# Does the Thoracoscopic Pericardial Fenestration Side Matter in Patients With Cardiac Tamponade?

**Murat Akkuş[1](İD), Yunus Seyrek[1](İD)**

[1] University of Health Sciences, İstanbul Mehmet Akif Ersoy Thoracic and Cardiovacular Surgery Training and Research Hospital, Department of Thoracic Surgery, İstanbul, Turkey

## ABSTRACT

**Introduction:** In our study, we aimed to analyze and compare left pericardial fenestration (LPF) with right pericardial fenestration (RPF) in order to reveal the possible advantages or disadvantages in patients with cardiac tamponade (CT).

**Patients and Methods:** Between January 2011 and December 2018, the medical records of 168 patients referred from the cardiology department of our tertiary central hospital for surgical pericardial fenestration (PF) were reviewed retrospectively. Out of the 168 patients, 54 patients consisting of 31 patients with advanced stage cancer with CT and 23 patients with recurrent CT were included into the study. All patients were provided with percutaneous, echocardiographic-guided drainage prior to video-assisted thoracoscopic surgical PF to avoid instability associated with the induction of general anesthesia and opening of the pericardial window.

**Results:** There was no significant difference between the two groups in terms of age, sex, body mass index, symptoms, pericardium histology, length of hospital stay, preoperative measurement of pericardial effusion, operative time, preoperative ejection fraction, duration of chest tube drainage, and volume of pericardial fluid drainage. Complication rate was significantly lower in the RPF group. There was no reported ventricular failure in RPF.

**Conclusion:** After a sweeping highlight of the literature examining the complications of PF, we did not find an eligible reason other than the intervention side for experiencing LV failure in LPF and not in RPF. We hypothesize that to reduce the risk of LV failure, right-sided intervention may be considered in patients with CT who will undergo surgical PF.

**Key Words:** Pericardial fenestration; cardiac tamponade; ventricular failure

## Kardiyak Tamponadlı Hastaların Torakoskopik Perikardiyal Pencere Açılma Tarafı Önemli mi?

## ÖZET

**Giriş:** Çalışmamızda, kardiyak tamponadlı (KT) hastalarda sol taraf perikardiyal pencere (SoPP) ve sağ taraf perikardiyal pencere (SaPP) açılmasının avantajlarını ve dezavantajlarını değerlendirmeyi amaçladık.

**Hastalar ve Yöntem:** Retrospektif olarak Ocak 2011-Aralık 2018 yılları arasında perikardiyal pencere (PP) açılması amacıyla 3. basamak merkez kardiyoloji kliniğinden kliniğimize sevkedilen kayıtlı 168 olgu değerlendirildi. 168 olgudan 31 olgu ileri evre akciğer kanseri ve 23 olgu tekrarlayan KT nedeniyle toplam 54 olgu çalışmaya alındı. Bütün hastalara, genel anestezi indüksiyonunda ve perikardiyal pencere açılması esnasında oluşabilecek instabiliteyi önlemek amaçlı videotorakoskopik PP operasyonu öncesi ekokardiografi eşliğinde perkutanöz perikardial drenaj uygulandı.

**Bulgular:** Yaş, cinsiyet, vücut kitle indeksi, semptomlar, perikard patolojileri, hastanede yatış süreleri, preoperativ perikardial effüzyon ölçümleri, operasyon süreleri, preoperativ ejeksiyon fraksiyonları, göğüs tüp drenaj süreleri ve perikardiyal sıvı drenaj volümleri arasında iki grup arasında anlamlı farklılık saptanmadı. Komplikasyon oranı SaPP grubunda anlamlı derecede düşük izlendi. Ventriküler yetmezlik SaPP grubunda görülmedi.

**Sonuç:** PP komplikasyonları literatürler eşliğinde kapsamlı incelendikten sonra sol ventriküler yetmezliğin, girişim yapılan taraf dışında SoPP olup SaPP gelişmemesine sebep olabilecek başka uygun neden bulunamadı. PP operasyonuna alınan KT hastalarda sol ventriküler yetmezlik riskini azaltmak için sağ taraf yaklaşımının göz önüne alınması düşünülebilir.

**Anahtar Kelimeler:** Perikardiyal pencere; kardiyak tamponad; ventriküler yetmezlik

## INTRODUCTION

Due to the pericardial sac's limited reserved volume, small increases in the pericardial volume, which occur in pathologic conditions, can exert a significant hemodynamic hindrance on ventricular compliance and diastolic filling[1]. Cardiac tamponade (CT) is a life-threatening clinical syndrome characterized by hemodynamic anomalies resulting from an increase in peri-

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**Correspondence**

**Murat Akkuş**

**E-mail:** akkusmdr@gmail.com

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cardial pressure due to the accumulation of serous fluid, blood, or pus[2]. The primary cause of CT is iatrogenic, followed by malignancy, tuberculosis, pericarditis, and acute myocardial infarction, while CT recurrence is mostly due to malignancy or tuberculosis[3]. Patients typically present with hypotension, tachycardia, and prominent jugular venous pressure[4].

Pericardiocentesis is a lifesaving procedure that instantly reduces pericardial pressure on CT to some degree; however, permanent treatment cannot be achieved. While methods such as percutaneous catheter drainage or balloon pericardiotomy are performed for diagnostic and therapeutic purposes, recurrent or loculated pericardial effusions are best managed surgically with a pericardial window[5]. In our study, we aimed to analyze and compare left pericardial fenestration (LPF) with right pericardial fenestration (RPF) in order to reveal the possible advantages or disadvantages in patients with CT.

## PATIENTS and METHODS

Between January 2011 and December 2018, the medical records of 168 patients referred from the cardiology department of our tertiary central hospital for surgical pericardial fenestration (PF) were reviewed retrospectively. Patients with recurrent pericardial effusions and recurrent tamponades and those with cancer with tamponades are routinely referred to the thoracic surgery clinic for PF. Patients without recurrent CT (except for malignancy) are not offered PF by our cardiology clinic. Exclusion criteria of the study included the following: patients with echocardiographic or radiologic signs of constrictive pericarditis, those without a history of CT, those who underwent fenestration through anterolateral thoracotomy, those with a known tuberculosis diagnosis, those who underwent bilateral PF, and those who were lost to follow-up. Out of the 168 patients, a total of 54 patients consisting of 31 patients with advanced stage cancer with CT and 23 patients with recurrent CT were included into the study. Video-assisted thoracoscopic surgical (VATS) PF was performed in all cases (n= 54). In our cardiology clinic, a diagnosis of CT is defined by clinical and echocardiographic criteria[6,7]. Two-dimensional echocardiographic criteria of CT include early diastolic collapse of the right ventricle, late diastolic collapse of the right or left atrium, and plethora of the inferior vena cava with pericardial effusion[8]. In all cases, the location and distribution of pericardial effusion leading to tamponade were confirmed by Doppler echocardiography. All patients were provided with percutaneous, echocardiographic-guided drainage prior to PF (one day before surgery) to avoid instability associated with the induction of general anesthesia and opening of the pericardial window. In order to plan the intervention side of PF, a computed tomography scan was performed to identify additional pleural or parenchymal pathology and determine the predominant localization if pericardial effusion was loculated.

Patients were analyzed in two groups: patients who had LPF and RPF. Although LPF is mostly preferred in the literature, we performed RPF in certain groups of patients who had left-sided pleural adhesions to facilitate VATS PF and decrease operation time. RPF was performed in patients with right pleural effusions, history of left-sided thoracic surgery, left mastectomy, probable left apical past tuberculosis sequelae spotted through computed tomography, and right-side loculated pericardial effusions spotted on echocardiography due to adhesions resulting from recurrent pericardiocentesis. LPF was performed in the remaining patients.

### Surgical Technique

PF was performed in the lateral decubitus position under general anesthesia and single-lumen intubation; 2 thoracic incisions for 5-mm trocars at the level of the fourth and fifth (camera port) intercostal space (ICS) and 1 thoracic incision for 10-mm trocar of the sixth ICS were opened. Warm $CO_2$ insufflation (pressure/flow $< 10$ mmHg and 8 mL/s) was used through the port at the fourth ICS, and endoscopic surgical instruments were used through the port at the fourth and sixth ICS. The pleural cavity and lung were examined first, and pleural effusion was removed and sent for cytology. After the phrenic nerve had been identified, a stab incision was usually created on the surface of the distended pericardium using ultrasonic scalpel. The pericardium was then grasped with endoscopic forceps and incised at least 4 cm2 of the pericardium. Loculations and septa were removed using a thoracoscopic suction device for healthy circumferential drainage. A chest drain was inserted into the thoracic cavity without an attempt to drain the pericardium. Operative time was defined as the time from the induction of anesthesia until the time the patient left the operative room. Follow-up for 3 months was performed for all patients after discharge from the hospital. Local institutional ethical committee approval was obtained (2020/29).

### Statistical Analysis

Means, standard deviations, medians, minimums, maximums, frequencies, and percentages were used for descriptive statistics. Distributions of the variables were checked using the Mann-Whitney U test to compare quantitative data. The Chi-square test was used to compare qualitative data. IBM SPSS Statistics for Windows, version 22.0, was used for statistical analyses.

## RESULTS

The included patients (n= 54) were analyzed in two groups: LPF (n= 30) and RPF (n= 24). Mean age of the cohort was 57 ± 12.7 years (range, 44-74). Male patients consisted of %55 of the study group (n= 30). Preoperative symptoms were mostly isolated dyspnea with anxiety (n= 28), followed by chest pain (n= 9) and pyrexia (n= 2). Fifteen patients were clinically asymptomatic. Markers of myocardial lesions were elevated in none of the patients. Mean operative time was 34 ± 11 min (range, 25-40). Mean length of hospital stay was 4.4 ± 3.5 days (range, 3-15 days), and mean duration of postoperative chest tube drainage was 2.4 ± 0.6 days (range, 1-5 days). Effusion was localized in 8 cases. Mean measurement of pericardial effusion was 2.6 ± 1.2 cm (range, 2-5). Mean volume of echocardiographic-guided drainage prior to surgical fenestration was approximately 150 mL. Mean volume of drained pericardial fluid was approximately 500 mL (range, 300-900 mL). Pericardial fluid was hemorrhagic in patients with malignancies; nevertheless, anemia was not reported postoperatively.

Of the 54 patients, 31 had advanced stage cancer and the remaining 23 did not have a known diagnosis. Histopathology reported malignancy in 31 patients (57%), tuberculosis in 13 patients (24%), and chronic nonspecific pericarditis in 10 patients (19%). Malignancy consisted of 21 lung carcinomas (68%), 7 breast carcinomas (23%), and 3 ovarian carcinomas (9%). Thirty-six of the 54 patients underwent a second echocardiography examination at a mean of 3 months after surgery (range, 2-5 months). None of the patients in either group showed recurrent pericardial effusion after PF. Twenty-two patients died during follow-up, of whom 3 died from pulmonary embolus, 3 from ischemic heart disease, and 16 from malignancy. Postoperative complications (n= 12, 22%) were as follows: 6 left ventricular (LV) failure (LPF [n= 6] vs. RPF [n= 0]) and 6 postoperative new atrial fibrillations (AF) (LPF [n= 4] vs. RPF [n= 2]). A coronary angiogram was performed in 6 patients who developed LV failure to exclude any significant obstructive coronary artery disease and demonstrated normal coronary arteries. Six patients who had LV failure were evaluated according to the Clavien-Dindo classification 9: Three patients with grade II who recovered by pharmacological treatment; two patients with grade IVa who had acute renal failure, which necessitated dialysis; and 1 patient with grade V who lost his life postoperatively due to cardiogenic shock.

There were no significant differences between the two groups in terms of age, sex, body mass index (BMI), symptoms, pericardium histology, length of hospital stay, preoperative measurement of pericardial effusion, operative time, preoperative ejection fraction, duration of chest tube drainage, and volume of pericardial fluid drainage (Table 1). On the other hand, complication rate was significantly lower in the RPF group (p= 0.028); there was no reported ventricular failure in the RPF group, and the difference was statistically significant (p= 0.02).

**Table 1. Patient characteristics according to the analyzed groups**

| Parameter | LPF (n= 30) | RPF (n= 24) | p |
|---|---|---|---|
| Male | 19 | 14 | 0.708$^{c}$ |
| Female | 11 | 10 | 0.7$^{c}$ |
| Age (years) | 55.8 ± 13.4 | 58.2 ± 4.6 | 0.98$^{m}$ |
| BMI | 29.2 ± 3.4 | 30.3 ± 2.1 | 0.79$^{m}$ |
| Pre-op symptoms | 23 | 16 | 0.415$^{c}$ |
| Pre-op EF (%) | 33.3 ± 1.2 | 32.6 ± 2.4 | 0.45$^{m}$ |
| Operative time (min) | 36.5 ± 4.6 | 33.7 ± 8.5 | 0.92$^{m}$ |
| Length of hospital stay (days) | 4.2 ± 3.8 | 4.6 ± 2.7 | 0.42$^{m}$ |
| Chest tube duration (days) | 2.3 ± 1 | 2.6 ± 0.3 | 0.58$^{m}$ |
| Pre-op pericardial effusion (cm) | 2.7 ± 0.8 | 2.4 ± 1.8 | 0.59$^{m}$ |
| Post-op pericardial fluid drainage (mL) | 510 | 480 | 0.28$^{m}$ |
| Lung carcinoma | 12 | 9 | 0.851$^{c}$ |
| Breast carcinoma | 4 | 3 | 0.928$^{c}$ |
| Ovary carcinoma | 2 | 1 | 0.69$^{c}$ |
| Tuberculosis | 8 | 5 | 0.618$^{c}$ |
| Nonspecific pericarditis | 6 | 4 | 0.754$^{c}$ |
| Post-op LV failure | **6** | - | **0.02$^{c}$** |
| Post-op AF | 4 | 2 | 0.561$^{c}$ |

AF: Atrial fibrillation, BMI: Body mass index, $^{c}$: Chi-square test; cm: Centimeter, EF: Ejection fraction, LPF: Left pericardial fenestration, LV: Left ventricle, Pre-op: Preoperative, Post-op: Postoperative, RPF: Right pericardial fenestration, m: Mann-Whitney U test; mL: Milliliter.

## DISCUSSION

CT is a treatable cause of cardiogenic shock that can be rapidly fatal if unnoticed. Patients with CT are usually anxious and complain of dyspnea and chest pain[10]. Malignant pericarditis and tuberculosis are frequent reasons for recurrent CT[11]. CT is called malignant cardiac tamponade (MCT) when it is due to malignancy. MCT is not a rare incident, whereas it accounts for up to 30% of the cases seen in autopsy studies[12]. In our study, 57% of the studied cases had MCT. The pathogenesis behind MCT is based on Fraser's hypothesis of retrograde lymphatic dissemination from malignant mediastinal lymph nodes[13,14]. Nonetheless, pericardiocentesis and pericardial drainage have been associated with recurrence rates of up to 55% in MCT[15]. Thus, PF is routinely performed in patients with MCT, assuming it will be recurrent. Lung carcinoma is the most common malignancy causing malignant pericardial effusion and comprises nearly half of all metastatic lesions to the heart[16]. In our study, lung carcinoma was the most frequent malignancy (21/31), followed by breast carcinoma (7/31).

In our study, we compared the postoperative data of the LPF and RPF groups, and no parameter was differential except for complications. The complication rate of LPF (35%, n= 10) was significantly higher than that of RPF (14%, n= 2). Successful pericardial decompression may also induce hemodynamic compromise, such as ventricular dysfunction associated with ventricular impairment, cardiac arrhythmia, and cardiogenic shock[17]. Ventricular dysfunction is predominantly LV failure (40%), followed by right ventricular and biventricular failure[18]. In our study, we postoperatively observed LV failure (n= 6) as ventricular dysfunction in the LPF group and AF as cardiac arrhythmia in both the LPF and RPF groups. AF, which is a facilely recognized and medically treated event, is not an actual substantial complication, whereas LV failure is an uncommon complication and its exact pathophysiology is still being speculated. Hypotension, tachycardia with a pulsus paradoxus, and enlarged jugular veins are the first evidence of LV failure. Low-voltage QRS wave and enlarged cardiac silhouette on chest radiography are additional findings. The mechanism is unclear, and no single pathologic pathway has been elucidated; however, there are several proposed mechanisms. The first proposed mechanism is that the development of acute LV dysfunction is a result of interventricular volume mismatch after sudden depression of the CT. The right ventricular end-diastolic volume overloads the left ventricle, resulting in increased LV wall stress, and increased LV end-diastolic pressure. Consequently, acute LV dysfunction occurs[19]. A second hypothesis is myocardial stunning due to oxygen supply-demand mismatch across the LV and right ventricular myocardium. An acute increase in myocardial wall stress due to the sudden increase in stretch of the cardiac chambers, after the increase of venous return at high filling pressures, is combined with a relatively negative-pressure environment in the pericardial cavity after pericardial fluid evacuation. This instant increase in wall stress can result in significant cellular injury and tissue dysfunction, which may cause ventricular failure[20].

There are proposed precautions for preventing ventricular failure in the literature. The controlled rate of pericardial fluid drainage allows adaptive changes in coronary flow, myocardial mechanics, and wall stress to develop so that intrapericardial pressure does not drop rapidly and predispose LV dysfunction. Moreover, patients with a lower BMI may have lower tolerance to pericardial decompression compared to individuals with as higher BMI; therefore, monitoring is advised for at least 24 h for these patients so that any signs of acute LV dysfunction can be recognized and treated early[20]. In our study, we had already taken these precautions. First, all patients were provided with percutaneous, echocardiographic-guided drainage before PF to avoid instability preoperatively and postoperatively due to the rapid drop of intrapericardial pressure. Second, all patients with both high and low BMIs were routinely monitored postoperatively for at least 24 h. Furthermore, there was no difference between LPF and RPF in terms of BMI. Additionally, some predisposing factors such as low arterial gas saturation and some form of already established myocardial dysfunction are mentioned as facilitators for LV failure[21]. In our study, most of the patients had low arterial gas saturation preoperatively, and none of the patients had a history of cardiac pathology. We speculate that the surgically opened left pericardial window may be enlarged due to the considerably more powerful LV systole compared to RV. Cardiac axis may shift through the enlarged left pericardial window and cause the prevention of heart's outflow and inflow, which results in LV failure.

There are not many case series on pericardial window procedures in patients with CT. Philippakis et al.[22] have reported 16% acute LV failure rate after left pericardial window in their series. They have stated that this rare complication has a high mortality rate and seems more probable in cases of CT. They recommend starting the patients on diuretics prior to the operation if the condition of the patient allows and trying to initially decompress the pericardial cavity slowly by pericardiocentesis, which we have already performed, to prevent LV failure. In our study, acute LV failure rate was 11%, and it was not spotted in patients without CT who underwent PF (n= 114), which also implies that it is more probable in patients with CT.

The right atrium and right ventricle of the heart are structures that function at lower pressures compared with the left side and may be easier to be compressed with less pericardial effusion compared with the left atrium and ventricle. Thus, it is easier for CT to occur in right-sided chambers[23]. After all, RPF may be more convenient to prevent CT formation, especially in patients with pericardial adhesions and localized pericardial effusions[24]. Additionally, a right-sided intervention provides an expanded surgical workspace compared with the left side while performing VATS PF.

**Limitations**

This was a retrospective and single-centered study that presented initial results with a limited number of cases. Although there is a statistically significant difference between the groups in terms of LV failure, the effect of accompanying pathologies (i.e pleural effusion or malignancy) on LV failure after PF cannot be eradicated.

## CONCLUSION

Ultimately, after a sweeping highlight of the literature examining the complications of PF, we did not find an eligible reason other than the intervention side for experiencing LV failure in LPF and not in RPF. Furthermore, there is no case report presenting ventricular failure after RPF and no literature comparing left versus right PF. We hypothesize that to reduce the risk of LV failure, right-sided intervention may be considered in patients with CT who will undergo surgical PF.

**Ethics Committee Approval:** The approval for this study was obtained from University of Health Sciences, İstanbul Mehmet Akif Ersoy Thoracic and Cardiosvascular Surgery Training and Research Hospital Ethics Committee (Decision no: 2020/29 Date: 27.08.2020).

**Informed Consent:** This is retrospective study, we could not obtain written informed consent from the participants.

**Peer-review:** Externally peer-reviewed.

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**Conflict of Interest:** The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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