6-year Pulmonary Lobectomy Analysis Comparing Robotic to Thoracotomy and VATS: Impact to a State University Cardiothoracic Training Program

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Introduction

Surgical approaches for lung resection have steadily evolved over the years. Video assisted thoracoscopic (VATS) approaches have replaced many of the traditionally open thoracotomy cases due to better surgical outcomes.[1] Recently, robotic surgery has emerged as an even more minimally invasive approach with both therapeutic and post-operative recovery advantages.[2] Some studies, though, have shown robotic thoracic surgery to be more costly than VATS and to have longer operative times with equivocal, not superior, post-operative outcomes.[3,4] If this is the case, then the costly implementation of a robotic thoracic surgery program at a new institution, along with its steep learning curve, might not be justified. However, current understanding of the robotic lobectomy is largely from established thoracic surgical programs, often with a single-surgeon experience, and does not involve trainees. Additionally, it is unknown at what time point during the implementation of an institution's robotic program the data for a respective study is produced. This leaves the question of how the implementation of a robotic thoracic surgery program affects an institution and how trainees at an institution affect a robotic program.

Figure 1: Typical operating room and instrument setup for robotic lung resection.[5]

Our objective is to assess the effect that a new robotic lobectomy program has on a state university cardiothoracic training program with regards to patient care, cardiothoracic training, and the institution.

METHODS

Our prospectively maintained Society of Thoracic Surgeons (STS) database was queried for anatomic lung resections at our institution between 1/1/2006 to 6/30/2016. All wedge resections were excluded, and all sleeve pneumonectomies and extra-pleural pneumonectomies were excluded. Patients with a prior history of lung transplant were also excluded. Any case with insufficient record was also excluded (Figure 1). The initial query was verified using the medical center's electronic medical record and data was entered by blinded double-entry. Cost and oncologic data was obtained from the analytics department and tumor registry, respectively. For the statistical analysis, propensity scores were assigned based on age, sex, and 5 comorbidities. Differences were confirmed using multiple regression analysis. For the oncologic analysis, only cases with non-small cell lung cancer (NSCLC) were included. Lung cancer survival was analyzed by the Kaplan-Meier method and compared to the SEER national database. Our robotic CT training method consists of a 6-month program over 3 years; the first 3 months focus on simulation and bedside-assist and the last 3 months, on complete case set-up and console training. Adjustments are made dependent upon the trainees' prior minimally invasive experience.

Results

367 LUNG RESECTION CASES IDENTIFIED

The current STS database (2009-present) was queried for lung resections coded for the following:

32663 – Thoracoscopy, surgical; with lobectomy
32669 – Thoracoscopy with removal of a single lung segment
32670 – Thoracoscopy with removal of two lobes
32671 – Thoracoscopy with removal of lung, pneumonectomy
32440 – Removal of lung, total pneumonectomy
32480 – Removal of lung, single lobe
32482 – Removal of lung, two lobes
32484 – Removal of lung, single segment
32486 – Removal of lung, sleeve lobectomy
32488 – Removal of lung, completion pneumonectomy

112 LUNG RESECTION CASES IDENTIFIED

A previous version of STS was queried to identify cases between 2006-2008:

32663 – Thoracoscopy, surgical; with lobectomy
32669 – Thoracoscopy with removal of a single lung segment
32670 – Thoracoscopy with removal of two lobes
32671 – Thoracoscopy with removal of lung, pneumonectomy
32440 – Removal of lung, total pneumonectomy
32480 – Removal of lung, single lobe
32482 – Removal of lung, two lobes
32484 – Removal of lung, single segment
32486 – Removal of lung, sleeve lobectomy
32488 – Removal of lung, completion pneumonectomy

An EMR (Epic) query using the same procedure codes identified an additional 44 cases not found in STS for the study period (1/1/06 to 6/30/16)

523 LUNG RESECTION CASES

91 Cases Excluded
- 60 Cases excluded from hospital outcomes for poor chart records
- 5 cases excluded for transplant-related procedures
- 26 cases excluded for incorrect procedure
  - 18 wedge resections
  - 4 en bloc resection of lung tissue for other disease (esophagectomy and lymphatic system resection)
  - 2 had no lung resection per the Operative Report
  - 1 extrapleural pneumonectomy
  - 1 reparative procedure for lobectomy already included in the study

432 LUNG RESECTION CASES
1. 212 Robotic Cases
2. 160 Thoracotomy Cases
3. 60 VATS Cases

Figure 2: 523 consecutive cases were identified, 91 cases were excluded. The query identified 212 robotic (179 NSCLC), 160 thoracotomy (117 NSCLC) and 60 video-assisted (VATS) (44 NSCLC) cases. Multiple surgeons performed each approach.

Robotics was compared to the other approaches and assessed for differences in operative results, clinical outcomes, oncologic outcomes, and cost. Operative results and clinical outcomes favored robotic surgery compared to thoracotomy and showed little difference with VATS (Figure 2).

	Robotic (212)	Thoracotomy (160)	VATS (60)	Robotic vs Open p-value	Robotic vs VATS p-value
Median Skin-to-Skin Resection Time (minutes)	150	162	175	0.0579	0.0048
Median Estimated Blood Loss (mL)	75	200	100	<.0001	0.0961
Median Length of Stay (days)	3	7	5	<.0001	0.0004
Median Initial ICU Days	0	1	1	<.0001	0.0095
Overall Morbidity (cases, %)	69 (32.5)	90 (56.3)	25 (41.7)	<.0001	0.85
Pneumonia (cases, %)	16 (7.5)	19 (12.0)	5 (8.3)	0.4557	1
30-Day Readmissions (cases, %)	24 (11.7)	21 (14.3)	6 (11.9)	0.7351	0.7685

Figure 3: Operative measures and clinical outcomes for each approach. p-values taken from the propensity matched analysis. Robotics significantly lowered skin-to-skin time, blood loss, inpatient stay, and ICU days after surgery. There was significant reduction in post-op morbidity in robotics compared to open, but no difference compared to VATS.

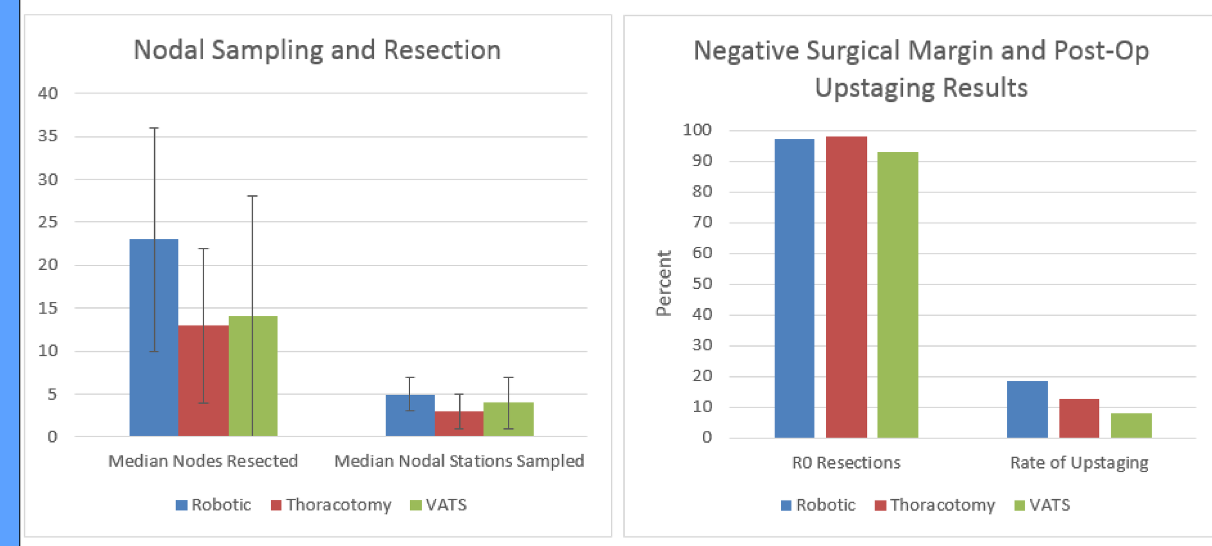

Figure 4: Oncologic outcomes. Error bars indicate the standard deviation. Robotic surgery significantly improved nodal resection compared to open (p<.0001) and VATS (p=.0005). There was no statistically significant difference in station sampling, R0 resection rate, or upstaging rate.

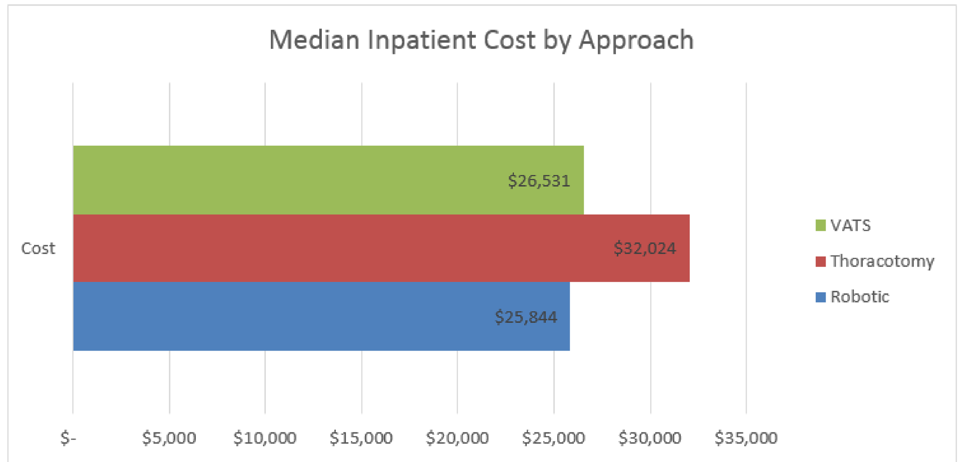

Figure 5: Robotics significantly reduced hospitalization costs compared to open (p=.0004) but showed no difference to VATS (p=.4231).

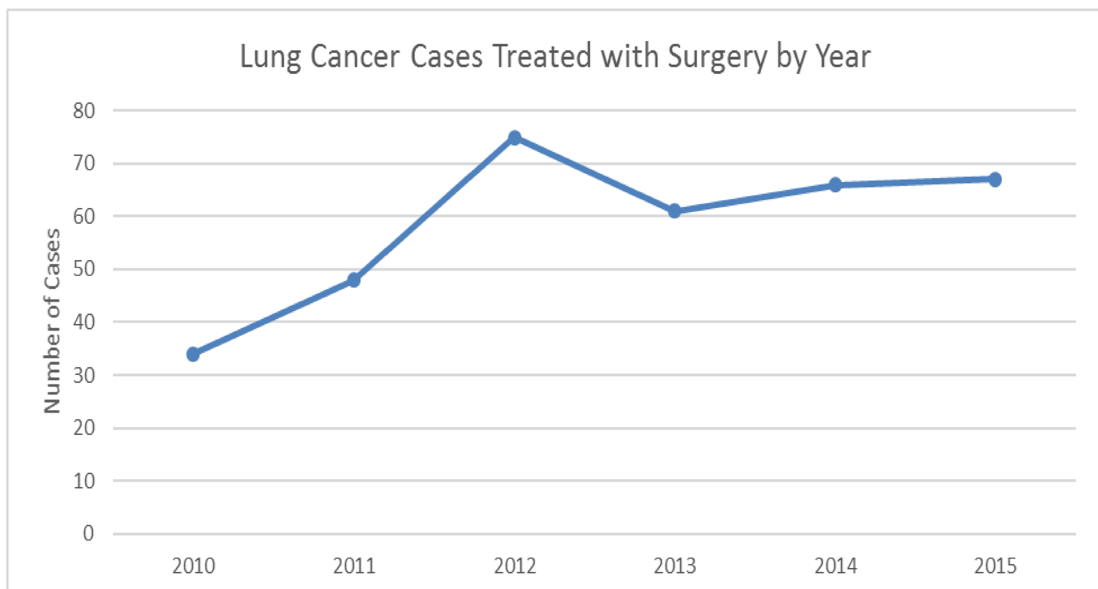

Figure 6: Number of primary lung cancers where a component of treatment at our institution was surgery (includes cases with surgery and additional therapies). The increase in robotic surgeries since its introduction in 2010 is associated with this increase in surgical cases at our center.

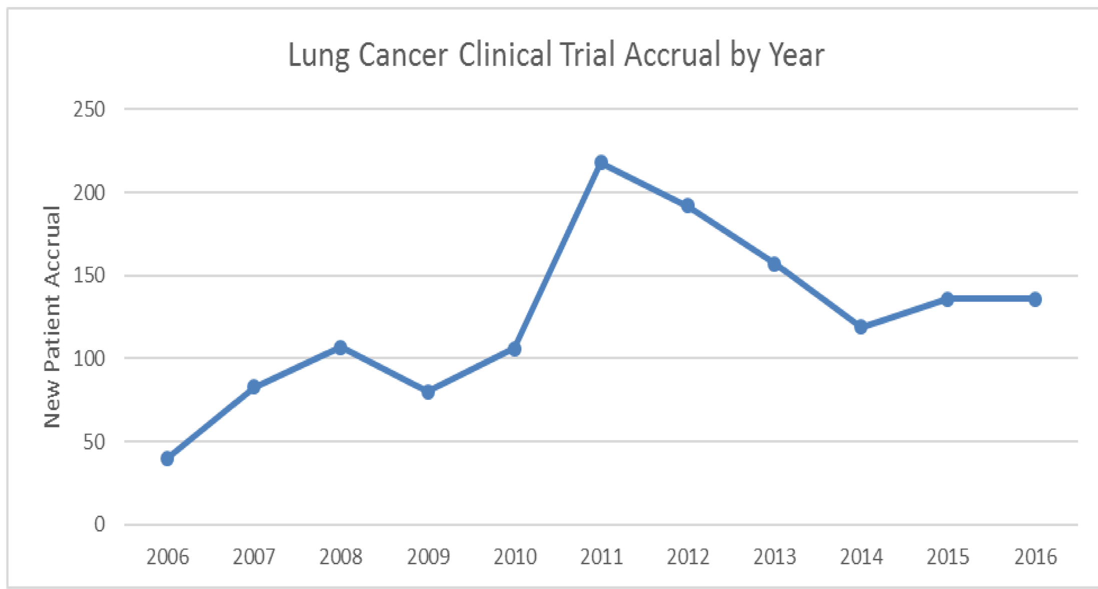

Figure 7: The initiation of our robotic program in 2010 is similarly associated with an increase in annual accrual in clinical trials at our institution.

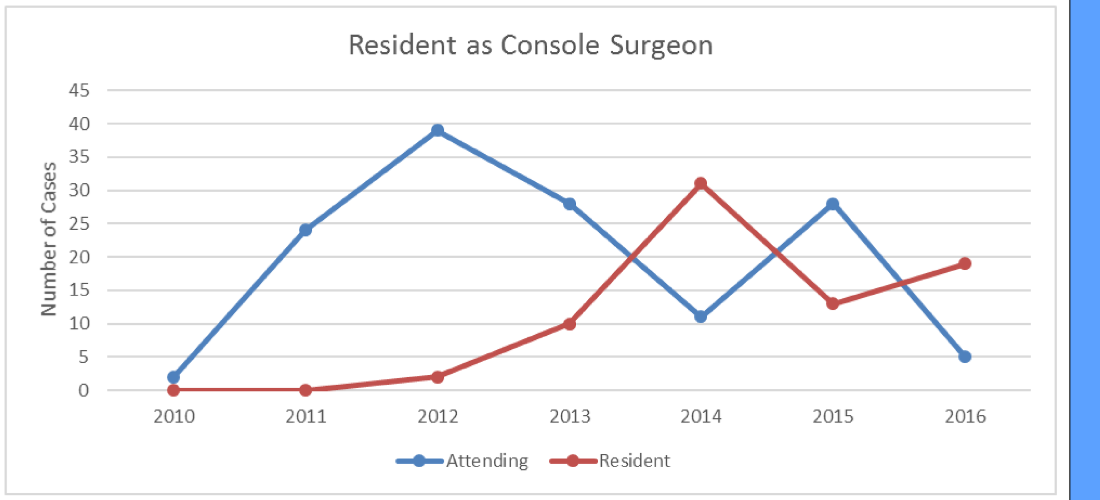

Figure 8: CT Resident participation as the console surgeon has increased since our introduction of robotic lobectomy in 2010. Residents did not serve as the console surgeon during this first two years of the program, but 79% of cases in the latest year involved the CT Resident as the console surgeon.

Conclusion

In this case series, robotic surgery for anatomic lung resection appears to offer the same or better clinical results as thoracotomy and VATS approaches. Additionally, robotic surgery produces the same or better oncologic results when compared to thoracotomy and VATS in our study. Importantly, robotic surgery significantly improved nodal dissection in our study. This is an important benefit of robotic surgery, which has been shown previously[6] and further supported here. This study showed no significant difference in hospital costs across the three approaches, despite significant reductions in ICU days and inpatient days for robotic patients. Reducing instrument use in the OR, shortening operative times, and minimizing time in the PACU are opportunities that we identified during this analysis as areas to focus on in making robotic lobectomy more cost effective. As CT residents increasingly seek training programs that offer robotics exposure[7] and patients increasingly seek minimally invasive approaches for anatomic lung resection, more academic medical centers may be considering implementing a robotic lobectomy program, with a CT resident training component. This study shows that implementing such a program offers the same or better clinical and oncologic results and is cost-effective, with further opportunities to reduce cost as proficiency and experience with the robotic approach continues.

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