Review Article



# Cost analysis of VATS approaches

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**Abstract:** Video-assisted thoracoscopic surgery has become the recommended approach for pulmonary anatomic resections performed for early stage lung cancer. Several retrospective studies have shown that VATS is associated with reduced incidence of complications and shorter hospital stay compared to open surgery. This translates into reduced postoperative hospital costs. A number of investigators have analysed the impact of this surgical approach on hospital costs compared to thoracotomy. In general they found that VATS intraoperative costs are higher owing to increased use of disposables, whilst postoperative costs are lower owing to shorter hospital stay. Whether this translates into an overall cost saving for the provider depends on the local financial setting. Other authors have tried to identify factors associated with cost variability after VATS lobectomy. The objective is to find areas or groups of patients, where to implement strategies of practice and financial improvement. In addition, the identification of patient and procedure related factors associated with increased costs should be taken into account when defining reimbursement tariffs for specific procedures. We reviewed the existing literature about the financial aspects of VATS lobectomy.

**Keywords:** Hospital costs; video-assisted thoracoscopic surgery (VATS) lobectomy; risk model; finances; practice evaluation

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## Introduction

Recent evidence and clinical experience have shown that the use of video-assisted thoracoscopic surgery (VATS) to perform curative anatomic lung resections in patients with early stage lung cancer is superior to thoracotomy in terms of early outcomes (postoperative pain, length of stay, morbidity and, in some reports mortality) (1-4), and has at least equivalent efficacy in terms of cancer cure and long term prognosis (2,5,6).

The recently updated Lung Cancer Management Guidelines from the American College of Chest Physicians have recommended the use of VATS in patients with stage I non-small cell lung cancer (7).

Nevertheless, the adoption of this minimally invasive approach is not global and remains slow in some Countries. Certainly, one of the factors of greatest concern is the increased surgical costs associated with this new procedure related to the use of dedicated instruments, prolonged duration of intervention, particularly in its learning curve phase, and increased use of consumables.

Nowadays, due to the financial restrains of the health care systems, it is becoming more apparent that the costs of various treatments need to be taken into account as well as medical outcomes themselves when assessing patient care pathways. It becomes a balancing act to maintain the quality of an intervention whilst optimizing its efficiency. In the interest of public health, an evaluation of the costs incurred by VATS lobectomy procedures appears therefore beneficial to see if and where financial resources can be spared or allocated.

Several papers have addressed the economic impact of a VATS approach to lobectomy comparing this procedure with open surgery.

## VATS versus thoracotomy costs

Most of the papers comparing the financial figures of VATS

lobectomy with those associated with thoracotomy showed an overall cost saving mostly explained by the shortened hospital stay.

Park and coll. (8) compared 269 thoracotomy lobectomy patients with 99 VATS counterparts operated on during one year. They found that costs after thoracotomy were $7969 higher than those after VATS, mostly attributable to longer hospital stay by 2 days, resulting in $5,098 of additional cost.

Casali and Walker compared 93 VATS lobectomy patients with 253 thoracotomy ones operated on during two years at their unit (9).

They found that the mean theatre cost for a VATS lobectomy almost doubled the one for a thoracotomy lobectomy (€2,533 *vs.* €1,280, P=0.00001). Conversely, the use of VATS reduced high dependency unit stay and ward stay costs (€1,713 *vs.* €2,571 and €3,776 *vs.* €4,325, respectively). Therefore, the overall cost of VATS lobectomy was €8,023 compared to open lobectomy which was €8,178 (P=0.00002). The authors concluded that the increased theatre costs were offset by shorter hospital length in VATS lobectomy, which was found to be less expensive. Interestingly they also found that both VATS and open costs varied according to the type of resections. For instance, the VATS resection with the highest theatre cost was upper bilobectomy, which cost €1,400 more than left lower lobectomy, the cheapest one. In this case the reduced postoperative costs were not able to offset the intra-operative ones. Left upper, right upper and right lower lobectomies were associated with the highest intraoperative cost differences between VATS versus open, ranging between €2,000 and €2,500. Most of the difference in theatre costs between VATS and open lobectomies were due to the cost of disposables (staplers and reload) and endo-instruments. The greatest limitation of this study was that costs were not risk adjusted for patient characteristics. Since hospital stay and complications may depends not only upon the surgical approach but also on the case mix of the population. For instance, compared to open ones VATS patients had a much higher proportion of early NSCLC stage and adenocarcinoma and were more often female. No information about pulmonary function, other co-morbidities or fitness was reported in the paper.

Similar findings were reported by Ramos and coll. (10), who compared 98 thoracoscopic lobectomies or segmentectomy versus 189 open resections (posterolateral thoracotomy) performed at their institution over 2 years.

They found increased intraoperative costs for VATS compared to thoracotomy (€2,861 *vs.* €2,260, P<0.0001), mostly due to the added costs of disposables and staplers, which were two-fold higher in VATS cases (€1,800 *vs.* €900) and prolonged operative time (80 minutes longer for VATS lobectomies).

However, the increased surgical costs of VATS lobectomies were offset by the lower cost of hospital stay. Therefore, the authors found that the overall cost of VATS resections was lower than the one associated with thoracotomy (€11,934 *vs.* €14,146, P<0.0001).

Similar to the previous paper, the cost comparison was not adjusted for case mix. VATS patients were more frequently nonsmokers and with significantly lower incidence of cardiac co-morbidity. They also showed a trend toward a higher incidence of COPD and were more frequently female. Some of these factors have been associated with cost variability following lung resection in subsequent studies (11,12).

The financial advantage of using VATS for lobectomies instead of thoracotomy was confirmed by a large study based on the Premier Perspective database. This database is the largest hospital clinical and economic registry in the US created for quality assurance and resource utilization benchmarking. Swannson and coll. (13). compared 1054 VATS lobectomies with 2907 open cases performed by a thoracic surgeon in one of the 201 contributing hospitals over 15 months.

They were able to compare costs of the two different approaches after risk adjustment for several patient and hospital characteristics that could have potentially influenced the results. The adjusted hospital costs of an open lobectomy were found to be significantly higher than the one performed using VATS ($21,016 *vs.* $20,316, P=0.027). They also found a 1.7 days shorter hospital stay and a reduction of adverse events in VATS cases compared to thoracotomy cases. The discrepancy between the clinical benefits and the relatively little economic benefits (only 3% of overall cost) observed in VATS patients prompted a post-hoc analysis on a selected group of patients to verify whether the surgical experience in the previous 6 months had an influence on costs. The authors were able to find a great cost variability between low volume surgeons (16 cases or less) and high volume surgeons for VATS cases ($22,050 *vs.* $18,133). Conversely, in the open surgery group there was no difference in hospital cost between high volume and low volume surgeons (approximately $21,000 each).

Another smaller single center study from North America was not able to find any significant difference in

 

hospital cost between open (muscle sparing nerve sparing posterolateral thoracotomy) and VATS lobectomies (14). The authors found that the 69 open cases cost on average $1,207 more than the 59 VATS ones. This difference although larger than the one found in the paper from the Premier database discussed above, did not result statistically significant, presumably due to small numbers. The analysis of cost categories identified area of possible cost improvement. Lowering operative time and supplies costs were targets for cost saving in VATS lobectomies.

The occurrence of postoperative complications is certainly one of the main drivers of hospital cost. However, some complications may occur after discharge. A recent study queried the MarketScan database, an all payer registry with in hospital and primary care costs, to assess the total direct medical costs for up to 90 days after discharge from an index hospitalization for a lobectomy (15).

The authors analysed 9962 lobectomy patients (31% performed by VATS). They found that VATS lobectomy was associated with significantly lower total unadjusted 90-day ($42,076 *vs*. $46,470, P=0.001), index hospitalization ($35,307 *vs*. $37,673, P=0.002), and outpatient use ($3,530 *vs*. $3,828, P=0.043) costs compared to thoracotomy.

Index hospitalization cost accounted for 81% of the total 90 days costs after lobectomy.

Regression models were used to adjust for potential confounders influencing costs. VATS was associated with 90-day total costs that were $3,476 lower than those for thoracotomy after adjustment for age, sex, comorbidity index, health plan, and use of epidural anesthesia.

A significantly smaller number of patients had a prolonged length of stay (PLOS: >14 days) after VATS compared to thoracotomy (3% *vs*. 7.1%). The reduced incidence of PLOS after VATS explained most of the cost differential. In fact, adding PLOS as covariate to the regression model reduced the differential cost by 63% (-$1,276) and the difference between VATS *vs*. open lobectomies was no longer significant. However, results from the MarketScan database could not be generalizable to all lung cancer patients as the authors of the paper suggested. Besides, no information was available on surgeon and hospital-level characteristics. These factors could conveniently contribute to bias in favour of better outcomes of VATS lobectomy.

Although not specifically aimed at comparing VATS versus thoracotomy, we recently published a study trying to identify factors associate with cost variability in patients without major complications following lung cancer resection (16). Multiple regression analysis showed that performance of thoracotomy instead of VATS increased the cost of €648. This added cost was mainly due to a shorter hospital stay (-0.9 days) possibly associated with lower pain and lower incidence of minor complications after VATS.

The financial benefit of VATS compared to open surgery was not a consistent finding.

Other authors were not able to find a cost saving after VATS lobectomy.

In a large study on 13,619 lobectomy patients from the Nationwide Inpatient Sample (NIS), the largest all payer inpatient care database in US, the authors tested the role of VATS (performed in 759 patients) on different early outcomes such as mortality morbidity and hospital costs (17). They were not able to find any differences in terms of mortality rates, total complications, hospital stay and, consequently, hospitalization costs between the two groups (open $23,862 *vs*. VATS $25,125, P=0.16). The NIS database is a non-voluntary national database representing 20% of all hospital discharges from non federal facilities within US. In this regard, it may capture a different population compared to the more selected one included in reports from large academic centers or organizational database such as STS or ESTS. This may explain the low proportion of VATS cases in this population and the discrepant financial results compared to other studies.

Other two small retrospective studies did not find any financial benefit in VATS lobectomy patients compared to open ones. These studies are interesting because they come from Countries with more limited resource availability compared to US or other Western European Countries.

A study from Turkey (18) retrospectively analysed 81 lung cancer patients submitted to lobectomy either by VATS (32 patients) or muscle sparing posterolateral thoracotomy (49 patients). Interestingly, in the thoracotomy group no stapling devices were used to close the vessels or the bronchus.

The authors found that thoracotomy patients experienced a longer hospital stay. However, in their setting the cost of one day in the ward is only $15, justifying the fact that a shorter hospital stay did not offset the increased surgical costs due to the use of disposables in the VATS patients. The total cost of VATS lobectomy cases was therefore higher than the one found in thoracotomy ones ($3,970 *vs*. $3,073).

Another Polish study (19) included 212 patients submitted to pulmonary lobectomy for lung cancer smaller than 5 cm and without mediastinal nodal involvement visible

 

at CT scan. Open cases (104 patients) were performed through a muscle sparing anterolateral thoracotomy and hilar structures were divided without using staplers whilst the fissures were completed by using staplers. In VATS cases (108 patients) all anatomical structures such as vessels, bronchus and lung parenchyma were divided by endo staplers.

Cost analysis showed considerably higher median theater costs for the VATS group compared to the thoracotomy group (€1395 *vs.* €479, P=0.0001). This difference was mainly associated with the increased utilization of endo staplers during VATS. The stapler costs in the VATS group were over five times higher than in thoracotomy patients (€1,069 *vs.* €161, P=0.0001).

The higher hospital stay costs associated with thoracotomy (VATS €700 *vs.* open €1,000, P=0.0001) and due to longer hospital stay (10 days *vs.* 7 days, P=0.0012) and higher rate of complications in this group (46% *vs.* 23%, P=0.0006), was not able to offset the high theater costs of VATS lobectomy (total median costs, VATS €2,445 *vs.* open €2,047, P=0.0046).

These two latter studies highlight the fact that economic studies of VATS lobectomies may be difficult to generalize in different health care systems. The financial implications of this surgical approach should be always interpreted in the context of the local economic and clinical settings.

## Cost variability in VATS lobectomy

The above evidences show that VATS lobectomy may have variable financial benefits compared to open surgery that depends on the health care system and local arrangements. It is clear that intraoperative costs of VATS lobectomy are higher than in open cases, especially if no stapling devices are routinely used during open cases. Whether the clinical benefits of a shortened hospital stay would offset this increased intraoperative costs will depend much on the local cost of a hospital bed day.

In general the most recent studies have therefore shifted their focus on the identification of areas of cost improvement/saving in VATS lobectomy cases.

The isolation of patient or surgical characteristics that can define outliers of increased costs is of paramount importance as it can trigger audits aimed at streamlining pathways of care of selected patients.

Medebery and coll. (11) retrospectively analyzed 149 patients who had VATS lobectomy at their institution during 2 fiscal years to identify factors driving cost variability.

They found that the mean intraoperative cost was $8,492, ranging from $4,033 to $20,380. The mean postoperative cost was $10,145 with a much larger variability (from $3,200 to $63,480). Regression analysis showed that amongst the patient characteristics the two associated with increased total costs were presence of COPD (added hospital cost: $3,340) and coronary artery disease (CAD) (added hospital cost: $5,733). A patient with both COPD and CAD was $9,000 more expensive than those without them.

The authors tested also different perioperative outcomes to verify their impacts on postoperative hospital costs and found that intraoperative blood transfusion, unplanned admission to ICU, urinary tract infection and postoperative blood transfusions were each associated with increased costs. In particular intraoperative blood transfusion was the situation with the highest price with an added postoperative cost of $15,000 compared to patients without transfusions.

We (12) recently published a similar analysis on 236 VATS lobectomies to develop a clinically risk adjusted financial model to estimate hospital costs after this procedure. We found that in their setting the mean intraoperative cost (€8,226) was almost 3-fold higher than the postoperative cost (€3,029). However, the cost variability was much greater for the postoperative costs (intraoperative cost range €5,656–€13,296; postoperative cost range €529–€51,970). This notion is of clinical relevance as a large variability implies the presence of potential areas of practice improvement, that if implemented can lead to cost saving. Linear regression analysis showed that a DLCO<60% and the presence of COPD were independent factors associated with increased hospital costs. As a result, the following regression model to estimate the total hospital costs following VATS lobectomy was developed: 10,523 + 1,894× COPD + 2,376× DLCO<60%.

Therefore, in a patient with both COPD and DLCO less of 60% the expected cost after VATS lobectomy would be €4,270 higher than in a patient without these characteristics.

Interestingly, we were not able to identify patient or surgical factors associated with increased intraoperative costs. Conversely, we found that the presence of COPD (added postoperative cost €1,997), DLCO<60% (added postoperative cost €2,236) and diabetes (added postoperative cost €1,614) were all associated with increased postoperative costs.

Risk adjusting the cost of a surgical procedure based on the case mix of the target population appears critical in the current era of financial restrains for an appropriate

 

allocation of resources and for realistic budgeting arrangements. Moreover, tariff regulators would need to keep in mind the cost variability associated with each procedure when defining bundle payments in order not to penalize hospitals caring for sicker patients.

The identification of groups of patients with increased costs has also a clinical implication. In fact a scrupulous audit of their pathways of care should be performed to implement measures aimed at improving their care ultimately leading to improved outcomes (morbidity, mortality and hospital stay) and cost saving.

Khullar and coll. (20). recently analyzed 236 VATS lobectomies patients at their institution with the aim to evaluate which events during intraoperative and postoperative care contribute most to their costs.

They found that the median hospital cost was $19,769 (SD $9,753). The largest contributors to the overall cost and accounting for more than 60% of the overall hospital cost were operating room costs ($7,424) and floor/room (length of stay) costs ($4,048). The authors broke down surgical costs and found that the costs of the operating room time and disposables (staplers) accounted for 80% of the overall surgical costs. In addition to be the largest contributors to the total hospital costs, OR time, staplers and floor room costs showed also the greatest variability, implying the they would be ideal targets for improvement strategies aimed at process optimization and reduction of variability and costs. The authors further evaluated the impact of complications on costs and found that the mean cost of VATS resection in patients with no complications was $17,699. The cost was directly correlated with the number of postoperative complications. In fact, compared to patients without complications, the occurrence of one, two or three complications increased the hospital costs of $6,438, $10,108, and $57,514, respectively.

The association between adverse outcomes and cost variability should be taken into consideration by tariff regulators when constructing bundle payments. In this regard, it is equally important to financially reward high quality outcomes, particularly in sicker patients, and to account for a certain number of postoperative complications in order to minimize risk aversion and "gaming" of the system.

## Conclusions

In conclusion, VATS lobectomy has been variably found associated with reduced costs compared to thoracotomy. The financial benefits depend on the health care systems, local cost setting and practice. In this regard, they do not consistently match the attending clinical benefits compared to thoracotomy.

A greater focus on analyzing factors associated with cost variability of VATS procedures is needed and should be tailored to the local pathways of care in order to maximize quality of care and cost containment.

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