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Has VATS Become Too Expensive? A Cost Analysis of VATS versus Open Lobectomy in a Canadian Tertiary Care Hospital

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Abstract

Background: Video-assisted thoracoscopic surgery (VATS) lobectomy is a minimally invasive anatomic lung resection that has been associated with decreased pain and hospital stay compared to open resection. However, with the higher costs of disposable VATS instruments it is unclear whether or not the overall hospital costs are equivalent. The objectives of this study are to compare the overall in-hospital costs of VATS to open lobectomy and assess the financial impact of performing VATS lobectomy procedures in a Canadian tertiary care hospital.

Methods: A retrospective cost analysis was done comparing 78 VATS to 151 open lobectomies. Intraoperative costs, postoperative costs, total costs and length of hospital stay were compared. A regression analysis was done adjusting for age, gender, tumor size and tumor stage.

Results: The mean intraoperative, postoperative and total costs for VATS and open lobectomy were $4,770 and $2,166 (p=0.01), $3929 and $5,604 (p<0.0001), and $8,499 and $7,771 (p=0.3), respectively. The median hospital stay for VATS and open lobectomy were 4 and 5 days (p<0.0001), respectively. The mean intraoperative costs of VATS lobectomy in the first and second 39 VATS lobectomies were $4894 and $4246 (p = 0.003), respectively.

Conclusions: The total cost of VATS lobectomy is equivalent to open lobectomy. Increased cost of disposables and longer operating time account for higher intraoperative cost of VATS lobectomy. A shorter hospital stay and lack of requirement for the acute pain service (APS) reduce the postoperative cost of VATS. The intraoperative costs of VATS lobectomies decrease with experience.

Keywords: VATS; Thoracoscopic; Pulmonary resection; Cost analysis; Health economics

Introduction

Video-assisted thoracoscopic surgery (VATS) lobectomy is a minimally invasive approach for anatomic resection of a lobe most often used for surgical management of non-small cell lung cancer (NSCLC) and has replaced traditional open lobectomy in many centers. Previous studies have shown that overall and disease-free survival are equivalent for both approaches, with less patient morbidity and shorter hospital stay with the VATS approach [1,2]. However, cost differences between VATS and open lobectomy may be significant. Each VATS lobectomy procedure requires use of expensive disposable instruments such as staplers, cartridges and retrieval bags, as well as longer operative time due to the higher technical complexity of the procedure. However, VATS lobectomy has a shorter postoperative hospital stay.

Previous literature shows conflicting results when comparing the cost of open lobectomy to VATS lobectomy. Some studies have shown decreased cost with VATS [3,4] while others demonstrate cost equivalence [5-7]. To date there has not been a cost-analysis study of VATS versus open lobectomies in a Canadian health care institution. Given our single-payer, government-funded healthcare system and its inherent economic constraints, it is important to analyze global hospital costs when introducing new surgical techniques to see if there are overall differences in cost over standard approaches.

Patients and Methods

Ethics approval for this study was granted by the Capital District Health Authority's research ethics board. All lobectomies performed at the QEII Health Sciences Center in Halifax, Nova Scotia, Canada over an 18 month period were reviewed. All open lobectomies were performed for biopsy proven or presumed NSCLC. Lobectomies which followed a wedge resection with intraoperative frozen section were included. Cases where the major vessels and bronchus were not individually identified and divided were excluded. Four surgeons participated in the study. All VATS lobectomies were either performed by one surgeon or proctored cases where the surgeon was teaching another surgeon. Patient demographics, tumor size and stage were recorded.

Surgical approaches

At our institution VATS lobectomy was performed using two to three 5 -12 mm ports and a 3 to 4 cm utility incision with no rib spreading. A 10 mm 30 degree video thoracoscope was utilized. All vessels were divided with an endostapler (Ethicon ATS flex or Covidien Endo-GIA) with a white, gray or tan load (2.5 mm staples). The bronchus was divided with a blue/purple load (3.5 mm staples) or green load (4.8 mm staples). The fissure was completed using multiple firings of an endostapler with a green, blue or purple load. The specimen was always removed in an Ethicon Endopouch or Cook LapSac bag. Systematic lymph node dissection and sampling was routinely performed. Paravertebral or epidural catheters were not routinely used in VATS lobectomy cases.

Open lobectomy was performed using a fifth interspace posterolateral thoracotomy with or without rib resection. The majority of vessels were suture ligated but linear and right-angle staplers were occasionally used at the surgeon's discretion. The bronchus was divided with a TA-30 stapler with a green load. Systematic lymph node dissection or sampling was routinely performed. A paravertebral block was routinely placed at the end of the operation.

Post-operative care

Following either VATS or open lobectomy, all patients were monitored at least one night in an intermediate care unit (IMCU). Patients were transferred to a ward bed the following morning if deemed to be stable by the surgical team. Open lobectomy patients were followed by the acute pain service (APS) for pain management with a paravertebral block or a patient-controlled analgesia (PCA) pump. Generalized criteria for removal of chest tube were less than 300 milliliters drainage over 24 hours with no air leak.

Outcomes

The primary study outcomes were mean intraoperative, postoperative and total cost of VATS and open lobectomy and median days in hospital. Secondary outcomes included mean operating theatre time (the time the patient was in the operating theatre including anesthesia time), mean operating time (start of surgery until completion of skin closure), median number of stapler cartridges used, median days in an IMCU and ward bed, median days requiring a chest tube and APS, number of patients requiring transfusion of blood products, ICU stay, take back to the OR and/or a readmission within 30 days, and the number of patients having a prolonged air leak (defined as requiring a chest tube for greater than 5 days). Primary and secondary outcomes were all compared using either Student t-test (means), Wilcoxon test (median), or Fisher's exact test (proportions). Univariate regression analysis was used to adjust for age, gender, tumor size and tumor stage.

Cost calculation

All costs were reported in Canadian dollars (CDN), which traded at approximately par to the United States dollar (USD) during the study period. Intraoperative costs were computed by summing the cost of operating theatre time, anesthesia costs, and cost of disposables (eg. stapling devices and retrieval bags). The average cost of the thoracic operating theatre was $3.65 per minute, which included nursing costs, standard operating room equipment, medications and supplies. The cost for anesthesia was $16.40-32.80 per 15 minute time interval after an initial fee to induce anesthesia ($213.20). The cost of disposables for VATS and open lobectomy are listed in tables 1 and 2, respectively. Post-operative costs were computed by summing the average cost of days in ICU, IMCU and on the ward, as well as the days followed by APS (Table 3). The days with a chest tube, return to the operating room during hospitalization, and readmission within 30 days were also recorded. If a patient returned to the emergency department or required readmission within 30 days of their lobectomy, these costs were added to the postoperative cost. A secondary analysis was performed to compare the first half of VATS lobectomies to the second half to look at the impact of a "learning curve" on cost.

Instrument	Cost
Ethicon ATS45 handle	384.51
Ethicon ATS45 reload (white)	154.20
Ethicon ATS45 cartridge reload (blue/green)	143.98
Ethicon Echelon 60 handle	426.66
Ethicon Echelon cartridge reload (all)	198.09
Covidien Tristaple handle	195.50
Covidien EndoGIA45 reload (purple)	227.37
Covidien EndoGIA45 reload (tan)	221.05
Covidien EndoGIA60 reload (purple)	276.05
Covidien EndoGIA60 reload (tan)	277.35
Ethicon Endopouch 10 mm SpecimenRetrieval Bag	79.75

Table 1: Cost of disposables for VATS lobectomy (all costs are in Canadian dollars)

Instrument	Cost
Ethicon TLC75G stapler	167.08
Ethicon TLC75G reload	95.77
Ethicon TX30V stapler	138.34
Ethicon TX30V reload	56.56
Ethicon TX30G stapler	119.43
Ethicon TX30 reload	49.21
Ethicon TX60G stapler	127.95
Ethicon TX60 reload	63.19

Table 2: Cost of disposables for open lobectomy (all costs are in Canadian dollars)

Expense	Cost
ICU bed (per day)	1938
IMCU bed (per day)	945
ward bed (per day)	525
APS (initial consult)	252
APS (per day)	175.56

Table 3: Postoperative costs (all costs are in Canadian dollars)

Results

A total of 78 VATS and 149 open lobectomies were performed during the study period. Patient demographics, pathological tumor stage and the operations performed are summarized in table 4. While the majority of lobectomies were performed for proven or presumed NSCLC, three patients (3.8%) in the VATS group (final pathology showing colorectal metastasis in two cases and breast metastasis in one case) and 12 patients (8.1%) in the open group (final pathology showing colorectal metastasis in four cases, renal cell metastasis in three cases, endometrial metastasis in one case, adenocarcinoma in situ in one case, lymphoma in one case, tuberculosis in one case and fibrosis in one case) did not have NSCLC on final pathology. One VATS lobectomy was converted to open lobectomy and this was included in the cost analysis as a VATS lobectomy.

Primary outcomes

The primary outcomes are given in table 5. The mean intraoperative, postoperative and total costs for VATS and open lobectomy were $4,770 and $2,166 (p=0.01), $3929 and $5,604 (p<0.0001), and $8,499 and $7,771 (p=0.3), respectively. The median hospital stay for VATS and open lobectomy were 4 days and 5 days (p<0.0001), respectively. A regression analysis controlling for age, gender, tumor size and stage showed the adjusted difference in mean intraoperative, postoperative and total costs were $2413.45 (p<0.0001), $1792.15 (p=0.01) and 621.29 (p=0.37), respectively, suggesting there was no statistically significant difference between the adjusted and unadjusted costs.

Secondary outcomes

The secondary outcomes are given in table 6. Operating time for VATS was significantly longer than open lobectomy. No difference was found for length of stay in the IMCU for VATS and open lobectomy patients. One patient in the open lobectomy group transferred directly from the ICU to an outside institution and therefore did not require an IMCU or ward stay. Patients in the VATS group did have a significantly shorter ward stay. APS was not routinely used for VATS patients; however this service was generally used following open lobectomy. Therefore the difference in median days required of this service is significant between the two groups.

There was a shorter duration for chest tubes in the VATS patients, however no difference was found in the number of patients with prolonged air leak.

The intraoperative costs between the first and second 39 VATS lobectomies were found to be significantly different (Table 7). However, no difference between the postoperative and total costs was found. Figure 1 is a plot of the two main variables contributing to intraoperative costs:

theatre time and disposable endostapler cartridges. The graph shows that the cost of both variables decreases with experience. Lines of best fit for both cartridges and theatre time shown on the graph demonstrate that the reduction of endostapler cartridges with increased experience contributed the most to reducing the intraoperative costs for VATS lobectomy.

Factor	VATS Lobectomy (n=78)	Open Lobectomy (n=149)	p-value
Male: Female	35:43	66:83	0.93
Mean age (years)	67.4	66.1	0.29
Mean tumor size (cm)	2.7	3.0	0.20
Pathologic Stage			0.16
Pathologic Stage I	54 (69.2%)	87 (58.4%)	
Pathologic Stage II	16 (20.5%)	26 (17.4%)	
Pathologic Stage III	5 (6.4%)	23 (15.4%)	
Pathologic Stage IV	0 (0%)	1 (0.7%)	
Stage not applicable	3 (3.8%)	12 (8.1%)	
Operation			0.15
RUL lobectomy	32 (41.0%)	52 (39.9%)	
RML lobectomy	6 (7.7%)	11 (7.4%)	
RLL lobectomy	12 (15.4%)	21 (14.1%)	
LUL lobectomy	19 (24.4%)	43 (28.9%)	
Segmentectomy	3 (3.8%)	0 (0%)	
LLL lobectomy	6 (7.7%)	19 (12.8%)	
RML & RLL bilobectomies	0 (0%)	3 (2.0%)	

Table 4: Patient demographics, tumor staging and operations performed

Outcome	VATS	Open	p-value
Mean intraoperative cost (Canadian dollars, range)	4570 (3709-8486)	2167 (1233-4807)	<0.0001
Mean postoperative cost (Canadian dollars, range)	3929 (1470-26,220)	5605 (2529-60,078)	0.01
Mean total cost (Canadian dollars, range)	8499 (4303-30,937)	7771 (4354-62,707)	0.3
Median days in hospital (days, range)	4 (2-73)	5 (3-31)	<0.0001

Table 5: Primary outcomes

Outcome	VATS	Open	p-value
Mean operating time (mins, range)	213 (117-378)	170 (77-540)	<0.0001
Mean theatre time (mins, range)	277 (191–499)	225 (123–714)	<0.0001
Median cartridges (number, range)	11 (5-34)	5 (1-14)	<0.0001
Requiring ICU (patients, percentage)	2 (2.6%)	5 (3.4%)	1
Median days in IMCU (days, range)	1 (1-8)	1 (0-11)	0.22
Median days in ward bed (days, range)	3 (0-67)	4 (0-17)	<0.0001
Median days of APS (days, range)	0 (0-5)	4 (0-6)	<0.0001
Median days of chest tube (days, range)	3 (1-35)	4 (1-37)	<0.0001
pRBC transfusion (patients, percentage)	3 (3.9%)	15 (10.1%)	0.1238
Prolonged air leak (patients, percentage)	13 (16.7%)	25 (16.8%)	1
Second operation (patients, percentage)	2 (2.6%)	4 (2.7%)	1
Re-admission (patients, percentage)	3 (3.9%)	4 (2.7%)	0.69

Table 6: Secondary outcomes

Outcome	First VATS Lobectomies (39)	Second VATS Lobectomies (39)	p-value
Mean intraoperative cost (Canadian dollars, range)	4894 (2782-8486)	4246 (2709-6942)	0.003
Mean postoperative cost (Canadian dollars, range)	4123 (1470-12,385)	3736 (1470-26,220)	0.64
Mean total cost (Canadian dollars, range)	9017 (4303-17,054)	7982 (4587-30,937)	0.23
Median days in hospital (days, range)	5 (2-21)	4 (2-73)	0.01

Table 7: Comparison of the primary outcomes between the first and second 39 VATS lobectomy cases

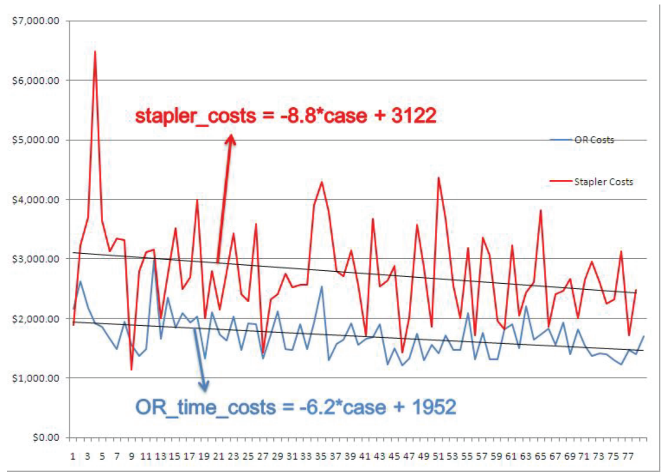

Figure 1: A plot of the cost of staplers (red) and operating time (blue) with experience. The line of best fit is steeper for the cost of staplers, suggesting use of fewer cartridges with experience contributed the most to reducing intraoperative costs.

We further analyzed these two variables to compute the theoretical optimal use of theatre time and disposable endostapler cartridges for VATS lobectomy. Two scenarios were created where the intraoperative cost of VATS equaled the intraoperative cost of open lobectomy. In the first scenario the theatre time was minimized and the maximum number of endostapler cartridges was computed. In the second scenario, the number of endostaplers cartridges was minimized and the maximum theatre time was computed. Using the minimum theater time for a lobectomy in our study (123 minutes for an open lobectomy) as the theatre time for a VATS lobectomy, a maximum of six endostapler cartridges can be used. If the minimum number of endostapler cartridges in our study (five) were used for a VATS lobectomy, the maximum theater time that can be used is 161 minutes.

Discussion

In the adoption of new surgical technology or techniques, it is essential that comparison be made to the pre-existing standard of care. While numerous studies have evaluated VATS versus open lobectomies in terms of postoperative pain, morbidity and survival [1,2], relatively fewer studies have analyzed cost differences between the two techniques. With health care resources increasingly strained by a growing elderly population and global economic uncertainty, cost differences become paramount to analyze. In particular, the Canadian, single-tier, government funded public health care system is especially vulnerable and cost containment must be made whenever possible. Detailed cost analysis studies are essential to guide institutional decision-making prior to adoption of newer surgical techniques.

Intraoperative cost

Consistent with previously published literature [3,5-7] our study showed that intraoperative costs were significantly higher for VATS lobectomy compared to open resection, mainly due to longer operating time and use of disposable instruments. Furthermore, the introduction of VATS lobectomy in an institution inherently includes a surgeon learning curve. Improvements in the cost of VATS with experience have been reported in previous studies [4,6,8]. There was a significant difference between the intraoperative cost between the first and second 39 VATS lobectomies. The intraoperative cost decreased due to a reduction in both theatre time and use of fewer stapler cartridges, with a larger impact on cost resulting from decreased cartridges as illustrated in figure 1. Our analysis of optimizing theater time and endostapler cartridge use provides helpful benchmarks for surgeons to achieve in order to make intraoperative VATS costs more equivalent to open resection. With more judicious use of disposable instruments (eg. dividing multiple vessels with a single cartridge firing), one can realize ongoing cost savings with increased VATS experience.

Postoperative cost

The postoperative costs of open lobectomy were higher due to longer surgical ward stay and higher use of APS. Table 8 shows no difference in the days in IMCU between VATS and open lobectomy groups; however, open lobectomies stayed in hospital longer. Most open lobectomies have paravertebral catheters and are followed by APS for a median of 4 days, while the majority of the VATS lobectomy patients only require intermittent intravenous and oral analgesics managed by the surgical team, resulting in significant cost savings for VATS.

Total cost

Our study found no significant difference between the total in-hospital cost of VATS and open lobectomy, which is consistent with the majority of the previous studies [5-7]. Retrospective cost-comparison studies in Europe [5] and Asia [6] demonstrate that VATS lobectomies are associated with shorter hospital stay, but intraoperative costs are significantly higher compared to open lobectomy. Ultimately, these studies showed no difference in the total cost between the two techniques. An older study in Japan [9] and a more recent retrospective study in France [3] found total cost of VATS to be lower than open lobectomy. However, a significant portion of the cost difference in the study by Ramos et al. is due to the fact that most VATS lobectomy patients did not require an overnight stay in a high dependency unit, whereas all VATS and open lobectomy patients in our study were routinely admitted to these units postoperatively. Furthermore, mean length of stay in their open lobectomy patients was 14 days. This is significantly longer than in our study, with median length of stay of 4 days for VATS lobectomy and 5 days for open lobectomy. In fact the median length of stay in our study was shorter than that reported in most other studies. Cho et al. [6] reported a mean length of stay for VATS and open lobectomy of 7.1 and 11.5 days, respectively. Casili et al. [5] reported a similar mean length of stay of 7.1 and 12 days for VATS and open lobectomy, respectively. However, one study in the United States utilizing a fast track program for VATS lobectomy reported a median length of stay of 3 days [10]. A significant reduction in hospital stay for VATS patients is an important variable in maintaining patient throughput in a Canadian hospital. Since thoracic surgery is usually limited to larger metropolitan cities in Canada, hospital bed availability is a rate limiting factor in determining whether or not surgical cases may be performed on a daily basis. A reduction in hospital stay may translate into more available surgical beds to perform a greater number of cases.

Outcome	1st VATS Lobectomies (39)	2nd VATS Lobectomies (39)	p-value
Mean operating time (min, range)	236 (132–378)	189 (117–310)	0.0003
Mean theatre time (min, range)	301 (208-499)	253 (191-366)	<0.0001
Median no. cartridges (count, range)	13.5 (5-34)	11.1 (6-20)	0.01
Mean theatre costs (Canadian dollars, range)	1840 (1301–2988)	1565 (1206–2207)	0.0003
Mean stapler costs (Canadian dollars, range)	2951 (1145–6484)	2592 (1423–4360)	0.05

Table 8: Comparison of the secondary outcomes between the first and second 39 VATS lobectomy cases

Regarding overall costs, two large American database reviews yield somewhat conflicting results. One study showed VATS to be more cost effective compared to open lobectomy [4], while the second study from a different database showed no difference in total cost [7]. A study in Poland suggested that VATS lobectomy is not cost effective for middle income countries [11] while an older Korean study showed VATS to be more expensive compared to open lobectomy [12]. A review of VATS technology in 2003 suggested VATS would have limited utility in developing countries because of the high intraoperative costs [13]. To our knowledge, our study is the first Canadian cost analysis of VATS vs. open lobectomy, although a Canadian study of laparoscopic versus open colectomy showed an overall cost savings for the laparoscopic technique which was achieved through a shorter hospital stay [14].

This study is inherently limited by its retrospective design, similar to all previous studies looking at this issue. There were also differences in surgical technique in particular for open lobectomy, especially in the use of disposable instruments which could vary the intraoperative costs considerably. However, postoperative care was routine among the two groups, particularly in terms of overnight IMCU stay, routine APS involvement for open cases, and generalized criteria for chest tube removal and discharge home. Nevertheless, this study demonstrates that within a Canadian health care institution the total in-hospital costs of VATS lobectomy are equivalent to open resection, with potential for further intraoperative cost saving with ongoing surgeon experience.

Conclusion

The total in-hospital cost of VATS lobectomy is not significantly different from open lobectomy. Intraoperative costs were higher for VATS, but postoperative costs are less than open lobectomy. VATS lobectomy patients spend one less day in a ward bed representing an opportunity to treat more patients with the currently available beds. There appears to be a significant impact of a learning curving when introducing new technology into an institution that is realized as higher initial intraoperative costs. This should not discourage institutions from introducing new technology since with increased experience further cost savings may be realized.

To make VATS lobectomy overall more cost effective than open lobectomy, the two variables than can be controlled and optimized by the surgeon are operating time and judicious use of disposable instruments. Surgeons are encouraged to prospectively and accurately track these two variables to optimize their performance in a cost efficient manner.

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