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# A Review of the Surgical Treatment for Constrictive Pericarditis

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Review Article

## Abstract

Chronic constrictive pericarditis results in the signs and symptoms of heart failure due to the chronic compression of the myocardium. When the pericardium becomes thickened and fibrosed, surgery is the sole curative management strategy. Surgery leads to an improvement in functional status and survival, but it is associated with significant mortality and morbidity. Over the years, the surgical approach to this pathology has largely remained unchanged, but there has been a shift in the etiological mechanism of constrictive pericarditis from predominantly tuberculous to post-cardiac surgery and idiopathic pathologies. This review offers an overview of the surgical management of constrictive pericarditis.

**Keywords:** Constrictive pericarditis, Surgery, Pericardiectomy

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## Introduction

The pericardium is a conical sac that encloses the heart and great vessels. It is situated retrosternally, at the level of the 2nd to 6th costal cartilages anteriorly and the 5th to 8th thoracic vertebrae posteriorly. It consists of a parietal and a visceral component. The parietal pericardium has an outer fibrous and inner serous layer, while the visceral pericardium is composed solely of the serous pericardium. Normally, there is a space between the two parts of the serous pericardium, i.e., between the parietal and visceral pericardium, which contains a small amount of fluid [1].

Pericarditis affects all the layers, and repeated chronic inflammation leads to the thickening of both the parietal and visceral pericardium. The degree of involvement varies, depending on the etiology. The two layers of the serous pericardium may either remain separate, with the small gap being filled with fibrinous deposits, or fuse together, forming a single thick layer over the heart.

Constrictive pericarditis (CP) refers to the thickening of the pericardium with subsequent constriction of the heart. While the thickening can have different causes, almost all leave the pericardium fibrosed and inelastic, and occasionally even calcified. The calcification may sometimes be so severe that it invades the myocardium, making surgical resection impossible. The resultant effect of the constriction manifests in various forms, such as diastolic dysfunction, endomyocardial fibrosis, right heart failure presenting as ascites, pedal edema, and exercise intolerance.

The underlying pathologic mechanism that leads to pericardial thickening is always inflammation of both the parietal and visceral membranes, sometimes recurrent, leading to a loss of elasticity and eventually constriction. (Figure 1)

Constriction of the myocardium due to a thickened pericardium is a mechanical problem, which can only be definitively resolved by means of pericardiectomy.

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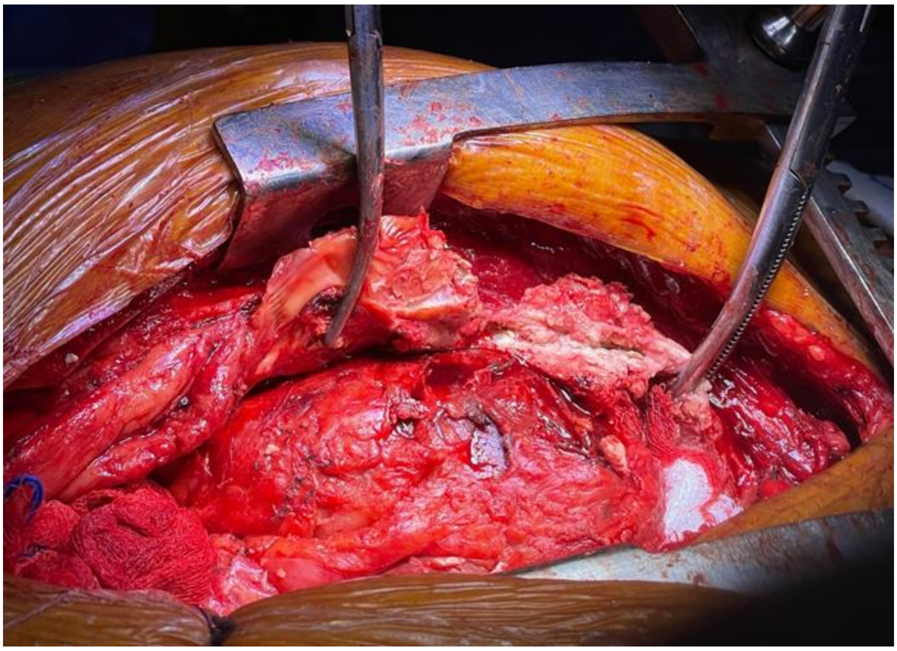

**Figure 1.** Extensively calcified pericardium

The diagnosis of constricting pericarditis with symptoms is considered an indication for surgery. The outcomes of pericardiectomy for constrictive pericarditis are associated with its etiology, which has notably changed recently from bacterial or mycobacterial to viral.[2]

Over the years, the basic surgical approach to pericardiectomy has essentially remained the same, while the disease pattern has changed in many areas of the world, leading to changes in outcomes. This review presents an overview of surgical pericardiectomy techniques, as well as its outcomes.

## Etiology

Historically, pericardiectomy has most commonly been performed for idiopathic pericarditis in the developed world and tuberculosis in most of the developing countries. With the increasing use of radiation, as well as a rise in the number of open-heart surgeries, a large number of pericardiectomies are performed for constrictive pericarditis post cardiac surgery and radiation-induced constrictive pericarditis. Constrictive pericarditis due to tuberculous etiology has been decreasing in many underdeveloped regions of the world, but with the emergence of resistant strains of tuberculosis (TB) due to AIDS in African countries, TB is likely to remain a common cause of constrictive pericarditis.[3]

The etiology of constrictive pericarditis not only affects the surgical outcomes, but also poses different technical challenges. Patients with post-radiation pericarditis may present with extensive calcification (Figure 2). On the other hand, patients with tuberculous etiology may present with purulent pericarditis with fibrinous exudate on the epicardium, which can easily be removed, even with a left antero-lateral thoracotomy.[4]

The predominant causes of pericarditis in different parts of the world depends upon the disease pattern in that area and the era being analyzed. The incidence of tuberculous pericarditis decreased in Western countries after 1990 due to improved treatment options and public health measures [5]. The significant causes of pericarditis in the modern era in the Western world are idiopathic (most likely viral), post-surgical, and radiation-induced. Modalities like CT scans, which are used daily, have increased the incidence of radiation-induced pericarditis. Radiation-induced cardiomyopathy, valvular problems, and aortic calcification


**Figure 2.** Extensively calcific pericardium causing constrictive pericarditis

are well-known long-term complications. Tuberculosis remains the major cause of Constrictive Pericarditis (CP) in South Asia and the Far East, making it the most common cause of CP in these countries.[6]

*Extent of pericardiectomy*

The pathophysiologic effect of constriction is compression and diastolic restriction of the cardiac chambers. Right sided chambers, being thin and comparatively low-pressure chambers, are constricted first, leading to presentation with signs and symptoms of right heart failure. With advanced pathology, the left ventricle is also affected, and patients develop signs and symptoms of low cardiac output. The optimal extent of resection of the constricting pericardium is not clearly defined in the literature. Terms like "complete", "total", "subtotal", "radical" and "partial" pericardiectomy have been used to describe different extents of resection (Table 1).

Most authors agree that a full pericardiectomy involves freeing all the chambers of the heart, including the superior vena cava and inferior vena cava. As early as 1944, Harrington established in a series of 24 cases that resection of only anterior pericardium might not free the left ventricle and freeing of the right ventricle from the diaphragm was necessary.[7] Bertog et al described those least likely to be treated with complete pericardiectomy were patients with post radiation CP due to the presence of mediastinal fibrosis.[8] McCaughan et al described, for the first time, radical pericardiectomy as resection of the pericardium in all the areas including posterior to left phrenic and left pulmonary vein.[9] Decompression of the right sided cavities was considered the key factor in the procedure. With this extent of resection, they reported 5 years survival of 79.4% in their cohort.

Chowdhury and colleagues reported a hospital mortality rate of 7% with complete pericardiectomy, suggesting its safety.[10] They achieved a long-term survival rate of 83.8%± 0.04% over a follow-up period of 17.9 years. The survival rate was significantly lower (73.9% ± 0.06%) in patients who underwent less complete pericardiectomy. Avgerinos and colleagues reported a 15-year survival rate of 78.3% with total pericardiectomy. The importance of clearing the diaphragmatic surface was further emphasized by Cho and colleagues, who reported poor results when this part of the pericardium was not released.[12]

Partial pericardiectomy is any pericardiectomy that does not involve radical resection as de-

**Table 1.** Various extents of resection during pericardiectomy as defined by different authors.

| Extent of pericardiectomy | Definition | Authors |
|---|---|---|
| Complete pericardiectomy | Phrenic to phrenic resection of the pericardium along with diaphragmatic surface | Bertog et al [8] |
| | Resection of pericardium on both ventricles, great vessels, diaphragmatic surface and posterior to the left phrenic nerve. | Chaudhry et al [6] Szabzo et al [19] |
| Radical pericardiectomy/Total pericardiectomy | Resection of pericardium on all the visible areas including the part posterior to the left phrenic nerve and also left pulmonary vein. | McCaughan et al [9] |
| | Resection of all areas, from great vessels above to diaphragm below, but phrenic to phrenic on the ventricles. | Vistarini et al [14] |
| | Resection from great vessels superiorly to diaphragmatic surface inferiorly and phrenic to phrenic on the ventricles. Atria and venae cavae decorticated only when technically feasible. | Ling et al [33] |
| Partial pericardiectomy | Phrenic to phrenic resection only avoiding posterior aspect of left atrium and pulmonary veins | Nataf et al [13] |
| Conventional pericardiectomy | Anterior pericardiectomy along with resection of diaphragmatic pericardium but not involving pericardium posterior to left phrenic nerve. | Choi et al [17] |

scribed above. Nataf et al achieved a 7 years survival of 87% with all the patients in NYHA I or II with partial pericardiectomy.[13] Vistarini et al described phrenic to phrenic as sufficient resection and they achieved survival of 79.4% over 5 years with this technique in those who underwent isolated pericardiectomy for constrictive pericarditis.[14]

It appears form the literature that most of the reports from the 80's and 90's are content with phrenic to phrenic resection of the pericardium. But the literature published on the subject in the last two decades shows that this is a limited resection and may lead to suboptimal results. Most recent reports from high volume centers of the world advocate complete removal of the pericardium including the part posterior to the left phrenic nerve, pulmonary veins, superior and inferior venae cavae, diaphragmatic surface and both the atria.

*Median Sternotomy vs Left Anterior Thoracotomy*

Various surgical approaches, such as median sternotomy (MS), left anterior thoracotomy (LAT), and clamshell incisions, have been described in the literature, each with its own inherent advantages and disadvantages. Left anterior thoracotomy (LAT) can be employed in cases of purulent tuberculous or pyogenic pericarditis because the adhesions are soft, and the areas on the right side of the heart can be cleared off. [10] While there are certainly some indications for LAT, some authors also suggest performing LAT for cosmetic reasons.[15]

Median sternotomy is utilized in cases of constrictive pericarditis with more extensive disease, such as pericardial calcifications, constrictive pericarditis post-surgery, and those with recurrent constrictive pericarditis.[16] Similarly, patients requiring additional cardiac procedures and post-radiation constrictive pericarditis should be operated on through median sternotomy. The complete freeing of the right-sided chambers is crucial to the success of pericardiectomy because most of the signs and symptoms are related to the compression of these chambers. Vistarini and colleagues had to extend a left anterior thoracotomy (LAT) incision to median sternotomy in three patients to gain access to the right side, thus allowing full pericardiectomy.[14] They performed median sternotomy in most of their patients and were able to perform complete pericardiectomy (anterior phrenic to phrenic) in 61% of their patients.

It can be concluded that most contemporary pericardiectomy procedures are performed through median sternotomy.[13] With increasing experience with this procedure and an apparent change in the etiology of CP, more and more patients are being operated because of post open heart surgery and post radiation CP. The preferred approach in these patients is median sternotomy. Moreover, radical pericardiectomy carries better long-term outcome and this can be performed only through MS. Left anterior thoracotomy carries some disadvantages. It cannot be used when additional cardiac procedures are contemplated and is also contraindicated in patients with pulmonary dysfunction. Nonetheless, LAT is still being performed, especially in those parts of the world where tuberculous pericarditis is still common and also for cosmetic reasons.

### *Use of Cardiopulmonary bypass*

Historically, pericardiectomy has been performed without the use of cardiopulmonary bypass (CPB). In early reports on pericardiectomy for constrictive pericarditis (CP), the use of CPB was advised only when there was inadvertent entry into any cardiac chamber.[13] With the change in the etiological pattern of constrictive pericarditis, an increasing number of patients with a history of prior cardiac surgery and prior irradiation are being referred for surgery. These patients develop dense adhesions and also calcification in the case of CP post-radiation. These factors may necessitate the use of CPB for safe resection of the pericardium.

Pericardiectomy for tuberculous or pyogenic causes can be done through left anterior thoracotomy (LAT), without the use of CPB, as there are no dense adhesions or calcification. Another instance where CPB may not be routinely necessary is the phrenic-to-phrenic pericardiectomy, which can be done through median sternotomy without extensive manipulation of the heart. However, this approach may not be therapeutic in some cases.[10] CPB is indicated in patients who require radical pericardiectomy as they require manipulation of the heart. CPB also helps to empty the heart and identify the proper plane for dissection, and may be inevitable, should calcifications penetrate the cardiac valves, necessitating reconstructive surgery. Thus, it serves to improve not only the extent of resection, but also the overall quality of operation by allowing more constricting pericardium to be resected.[17] High volume referral centers for pericardiectomy advocate the use of CPB in more than 50% of the patients for these important reasons.[5]

### *Tricuspid regurgitation*

Increased pressure inside the pericardium translates to increased pressure in the right ventricle (RV), leading to functional tricuspid regurgitation (TR)[5]. For this reason, some degree of TR is common in almost all patients with constrictive pericarditis (CP), affecting postoperative hemodynamics and long-term survival. Gongora et al., in their cohort of 261 patients, described moderate TR in 36 (14%) patients and severe TR in 18 (7%) patients.[18] Early mortality for those with moderate to severe TR was significantly higher (13%), compared to patients who did not have moderate or severe TR (4%). Notably, an adequate repair did not decrease mortality. This might be because tricuspid regurgitation is an indicator of a more severe underlying disease. TR was relieved in 29% of patients after pericardiectomy in their cohort. Choi et al. reported increased long-term mortality in patients with a moderate to severe degree of tricuspid regurgitation.[17]

With a better understanding of the deleterious effects of tricuspid regurgitation on long-term outcomes, the trend has shifted towards a more aggressive strategy to repair the valve in the presence of regurgitation. This is evident in a large study by Murashita and colleagues where tricuspid repair was done in 12.4% of their contemporary cohort compared to 0.8% in the historical one[5].

The issue of tricuspid regurgitation in patients with CP undergoing pericardiectomy has been addressed by a few reports in the past. But it seems that with time, the early and long-term deleterious effects of TR were recognized and more and more reports advocated aggressive treatment for at least moderate to severe TR. Most of the contemporary authors advise repair aggressively, keeping in mind the association of TR with late mortality and also the fact that TR may worsen after pericardiectomy in some patients.

*Pericardiectomy for post radiation constrictive pericarditis*

The impact of irradiation on the heart, lungs, and surrounding tissues is a complex combination of accelerated arteriosclerosis, scarring, and degeneration of the valves, cardiomyopathy, and interstitial fibrosis. Microvascular dysfunction secondary to interstitial fibrosis reduces tolerance to ischemic events and limits exercise capacity. These are permanent and irreversible changes, leading to prolonged low output syndrome in the early postoperative period, frequently seen in patients who undergo pericardiectomy for constrictive pericarditis (CP). For these reasons, it is cardiac insufficiency, not the recurrence of malignancy, that leads to long-term mortality.[19]

The peculiar effects of irradiation on the myocardium, and hence poor early and late results, pose a question regarding the effectiveness of pericardiectomy in post-radiation CP. Ni et al. presented their report of two patients along with a review of 44 patients from the literature.[20] There were only 20 survivors out of these 46 patients in the short term. They cited a combination of myocardial fibrosis, conduction disturbances, accelerated coronary artery disease, pulmonary fibrosis, and the general poor health of the patients as contraindications to surgery for these patients. Karram et al. followed their patients who underwent surgery for radiation-induced CP, and all of them died during a follow-up of 11 years.[21]

Buyukbayrak and colleagues presented their report of eight patients who had surgery for post-irradiation CP.[22] In their cohort, 62% achieved NYHA class of I or II before discharge, although seven out of these eight patients died at a follow-up of up to 26.78 months. They suggested that despite the poor long-term outcome, pericardiectomy should be offered to those who have a life expectancy of more than one year because of the symptomatic benefit of surgery.

Constrictive pericarditis post-radiation poses a unique challenge. The decision for surgery in these patients should be taken in light of the prognosis from the primary diagnosis point of view. Those with good life expectancy should be offered surgery because of a good symptomatic improvement and hence quality of life.

*Pericardiectomy for CP after open heart surgery*

A repeat pericardiectomy may be required in patients who have already undergone open heart surgery. Some of these patients may have patent grafts, posing a special challenge. Gillaspie et al. were able to achieve good symptomatic results with radical pericardiectomy in their cohort of 98 patients for post-CABG constrictive pericarditis [23]. They advise leaving the pericardium as a pedicle around the graft, especially the internal mammary artery.

Nataf et al. advocated for only anterior resection due to the older age of these patients[13]. A Waffle procedure may also be relevant in patients with extensive scarring and older age. Most authors have reported good outcomes with total pericardiectomy (Table 2).

A repeat pericardiectomy may be required for patients with recurrent constrictive pericarditis. Yunfei and colleagues compared median sternotomy to left anterior thoracotomy in their cohort of patients undergoing a repeat pericardiectomy.[24] Although there were more pulmonary complications in the LAT group, the incidence of deep sternal wound infection was high in the MS group and they advised LAT as the approach of choice where possible.

*Early outcomes*

Contemporary mortality has been quoted as

Table 2. A summary of reports who had more than 30% patients with constrictive pericarditis post open-heart surgery

| Authors | Patients (n) | Etiology | Incision | Extent of resection | Use of CPB | Short term outcomes | Long-term outcomes | Comment |
|---|---|---|---|---|---|---|---|---|
| Bertog et al [8] | 163 | Idiopathic, 46%, post cardiac surgery, 37% post radiation,9%. | Median sternotomy, 90% Bilateral thoracotomy in 5%. LAT in 4%. | Phrenic to phrenic including the diaphragmatic aspect. Those with post radiation pathology were least likely to be treated with complete resection | Not mentioned | Perioperative mortality, 6.1% Post radiation CP had the highest mortality (21.4%) | Median survival: 6.9 years | Post-surgical CP, the median duration between surgery and pericardiectomy was 16 months. Post radiation CP less likely to undergo complete pericardiectomy. |
| George et al [28] | 98 | Idiopathic in 44 patients Postoperative in 30 patients Post radiation in 17 patients | Median sternotomy (MS) in 93, LAT in 6 patients They achieved total pericardiectomy in 95% of their patients through MS approach. | Total pericardiectomy in 94 out of 98 patients | CPB used in 34 patients who needed concomitant procedures | In hospital survival was 92.9% | 5 years survival 64.3%, 10 years survival 49.2%. 5 years survival in idiopathic was 79.8%, in postoperative was 55.9% and post radiation was 11.0% | The short-term survival was similar for all aetiologies. But the long-term outcome was best for idiopathic and worse for post radiation CP. |
| Cho et al [12] | 41 | Idiopathic in 49%, Post cardiac surgery in 32%, Post radiation in 15%, Post trauma in 5%. | MS 75.6%, LAT 19.5% and bilateral thoracotomy in 4.9% | Not mentioned | CPB used in 30 patients out of 41 who had MS and 1 patient who had LAT. | In hospital mortality was 12%. | 5 years survival 49% | Underlying restrictive cardiomyopathy and pulmonary hypertension are causes for high early mortality. So complete pericardiectomy is recommended at the time of first operation. |
| Avgerinos et al [11] | 36 patients between 1997 and 2012. Mean follow up was 68.8 months. | Idiopathic in 55.6%, postoperative in 30.5%, post radiation in (8.3%) and tuberculous in 5.6% patients. | Median sternotomy except one patient who had Left anterior thoracotomy | Total pericardiectomy was performed in 35 patients | CPB used only when there was iatrogenic injury, or concomitant procedure | No perioperative mortality | 10 years survival 86.5% and 15 years survival was 78.3%. Significant decrease in survival of post radiation | Total pericardiectomy improves both early and late outcomes. |

4.9-12% in the recent reports about pericardiectomy for constrictive pericarditis.[12] Bertog et al reported a mortality of 6.1% with low output syndrome being the most common cause of early mortality.[8] The cause of low cardiac output early after surgery can be related to the prolonged myocardial compression by the constricting pericardium.[25] Moreover, the pathophysiologic effects of constriction on the heart lead to deleterious effects like ascites, pedal edema and liver injury which leaves the patient vulnerable to bleeding diathesis. All these effects may act cumulatively in the postoperative period, leading to poor outcomes. Another important factor is the duration of symptoms before the surgery. Longer the duration of the symptoms, poorer the early results.[26]

RV failure was described as a predictor of poor early outcomes by Peset et al in their report of 31 patients.[27] George and colleagues in their cohort of 98 patients, reported early mortality of 8.1%. They found the use of cardiopulmonary bypass as a predictor of early mortality.[28] This was likely because of more concomitant procedures in patients in whom CPB was used. Completeness of pericardiectomy, although an important protective factor for late mortality, did not predict perioperative mortality in the report by Mutyaba et al.[3]

*Late outcomes*

Although with better understanding of the pathophysiology of CP and perioperative management in pericardiectomy, there has been an improvement in the early outcomes of pericardiectomy. But long-term outcomes have only gotten worse. This might be explained by relatively high-risk profile of the patients and a change in the etiology of the CP. Long standing CP leads to signs and symptoms of right heart failure initially and later on left heart failure. Diastolic dysfunction, myocardial atrophy and pulmonary hypertension are some of the sequelae of CP that ultimately leads to reduced exercise capacity and systemic congestion.

CP due to tuberculosis, post cardiac surgery CP and idiopathic CP have relatively good long-term outcomes. Bicer et al performed pericardiectomies in 47 patients and more than 2/3 had tuberculous or idiopathic etiology.[29] The 10 years survival in their cohort was 81%. On the other hand, patients with post radiation constrictive pericarditis who undergo pericardiectomy have poor long-term outcomes.[5]

The extent of pericardiectomy has also been described as a predictor of long-term outcomes. Nozohoor et al in their median follow up of 10 years, described a 10-year survival of 94% for those who had undergone radical pericardiectomy, as compared to 55% in those who had subtotal pericardiectomy.[30] Choi and colleagues also described better long-term results for those who had radical resection of the pericardium.[17] In the article by Gillaspei et al, radical versus subtotal pericardiectomy had a non-significant difference in the long-term outcome.[31]

Operating patients before more extensive damage in the heart and limitation of exercise capacity was emphasized by Zhu et al who showed better long-term results when the patients were operated before the onset of class III symptoms.[32] The importance of early surgery may also be explained by the failure in improvement of symptoms of heart failure in some patients who undergo pericardiectomy. Ling et al, in their cohort of 135 patients, observed new onset or recurrent class III or IV dyspnea in 31% patients even though they performed radical pericardiectomy in 89% of their patients.[33]

## Conclusion

Inflammation of the pericardium leads to constrictive pericarditis, resulting in the constriction of the cardiac chambers. Idiopathic causes, post-cardiac surgery, and post-radiation constrictive pericarditis are common etiologies in the developed world, while tuberculous pericarditis remains prevalent in developing countries. Pericardiectomy is the only curative strategy for constrictive pericarditis. The extent of pericardiectomy is still a subject of debate, but as we gain more knowledge about the long-term results of pericardiectomy, it appears that radical pericardiectomy should be performed where possible. Most pericardiectomies can be performed without the use of cardiopulmonary bypass (CPB), but it should be used whenever a radical resection is not possible without it. Early diagnosis and surgery are key to achieving good early outcomes.

## Conflict of interest declaration

The authors declare no conflict of interest related to this manuscript.

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