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How to facilitate concurrent lower lobectomy after coronary artery bypass grafting via median sternotomy without adding anterolateral thoracotomy?

Yunus Seyrek * and Murat Akkuş †

*Department of Thoracic Surgery, Yedikule Chest Disease and Thoracic Surgery Training and Research Hospital, Istanbul, Turkey and
†Department of Thoracic Surgery, Istanbul Mehmet Akif Ersoy Thoracic and Cardiovascular Surgery Training and Research Hospital, Istanbul, Turkey

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Correspondence
Associate Professor Yunus Seyrek, Department of Thoracic Surgery, Istanbul Mehmet Akif Ersoy Thoracic and Cardiovascular Surgery Training and Research Hospital, Istanbul, Turkey.
Email: yunusseyrek@gmail.com

Y. Seyrek MD; **M. Akkuş** MD.

Yunus Seyrek and Murat Akkuş contributed equally to this study.

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Abstract

Background and aim: Median sternotomy is an unfavourable approach for performing lung resection and mediastinal lymphadenectomy. Some studies have speculated that concurrent pulmonary resections other than upper lobectomy, necessitate anterolateral thoracotomy in addition to sternotomy. In this study, we aimed to discuss the feasibility and advantages of concomitant video-thoracoscopy (VATS) assisted lower lobectomy after coronary artery bypass grafting (CABG).
Methods: We analysed 21 patients who underwent a single combined procedure that includes CABG followed by anatomical pulmonary resection and divided them into two groups: patients who underwent upper lobectomy via median sternotomy incision (Group A, $n = 12$) and patients who underwent lower lobectomy with video-thoracoscopic assistance (VATS) next to sternotomy incision (Group B, $n = 9$).
Results: There were no significant differences between the groups in age, sex, comorbidities, tumour side or size, tumour stage, tumour histopathology, number of dissected lymph node stations, N status, CABG type, number of grafts used, operative time, hospitalization and complication rates.
Conclusion: The feasibility of upper lobectomies via median sternotomy is clear; however, performing lower lobectomies is challenging. In our study, we concluded that the operative feasibility of concurrent lower lobectomy by VATS assistance showed no essential difference to that of concurrent upper lobectomy by presenting that there was no statistically significant difference between the groups in terms of any studied parameters. We can speculate that median sternotomy with VATS assistance should be especially considered instead of anterolateral thoracotomy for lower lobectomies at centres where VATS lobectomies are performed.

Introduction

Synchronous coronary artery disease with lung cancer is rare, and the number of patients referred for concurrent cardiothoracic procedure accounts for only 0.5% of all bypass operations reported by cardiac surgeons.[1] However, the incidence of this patient subgroup in our hospital has increased over the past 2 years due to the numerous requests for thoracic computed tomography (CT) scans during the COVID-19 pandemic.

Median sternotomy is the most frequent approach for combined heart and lung surgery.[2] However, sternotomy is a less suitable approach for performing lung resection and mediastinal lymphadenectomy. Some studies have speculated that only tumours of the upper lobes and the corresponding mediastinal lymph node dissection could be safely performed via median sternotomy, whereas the remaining pulmonary resections necessitate anterolateral thoracotomy.[3,4] Recent studies have shown that all types of pulmonary resections in patients with coexisting cardiac disease and lung cancer are feasible, especially with the assistance of a video-thoracoscope next to median sternotomy.[5,6] In our hospital, we have been performing a single combined procedure that includes coronary artery bypass grafting (CABG) followed by anatomical pulmonary resection in lung cancer patients who require myocardial revascularization due to coronary heart disease (CHD).

We perform upper lobectomies via sternotomy while using video-assisted thoracoscopic surgery (VATS) during concurrent lower lobectomies after CABG.

To our knowledge, there are no reports related to the efficacy of VATS assistance in concurrent thoracic and cardiac operations involving median sternotomy. In this study, we aimed to discuss the feasibility and advantages of concomitant VATS assisted lower lobectomy after CABG and to analyse the efficacy of adding thoracic ports in addition to median sternotomy. Accordingly, we compared the results of patients who underwent upper lobectomy through sternotomy alone after CABG with those of patients who underwent lower lobectomy with additional VATS assistance. To clarify our purpose in this study, we would like to mention that our aim was not to compare the feasibilities of concurrent upper lobectomy with lower lobectomy because it is undebatable that concurrent upper lobectomies can be performed via only median sternotomy incision without the need for either anterolateral thoracotomy or VATS. Thus, we intended to demonstrate that performing a concurrent lower lobectomy via VATS assistance makes it feasible as a concurrent upper lobectomy.

Materials and methods

The clinical records of 29 patients who underwent combined cardiac surgery and pulmonary resection between January 2011 and June 2021 were reviewed retrospectively. Patients who underwent anterolateral thoracotomy in addition to median sternotomy ($n = 2$), those who had cardiac mass or valvular stenosis ($n = 5$), and those with a lack of clinical data ($n = 1$) were excluded from the study. The remaining 21 patients were included. The local ethics committee granted permission to conduct the study (27 September 2019).

Clinical examination, blood serum analysis, cardiac echocardiography, and electrocardiography (ECG) were performed for all patients. Each patient underwent coronary angiography and preoperative evaluation by positron emission tomography (PET) or thoracic computed tomography (CT) imaging, cranial magnetic resonance imaging (MRI), pulmonary function tests, or bronchoscopy, and, if necessary, transthoracic needle aspiration (TTIA).

Patients were considered for simultaneous cardiac surgery and pulmonary resection if they had severe CHD diagnosed through angiocardiography and resectable lung cancer. The criteria for lymph node positivity were the shortest nodal diameter of ≥10 mm on CT or metabolic activity of nodes higher than that of adjacent normal mediastinal and soft tissue on PET.[7] The regional LN classifications of Mountain and Dressler were used.[8] Patients; who have at least one hilar lymph node positivity are referred as cN1, mediastinal lymph node positivity as cN2 and without a lymph node positivity as cN0. Patients with clinical N1 (cN1) and clinical N2 (cN2) disease were diagnosed according to institutional clinical conferences or cancer boards. Patients with cN0, cN1 and single-station cN2 disease were included in the study in accordance with our hospital's cancer board. Cervical mediastinoscopy and bronchoscopy were unfavourable in the patients with CHD before CABG due to potential myocardial stress, which predisposed patients to acute myocardial infarction (MI).[9]

In our study, if a patient did not have a preoperative lung cancer diagnosis achieved by TTIA, an intraoperative tumour biopsy was performed either via wedge resection or pneumotomy before CABG. In addition, intraoperative mediastinal staging was performed by mediastinal lymph node dissection at the start of the combined procedure after sternotomy and studied frozen section. After the frozen section reported that tumour biopsy was lung carcinoma and dissected mediastinal lymph nodes were pathologically negative, pulmonary resection was performed following CABG. There were two patients who had metastatic mediastinal lymph nodes confirmed by frozen section report after intraoperative mediastinal lymph node dissection. Lung resection was not performed in those two patients following CABG due to N2 disease and they were referred to neoadjuvant treatment after CABG.

Combined procedure was performed under general anaesthesia with double-lumen endotracheal tube intubation. Thoracic and cardiac surgical procedures were simultaneously performed. Cardiac surgery included coronary anastomoses on the beating heart using off-pump CABG (OPCAB) or on-pump CABG (ONCAB) surgery via median sternotomy, followed by lobectomy for resection of lung cancer. The CABG procedure included harvesting of an arterial or venous graft followed by aortocoronary bypass graft implantation. All patients underwent complete coronary revascularization, with either a saphenous vein graft (SVG), left internal mammary artery graft (LIMA), or a combination of both. If ONCAB was performed, heparin neutralization was administered before pulmonary resection to reduce the risk of haemorrhage. An essential point of this combined surgical procedure is the sequence of the operative steps. It is critical to perform CABG before lung resection because the main purpose of a concomitant cardiac and thoracic operation is to prevent myocardial ischemia.[10]

Thoracic surgery included upper lobectomy and lower lobectomy on both sides. Upper lobectomies were performed through a median sternotomy incision. Lower lobectomies were performed through median sternotomy plus three thoracic 10 mm port incisions (one camera port + two working ports, without a rib spreading utility incision). After CABG and before starting the lower lobectomy, the operating table was rotated to provide an improved visual operative field. The camera port was placed in the ninth intercostal space (ICS) parasternal line positioned anterior to the level of the hilum and phrenic nerve. The additional two thoracic ports were placed at the ninth ICS posterior axillary line and the fifth ICS anterior axillary line, forming a triangle to operate in a bimanual fashion. We used the sternotomy incision as a utility thoracotomy, and lung retractions, stapling when necessary and specimen removal were performed through the sternotomy incision. With this anterior VATS approach, the typical course of lower lobectomy included division of the lower pulmonary ligament followed by the inferior pulmonary vein, the anterior part of the fissure, related pulmonary arteries and lower main bronchus, and finally dissection of the posterior fissure before specimen removal.

Inadequate exposure to subcarinal lymph node is one of the conflicts in one-stage operation. Posterior pericardium opening, heart compression, retraction of aorta and vena cava superior were necessary for subcarinal area dissection in concurrent upper lobectomy cases through sternal approach. On the other hand, none was necessary for subcarinal lymph node dissection in concurrent lower lobectomy due to VATS assistance.

We analysed 21 patients and divided them into two groups: patients who underwent upper lobectomy via median sternotomy incision (Group A, $n = 12$) and patients who underwent lower lobectomy with VATS assistance next to sternotomy incision (Group B, $n = 9$). Age, sex, comorbidity, cardiac and thoracic surgery types, operation time, tumour histopathology, tumour stage, lymph node stations, operation outcomes, hospitalization duration and postoperative complication rates were reviewed retrospectively and analysed descriptively. Total number of harvested lymph nodes include mediastinal and hilar lymph nodes combined.

Means, standard deviations, minimums, maximums, frequencies and percentages were used as descriptive statistics. The variable distributions were checked using the Kolmogorov–Smirnov test. The Mann–Whitney *U*-test was used to compare the quantitative data. The chi-square test was used to compare the qualitative data. Survival analysis was performed using Kaplan–Meier plots and log-rank tests. Statistical significance was set at $P < 0.05$. IBM SPSS Statistics for Windows (SPSS Inc., ver 22.0, IBM, Chicago), was used for statistical analyses.

Results

The patients in the study had a mean age of 63 ± 5.56 years (range, 49–76 years) and included 17 men and 4 women with CHD and lung cancer. The patients selected for the study were symptomatic, with symptoms that included cough, chest pain or chest discomfort after exercise. Patients either had prior MI ($n = 10$, 47.6%) or unstable angina ($n = 11$, 52.4%). Comorbidities included hypertension ($n = 10$, 47.6%), diabetes mellitus ($n = 7$, 33.3%), cerebrovascular artery disease ($n = 7$, 33.3%), peripheral vascular disease ($n = 5$, 23.8%), and hyperlipidemia ($n = 4$, 19.1%). Each studied patient had at least one comorbidity, whereas seven patients had multiple comorbidities (42.8%).

Of the 21 cases, nine had preoperative diagnosis achieved by TTIA and 12 had intraoperative diagnosis by frozen section analysis of the tumour (seven cases by wedge resection, five cases by pneumotomy). In total, 11 patients had a right lung tumour (52.3%) and 10 had a left lung tumour (47.7%). Pulmonary resections included right upper lobectomy ($n = 6$), right lower lobectomy ($n = 5$), left upper lobectomy ($n = 6$), and left lower lobectomy ($n = 4$). Adenocarcinoma was the most common histological type of tumour ($n = 12$, 57%). Squamous cell carcinoma was observed in seven cases (33.3%). The mean tumour size was 2.94 ± 1.21 cm (range: 2–6 cm). There was Stage I lung cancer in three patients (14.3%), Stage II lung cancer in 14 patients (66.6%) and Stage III lung cancer in four patients (19.1%).

There were six cN2 patients (28.6%), 10 cN1 patients (47.6%) and five cN0 patients (23.8%). The mean number of harvested lymph node stations was 4.4 ± 0.66 (range: 4–6). Mediastinal lymph node metastasis was detected in one patient who had intraoperative false negative frozen section report (N2, 4.8%), whereas five patients had hilar lymph node metastasis (N1, 23.8%). Out of five N1 cases, three of them had hilar lymph nodes which presented raised metabolic activity on PET and two of them had hilar lymph nodes with a shortest nodal diameter of ≥10 mm on CT. Patients with N1 and N2 disease ($n = 6$, 28.6%) were referred to adjuvant treatment.

All patients underwent a single operation combining CABG surgery and lung resection for non-small cell lung cancer (NSCLC) ($n = 19$) and small cell lung cancer ($n = 2$). CABG was on-pump in 8 patients (38%) and off-pump in 13 patients (62%). The mean number of anastomosed coronary vessels was 1.72 ± 1.01 (range 1–5). All patients survived the operation, and there were no deaths or new incidences of MI observed during the perioperative period. The mean operative time was 327.6 ± 16.4 min.

Postoperative complications were observed in eight patients (38.1%). Two patients had postoperative pneumonia, one of which developed respiratory failure requiring mechanical ventilation. Two patients required multiple bronchoscopic aspirations due to postoperative lobar atelectasis. Four patients developed atrial fibrillation, which necessitated intravenous infusions of amiodarone. No postoperative MI was observed by either ECG or elevation of serum myocardial enzymes. None of the patients required mechanical circulatory support. All patients were given infusions of dopamine and nitroglycerin until the second postoperative day. The mean duration of hospitalization was 9.14 ± 2.4 days.

As of July 2021, the mean follow-up period was 36.6 ± 22.3 months (range 1–95). The 3- and 5-year overall survival rates of the patients were 65% and 52%, respectively. Cancer recurrence occurred in two patients (one Group A patient with distant metastasis and one Group B patient with local cancer recurrence). The remaining patients showed no evidence of tumour recurrence.

A comparison of Groups A and B is presented in Table 1. There were no significant differences between the groups in age, sex, comorbidities, tumour side or size, tumour histopathology, tumour stage, number of dissected lymph node stations, N status, CABG type, number of grafts used, operative time, hospitalization and complication rates.

Discussion

The advantages of a combined surgical approach compared with two-staged approach include; less operative stress and pain, avoiding repeated anaesthesia, a shorter hospitalization, lower cost, and no delay in lung cancer surgery.[4,11–13] Furthermore, during pulmonary resection in patients with a previous CABG, dissection of mediastinal parenchymal adhesions may potentially damage vascular graft and cause vital myocardial ischemia. Removing the graft from the adjacent lung parenchyma by stapling may decrease the necessary oncological margin and consequently elevate the potential risk of local recurrence.[6]

Unfortunately, operative mortality in patients who have both lung cancer and CHD may be considerably increased, with a higher risk of postoperative complications due to the transactions between cardiac performance and pulmonary function. Performing myocardial revascularization before pulmonary resection, reduces postoperative morbidity and mortality.[14] In contrast, patients with lung cancer and concurrent unstable angina are at a high operative risk if pulmonary resection is performed before CABG.[4] In our study, we

Table 1 Comparison of Group A and Group B

Parameter	Group A ($n = 12$)	Group B ($n = 9$)	*P*
Sex			0.88 c
Male	9 (75%)	7 (77.8%)	
Female	3 (25%)	2 (22.2%)	
Age (years)	61.3 ± 7.2	63.8 ± 3.17	0.15 m
Patients with multiple comorbidities	4 (36.4%)	3 (33.3%)	0.88 c
Tumour size (cm)	2.6 ± 1.01	3.4 ± 1.36	0.22 m
Tumour side			0.4 c
Right	7 (58.3%)	4 (44.4%)	
Left	5 (41.7%)	5 (55.6%)	
Tumour histopathology			0.98 c
Adenocarcinoma	7 (58.3%)	5 (55.6%)	
Squamous cell carcinoma	4 (33.3%)	3 (33.3%)	
Small cell carcimoma	1 (8.3%)	1 (11.1%)	
Number of lymph node stations	4.16 ± 0.38	4.5 ± 0.88	0.46 m
N2 disease	1 (8.3%)	-	0.79 c
N1 disease	3 (25%)	2 (22.2%)	0.65 c
Tumour stage			0.91 c
Stage I	2 (16.6%)	1 (11%)	
Stage II	8 (66.6%)	6 (66.6%)	
Stage III	2 (16.6%)	2 (22.2%)	
CABG type			0.7 c
On-pump	5 (41.7%)	3 (33.3)	
Off-pump	7 (58.3%)	6 (66.7%)	
Number of grafts used	1.58 ± 0.79	1.89 ± 1.27	0.64 m
Operative time (min)	330.8 ± 17.3	323.3 ± 15	0.31 m
Hospitalization (days)	9.33 ± 2.38	8.88 ± 2.52	0.56 m
Complications			0.96 c
Pneumonia	1 (8.3%)	1 (11.1%)	
Lobar atelectasis	1 (8.3%)	1 (11.1%)	
Atrial fibrillation	2 (16.7%)	2 (22.2%)	
Adjuvant treatment	4 (33.3%)	2 (22.2%)	0.58 c

Group A, Upper lobectomies via sternotomy; Group B, Lower lobectomies via video-thoracoscopy; c, chi-squared test; CABG, coronary artery bypass grafting; cm, centimetre; m, Mann–Whitney *U*-test; min, minutes.

performed concomitant pulmonary resections after myocardial revascularization in this specially selected subgroup of patients in order to prevent tumour growth and stage progression, which, in our opinion, are the most crucial issues.

Some thoracic surgeons are reluctant to perform concurrent operations. The main conflicts are unfavourable and ineligible exposure to lung resection via median sternotomy, a hilar view of the lung anatomy and access to subcarinal/inferior mediastinal lymph nodes. Most thoracic surgeons, except those who perform lung transplant surgery, are not familiar with performing anatomic pulmonary resection via a median sternotomy incision.[2] In our study, median sternotomy which allowed the conduction of combined heart and lung surgery through a single incision, was performed in all included patients. Performing lower lobectomies via median sternotomy is considered cumbersome because access to the posterior mediastinum and lower compartments of the thoracic cavity is challenging via median sternotomy.[15] Mediastinal lymph node sampling is possible, but it is considerably more difficult than via thoracotomy. In addition to right lower lobectomy, which is considered possible but not optimal via only sternotomy incision in some studies; left lower lobectomy is technically the most compelling demanding pulmonary resection through a median sternotomy, because the pulmonary dissection is gruelling without heart retraction and unfortunately, retraction may cause dysrhythmias and hemodynamic instability resulting in higher morbidity and prolonged operative time. Consequently, the addition of anterolateral thoracotomy is generally advised in concomitant lower lobectomies.[16]

In our study, we did not employ anterolateral thoracotomy since reports show that application of sternotomy and anterolateral thoracotomy increases postoperative pain and mortality.[17] Overall, anterolateral thoracotomy is considered a greater source of pain than median sternotomy, and it also poses a perioperative additional haemorrhage risk in ONCAB cases due to heparinization, therefore we preferred VATS assistance while performing concurrent lower lobectomies instead of anterior thoracotomy.

The anterior VATS approach provides a better perspective for pulmonary resection than the sternal view due to a more ample and wider workspace, less need for cardiac retraction, and superior access to lower thoracic compartments, resulting in more straightforward lower lobectomy and systemic lymph node dissection. Most importantly, avoidance of heart retraction during the manoeuvres reduced the risk of hemodynamic compromise, arrhythmias and graft injury. There are some specific protocols that we follow in concurrent pulmonary resections after CABG, irrespective of whether CPB is included.

First, the thoracic surgeon should emphasize the importance of selective intubation to the anaesthetist before the operation because standard single-lumen endotracheal intubation is routinely used in CABG patients. Without effective lung deflation, VATS assistance is useless since the open-air sternotomy incision prevents CO_2 insufflation to compress the lung and provide a sufficient working space. Second, patients who were scheduled for concurrent lower lobectomy should be positioned with their arms open so that thoracic ports can be opened and they should be firmly secured to the operating table because we typically rotate the operating table to provide an improved visual operative field during VATS. However, CABG candidates are not routinely secured to the table since rotation is not necessary during the process. Third, some thoracic surgeons may find LIMA grafting unfavourable in patients with left-sided lung cancer due to graft injury risk during lobectomy. In our study, we used barrier to shield LIMA from pulmonary parenchyma.

Ultimately, we can hypothesize that there is no reason to avoid VATS assistance and preferer anterior thoracotomy in concurrent lower lobectomies; because there is no need for a utility thoracotomy due to the sternotomy incision, and only three thoracic ports are opened (one of which is used for tube drainage afterwards). In our opinion, additional ports (as opposed to anterolateral thoracotomy) are less likely to cause considerable pain in patients who undergo CABG. There was no significant difference between concurrent upper lobectomies and concurrent lower lobectomies in terms of operative time, postoperative complication rate or hospitalization. Consequently, both left lower lobectomy and right lower lobectomy with mediastinal lymph node dissection including subcarinal lymph node were facilitated by the anterior VATS approach. We can speculate that if we had not used VATS assistance in lower lobectomies, at least the operative time would have been significantly longer in Group B, increasing the risk for the development of postoperative complications in patients with CHD and possibly resulting in longer hospitalizations.

This retrospective study has some limitations. A limited number of patients were included in both groups because of the single-institution design. Inclusion of ONCAB cases created heterogeneity in the cohort, but we could not exclude them from the study due to the limited number of patients. A power analysis could not be performed based on a lack of available data in the literature. Indication of the usefulness of VATS assistance while performing concurrent lower lobectomy would be more elaborate if we could have compared VATS-assisted lower lobectomies in combined surgeries with those performed through anterolateral thoracotomy in terms of operative feasibility and clinical outcomes. A multiple-institution design is necessary to perform this future work.

Conclusion

In summary, concurrent myocardial revascularization and lung resection are both safe and effective treatments. The feasibility of upper lobectomies via median sternotomy is clear; however, performing lower lobectomies is challenging. In our study, we concluded that the operative feasibility of concurrent lower lobectomy by VATS assistance showed no essential difference to that of concurrent upper lobectomy by presenting that there was no statistically significant difference between the groups in terms of any studied parameters. We can hypothesize that VATS assistance greatly facilitates lower lobectomy in combined surgical approaches involving median sternotomy and speculate that median sternotomy with VATS assistance should be especially considered instead of anterolateral thoracotomy for lower lobectomies at centres where VATS lobectomies are performed.

Conflict of interest

None declared.

Author contributions

Yunus Seyrek: Conceptualization; data curation; formal analysis; investigation; methodology; project administration; software; supervision; validation; writing – original draft; writing – review and editing. **Murat Akkuş:** Conceptualization; data curation; investigation; methodology; supervision; validation; writing – review and editing.

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