

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

Mertol Gokce,¹ Osman Korcan Tilkan,² Serkan Uysal,³ Muhammet Rasit Sayin,⁴ Bengu Gulhan Aydin,⁵ Burak Bahadır⁶

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, 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.

Keywords: Pericardial effusion, One lung ventilation, Two lung ventilation, Video-assisted thoracoscopic surgery, Pericardial window. (JPMA 70: 1742; 2020) DOI: <http://doi.org/10.5455/JPMA.28968>

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 $>20\text{mm}$, 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.⁴⁻⁷ 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.⁴⁻⁸

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 a thoracic surgeon to properly visualise the operative field and perform adequate resection.⁹⁻¹¹ Nevertheless, OLV may lead to trans-pulmonary shunts which may destroy oxygenation and cause hypoxaemia. In addition, in some patients, OLV cannot be performed because these patients are either high-risk cases for OLV or difficult intubation cases.¹⁰ It has been clearly stated that OLV is required to create thoracoscopic PW.⁴⁻⁸ 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.^{12,13} However, thoracoscopic PW can be successfully performed using

.....
¹⁻³Department of Thoracic Surgery, ⁵Department of Anaesthesiology, ⁶Department of Pathology, Bulent Ecevit University, Zonguldak, ⁴Department of Cardiology, Health Sciences University, Ahi Evren Chest, Heart and Vascular Surgery Education and Research Hospital, Trabzon, Turkey.
Correspondence: Mertol Gokce. Email: dr.mertol@gmail.com

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, Bulent 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.¹⁴ 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 ≥ 20 mm at thorax computed tomography (CT) and a sum of end-diastolic anterior and posterior echo-free space >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 2.5cm 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 were 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 the 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.

Results

Of the 20 patients, 9(45%) were males and 11(55%) were females. The overall mean age was mean: 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

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

Patient	Gender	Age (years)	Aetiology	Symptoms	Comorbidity	Operation Side	Ventilation type	Operation Time(min)	Drainage (mL)	Complication	Pathology
1	F	58	HF	DOE, fatigue	HT	Left	OLV	40	700	None	CI
2	F	70	HF	Dyspnoea, oedema	HT, DM	Right	OLV	35	600	None	CI
3	F	81	Malignancy	Dyspnoea, oedema	BC, COPD	Right	TLV	25	750	None	CI
4	F	50	Idiopathic	DOE, oedema	None	Left	OLV	35	800	None	CI
5	M	72	HF	Dyspnoea, tachycardia	Parkinsonism, dementia	Left	TLV	40	900	None	FP
6	M	32	Vasculitis	Oliguria, oedema	HT, CAD	Left	OLV	55	800	None	FP
7	F	32	Idiopathic	DOE, fatigue	None	Left	OLV	25	850	None	CI
8	F	71	HF	Dyspnoea, tachycardia	HT, COPD, CKD	Right	TLV	30	800	None	CI
9	M	70	Idiopathic	DOE, oedema	HT	Left	OLV	30	950	None	FP
10	M	33	Idiopathic	Fatigue	None	Left	OLV	30	900	None	CI
11	F	71	Malignancy	Dyspnoea, fatigue	CAD, CC	Left	OLV	45	900	None	FP
12	F	34	HF	DOE	None	Left	OLV	60	1400	None	FP
13	F	64	HF	Fatigue	HT	Left	OLV	25	650	None	CI
14	M	61	Idiopathic	Fever, fatigue	None	Left	OLV	25	800	LEF	TB
15	M	37	Idiopathic	Dyspnoea, tachycardia	None	Right	TLV	40	1400	Arrhythmia	CI and FP
16	M	79	HF	Dyspnoea, oedema	HT	Left	TLV	35	650	None	CI and FP
17	M	68	HF	DOE, fatigue	DM	Right	OLV	30	700	None	CI
18	M	51	Malignancy	DOE, fatigue	HT, DM, TC	Left	OLV	35	650	None	Malignant
19	F	49	Idiopathic	DOE	DM	Right	OLV	40	900	None	FP
20	F	58	HF	Dyspnoea, oedema	COPD	Right	TLV	35	800	None	CI

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.

		Group 1	Group 2	p
Gender	Male	6 (%42.9)	3 (%50.0)	1.000*
	Female	8 (%57.1)	3 (%50.0)	
Age (year)	Median (Min-Max)	54.5 (32-71)	71.5 (37-81)	0.041#
	Mean $\pm$ SD	53.1 $\pm$ 15.2	66.3 $\pm$ 16.5	
Operation side	Right	3 (%21.4)	4 (%66.7)	0.122*
	Left	11 (%78.6)	2 (%33.3)	
Operation time (minutes)		35.0 (25-60)	35.0 (25-40)	0.968#
Drainage volume (mL)		800 (600-1400)	800 (650-1400)	0.904#
Complication	No	13 (%92.9)	5 (%83.3)	0.521*
	Yes	1 (%7.1)	1 (%16.7)	

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

SD: standard deviation

Values are presented by median (minimum and maximum).

3(21.4%) underwent right-sided approach. After PW creation, median drainage volume was 800ml (IQR: 600-1400ml). The median operation time skin-to-skin was 35min (IQR: (25-60min)). 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 800ml (IQR: 650-1400ml). 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 ($2,0 \pm 1,75$). 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 tuberculosis in 1(5%) case. Follow-up evaluations with TTE and radiologic examinations on post-operative 3, 6, and 12 months revealed no

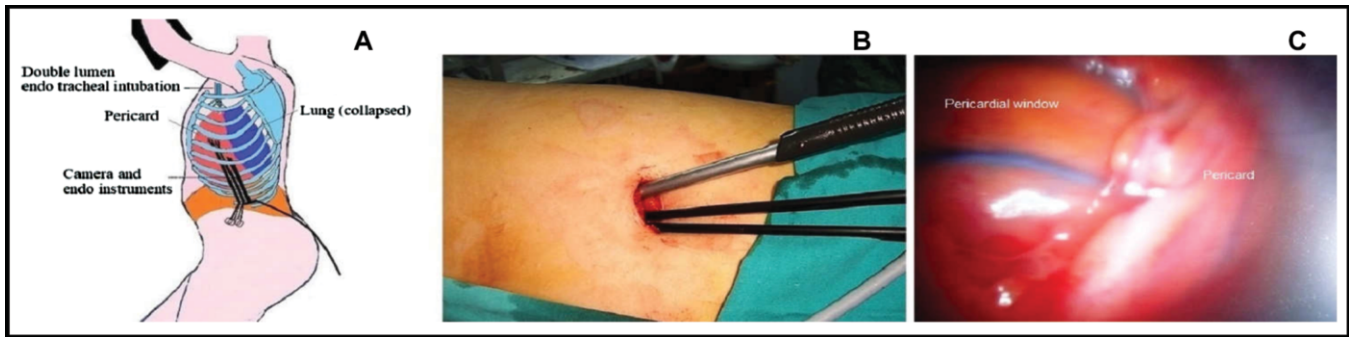


Figure-1: (A) Schematic drawing of pericardial window creation with uniportal video-assisted thoracoscopic surgery (VATS) approach in left hemithorax in lateral decubitus position. One lung ventilation was provided under general anaesthesia. (B) A trocar was through a 2.5 cm incision at the junction of the anterior axillary line and 6th intercostal space. Implementation of 5 mm 30° videothoracoscope and roticulator 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.

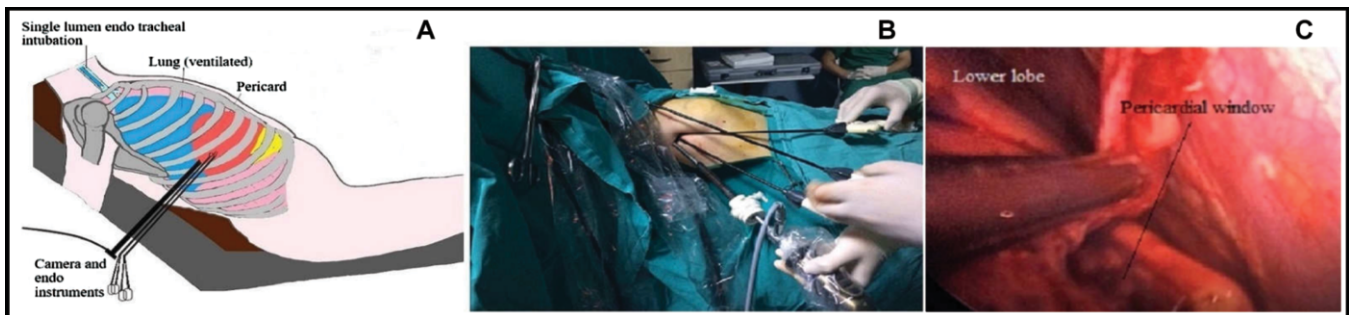


Figure-2: (A) Schematic drawing of pericardial window creation with uniportal video-assisted thoracoscopic surgery (VATS) approach in right hemithorax in supine position with the back at a 45° angle to the operating table. Two lung ventilation was provided under general anaesthesia. (B) A trocar was 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.

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.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.^{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.¹² Subxiphoid pericardial fenestration does not create a true PW since it does not provide pleuropericardial connection.¹⁶ Subxiphoid pericardial fenestration is preferred in patients with cardiac

tamponade or purulent pericarditis and who are not suitable for OLV.^{12,13}

The in-hospital mortality rate has been reported approximately 5-15% in many series.^{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.^{16,17} Using video-thoracoscopy, complete visualisation of the pleural and pericardial areas may be achieved and, thus, PW is created safely, 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.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 hypoxaemia.¹⁰ One of the leading causes of death following thoracic surgery is acute lung injury associated with OLV.¹⁰ When the collapsed lung is re-expanded, inflammatory marker levels increase and ischaemia-reperfusion injury may develop. Exposure of lung epithelial and endothelial cells to hyper-oxidation may lead to the formation of reactive oxygen radicals.^{10,18} 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 cardiac output (CO) to the dependent lung.¹⁸⁻²⁰ 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 case¹⁶. 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.^{4-8,21,22} One study²³ 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 study²⁴ 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.^{23,24} Moreover, single-lumen endotracheal intubation TLV is cost-effective.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.

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.

Disclaimer: None.

Conflict of Interest: None.

Source of Funding: None.

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 executive summary; The Task force on the diagnosis and management of pericardial diseases of the European society of cardiology. *Eur Heart J*. 2004; 25:587-610.
2. Sagristà-Sauleda J, Angel J, Permanyer-Miralda G, Soler-Soler J. Long-Term Follow-Up of Idiopathic Chronic Pericardial Effusion. *N Engl J Med*.1999; 341:2054-9.
3. Piehler JM, Pluth JR, Schaff HV, Danielson GK, Orszulak TA, Puga FJ. Surgical management of effusive pericardial disease. Influence of extent of pericardial resection on clinical course. *J Thorac Cardiovasc Surg*. 1985; 90:506-12.
4. Hazelrigg SR, Mack MJ, Landreneau RJ, Acuff TE, Seifert PE, Auer

- JE. Thoracoscopic Pericardiectomy for Effusive Pericardial Disease *Ann Thorac Surg.* 1993; 56:792-5.
5. GP Georgioui, A Stamler, E Sharoni, S Fichman-Horn, M Berman, BA Vidne, et al. Video-Assisted Thoracoscopic Pericardial Window for Diagnosis and Management of Pericardial Effusions. *Ann Thor Surg.* 2005; 80:607-10.
6. Nataf P, Cacoub P, Regan M, Baron F, Dorent R, Pavie A, et al. Video-thoracoscopic pericardial window in the diagnosis and treatment of pericardial effusions. *Am J Cardiol.* 1998; 82:125-6.
7. Muhammad MIA. The pericardial window: is a video-assisted thoracoscopy approach better than a surgical approach? *Interact Cardiovasc Thorac Surg.* 2011;12:174-8.
8. Sakanoue I, Hamakawa H, Okubo Y, Minami K, Miyamoto E, Shomura Y, et al. Efficacy and safety of thoracoscopic pericardial window in patients with pericardial effusions: a single - center case series. *J Cardiothorac Surg.* 2016;11:92-5.
9. Cohen E. Methods of lung separation. *Minerva anestesiol.* 2004; 70:313-8.
10. Lohser J, Slinger P. Lung Injury After One-Lung Ventilation: A Review of the Pathophysiologic Mechanisms Affecting the Ventilated and the Collapsed Lung. *Anesth Analg.* 2015; 121:302-18.
11. Lewis JW Jr, Serwin JP, Gabriel FS, Bastanfar M, Jacobsen G. The utility of a double-lumen tube for one-lung ventilation in a variety of noncardiac thoracic surgical procedures. *J Cardiothorac Vasc Anesth.* 1992; 6:705-10.
12. McDonald JM, Meyers BF, Guthrie TJ, Battafarano RJ, Cooper JD, Patterson GA. Comparison of open subxiphoid pericardial drainage with percutaneous catheter drainage for symptomatic pericardial effusion. *Ann Thorac Surg.* 2003; 76:811-6.
13. O'Brien PK, Kucharczuk JC, Marshall MB, Friedberg JS, Chen Z, Kaiser LR, et al. Comparative study of subxiphoid versus video-thoracoscopic pericardial window. *Ann Thorac Surg.* 2005; 80:2013-19.
14. Cohen J. *Statistical Power Analysis for the Behavioral Sciences*, 1977.
15. Vayre F, Lardoux H, Pezzano M, Bourdarias JP, Dubourg O. Subxiphoid pericardiocentesis guided by contrast two-dimensional echocardiography in cardiac tamponade: experience of 110 consecutive patients. *Eur J Echocardiography.* 2000; 1:66-71.
16. Naunheim KS, Kesler KA, Fiore AC, Turrentine M, Hammell LM, Brown JW, et al. Pericardial drainage: subxiphoid vs transthoracic approach. *Eur J Cardiothorac Surg.* 1991; 55:99-104.
17. Olsen PS, Sørensen C, Andersen HO. Surgical treatment of large pericardial effusions. Etiology and long-term survival. *Eur J Cardiothorac Surg.* 1991; 5:430-2.
18. Wulff KE, Aulin I. The regional lung function in the lateral decubitus position during anesthesia and operation. *Acta Anaesthesiol Scand.* 1972; 16:195-205.
19. Della Rocca G, Coccia C. Ventilatory management of one-lung ventilation. *Minerva Anesthesiol.* 2011; 77:534-6.
20. Katlic MA, Factor MR. Non-intubated video-assisted thoracic surgery in patients aged 80 years and older. *Ann Transl Med.* 2015; 3:101.
21. Passera E, Rocco G. From full thoracotomy to uniportal video-assisted thoracic surgery: lessons learned. *J Vis Surg.* 2017;3:36.
22. Rocco G, La Rocca A, La Manna C, Scognamiglio F, D'Aiuto M, Jutley R, et al. Uniportal video-assisted thoracoscopic surgery pericardial window. *J Thorac Cardiovasc Surg.* 2006;131:921-2.
23. Cerfolio RJ, Bryant AS, Sheils TM, Bass CS, Bartolucci AA. Video-assisted thoracoscopic surgery using single-lumen endotracheal tube anesthesia. *Chest.* 2004; 126:281-5.
24. Kim H, Kim HK, Choi YH, Lim SH. Thoracoscopic bleb resection using two-lung ventilation anesthesia with low tidal volume for primary spontaneous pneumothorax. *Ann Thorac Surg.* 2009; 87:880-5.