



Is Video-Assisted Thoracic Surgery Lobectomy the Best Choice for the Treatment of Lung Cancer?

Giulio Maurizi^{1*}, Mohsen Ibrahim¹, Antonio D'Andrilli¹, Anna Maria Ciccone¹, Claudio Andreetti¹, Camilla Poggi¹, Camilla Vanni¹, Federico Venuta^{2,3} and Erino Angelo Rendina^{1,3}

¹Division of Thoracic Surgery, Sapienza University of Rome, Italy

²Division of Thoracic Surgery, Sapienza University of Rome, Italy

³Lorillard Spencer Cenci Foundation, Italy

Abstract

Video-assisted lobectomy has proved to be safe and effective since it was initially reported in 1994.

Over time, many comparative studies have shown that video-assisted thoracic surgery (VATS) lobectomy is better than open lobectomy in terms of postoperative complications and length of hospital stay (LOS). There is also evidence suggesting that acute and chronic postoperative pain rates are lower after VATS lobectomy than after open lobectomy.

An accurate lymphadenectomy can be performed easily and safely during VATS lobectomy; however its completeness is still being debated, particularly in terms of peribronchial and hilar lymph node evaluation.

Previous data have shown that VATS lobectomy is indicated for the treatment of early stage lung cancer. Long-term oncologic results in patients with early stage non-small cell lung cancer (NSCLC) appear to be comparable between VATS and open lobectomy.

Published experiences showing have shown good results after VATS lobectomy for advanced stage lung cancer and after VATS lobectomy associated with bronchoplasty and/or angioplasty have appeared.

More recently, cost analysis studies have reported that the overall cost of VATS is similar or less than open lobectomy because of its association with shorter LOS, faster recovery, and fewer adverse events. Moreover, the economic impact of the VATS approach is magnified with increased experience of the surgeon.

Nevertheless, to the best of our knowledge, a large prospective and randomized multi-institutional study comparing results of patients undergoing VATS lobectomy with those of patients undergoing open lobectomy has never been conducted. Therefore, a large clinical trial is needed in order to validate the results shown in previous studies and clarify some controversial aspects.

Keywords: VATS lobectomy; Open lobectomy; NSCLC

Introduction

Since it was initially reported in 1994, lobectomy performed using a video-assisted approach has proved to be safe and effective [1,2]. Published experiences since then suggest that video-assisted thoracic surgery (VATS) lobectomy is indicated for the treatment of early-stage lung cancer. Although no large prospective, randomized, controlled trial has compared VATS lobectomy with lobectomy performed via open thoracotomy, over time many well designed retrospective studies have consistently shown that VATS has comparable oncologic outcomes and is associated with fewer complications, reduced length of hospital stay, improvement in patient quality of life, and superior tolerance of adjuvant therapies [3,4]. Moreover, some authors have suggested the possibility of a potential survival benefit after VATS lobectomy due to the resulting decreased release of cytokines which would reduce the level of postoperative immunosuppression [5,6].

Recent reports have examined the feasibility of bronchial and/or vascular sleeve lobectomy performed by VATS rather than by standard thoracotomy approaches. Other investigations examined acute and chronic postoperative pain and quality of life evaluation after VATS lobectomy.

Cost analyses of VATS lobectomy and lymphadenectomy during VATS lobectomy are two

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*Correspondence:

Giulio Maurizi, Department of Thoracic Surgery, Sapienza University of Rome— "Sant'Andrea" Hospital, Via di Grottarossa, 1035, 00189 Rome, Italy, Tel: 003933775773; Fax: 003933775578;

E-mail: giulioaurizi@libero.it

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Table 1: Main published experiences comparing VATS versus open lobectomy for stage I lung cancer.

Author (year)	Patients		Mortality (%)			Morbidity (%)			Survival (%)		
	Open	Vats	Open	Vats	P	Open	Vats	P	Open	Vats	P
Tatsumi (2003) [7]	121	118	1.7	0	NR	NR	25.4	-	79.3 (5-y)	91.9 (5-y)	0.27
Park (2007) [8]	122	122	0	2.5	0.3	27.9	17.2	0.046	NR	NR	-
Sawada (2007) [9]	123	165	NR	NR	-	NR	NR	-	81.5 (5-y)	94.5 (5-y)	0.002
Whitson (2007) [10]	88	59	0	0	NS	6.85	3.4	NS	66 (4-y)	72 (4-y)	0.6
Kawachi (2009) [11]	176	73	2.3	1.4	0.6	24.4	19.2	0.1	NR	NR	-
Flores (2009) [12]	343	398	0.3	0.25	NS	30	24	NS	75 (5-y)	79 (5-y)	0.8
Ilonen (2011) [14]	212	116	2.8	2.6	1	26.9	15.5	0.020	-	-	0.4 (4-y)
Park JS (2011) [13]	136	136	0	0	NS	16.2	12.5	0.65	97.4 (3-y)	96.6 (3-y)	0.76
Falcoz (2015) [15]	2,721	2,721	31.7	29.1	0.03	1.9	1	0.002	NR	NR	-

NS: Not Significant; NR: Not Reported

crucial areas that need to be evaluated. The latter main aspects will be the object of the present literature data review.

Early stage lung cancer: results of surgery

The current indication for VATS lobectomy is the treatment of early stage lung cancer.

Since the initial reports of McKenna and Roviario, other published experiences have confirmed this indication and showed comparable results with those of patients undergoing open lobectomy. [Table 1] [7-15].

A systematic review from Whitson et al. [16] including 39 studies with an aggregate number of 3,256 thoracotomy lobectomy patients and 3,114 VATS lobectomy patients, demonstrated that VATS lobectomy, when compared to thoracotomy, was associated with significantly shorter chest tube insertion duration, shorter LOS, and improved survival (4 years after pulmonary resection). Their data analysis concluded that compared to lobectomy performed by thoracotomy, VATS lobectomy for patients with early-stage non-small cell lung cancer (NSCLC) had lower morbidity and improved survival rates.

In 2006, McKenna et al. [17] reported short term and long term results on more than 1,000 VATS lobectomies. The patients included in this series experienced a median LOS of 3 days, a mortality rate of 0.8%, and a postoperative complication rate of 15.3%. Five year survival rates based on the pathological stage were comparable than those of other published series, including open lobectomy patients.

In 2009, Flores et al. [12] compared long-term outcomes of 398 patients who had undergone triportal VATS lobectomy with those of 343 patients who had undergone posterolateral thoracotomy lobectomy for NSCLC. They found significant differences in terms of complications and 5-year survival rates (VATS group 79% vs. thoracotomy group 75%, $p=0.08$). They also reported a statistically significant difference between the VATS group and open thoracotomy group in terms of LOS; VATS lobectomy patient LOS was 2 days shorter than thoracotomy patients ($p=0.0001$).

Although literature data suggested comparable survival rates between the two surgical approaches to lobectomy, published series showed overall better short term results after VATS lobectomy. In 2010, data from 752 patients of the American College of Surgeons Oncology Group Z0030 randomized clinical trial [18] were used to construct propensity scores for VATS versus open lobectomy. The median operative time was shorter for VATS lobectomy (VATS 117.5

min vs. 171.5 min, $p < 0.001$). Patients undergoing VATS lobectomy had fewer chest tube placement lasting longer than 7 days (1.5% vs. 10.8%, $p=0.29$) and shorter median LOS (5 days vs. 7 days). No difference in operative mortality was observed between the two groups.

Another propensity-matched analysis of outcome comparing VATS versus open lobectomy for primary lung cancer was published by Falcoz et al. [15] in 2015 using data from the European Society of Thoracic Surgeons database. Results of two matched groups of 2,721 patients who underwent surgery between 2007 and 2009 were compared. They reported the VATS group had significantly lower rates of postoperative complications (29.1% vs. 31.7%, $p=0.03$); 2 days shorter LOS (7.8 days vs. 9.8 days, $p=0.0003$); and lower mortality rates (1% vs. 1.9%, $p=0.02$).

In 2013, CAI et al. [19] published a meta-analysis of VATS versus open lobectomy. A total of 23 studies that included only Stage I NSCLC patients were evaluated; 21 were retrospective and 2 prospective. According to their analysis, VATS was associated with increased 5-year survival ($p \leq 0.001$), higher local recurrence rate ($p=0.001$), similar distant recurrence rate ($p=0.8$), and lower complication rate ($p=0.013$) compared to open lobectomy.

Tumors infiltrating the bronchus and/or the pulmonary artery

Some authors have reported single case or small case-series of patients undergoing sleeve lobectomy by VATS; the latter authors reported good short and medium term results [20,21]. Gonzalez-Rivas et al. [22,23] also examined on the uniportal VATS "y" sleeve lobectomy and uniportal VATS double sleeve lobectomy and showed encouraging results. A recent retrospective study from Zhou et al. [24] compared results of 10 patients who underwent VATS sleeve resections with patients who underwent open sleeve lobectomy. No significant differences were found in terms of complications ($p=0.57$) and 3 and 4 year survival rates (VATS: 73% and 40% vs. open: 63% and 56%, $p=0.58$); while significant differences were observed in favor of VATS patients in terms of shorter LOS ($p=0.009$) and in favor of open patients in terms of operating time ($p=0.001$).

Lymphadenectomy

One of the chief concerns of VATS lobectomy is that lymph node dissection may be inadequate. However, these concerns seem to be unjustified, as studies have indicated that a standard lobectomy with lymph node dissection can be performed via VATS [25,26].

Table 2: Lymphadenectomy; main series comparing VATS vs. Open Lobectomy.

Author (year)	Patients		Lymph nodes retrieved (n, mean)		
	Open	VATS	Open	VATS	P
Sugi (2000) [5]	52	48	8.4(hilar), 13.4(mediastinal)	8.2 (hilar) 13 (mediastinal)	0.88
Tatsumi (2003) [7]	121	118	23	21	0.061
Whitson (2007) [10]	88	59	10.9	6.3	0.0001
Flores (2009) [12]	343	398	4.5#	3.6#	<0.0001
Scott (2010) [18]	686	66	15	19	0.14
Ilonen (2011) [13]	212	116	4.6#	2.8#	0.001

Number of lymph node stations.

A comparative study from Sugi et al. [5] (including 48 VATS lobectomy and 52 open lobectomy cases) reported an overall mean number of 8 hilar and 13 mediastinal lymph nodes removed, with no significant differences between VATS and open lobectomy. Five-year survival rates were 90% and 85% after VATS and open lobectomy, respectively ($p=ns$); while reported locoregional recurrence rates were 10% after VATS and 19% after open lobectomy. Sagawa et al [27] reported a series that included 35 patients who underwent VATS lobectomy for stage-I lung cancer and sequential lymph node stations re-exploration by minithoracotomy to assess the adequacy of lymph node evaluation during VATS. They showed a 2-3% rate of resectable nodes underestimated by VATS, with a mean number of 40.3 lymph nodes removed on the right side and 37.1 on the left side. Data from the ACOSOG Z0030 clinical trial showed that the median total number of lymph nodes retrieved was similar between VATS and open lobectomy (VATS group: 15 nodes vs. open group: 19 nodes, $p=0.14$) [18].

Conversely, an important comparative study between VATS and open lobectomy patients showed that the open approach provided a significantly higher number of lymph node stations removed than VATS [Table 2] [12].

Whitson et al. [10] reported an overall significant higher (mean) number of lymph nodes retrieved after open lobectomy. Interestingly, this paper also reported that the number of lymph nodes collected for the last 10 patients in each approach was similar, with a mean of 14 nodes for thoracotomy and 10 nodes for VATS ($p=0.2551$), thus indicating that the number of lymph nodes collected over time in (all 59) VATS patients increased.

In a 2010 paper, Kim et al. [28] reported that patients with pathological N1 and N2 tumors after VATS lobectomy had a 3-year survival rate of 98% and 89%, respectively, with no differences in comparison to open lobectomy. These data suggest that even if lymph node involvement is found during VATS operations for clinical stage-I disease, conversion to an open procedure is not necessary.

Pain and quality of life

The efficacy of VATS lobectomy has been validated in terms of postoperative morbidity including pain and quality of life [29,30], with an extremely low rate of complications [31]. However, many other studies have compared the minimally invasive technique with the standard posterolateral thoracotomy. A recent study from the current authors that compared lobectomy executed through VATS versus an open muscle-sparing mini-thoracotomy [32].

The above mentioned study demonstrated that the incidence of severe intraoperative complication during VATS lobectomy was low and similar to open lobectomy. The severe intraoperative

complications during VATS lobectomy are manageable, and the surgeons need to take proper caution in performing VATS lobectomy. The conversion rate to open surgery in our experience is very low (3 patients, 4.00%). The authors found in patients who underwent VATS lobectomy lower pain scores. The differences between mean postoperative pain values were significant at 1, 12, 24 and 48 h (6.24 vs. 8.74, 5.16 vs. 7.66, 4.19 vs. 6.89, 2.23 vs. 5.33; $P=0.000$). Reduced hospital stay (median: 4.00 vs. 6.00) was not normally distributed and it did not significantly differ ($p=0.088$). Quality of life functional results showed significant differences, as FEV1 and 6MWT values (FEV1: $p=0.028$; 6MWT: $p=0.000$; comparisons: $p=0.000$) were better in the VATS group [32].

Cost analysis

One of the main issues that has limited the wide acceptance of VATS lobectomy has been the presumed increased cost of VATS. Although VATS lobectomy offers advantages with regard to pain, respiratory function, and mobility, concern is often expressed regarding the costs of stapling devices and increased operative time. Casali and Walker [33] compared the costs of VATS and open lobectomy in order to assess the overall economic sustainability of a VATS program. More recently, a cost analysis study reported that the overall cost of VATS is similar to or less than that of open lobectomy due to its association with shorter LOS, faster recovery, and fewer adverse events [34].

In a retrospective multi-institutional North American database analysis [35] where a total of 3,961 patients underwent lobectomy (open: 2,907, VATS: 1,054), hospital costs were higher for open versus VATS. However, adjustment for the surgeon's experience with VATS over the 6 months prior to each operation showed a significant association between surgeon experience and cost; indicating that the economic impact of the VATS approach is magnified with increasing surgeon's experience.

Recently, a multi-institutional taskforce assessed a risk-adjusted financial model to estimate the cost of a video-assisted thoracoscopic surgery [36].

Conclusion

The shared conclusions of the main published experiences of the use of VATS have shown that it has become the standard approach for the surgical resection of early-stage lung cancer and provides excellent results that are better than those of open lobectomy. In recent years, some limited experiences have demonstrated the feasibility of VATS even for complex lung sparing bronchovascular operations.

Lymph node dissection appears to be adequate during VATS lobectomy and cost analyses performed up to now have shown comparable or even better performance in favor of VATS.

Nevertheless, to the best of our knowledge, a large prospective and randomized multi-institutional study comparing results of patients undergoing VATS lobectomy with those of patients undergoing open lobectomy has never been conducted. Therefore, a large clinical trial is needed in order to validate the results that arise from published series and to clarify some controversial aspects that are still under debate.

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