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Research Article

Efficacy of uniportal video-assisted thoracoscopic pericardial window creation using two lung ventilation in chronic large pericardial effusions

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Abstract

Objective: To demonstrate that two lung ventilation under general anaesthesia may also be safely performed to create pericardial window with uniportal video-assisted thoracoscopic surgery.

Methods: The single-centre, retrospective, comparative study was conducted at Bulent Ecevit University, Zonguldak, Turkey, and comprised data from March 2011 to March 2018 of patients with recurrent and/or with chronic large pericardial effusions unresponsive to medical therapy and/or to pericardiocentesis and who underwent pericardial window creation with uniportal video-assisted thoracoscopic surgery. Group 1 had data of patients in whom pericardial windows were created under general anaesthesia, while group
2 had patients with two lung ventilation. Parameters compared between the groups were gender, age, operation side, operation time, amount of drainage, complication, recurrences and survival. Data was analysed using SPSS 19.

**Results:** Of the 20 patients, 9(45%) were males and 11(55%) were females. Group 1 had 14(70%) patients, while group 2 had 6(30%). The age of patients in group 2 was significantly higher than those in group 1 (p=0.041). There was no significant difference between the groups with respect to gender, amount of drainage, operation time, and post-operative complications (p>0.05). There was no recurrence or mortality in either of the two groups.

**Conclusion:** Pericardial window could be created safely with video-assisted thoracoscopic surgery under two lung ventilation for patients carrying high risk for one lung ventilation.

**Key Words:** Pericardial effusion, One lung ventilation, Two lung ventilation, Video-assisted thoracoscopic surgery, Pericardial window.

**Introduction**

Treatment options for pericardial effusion (PE) include observation, anti-inflammatory or anti-neoplastic chemotherapy, pericardiocentesis, percutaneous catheter drainage, and surgical procedures. Large idiopathic chronic PE is defined as a transthoracic echocardiographic-proven persistent PE with a sum of end-diastolic anterior and posterior echo-free space >20mm, of ≥3 months duration and without elucidated aetiology.1,2 Furthermore, approximately one-third of patients with large PEs have been reported to be at risk of developing cardiac tamponade.2 Surgical treatment is recommended in patients with very large chronic effusions where recurrent pericardiocentesis and/or intrapericardial treatment is not successful.1-3 Currently there are three methods in the surgical treatment of pericardial effusions: subxiphoid fenestration,
pericardial window (PW) creation with thoracotomy, and PW creation with video-assisted thoracoscopic surgery (VATS).

PW creation with VATS is a minimally invasive surgical procedure that is increasingly used over other methods. Using this technique, exploration of the thoracic cavity with excellent visualisation of the pericardial surface can be performed accurately and complete drainage of the PE is provided by a true PW creation procedure. It has been reported that VATS PW creation is superior to other surgical methods and that one lung ventilation (OLV) is necessary for this operation.

OLV is a term used in thoracic anaesthesia to describe the ventilation technique that allows the ventilation of one of a patient's lungs and the collapse of the other lung. A well-collapsed lung is essential for thoracic surgeon to properly visualise the operative field and perform adequate resection. Nevertheless, OLV may lead to trans-pulmonary shunts which may destroy oxygenation and cause hypoxemia. In addition, in some patients, OLV cannot be performed because these patients are either high-risk cases for OLV or difficult intubation cases. It has been clearly stated that OLV is required to create thoracoscopic PW. Open surgical methods subxiphoid pericardial fenestration and thoracotomy are preferred in patients with cardiac tamponade or purulent pericarditis and who are not suitable for OLV. However, thoracoscopic PW can be successfully performed using two lung ventilation (TLV) and there is no study comparing these two methods in literature. The current study was planned to demonstrate that uniportal VATS PW can be created safely and successfully under TLV in patients with high risk for OLV or in patients in whom OLV cannot be performed.

Patients and Methods
The single-centre, retrospective, comparative study was conducted at the Department of Thoracic Surgery, Bülent Ecevit University, Zonguldak, Turkey, and comprised data from March 2011 to March 2018 of patients who underwent PW creation with uniportal VATS.

After approval from the institutional review board, the sample size was calculated using G-Power 3.1.9.2 software. Data was retrieved from the database and it related to patients with recurrent PE or with chronic large PE unresponsive to medical therapy comprising non-steroid anti-inflammatory drugs (NSAIDs), colchicine, or both, and/or to pericardiocentesis. All patients had PE width $\geq 20$ mm at thorax computed tomography (CT) and a sum of end-diastolic anterior and posterior echo-free space $\geq 20$ mm at transthoracic echocardiography (TTE). These patients subsequently underwent PW procedure with uniportal VATS using OLV or TLV. Data excluded related to patients with cardiac tamponade and a history of chest trauma. The dominant side of the PE, concomitant pleural pathology, and, hence, the operation side were decided by thoracic CT scans. All patients were given prophylactic first-generation cephalosporins and NSAIDs 12-24 hours before the operation.

The patients were then divided into two groups according to the type of intubation. Group 1 had patients who had PW creation with uniportal VATS and OLV using a double-lumen endotracheal tube placement under general anaesthesia. Group 2 had PW creation with uniportal VATS and TLV using a single-lumen endotracheal tube placement under general anaesthesia.

In group 1, lateral decubitus position of the hemithorax was augmented 45° with an axillary roll, and OLV was provided under general anaesthesia. In group 2, the patients were placed in the supine position with the back at a 45° angle to the operating table. TLV was provided under general anaesthesia. A trocar was placed through a 2.5 cm incision at the junction of the mid-axillary line and 6th intercostal space in both groups (Figures 1A-B; 2A-B). A 5-mm 30° video-
thoracoscope was introduced via the trocar, and the trocar was withdrawn, but it remained within the thorax. Pleural cavity and lung parenchyma was first evaluated, followed by the placement of two roticulating endoscopic instruments, endo-scissors and an endo-grasper, via the thoracoscope side ports. Cytological and microbiological samples were obtained from the effusion with transthoracic pericardiocentesis using a 20G lumbar puncture needle under video-thoracoscopic guidance. Subsequently, the pericardium was grasped with an endo-grasper by preserving the anterior portion of the phrenic nerve, and pericardial resection was completed through a 4×4cm circumferential incision with endo-scissors (Figures 1C; 2C). The samples from pericardium were sent to pathology laboratory for histopathological evaluation. PEs were evacuated through the PW and a 28F chest tube was placed in the pleural space through the same trocar site and connected to an underwater seal drain. Since PW created sufficient pleuropericardial connection and complete drainage in all cases, intra-pericardial tube was not needed. All patients were extubated during the post-operative period and transferred to inpatient service beds.

Patients were then compared with respect to gender, age, operation side, operation time, amount of drainage, complication, recurrences, and survival.

Data was analysed using SPSS 19. Descriptive statistics were presented as frequencies and percentages for categorical variables with median along with interquartile range (IQR) for continuous data. Shapiro-Wilk test was used as a test of normality. Mann-Whitney U test was used for inter-group comparisons of continuous variables. Fisher exact chi-square test was used for comparison of categorical variables between the groups. P<0.05 was considered statistically significant. 54.5 (32-71) 71.5 (37-81)
Results

Of the 20 patients, 9 (45%) were males and 11 (55%) were females. The overall mean age was 53.1 ± 15.2 years (range: 32-71 years). Group 1 had 14 (70%) patients with a median age of 54.5 years (IQR: 32-71), while group 2 had 6 (30%) patients with a median age of 71.5 years (IQR: 37-81). The most common aetiology was heart failure (HF) 9 (45%) followed by malignancy 3 (15%) and vasculitis 1 (5%), while 7 (35%) cases were idiopathic. The most common symptom was dyspnoea 8 (40%). Comorbidity was present in 14 (70%) cases and 3 (15%) had history of malignancy. Overall, 13 (65%) patients had previously undergone pericardiocentesis, while 7 (35%) were found inappropriate for pericardiocentesis. In group 2, 3 (50%) patients had low cardiopulmonary function, 2 (33.3%) were difficult to intubate and 1 (16.6%) was at high risk for cardiac tamponade.

In group 1, there were 8 (57%) females and 6 (43%) males. 11 (78.5%) patients underwent left-sided approach, while 3 (21.4%) underwent right-sided approach. After PW creation, median drainage volume was 800 ml (IQR: 600-1400 ml). The median operation time skin-to-skin was 35 min (IQR: 25-60 min). All patients were extubated at the end of the operation and transferred to inpatient service beds. There was 1 (7%) partial lung expansion failure as the lone post-operative complication. The patient recovered on the 8th post-operative day without additional intervention and subsequent pathological diagnosis of the case was tuberculosis (TB).

In group 2, there were 3 (50%) females and as many males. Among them, 4 (66.6%) cases were approached from the right hemithorax. After PW creation, median drainage volume was 800 ml (IQR: 650-1400 ml). The median operation
time skin-to-skin was 35min (IQR: 25-40min). All patients were extubated at the end of the operation and transferred to inpatient service beds. There was 1(16.66%) case of arrhythmia in the post-operative period which was controlled with anti-arrhythmic agents (Table 1).

Daily activities of the patients improved significantly on the first postoperative day with a considerable increase in physical performance (p<0.05). The chest tubes were removed when the total drainage volume was ≤100 ml/day. The patients were discharged on average post-operative day 2 (2,0 ± 1,75). All patients in both groups had negative microbiological tests. Cytological diagnosis of 1(5%) case was consistent with malignancy which was then histologically diagnosed as thymic carcinoma. Histopathological diagnoses were either chronic inflammation or fibrinous pericarditis or both in 18(90%) cases and necrotising granulomatous inflammation consistent with TB in 1(5%) case. Follow-up evaluations with TTE and radiologic examinations on post-operative 3, 6, and 12 months revealed no pericardial or pleural effusions. Patients were followed up for an average of 12 months (11,85 ± 1,81) and no recurrences were observed. No recurrence and no mortality was observed in both groups.

The age of patients in group 2 was significantly higher than those in group 1 (p=0.041). There was no significant difference between the groups with respect to gender, amount of drainage, operation time, and post-operative complications (Table 2).

Discussion
To our knowledge, the current study is the first to compare PW creation by VATS under TLV with OLV in high-risk patients. Surgical interventions are superior to other methods for the diagnosis and/or treatment of recurrent PEs unresponsive to medical treatment.1-3 Many interventional procedures have been
described in literature for the diagnosis and treatment of PEs. The factors
determining the optimal interventional method are low recurrence and
complication rates as well as establishing a definitive diagnosis.\textsuperscript{1-3}
Pericardiocentesis is a technique guided by echocardiography under local
anaesthesia, but this technique often results in inadequate pericardial drainage
and is also associated with a high rate of recurrence with complications,
including cardiac laceration or cardiac puncture.\textsuperscript{2,15} Moreover,
pericardiocentesis is technically risky for a group of patients with chronic PE,
particularly patients with a small-volume PE involving the anterior aspect of the
right ventricle (RV) compared to the posterior and lateral aspects. Percutaneous
catheter drainage is a method in which the PE is drained via pericardial
insertion of a percutaneous catheter under the guidance of echocardiography,
but this procedure has been reported to be associated with high recurrence and
complication rates.\textsuperscript{12} Subxiphoid pericardial fenestration does not create a true
PW since it does not provide pleuropericardial connection.\textsuperscript{16} Subxiphoid
pericardial fenestration is preferred in patients with cardiac tamponade or
purulent pericarditis and who are not suitable for OLV.\textsuperscript{12,13}
The in-hospital mortality rate has been reported approximately 5-15% in many
series.\textsuperscript{3, 12-16} Open surgical thoracotomy may also be performed for creating PW.
Nevertheless, these procedures are associated with more frequent pulmonary
complications and longer hospital stays because open surgical methods are
major invasive in nature.\textsuperscript{16,17} Using video-thoracoscopy, complete visualisation
of the pleural and pericardial areas may be achieved, and, thus, PW is created
safety, pericardial biopsy is obtained, and PE is drained. Moreover, a true PW
may be formed in this way. This procedure has been considered to have an
obvious superiority over other methods because of various factors, including
wide intrathoracic vision, definite diagnosis and treatment, practicability, safety,
shorter operative time, and a lack of recurrence.\textsuperscript{4-8} In literature, it has been
clearly demonstrated that patients should undergo OLV to create a thoracoscopic PW, which is a minimally invasive surgical technique. However, there are some disadvantages of OLV which lead to transpulmonary shunts that may destroy oxygenation, and cause hypoxemia. One of the leading causes of death following thoracic surgery is acute lung injury associated with OLV. When the collapsed lung is re-expanded, inflammatory marker levels increase and ischemia-reperfusion injury may develop. Exposure of lung epithelial and endothelial cells to hyper-oxidation may lead to the formation of reactive oxygen radicals. OLV may present a higher risk, especially in patients with advanced age and co-morbidity and with low cardiopulmonary reserve. Positioning is also important as the lateral decubitus position allows for a gravity-induced reduction in shunt flow to the non-dependent lung. Perfusion is affected in the lateral decubitus position as the gravity-dependent distribution of flow is maintained, with a roughly 10% shift of carbon monoxide (CO) to the dependent lung. For these reasons, we preferred supine position with the back at a 45° angle to the operating table for cases in group 2. The current study performed PW creation in six of 20 patients with PEs using uniportal VATS under TLV group 2. The surgical procedure was performed with TLV because 6 patients could not undergo OLV due to reduced cardiopulmonary function, intubation difficulties, and high risk for cardiac tamponade case 16. Furthermore, four of these patients were aged >70 years. In this study, the age of patients in group 2 was significantly higher than those in group 1. That was because we preferred PW creation with uniportal VATS under TLV for patients with advanced age and with severe co-morbidity. Many studies have emphasised that PW creation procedures with conventional VATS or uniportal VATS for PE can be successfully performed. One study successfully treated PE patients under single lumen endotracheal tube anaesthesia with uniportal VATS, and found this to be significant in terms of
time and cost. A study\textsuperscript{24} reported successful VATS results for the surgical
treatment of primary spontaneous pneumothoraces using TLV. It is indisputable
that double-lumen endotracheal intubation for OLV takes more time compared
to endotracheal intubation for TLV, although we did not measure the time for
endotracheal tube placement.\textsuperscript{23,24} Moreover, single-lumen endotracheal
intubation TLV is cost-effective.\textsuperscript{24} In our opinion, the PW creation procedure
with uniportal VATS under TLV can be safely and effectively performed in
patients not suitable for OLV.

The current study has its limitations. First, it was a retrospective study with a
limited number of patients, Second, it only comprised patients with large
chronic and recurrent PEs. Larger studies comparing VATS operations under
OLV and TLV are required to confirm and determine if uniportal VATS under
TLV can be used safely used for all PEs.

\textbf{Conclusion}

There was no significant difference between OLV and TLV in uniportal VATS
PW creation in terms of drainage amount, complications, operation time and
recurrence, indicating that in patients with chronic large PE and those who are
not suitable for OLV, thoracoscopic PW can be successfully created by
performing TLV instead of open surgical procedures.

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\textbf{Conflict of interest:} None.

\textbf{Source of Funding:} None.

\textbf{References}

1. Maisch B, Seferovic P, Ristic A, Rienmüller R, Adler Y, Tomkowski W,
et al. Guidelines on the diagnosis and management of pericardial diseases


Table 1: Clinical and operative features and postoperative results of patients

<table>
<thead>
<tr>
<th>Patient</th>
<th>Gender</th>
<th>Age (years)</th>
<th>Aetiology</th>
<th>Symptoms</th>
<th>Comorbidity</th>
<th>Operation Side</th>
<th>Ventilation type</th>
<th>Operation Time (min)</th>
<th>Drainage (mL)</th>
<th>Complication</th>
<th>Pathology</th>
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<td>HT, DM</td>
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<td>Dyspnoea, tachycardia</td>
<td>HT, COPD, CKD</td>
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<td>800</td>
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<td>HT</td>
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<td>Left</td>
<td>TLV</td>
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<td>DM</td>
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<td>TLV</td>
<td>35</td>
<td>800</td>
<td>None</td>
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</table>

344 F female, M male, HF heart failure, DOE dyspnoea of effort, HT hypertension, DM diabetes mellitus, BC breast cancer, COPD chronic obstructive pulmonary disease, CAD coronary artery disease, CKD chronic kidney disease, CC colon cancer, TC thymic carcinoma, OLV one lung ventilation (group 1), TLV two lung ventilation (group 2), LEF lung expansion failure, CI chronic inflammation, FP fibrinous pericarditis, TB tuberculosis.
Table 2: Comparison of two groups in terms of gender, age, operation side, operation time, amount of drainage and complication

<table>
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<th></th>
<th>Group 1</th>
<th>Group 2</th>
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</thead>
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<td><strong>Gender</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>6 (%42.9)</td>
<td>3 (%50.0)</td>
<td>1.000*</td>
</tr>
<tr>
<td>Female</td>
<td>8 (%57.1)</td>
<td>3 (%50.0)</td>
<td></td>
</tr>
<tr>
<td><strong>Age (year)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median (Min-Max)</td>
<td>54.5 (32-71)</td>
<td>71.5 (37-81)</td>
<td>0.041#</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>53.1 ± 15.2</td>
<td>66.3 ± 16.5</td>
<td></td>
</tr>
<tr>
<td><strong>Operation side</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>3 (%21.4)</td>
<td>4 (%66.7)</td>
<td>0.122*</td>
</tr>
<tr>
<td>Left</td>
<td>11 (%78.6)</td>
<td>2 (%33.3)</td>
<td></td>
</tr>
<tr>
<td><strong>Operation time (minutes)</strong></td>
<td></td>
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<td>0.968#</td>
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<tr>
<td></td>
<td>35.0 (25-60)</td>
<td>35.0 (25-40)</td>
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<tr>
<td><strong>Drainage volume (mL)</strong></td>
<td></td>
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<td>0.904#</td>
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<tr>
<td></td>
<td>800 (600-1400)</td>
<td>800 (650-1400)</td>
<td></td>
</tr>
<tr>
<td><strong>Complication</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>No</td>
<td>13 (%92.9)</td>
<td>5 (%83.3)</td>
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</tr>
<tr>
<td>Yes</td>
<td>1 (%7.1)</td>
<td>1 (%16.7)</td>
<td></td>
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</table>

*Fisher Exact Chi-Square test; # Mann Whitney U test

SD: standard deviation
Values are presented by median (minimum and maximum).

Figure-1: (A) Schematic drawing of pericardial window creation with uniportal video-assisted thoracoscopic surgery (VATS) approach in left hemithorax in lateral decubitus position. One lung ventilation was provided under general anaesthesia. (B) A trocar was through a 2.5 cm incision at the junction of the anterior axillary line and 6th intercostal space. Implementation of 5 mm 30° videothoracoscope and roticulator endo instruments in the same incision. (C) The pericardium was grasped with the help of endograsper by preserving the phrenic nerve, and pericardial resection was performed making a circumferential incision of approximately 4x4 cm in size with endoscissors.
Figure-2: (A) Schematic drawing of pericardial window creation with uniportal video-assisted thoracoscopic surgery (VATS) approach in right hemithorax in supine position with the back at a 45° angle to the operating table. Two lung ventilation was provided under general anaesthesia. (B) A trocar was through a 2.5 cm incision at the junction of the anterior axillary line and 6th intercostal space. Implementation of 5 mm 30° videothoracoscope and roticulator endoinstruments in the same incision. (C) The pericardium was grasped with the help of endograsper by preserving the phrenic nerve, and pericardial resection was performed making a circumferential incision of approximately 4x4 cm in size with endoscissors.