



Cost in video-assisted thoracic surgery versus robotic-assisted thoracic surgery for lung cancer: should we focus on other metrics?

Cathryn Coleman, Leonidas Tapias

Center for Thoracic Surgery, Baylor University Medical Center, Dallas, TX, USA

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Correspondence to: Leonidas Tapias, MD. 3410 Worth Street, Baylor University Medical Center, Dallas, TX 75246. USA.

Email: leonidas.tapias@bswhealth.org.

Abstract: Historically, pulmonary resections for lung cancer have been done in an open fashion. With the adoption of VATS, incisions became smaller but challenges such as cost, safety, and quality of resection became the center of the discussion. However, now we have extensive evidence of the benefit of minimally invasive approaches. With the introduction of robotic-assisted thoracic surgery (RATS), the discussion has gone back to cost as the main driver. This increased robotic cost has been evaluated by multiple studies without a general consensus, given the varying definitions of cost. Medical institutions and health systems will never share the details of what those technologies cost, which makes comparisons not truly significant. In this article, we analyzed the pros and cons of RATS versus VATS and tried to answer if cost is the adequate metric when comparing both techniques.

Keywords: Cost; robotic-assisted thoracic surgery (RATS); video-assisted thoracic surgery (VATS)

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Introduction

Posterolateral thoracotomy has been considered the gold standard for pulmonary lobectomy. However, with minimally invasive approaches gaining popularity given their equivocal oncologic outcomes, the question becomes which technique is superior: video-assisted thoracic surgery (VATS) versus robotic-assisted thoracic surgery (RATS). It has been well established in the literature that VATS and RATS do not compromise oncologic principles when compared to open thoracotomy (1-3). In addition, they offer the benefits of shorter length of stay, less post-operative pain, and decreased mortality (2,4-10). While both approaches are associated with a steep learning curve, they are cheaper than standard thoracotomy (5-6,8). RATS has several benefits to the surgeon including an improved depth perception and instrument articulation, but the issue

with its use has been centered around increased cost. This increased robotic cost has been evaluated by multiple studies without a general consensus given the varying definitions of cost (2,4,6,10,11).

Robotic assisted versus video assisted thoracic surgery: the pros and cons

An increasing number of anatomic lung resections are being undertaken with VATS; however, with the introduction of the da Vinci robot there is now a second minimally invasive option for patients (2,11). While VATS is the more common minimally invasive approach, it is not without its limitations. Non-articulating instruments and a two-dimensional view are two factors that contribute to its steep learning curve. In addition, the limited range of motion

afforded by the stiff instruments can make it difficult to control emergent bleeding (9). In contrast, the robot offers better depth perception and wrist articulation which can make difficult dissections more manageable. The benefits and difficulties of RATS and VATS approaches have been extensively studied in the literature. Some studies have described decreased conversion to open thoracotomy, improved lymph node retrieval, and reduction in mortality (7,9,12). The most significant hurdle to a RATS approach is the steep learning curve in addition to cost.

Cost

Generally speaking, indirect cost is associated with overhead expense while direct cost is associated with materials used in the care of a patient; however, the exact definitions varied by institution (2,10). Thus, the total cost of a robotic lobectomy ranged anywhere from \$15,440 to \$22,582 (2,10). The cost of the robot itself was also inconsistent with hospital facilities quoting prices anywhere from \$1 to \$2 million. Teaching institutions usually purchased an additional console for residents and fellows which cost \$450,000. Furthermore, the maintenance cost of each robotic system is \$140,000 per year (10). Deen *et al.* found that the statistically significant difference in cost between RATS and VATS disappeared when capital depreciation and the cost of robotic supplies were taken out of the equation (5). The exact cause of increased robotic costs varied by study with the majority citing prolonged operating room (OR) time as the cause while others cited robotic supplies as the main culprit. Kneuert *et al.* found similar total cost between RATS and VATS lobectomy with VATS lobectomy costing only \$36 more but these results were not statistically significant. In their study, the decreased cost of the robot was associated with decreased ward and nursing costs (8). The majority of other studies did not appreciate a difference in postoperative care costs or length of stay between RATS and VATS lobectomies (1,3-5,7,11).

Prolonged OR time appears to be the main contributor to increased robotic cost with times ranging anywhere from 88 to 324 minutes. Deen *et al.* concluded that if RATS and VATS were to become equivocal from a cost perspective, then a RATS lobectomy would need to decrease its OR time by 68 minutes or its length of stay by 1.68 days both of which were deemed unreasonable by the authors (5). Lee *et al.* went as far as to differentiate the operative time between upper and lower lobectomies. There was no difference in OR time between RATS and VATS with lower

lobectomies; however, there was a statistically significant prolonged OR time with a RATS upper lobectomy (172 *vs.* 134 minutes) (1). The steep learning curve is believed to be the root cause of prolonged OR times; however, Mungo *et al.* argues that the learning curve from VATS to RATS should be easier given the benefits of dexterity and visualization (9). It takes at least twenty cases to establish a baseline mastery of the robot (11,13). Veronesi *et al.* found that OR times decreased from 220 to 190 minutes after the first twenty cases and then from 190 to 150 minutes after ninety cases (13). Kaur *et al.* noted a difference of 71 minutes between the first 20 RATS procedures compared to the following 22 cases which equated to approximately \$883.38 in cost difference (11). Thus, with increasing experience with RATS lobectomies resulting in shorter OR times, the difference in cost may become irrelevant when compared to VATS. In addition, RATS are more likely to be cost effective at high volume centers where surgeons are more facile with robotic techniques.

In addition to OR time, the higher cost of specific robotic supplies contributes to the overall increased cost of RATS procedures when compared to VATS. Augustin *et al.* estimated an additional 770.55€ for robotic drapes and instruments (4). Likewise, Deen *et al.* found robotic specific supplies and equipment costs would need to be decreased by \$1,601 in order to be comparable to VATS (5). An additional study noted an increased cost of \$3,981 when compared to VATS of which \$730 was attributed to robotic instruments (13). Singer *et al.* argues that the increased operative cost can be resorbed in the post-operative period given shorter length of stays (2).

Discussion

RATS has its clear advantages over VATS given its improved visualization, depth perception and range of movement. While operative times tend to be longer than VATS lobectomies, many studies evaluated RATS during the early stages of their robotics programs which could contribute to their significantly prolonged OR times (3-5,9,11). As surgeons and trainees become more facile with robotics, one would expect to see a downward trend in OR time which would then lead to a decline in overall cost. The use of the robot will inherently add some operative time due to docking and positioning after port placement but this additional time should have minimal effect on cost. Furthermore, the setup time should decrease with

experience but some authors would argue that robotic setup will consistently be longer than VATS despite increased surgeon proficiency (6). Supplies such as robotic specific equipment was the other major cause of increased intraoperative cost. Intuitive's da Vinci robotic system is the only available robotic device on the market leading to complete control of pricing. With the development of other robotic systems, one can expect a decrease in cost with competition.

With comparable oncologic outcomes, length of stay and mortality, the decision for RATS versus VATS lobectomies should be based on surgeon preference. The claim of increased cost remains inconsistent across multiple studies given the varying definitions (2,4,6,10,11). In addition, the cost of the robot is affected by capital depreciation which decreases with the volume of cases; thus, further supporting that robotics are more cost effective at high volume centers (5).

Although cost is an important factor when considering a surgical approach, we are far from knowing exactly what the difference is between different techniques, and more so among different hospitals. In the setting of similar cost, the focus should be on excellent surgical outcomes without compromising oncologic principles, and in addition, allowing comfort for the operating surgeon.

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