamp occlusion balloon was inserted through the right femoral artery and positioned in the aorta directly above the aortic prosthesis. Cardiopulmonary bypass was initiated and systemic cooling commenced. At 30 °C, with the heart still beating, the EndoClamp was inflated and heart arrested with retrograde cardioplegia. The sternotomy was completed. Upon opening, it was confirmed that the posterior aspect of the sternum formed the anterior wall of the pseudoaneurysm. The operating field was completely dry in spite of the pseudoaneurysm being open (Fig. 2). The dissection was then completed, a standard aortic clamp placed and the EndoClamp removed. A superior vena cava cannula and standard retrograde catheter were added. By this time, the patients temperature was 20 °C and a brief...
circulatory arrest period was employed for replacing the distal ascending aorta. The composite graft and Peri-Guard were removed, the anulus debrided, and coronary buttons mobilized. Mitral valve repair was performed with an anuloplasty band. The aortic root was reconstructed with an aortic allograft. Finally, tricuspid valve was repaired with a lateral anulus plication. Total clamp time was 2 h 48 min and circulatory arrest time was 12 min.

Postoperative bleeding was minimal, and the patient was extubated the morning after. He was discharged after six days. All cultures were negative, but he was given a 6-week course of intravenous antibiotics.

3. Discussion

The most frequent strategy used for aortic pseudoaneurysms involves femoral cannulation and systemic cooling followed by chest entry during circulatory arrest [2]. This strategy is usually successful; however, there is high variability in circulatory arrest time that depends on the density of adhesions, size of pseudoaneurysm, size of leak, and time required to control the aorta. Strategies to decrease circulatory arrest time, such as direct Foley catheter placement through the sternotomy to tamponade bleeding, have had limited success [1].

Our present strategy addresses these issues and represents further refinements in technique [3–5]. There are five keys to this strategy. First, use of both right axillary and femoral arterial cannulation. Because the EndoClamp can occasionally migrate and occlude the innominate artery, cannulating both axillary and femoral arteries ensures adequate cerebral circulation. Additionally, an axillary cannulation allows for antegrade cerebral perfusion if extended circulatory arrest is required. Second, the EndoClamp has cardioplegia and venting ports. Once the balloon of the EndoClamp is inflated, the presence or absence of a distal leak can be surmised by the ability to decompress the heart. In the presence of a distal leak, the heart will not decompress because of continued flow through the pseudoaneurysm and into the heart; and adequate systemic perfusion will not be maintained. This would indicate the need for repositioning of the endoballoon in the proximal arch, system cooling and deep hypothermic circulatory arrest with the option of antegrade cerebral perfusion. Third, EndoPlege allows for delivery of retrograde cardioplegia at the onset. Fourth, opening the lower portion of the sternum allows for definition of the pericardial plane of dissection before entering the pseudoaneurysm. Finally, although femoral vein cannulation is adequate, right atrial cannulation through the lower sternotomy allows for more complete drainage. With this strategy, complete control of the aorta, heart, and brain is achieved, circulatory arrest is not required during sternal reentry, and best possible cerebral and myocardial protection is provided.

4. Conclusions

Using combined peripheral cannulation and PORT-ACCESS is effective in preventing exsanguination from sternal re-entry in patients with aortic pseudoaneurysms. This ability to arrest the heart prior to sternal reentry makes this strategy applicable to all other reoperations where a long period of circulatory arrest needs to be avoided, thereby reducing associated risks and increasing potential for improving short- and long-term outcomes. We believe this strategy can be adopted as the standard of care and can be replicated in most hospitals experienced with technology for minimal access surgery.
References


