Pericardiectomy for Constrictive or Recurrent Inflammatory Pericarditis
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Anatomy and Preoperative Considerations

The pericardial sac is composed of the outer fibrous pericardium and the inner serous pericardium.1 The fibrous pericardium is the tough external fibroelastic outermost layer. The inner layer is referred to as the serous pericardium; it is a smooth mesothelial layer. This inner layer or pericardium (the serous pericardium) consists of two parts: the outer parietal layer and the inner visceral layer. The potential space between the two layers of serous pericardium is termed the pericardial cavity and contains a small amount of fluid. The outer parietal layer is in continuity with the inner aspect of the fibrous pericardium. In addition, the outer, fibrous pericardium is attached to many surrounding structures. Attachments include the sternopericardial ligaments, vertebropericardial ligaments, and phrenopericardial ligaments. The phrenopericardial ligament is part of the wide area of fibrous continuity between the fibrous pericardium and the central tendon of the diaphragm. Importantly, when pericardiectomy is performed, the pericardium that is removed includes the tough fibrous pericardium; this must include the outer parietal layer of the serous (inner visceral layer) pericardium.

Complete symptom relief with pericardiectomy is possible in almost all patients with constrictive or recurrent inflammatory pericarditis, provided there is no restrictive cardiomyopathic component (as may be the case in the setting of radiation heart disease). It is important to distinguish between these two different diagnoses. A pericardial constriction results from a constrictive rind around the heart and operative correction requires removal of the pericardium that surrounds the right and left ventricles. The conventional teaching is to decorticate the left ventricle before the right ventricle, to avoid pulmonary edema. However, this is exceedingly difficult via sternotomy without cardiopulmonary bypass, as the left ventricle is posterior to the right ventricle. Decortication of the atria is not required for constrictive disease. Significant tricuspid regurgitation frequently coexists with constrictive pericarditis and should be looked for preoperatively. Diagnosis of constriction is confirmed by echocardiography and computed tomography or magnetic resonance imaging. Cardiac catheterization is used when there is uncertainty of the diagnosis of constriction by the previously mentioned techniques. Our preferred approach for pericardiectomy for constriction is median sternotomy. Cardiopulmonary bypass without aortic cross-clamping is frequently utilized, particularly when the etiology is postsurgical, because of the typical marked adherence of the visceral pericardium to the myocardium. Aortic occlusion is reserved for cases in which other left-sided intracardiac procedures need to be performed at the same time. In selected circumstances, left anterolateral thoracotomy can be used with or without bypass; however, the focus of this article is the sternotomy approach.

Recurrent inflammatory pericarditis is usually a diagnosis of exclusion because there is no diagnostic test available to confirm its presence. The appearance of the pericardium on imaging studies may be normal. Operation for this disease is most often via median sternotomy, because the principle of operation for recurrent inflammatory pericarditis is removal of the entire pericardium—ie, decortication of the atria and ventricles. The only remaining portion of pericardium should be that posterior to the left atrium in the oblique sinus. In the majority of cases, cardiopulmonary bypass can be avoided, unless there is marked adherence to the myocardium.

Anesthetic considerations include the routine use of transesophageal echocardiography. Central venous monitoring is utilized for recurrent inflammatory pericarditis; pulmonary artery catheter monitoring is used when constriction is present. A short-acting muscle relaxant is used so that phrenic nerve stimulation during and at the completion of the procedure can be performed to document integrity of the phrenic nerves. The left phrenic nerve is particularly vulnerable to injury during the course of pericardiectomy (for either diagnosis) because of poor visualization due to excessive fat, edema, scarring from previous cardiac surgery, etc.

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Operative Techniques in Thoracic and Cardiovascular Surgery
Operative Technique

Figure 1 Horizontal section of the heart as viewed from below. The pericardium completely encloses the four cardiac chambers and partially encloses the great vessels (not shown). When complete pericardiectomy is being performed for constriction, the pericardium removed includes that which surrounds the right and left ventricles. Importantly, this includes removal of the pericardium posterior to the left phrenic nerve and that between the inferior walls of the left and right ventricles and diaphragm. As shown in this figure, pericardiectomy “from phrenic to phrenic” fails to liberate a large portion of the left ventricle in the setting of constrictive pathology, and failure to do so has led to “recurrent constriction” requiring repeat—or more accurately—completion pericardiectomy. Removal of the pericardium that covers the right atrium is not required when the diagnosis is constriction; in fact, removal can be quite difficult and may result in inadvertent entry into the right atrium while attempting to remove the pericardium in this area. When pericardiectomy is performed for recurrent inflammatory pericarditis, radical removal of the pericardium around both ventricles and the right atrium is essential, as failure to remove the pericardium posterior to the left phrenic nerve may lead to recurrent symptoms for obvious reasons. The presence of the pulmonary veins (not shown) precludes removal of the posterior pericardium behind the left atrium. We have found that resolution of symptoms occurs despite leaving this small area of posterior pericardium intact. DTA = descending thoracic aorta; IVC = inferior vena cava; Lt. = left; LV = left ventricle; RA = right atrium; RV = right ventricle; rt. = right. (Copyrighted and used with permission of Mayo Foundation for Medical Education and Research.)
Figure 2. This figure demonstrates the pericardium and its relationship to the great arteries, right atrium, and right ventricle. Both pleural spaces are entered so that visualization of the phrenic nerves can be optimized. Superiorly, the phrenic nerves are positioned very medial and anterior. Dissection lateral to the main pulmonary artery is usually not necessary and avoids potential injury to the phrenic nerve in this location. The pericardium affected by constriction is often thickened and can be calcified. When recurrent inflammatory pericarditis is present, the pericardium is usually edematous and sometimes hemorrhagic. The pericardium is often of normal thickness or is only mildly thickened. If bypass is being planned, initial dissection is performed over the aorta. If there is marked adherence of the pericardium to the right atrium, then the superior vena cava can usually be safely and more easily exposed for venous cannulation. After cannulation, normothermic bypass is initiated and the dissection proceeds as outlined in the following diagrams. For simplicity, the aortic and venous cannulae are not shown in the figure. (Copyrighted and used with permission of Mayo Foundation for Medical Education and Research.)
Figure 3  The pericardium is initially divided in the midline or wherever a free space may be present. The dissection of the pericardium off the heart is done sharply with scissors. Cautery (or harmonic scalpel) dissection can sometimes be performed, more commonly with recurrent inflammatory pericarditis. The additional use of the Cavitational Ultrasonic Surgical Aspiration System (CUSA) can also be helpful when calcification is present. It is important that the coronary arteries be visualized as the pericardium is removed. This occurs when the dissection plane is correct. When the dissection plane is correct, the fibrous pericardium along with its serous inner layer is removed. When it is done properly, there will be clear visualization of the coronary arteries. Inability to visualize the coronary arteries indicates that the dissection plane is not deep enough, ie, the dissection plane is not including the inner serous layer of the fibrous pericardium. The edges of the cut pericardium can be grasped with a Kocher or Alice clamp. Retraction of the heart can be done with the left hand and a sponge on the heart by the operating surgeon, or a sponge forceps held by the assistant. (Copyrighted and used with permission of Mayo Foundation for Medical Education and Research.)
Figure 4 The dissection proceeds laterally on the right side when pericardiectomy is performed for recurrent inflammatory pericarditis to remove the pericardium surrounding the right atrium. The posterior extent of this dissection line is approximately 1 cm anterior to the right phrenic nerve. It is helpful to periodically stimulate the left phrenic nerve with a nerve stimulator; it frequently has a more anterior position than one would think. (Copyrighted and used with permission of Mayo Foundation for Medical Education and Research.)
The dissection proceeds to the left side as shown so that a plane is developed between the heart and pericardium. The posterior extent of the anterior pericardium ends approximately 1 cm anterior to the left phrenic nerve. The left anterior descending coronary artery should be well visualized in the operative field at this juncture. The anterior pericardium is outlined by the dotted line. (Copyrighted and used with permission of Mayo Foundation for Medical Education and Research.)
The anterior pericardium is then removed sharply. At this juncture, a marking pen can be utilized to mark the position of the entire length of the left phrenic nerve to minimize inadvertent injury to it. (Copyrighted and used with permission of Mayo Foundation for Medical Education and Research.)
Figure 7 The anterior pericardium has been removed. The left anterior descending coronary artery is well visualized. It should be noted that this is frequently the extent of pericardiectomy performed in many centers. This is inadequate for either diagnosis and the remaining portion of the pericardium behind the left phrenic nerve and along the diaphragm needs to be removed for a successful result, regardless of the diagnosis. (Copyrighted and used with permission of Mayo Foundation for Medical Education and Research.)
Figure 8 Additional dissection is then done between the pericardium and the posterolateral left ventricular wall and along the inferior walls of the left and right ventricles. Laterally, the pericardium posterior to the left phrenic nerve down to the left-sided pulmonary veins is dissected. In addition, the diaphragmatic pericardium is dissected off of the inferior left and right ventricular walls. The left phrenic nerve can be visualized in the drawing. Care should be taken when freeing up the left ventricular apex because the left phrenic nerve is in close proximity and is difficult to visualize because of a large amount of fat in this area. (Copyrighted and used with permission of Mayo Foundation for Medical Education and Research.)
Figure 9  Dissection then proceeds with removing the inferior pericardium off of the diaphragm. Care is taken to avoid unintentional entry into the dilated and sometimes thinned inferior vena cava. (Copyrighted and used with permission of Mayo Foundation for Medical Education and Research.)
Figure 10  The posterior pericardium (behind the left phrenic nerve) has been removed and the inferior pericardium (ie, pericardium adjacent to the diaphragm) has been removed. The right phrenic nerve has been preserved from the superior mediastinum down to the diaphragm just anterior to the right-sided pulmonary veins. The left phrenic nerve has been preserved on an intact pedicle from the superior mediastinum down the diaphragm. The left pulmonary artery appears lower than the left-sided pulmonary veins in this drawing because the heart has been retracted out of the mediastinum. (Copyrighted and used with permission of Mayo Foundation for Medical Education and Research.)
Special Circumstances

There can be occasional circumstances when a white fibrous rind remains on the epicardial surface of the heart after the pericardium has been removed. This rind is still constrictive and should also be addressed. If removal of this fibrous rind cannot be performed safely with sharp dissection (even with the help of cardiopulmonary bypass), it can be treated by making numerous scores in it. This results in a checkerboard appearance on the epicardium and will allow the myocardium to expand during diastole. This is usually done sharply with a no. 15 blade and it should incorporate the areas affected by this white fibrous scar. Care is taken to avoid injury to the coronary arteries.

Dense calcification in the pericardium can cause severe adherence to the myocardium. When this is encountered, it is safest to leave these areas of calcification behind and to avoid extensive dissection down into the myocardium. CUSA dissection is often helpful in this situation.

Patients who have received radiation therapy in the past may present with valvular heart disease, coronary artery disease, and/or constriction. If constriction is not present at the time of valve and/or coronary artery bypass surgery, consideration should be given to prophylactic pericardiectomy.

Reference


Figure 11 The completed pericardiectomy demonstrates complete removal of all sides of the pericardium except that which is posterior to the left atrium. The edges of the cut pericardium are treated gently with electrocautery to obtain hemostasis. All of the coronary arteries are typically well visualized when the pericardiectomy has been performed in the correct plane. IVC = inferior vena cava; Lt. = left; n. = nerve; rt. = right. (Copyrighted and used with permission of Mayo Foundation for Medical Education and Research.)