Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 October 2018 doi:10.20944/preprints201810.0152.v1

Can The Advantages Of Video Assisted Thoracoscopic Lobectomy Be Reproduced In A Low Volume Center?

Shagufta Shaheen[1], Salman Otoukesh[1], Brice Jabo[2], Manmeet Kaur[1], Nicole Wheeler[1], Saied Mirshahidi[3], Salman Zaheer[1], Hamid R. Mirshahidi[1]

[1]Loma Linda University Medical Center, Loma Linda/United States of America, [2]Loma Linda University School of Public Health, Loma Linda, CA/United States of America. [3] Loma Linda University Cancer Center, Biospecimen Laboratory, Loma Linda/United States of America

---

Background:

Video assisted thoracoscopic surgery (VATS) has become the recommended approach for treatment of resectable lung cancer. However, no large randomized clinical trial has been conducted formally comparing surgical resections completed by VATS to those done by open thoracotomy (OT) in low volume centers. The current study sought to assess differences in recurrence-free survival (RFS), overall survival (OS), positive margins and postoperative length of stay (LOS) between VATS and OT lobectomies in our center.

Method:

A single institution retrospective chart review from May 2005 through May 2015 was conducted. All patients diagnosed with stage I through III lung cancer who underwent surgical resection were selected. Patient and tumor characteristics recorded included age at diagnosis, sex, tobacco use, tumor location (side and lobe), stage, size and receipt of chemotherapy or radiotherapy. Chis-square and Wilcoxon-Mann-Whitney tests were used to compare demographics, tumor characteristics and LOS. Multiple logistic and Cox regression analyses were used to compute relative risk (RR) for positive margins and mortality hazard ratios along with 95 percent confidence intervals (95%CI), respectively.

Results:

Of the 235 patients, 101 subjects had VATS while OT was performed in 134 patients. Age at diagnosis, sex, tobacco use, tumor location, and size were comparable for VATS and OT. No significant difference was observed in the relative risk of positive margins for VATS versus OT, RR = 0.56 (95%CI = 0.26, 1.05). However, VATS had shorter median LOS compared to OT (4 vs. 6 days, respectively), p = 0.002. A comparison of VATS versus OT showed no significant difference in the risk of recurrence, HR = 1.21 (95%CI = 0.74, 2.00), or death, HR = 1.34 (95%CI = 0.88, 2.06), in the intent-to-treat population. Similarly, no significant differences in recurrence or mortality risk were observed between VATS versus OT for analyses conducted separately for each cancer stage group or those limited to patients with negative margins.

Conclusion:

Our study indicates that compared to OT, VATS leads to shorter LOS while achieving comparable margins status, recurrence-free and overall survival regardless of tumor stage at diagnosis.

Key words: video assisted thoracic surgery, open thoracotomy, recurrence-free survival, overall survival, positive margins, postoperative length of stay.

INTRODUCTION:

Surgical resection remains the mainstay of treatment in resectable lung cancers. The introduction of video assisted thoracoscopic surgery (VATS) in 1994 [1] sparked interest in minimally invasive tumor resection. VATS has also been shown to have fewer postoperative complications [2] and has been associated with decreased postoperative pain and increased quality of life compared to OT [3]. Several studies have compared these two approaches indirectly, but no randomized controlled trial has investigated the long-term effect on outcomes. We sought to investigate the long-term disease-free survival and overall survival of patients with lung cancer undergoing lung resection by OT or VATS for resectable stage lung cancer.

PATIENTS AND METHODS:

Surgical Methods:

VATS lung resections were performed via a three-port incision technique including a 4-centimeter anterior axillary working port. The specimens were removed via the working port. Rib spreading was not required. A hilar dissection proceeding from anterior to posterior was performed for lobectomies. For OT resections, a standard posterolateral thoracotomy was used. Generally, bulky tumors, inability to tolerate one lung ventilation, dense adhesions, en bloc chest wall resections, sleeve resections, neoadjuvant radiation therapy, or intraoperative complications were reasons for selecting an OT approach or for requiring a conversion from VATS to OT.

Study population:

Records for patients diagnosed with stage I through III resectable lung cancer treated at Loma Linda University Medical Center from May 2005 through May 2015 were retrieved through a retrospective chart review. Patients were subsequently divided into video assisted thoracoscopic surgery (VATS) and open thoracotomy (OT) groups.

Study outcomes:

Recurrence-free survival was the primary outcome and overall survival was the secondary outcome. Survival was calculated from the date of surgery to the date of recurrence diagnosis/death or end of study follow-up (May 2016).

Study covariates:

Patient and tumor characteristics included age at diagnosis, sex, tobacco use, tumor location (side and lobe), stage, size and type of the treatments including chemotherapy or radiotherapy.

Statistical analyses:

Tumor and demographic characteristics were compared using Chis-square and Wilcoxon-Mann-Whitney tests. Purposeful variable selection approach was used to identify covariates that were included in the final models. A covariate-adjusted Cox proportional hazards model was used to compare recurrence-free and overall survival between patients treated with VATS and those treated with OT. Profile likelihood was used to estimate 95 percent confidence intervals. Proportionality was assessed using Shoenfeld residuals correlations and log-log survival plots. All tests were conducted using R software. R Core Team (2017). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RESULTS:

Study population description:

From May 2005 through May 2015, 235 patients were diagnosed with stage I through III lung cancer. Of those, 134 and 101 patients received OT and VATS, respectively (Table 1). Median age at surgery (with interquartile rages, IQR) was similar for the two groups, OT 69 (IQR = 61, 77) and VATS 70 (IQR = 63,76), p = 0.48. Similarly, no difference in gender distribution was observed, p = 0.92. Both VATS and OT had a higher proportion of tumors located in the right lung, 62 (61.39%) and 78 (58.21%) respectively, p = 0.31. Additionally, more than half of all tumors were located in the upper lobe with a slightly higher proportion seen for OT [78 (57.58%)] than VATS [53 (52.48%)], p = 0.02. In contrast, a higher proportion of stage I cancers were treated by VATS versus OT, p = 0.02. There was no significant difference in median tumor size [3 (IQR= 2, 5) vs. 3 (IQR = 2, 4), p = 0.41] or percentage of tumors with negative margins [104 (89.66%) vs. 89 (95.70%), p = 0.13] between OT and VATS, respectively. Compared to VATS, a higher proportion of OT patients received chemotherapy [38 (28.36%) vs. 13 (12.87%), p = 0.02] and radiotherapy [30 (22.39%) vs. 4 (3.96%), p <0.001].

Recurrence-free and overall survival:

No significant differences in recurrence-free survival (Figure 1, p = 0.23) or overall survival (Figure 2, p = 0.68) were observed between VATS versus OT in the Kaplan-Meier survival curves. After adjusting for covariates, the Cox regression models (Table 2 and Table 3), show no difference in recurrence-free survival, HR = 1.26 (95%CI = 0.73, 2.19), or overall survival, HR = 1.34 (95%CI = 0.85, 2.10), between VATS and OT.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 October 2018 doi:10.20944/preprints201810.0152.v1

Length of stay (LOS):

The median LOS was 2 days shorter among patients treated with VATS compared to those treated with OT [4 (3, 6) vs. 6 (4, 7), p = 0.002], Figure 3.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 October 2018 doi:10.20944/preprints201810.0152.v1

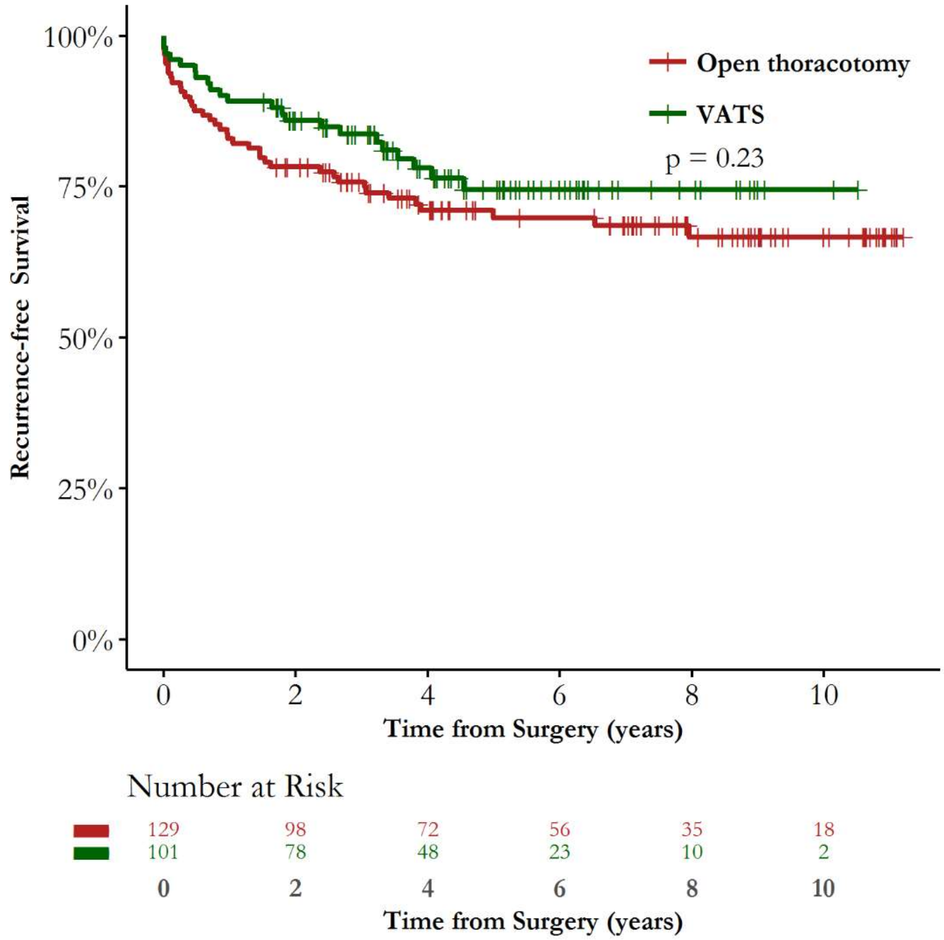
Table 1. Patients' characteristics by type of procedure

Patients characteristics	Open thoracotomy (n = 134)	VATS (n = 101)	p-value
Age at diagnosis ǂ	69 (61-77)	70 (63-76)	0.48
Sex			0.92
Male	50 (37.31%)	37 (36.63%)	
Female	84 (62.69%)	64 (63.37%)	
Side			0.31
Left	53 (39.55%)	39 (38.61%)	
Right	78 (58.21%)	62 (61.39%)	
Bilateral/unknown	3 (2.24%)		
Lobe			0.02
Lower	33 (25.00%)	40 (39.60%)	
Middle	10 (7.58%)	6 (5.94%)	
Upper	76 (57.58%)	53 (52.48%)	
Bilateral/unknown	13 (9.85%)	2 (1.98%)	
Stage†			0.02
1	62 (46.27%)	66 (65.35%)	
2	33 (24.63%)	20 (19.80%)	
3	30 (22.39%)	13 (12.87%)	
Unknown	9 (6.72%)	2 (1.98%)	
Size ǂ	3 (2-5)	3 (2-4)	0.41
Margin status			0.13
Negative	104 (89.66%)	89 (95.70%)	
Positive	12 (10.34%)	4 (4.30%)	
Unknown	18 (13.43%)	8 (7.92%)	
Chemotherapy			0.02
No	85 (63.43%)	80 (79.21%)	
Yes	38 (28.36%)	13 (12.87%%)	
Unknown	11 (8.21%)	8 (7.92%)	
Radiotherapy			<0.001
No	99 (73.88%)	97 (96.04%)	
Yes	30 (22.39%)	4 (3.96%)	
Unknown	5 (3.73%)		
Postoperative length of stay	6 (4-7)	4 (3-6)	0.002

ǂ Median with interquartile range (IQR); † Pathological stage; Abbreviations: VATS, video assisted thoracoscopic surgery

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 October 2018 doi:10.20944/preprints201810.0152.v1

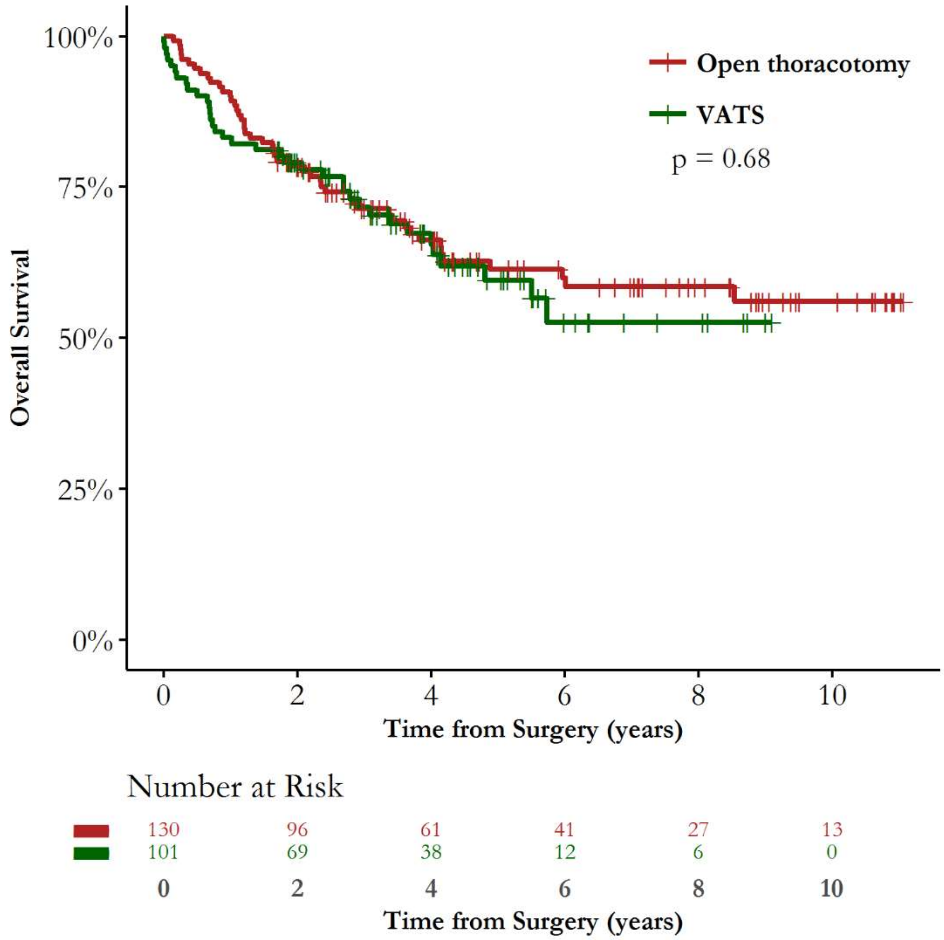
Figure 1. Kaplan-Meier survival curves for recurrence-free survival



Abbreviations: VATS, video assisted thoracoscopic surgery

 doi:10.20944/preprints201810.0152.v1

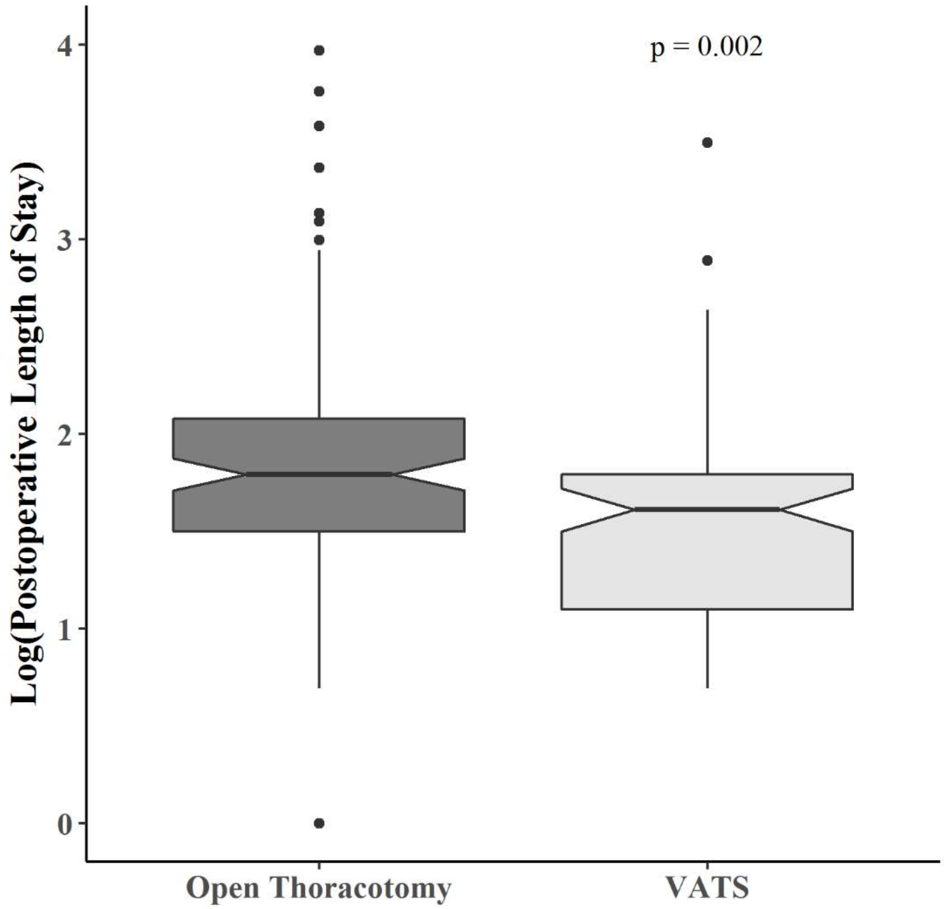
Figure 2. Kaplan-Meier survival curves for overall survival



Abbreviations: VATS, video assisted thoracoscopic surgery

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 October 2018 doi:10.20944/preprints201810.0152.v1

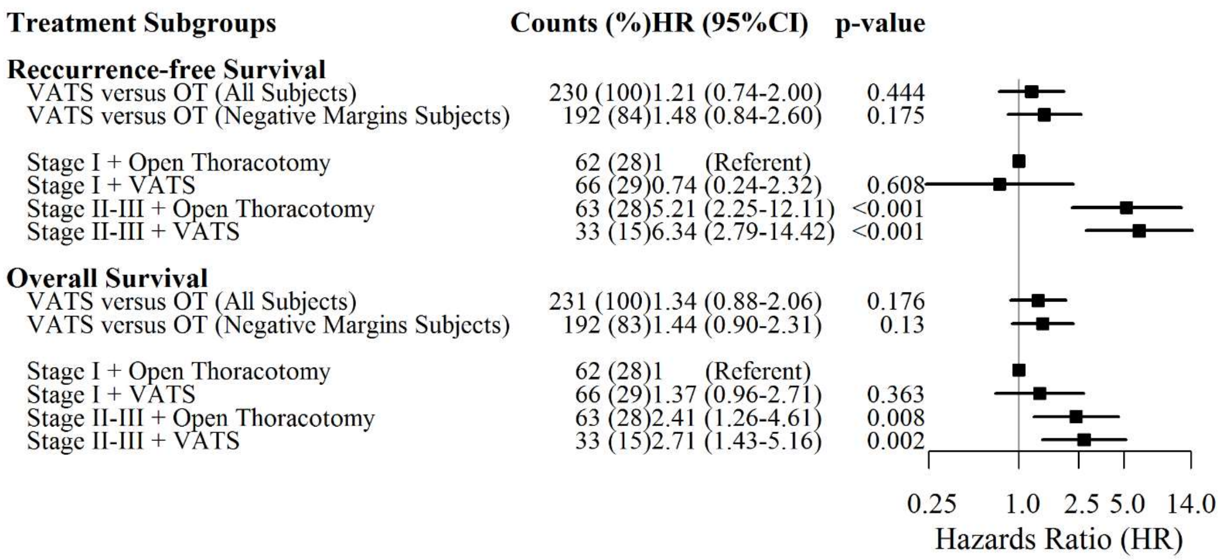
Figure 3. Postoperative length of stay by type of procedure.



Abbreviations: VATS, video assisted thoracoscopic surgery

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 October 2018 doi:10.20944/preprints201810.0152.v1

Figure 4. Forest plot for various treatment subgroups.



Abbreviations: VATS, video assisted thoracoscopic surgery; OT, open thoracotomy; HR, hazard ratio; CI, confidence interval

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 October 2018 doi:10.20944/preprints201810.0152.v1

Table 2. Covariate-adjusted Cox regression recurrence hazards ratios with 95 percent confidence interval (95%CI)

Patients characteristics	HR (95%CI)
Procedure	
Open thoracotomy	1
VATS	1.26 (0.73, 2.19)
Age	1.10 (0.90, 1.35)
Stage	
0-1	1
2	5.71 (2.73, 11.93)
3	9.81 (4.87, 19.78)
Unknown	3.18 (0.86, 11.81)
Margin status	
Negative	1
Positive	2.21 (0.92, 5.34)
Unknown	2.21 (1.12, 4.38)

Abbreviations: VATS, video assisted thoracoscopic surgery; HR, hazard ratio; CI, confidence interval

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 October 2018 doi:10.20944/preprints201810.0152.v1

Table 3. Covariate-adjusted Cox regression mortality hazards ratios with 95 percent confidence interval (95%CI)

Patients characteristics	HR (95%CI)
Procedure	
Open thoracotomy	1
VATS	1.34 (0.85, 2.10)
Age	1.36 (1.11, 1.68)
Stage	
0-1	1
2	1.82 (1.03, 3.19)
3	3.25 (1.90, 5.55)
Unknown	3.21 (1.30, 7.89)
Margin status	
Negative	1
Positive	2.12 (1.04, 4.32)
Unknown	1.10 (0.54, 2.25)

Abbreviations: VATS, video assisted thoracoscopic surgery; HR, hazard ratio; CI, confidence interval

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 October 2018 doi:10.20944/preprints201810.0152.v1

TABLE 4

Author	N = total pts	Shorter LOS VATS vs. OT	LOS p-value	DFS p-value	OS p-value	DFS / OS years
Higuchi 2015[4]	N = 160 114 VATS 46 OT			No difference p=0.27	No difference p=0.55	5
Jung 2015[5]	Propensity score matching 88 per group	VATS 2 days	p<0.05	No difference p=0.63	No difference p=0.27	3
Nwogu 2015[6]	Propensity score matching 175 per group	VATS	p<0.05	No difference p=0.35	No difference p=0.24	5
Erus 2014[7]	N = 55 25 VATS 30 OT	VATS	p<0.05			
Paul 2014[8]	Propensity score matching 1195 per group			No difference p=0.46	No difference p=0.55	3
Kuritzky 2013[9]	80 40 VATS 40 OT			No difference p=0.44 (IA) p=0.48 (IB)	No difference p=0.15 (IA) p=0.20 (IB)	5
Paul 2013[10]	N = 68350 10554 VATS	VATS	p<0.001			

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 October 2018 doi:10.20944/preprints201810.0152.v1

	57796 OT	2 days				
Papiashvilli 2012[11]	N = 389 63 VATS 326 OT	VATS	p<0.001			
Ramos 2012[12]	N = 287 98 VATS 189 OT	VATS	p<0.001			
Park 2011[13]	N = 529 156 VATS 373 OT	VATS 2 days	p<0.05	No difference p=0.43	No difference p=0.76	3
Scott 2010[14]	N = 136 74 VATS 62 OT	VATS	p<0.001			
Flores 2009[15]	N = 741 398 VATS 343 OT	VATS 2 days	p<0.001		No difference p=0.12	5

Abbreviations: LOS, length of stay; VATS, video assisted thoracoscopic surgery; OT, open thoracotomy; DFS, disease-free survival; OS, overall survival

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 October 2018 doi:10.20944/preprints201810.0152.v1

DISCUSSION:

VATS was performed initially in the 1990's. Since then there have been multiple studies advocating the superiority of VATS over conventional OT in terms of short and long-term side effects as well as hospital length of stay [16-18]. However, some surgeons still prefer OT over VATS. In fact, according the Society of Thoracic Surgeons General Thoracic Surgery Database, the percentage of VATS lobectomies performed in the United States are performed by VATS [19, 20] at high volume centers. One explanation for this may be due to the controversial results between several comparative studies in this field [21] since during the resectable years of its development, there was a lack of a clear definition of VATS between thoracic surgeons [22-24]. The goal of this study was to evaluate the outcomes in a low volume university setting over the last 10-year period, 2005-2015, where VATS was initiated in 2009.

Our study, like other similar articles (Table 4), did not capture any statistically significant findings between VATS and OT groups in terms of recurrence-free survival and overall survival ($p = 0.23$ and $p = 0.68$, respectively). Also similarly, VATS lobectomy was associated with shorter length of stay and non-inferior long-term survival when compared with OT lobectomy. These results support previous findings from smaller single- and multi-institutional studies that suggest that VATS does not compromise oncologic outcomes when used for resectable stage lung cancer [26]. Over the last 15 years, there have been multiple studies (Table 4), which have compared VATS to OT. As noted in the table, these studies consistently showed decreased length of stay and no difference in three to five-year disease free or overall survival. Our data is consistent with other data sets retrospectively comparing VATS and OT for resection of resectable non-small cell lung cancer [8, 26].

VATS lobectomy seems to have similar oncological outcomes as OT lobectomy. In VATS lobectomy the incisions are smaller and rib spreading is not performed. These patients are likely to have an overall faster recovery and may tolerate adjuvant chemotherapy better. They are also likely to have less post-operative complications and hence more likely to start and complete adjuvant chemotherapy in a timely fashion possibly leading to improved long-term outcome [15, 27].

Our study has several limitations. First and most importantly, our study is a single institution retrospective study. Specific information on patient selection criteria as well as differences in surgeons' experience is lacking and may have led to selection bias. VATS, like all newly developed minimally invasive surgical techniques, requires skills and experience in which not all surgeons have been trained.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 October 2018 doi:10.20944/preprints201810.0152.v1

Conclusion:

Our study suggests that patients undergoing VATS lobectomy in a low-medium sized university setting have comparable long-term and short-term outcomes compared to national data in terms of disease-free survival, overall survival, and shorter length of stays. This suggests referrals to high volume centers for lobectomy is not required as even low-medium volume centers with board certified thoracic surgeons trained in VATS can achieve equivalent outcomes.

REFERENCES:

1. McKenna RJ, Jr.: **Lobectomy by video-assisted thoracic surgery with mediastinal node sampling for lung cancer**. *J Thorac Cardiovasc Surg* 1994, **107**(3):879-881; discussion 881-872.
2. Cao C, Manganas C, Ang SC, Peeceeyen S, Yan TD: **Video-assisted thoracic surgery versus open thoracotomy for non-small cell lung cancer: a meta-analysis of propensity score-matched patients**. *Interact Cardiovasc Thorac Surg* 2013, **16**(3):244-249.
3. Bendixen M, Jorgensen OD, Kronborg C, Andersen C, Licht PB: **Postoperative pain and quality of life after lobectomy via video-assisted thoracoscopic surgery or anterolateral thoracotomy for early stage lung cancer: a randomised controlled trial**. *The lancet oncology* 2016, **17**(6):836-844.
4. Higuchi M, Yaginuma H, Yonechi A, Kanno R, Ohishi A, Suzuki H, Gotoh M: **Long-term outcomes after video-assisted thoracic surgery (VATS) lobectomy versus lobectomy via open thoracotomy for clinical stage IA non-small cell lung cancer**. *J Cardiothorac Surg* 2014, **9**:88.
5. Jung HS, Kim HR, Choi SH, Kim YH, Kim DK, Park SI: **Clinical feasibility and efficacy of video-assisted thoracic surgery (VATS) anatomical resection in patients with central lung cancer: a comparison with thoracotomy**. *J Thorac Dis* 2015, **7**(10):1774-1779.
6. Nwogu CE, D'Cunha J, Pang H, Gu L, Wang X, Richards WG, Veit LJ, Demmy TL, Sugarbaker DJ, Kohman LJ *et al*: **VATS lobectomy has better perioperative outcomes than open lobectomy: CALGB 31001, an ancillary analysis of CALGB 140202 (Alliance)**. *The Annals of thoracic surgery* 2015, **99**(2):399-405.
7. Erus S, Tanju S, Kapdagli M, Ozkan B, Dilege S, Toker A: **The comparison of complication, pain, quality of life and performance after lung resections with thoracoscopy and axillary thoracotomy**. *Eur J Cardiothorac Surg* 2014, **46**(4):614-619.
8. Paul S, Isaacs AJ, Treasure T, Altorki NK, Sedrakyan A: **Long term survival with thoracoscopic versus open lobectomy: propensity matched comparative analysis using SEER-Medicare database**. *BMJ* 2014, **349**:g5575.
9. Kuritzky AM, Ryder BA, Ng T: **Long-term survival outcomes of Video-assisted Thoracic Surgery (VATS) lobectomy after transitioning from open lobectomy**. *Annals of surgical oncology* 2013, **20**(8):2734-2740.
10. Paul S, Sedrakyan A, Chiu YL, Nasar A, Port JL, Lee PC, Stiles BM, Altorki NK: **Outcomes after lobectomy using thoracoscopy vs thoracotomy: a comparative effectiveness analysis utilizing the Nationwide Inpatient Sample database**. *Eur J Cardiothorac Surg* 2013, **43**(4):813-817.
11. Papiashvilli M, Stav D, Cyjon A, Haitov Z, Gofman V, Bar I: **Lobectomy for non-small cell lung cancer: differences in morbidity and mortality between thoracotomy and thoracoscopy**. *Innovations (Phila)* 2012, **7**(1):15-22.
12. Ramos R, Masuet C, Gossot D: **Lobectomy for early-stage lung carcinoma: a cost analysis of full thoracoscopy versus posterolateral thoracotomy**. *Surg Endosc* 2012, **26**(2):431-437.
13. Park JS, Kim K, Choi MS, Chang SW, Han WS: **Video-Assisted Thoracic Surgery (VATS) Lobectomy for Pathologic Stage I Non-Small Cell Lung Cancer: A Comparative Study with Thoracotomy Lobectomy**. *Korean J Thorac Cardiovasc Surg* 2011, **44**(1):32-38.
14. Scott WJ, Matteotti RS, Egleston BL, Oseni S, Flaherty JF: **A comparison of perioperative outcomes of video-assisted thoracic surgical (VATS) lobectomy with open thoracotomy and lobectomy: results of an analysis using propensity score based weighting**. *Ann Surg Innov Res* 2010, **4**(1):1.
15. Flores RM, Park BJ, Dycoco J, Aronova A, Hirth Y, Rizk NP, Bains M, Downey RJ, Rusch VW: **Lobectomy by video-assisted thoracic surgery (VATS) versus thoracotomy for lung cancer**. *J Thorac Cardiovasc Surg* 2009, **138**(1):11-18.

 doi:10.20944/preprints201810.0152.v1

16. Yim AP, Wan S, Lee TW, Arifi AA: **VATS lobectomy reduces cytokine responses compared with conventional surgery**. *The Annals of thoracic surgery* 2000, **70**(1):243-247.
17. Muraoka M, Oka T, Akamine S, Tagawa T, Nakamura A, Hashizume S, Matsumoto K, Araki M, Tagawa Y, Nagayasu T: **Video-assisted thoracic surgery lobectomy reduces the morbidity after surgery for stage I non-small cell lung cancer**. *Jpn J Thorac Cardiovasc Surg* 2006, **54**(2):49-55.
18. Whitson BA, Andrade RS, Boettcher A, Bardales R, Kratzke RA, Dahlberg PS, Maddaus MA: **Video-assisted thoracoscopic surgery is more favorable than thoracotomy for resection of clinical stage I non-small cell lung cancer**. *The Annals of thoracic surgery* 2007, **83**(6):1965-1970.
19. Park BJ: **Cost concerns for robotic thoracic surgery**. *Annals of cardiothoracic surgery* 2012, 1(1):56-58.
20. Boffa DJ, Allen MS, Henning JD, Gaissert HA, Harpole DH, Wright DC: **Data from the Society of Thoracic Surgery General Thoracic Surgery database: the surgical management of primary lung** tumors. *J Thorac Cardiovasc Surg* 2008, 135(2):247-254.
21. Gopaldas RR, Bakaeen FG, Dao TK, Walsh GL, Swisher SG, Chu D: **Video-assisted thoracoscopic versus open thoracotomy lobectomy in a cohort of 13,619 patients**. *The Annals of thoracic surgery* 2010, **89**(5):1563-1570.
22. Swanson SJ, Herndon JE, 2nd, D'Amico TA, Demmy TL, McKenna RJ, Jr., Green MR, Sugarbaker DJ: **Video-assisted thoracic surgery lobectomy: report of CALGB 39802--a prospective, multi-institution feasibility study**. *Journal of clinical oncology : official journal of the American Society of Clinical Oncology* 2007, **25**(31):4993-4997.
23. Yan TD, Black D, Bannon PG, McCaughan BC: **Systematic review and meta-analysis of randomized and nonrandomized trials on safety and efficacy of video-assisted thoracic surgery lobectomy for early-stage non-small-cell lung cancer**. *Journal of clinical oncology : official journal of the American Society of Clinical Oncology* 2009, **27**(15):2553-2562.
24. Shigemura N, Akashi A, Funaki S, Nakagiri T, Inoue M, Sawabata N, Shiono H, Minami M, Takeuchi Y, Okumura M *et al*: **Long-term outcomes after a variety of video-assisted thoracoscopic lobectomy approaches for clinical stage IA lung cancer: a multi-institutional study**. *J Thorac Cardiovasc Surg* 2006, **132**(3):507-512.
25. Cattaneo SM, Park BJ, Wilton AS, Seshan VE, Bains MS, Downey RJ, Flores RM, Rizk N, Rusch VW: **Use of video-assisted thoracic surgery for lobectomy in the elderly results in fewer complications**. *The Annals of thoracic surgery* 2008, **85**(1):231-235; discussion 235-236.
26. Yang CJ, Kumar A, Klapper JA, Hartwig MG, Tong BC, Harpole DH, Jr., Berry MF, D'Amico TA: **A National Analysis of Long-term Survival Following Thoracoscopic Versus Open Lobectomy for Stage I Non-small-cell Lung Cancer**. *Annals of surgery* 2017.
27. Yamamoto K, Ohsumi A, Kojima F, Imanishi N, Matsuoka K, Ueda M, Miyamoto Y: **Long-term survival after video-assisted thoracic surgery lobectomy for primary lung cancer**. *The Annals of thoracic surgery* 2010, **89**(2):353-359.