Uptake of Video-Assisted Thoracoscopic Lung Resections Within the Veterans Affairs for Known or Suspected Lung Cancer

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IMPORTANCE  Minimally invasive lobectomy for early-stage lung cancer has become more prevalent. Video-assisted thoracoscopic surgery has lower rates of morbidity, better long-term survival, and equivalent oncologic outcomes compared with thoracotomy. However, little has been published on the use and outcomes of video-assisted thoracoscopic surgery within Veterans Affairs. There is a public assumption that the Veterans Affairs is slow to adopt new procedures and technologies.

OBJECTIVE  To determine the uptake of video-assisted thoracoscopic surgery within the Veterans Affairs for patients with known or suspected lung cancer.

DESIGN, SETTING, AND PARTICIPANTS  In this retrospective cohort study of national Veterans Affairs Corporate Data Warehouse data from January 2002 to December 2015, a total of 11 004 veterans underwent lung resection for known or suspected lung cancer. Data were analyzed from March to November 2018.

EXPOSURES  Open or video-assisted thoracoscopic lobectomy or wedge resection.

MAIN OUTCOMES AND MEASURES  Patient demographic characteristics and procedure and diagnosis International Classification of Diseases, Ninth Revision codes were abstracted from Corporate Data Warehouse data.

RESULTS  Of the 11 004 included veterans, 10 587 (96.2%) were male, and the median (interquartile range) age was 66.0 (61.0-72.0) years. Of 11 004 included procedures, 8526 (77.5%) were lobectomies and 2478 (22.5%) were wedge resections. The proportion of video-assisted thoracoscopic lung resections increased steadily from 15.6% in 2002 to 50.6% in 2015. Video-assisted thoracoscopic surgery use by Veterans Integrated Service Networks ranged from 0% to 81.7%, and higher Veterans Integrated Service Network volume was correlated with higher video-assisted thoracoscopic surgery use (Pearson $r = 0.35$; 95% CI, 0.15-0.52; $P < .001$). Video-assisted thoracoscopic surgery use and rate of uptake varied widely across Veteran Affairs regions ($P < .001$ by Wilcoxon signed rank test).

CONCLUSIONS AND RELEVANCE  Paralleling academic hospitals, most lung resections are now performed in the Veterans Affairs using video-assisted thoracoscopic surgery. More research is needed to identify reasons behind the heterogeneous uptake of video-assisted thoracoscopic surgery across Veterans Affairs regions.
Lung cancer is the leading cause of cancer mortality.\textsuperscript{1,2} Veterans are more likely to develop lung cancer than the general public.\textsuperscript{3} Population-based studies from Pennsylvania\textsuperscript{4} and the Pacific Northwest\textsuperscript{5} and other preliminary reports\textsuperscript{6-8} suggest that lung cancer-specific mortality is also higher in veterans. Overall survival after curative-intent therapy for lung cancer among veterans has improved since 2001; however, to our knowledge, the reasons for this have yet to be explored and are likely multifactorial.\textsuperscript{9}

Minimally invasive lobectomy, either video-assisted thoracoscopic surgery (VATS) or robotic, is becoming a standard approach for resecting early-stage lung cancer. Video-assisted thoracoscopic surgery lobectomy has lower morbidity and long-term mortality and equivalent oncologic outcomes compared with open thoracotomy, even in the elderly.\textsuperscript{10-16} This surgical approach should be especially well suited for veterans, with the multiple medical comorbidities in this population, yet VATS uptake in Veterans Affairs (VA) facilities is thought to be slow, although no one has chronicled this comprehensively.\textsuperscript{17,18} Indeed, to our knowledge, little has been published on the uptake and outcomes of VATS lung resections within the VA.

We sought to chronicle the adoption of VATS lung resections for known or suspected lung cancer nationally over time and across VA Veterans Integrated Service Networks (VISNs). We hypothesized that the uptake of the VATS approach for lung resections within the VA has increased over the last 15 years, paralleling trends in non-VA medical centers.

### Methods

#### Study Population

This national retrospective cohort study included veterans who underwent surgical resection for known or suspected lung cancer from January 2002 to December 2015. A subset of veterans were identified from the national VA Corporate Data Warehouse (CDW) by using International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) procedural codes 32480, 32500, 32657, and 32663 for open and VATS lobectomies and wedge resections for the VATS uptake analysis. For simplicity and to reduce possible confounding by patient acuity or disease complexity, other lung resections, including segmentectomies, sleeve resections, and pneumonectomies, were not included.

The Tennessee Valley Healthcare System Institutional Review Board approved this study and waived the need for patient consent in this retrospective cohort. Inclusion criteria included preoperative ICD-9-CM codes corresponding to known or suspected lung cancer. Exclusion criteria included ICD-9-CM codes denoting known metastatic or benign disease preoperatively as well as ICD-9-CM codes reflecting a personal history of lung cancer (to exclude known or suspected recurrent disease). For patients who underwent a second lung resection for a separate nodule or for a known or suspected recurrence during the study period, only the first surgical resection was included.

#### Data Collection and Definitions

The Veterans Health Administration provides care nationally to more than 20 million veterans historically at more than 1400 points of care. At the core of virtually all care processes is a broadly scoped and extensively used electronic health record system known as the Veterans Information System Technology Architecture (VistA). The VistA system provides a longitudinal health record for patients receiving care nationwide, including diagnoses, procedures, medications, laboratory results, physiologic measurements, and text notes and reports.

Data are aggregated from individual hospital VistA systems into the VA CDW, where it is modeled and prepared for use.\textsuperscript{19-21} The VA National Data Services and other data stewards regulate the right to use the data. After institutional review board and National Data Services approval was secured, project-specific data were extracted from the source databases and placed into structured query language tables in a relational database accessible only to the research team and VA data managers. An analytic data set including procedure details, patient demographic characteristics, facility location, and relevant dates was generated from the relational database tables provided using SQL Server Management Studio (Microsoft). Where available, Observational Medical Outcomes Partnership Common Data Model (Observational Health Data Sciences and Informatics) variables were used.

#### Statistical Analysis

RStudio software version 0.99.896 (RStudio) was used for all statistical analyses. Patient demographic characteristics and clinical characteristics were summarized using descriptive statistics. Fisher exact test, Pearson correlation, and Wilcoxon signed rank test were used for statistical comparisons. The level of significance was set at a P value less than .05, and all P values were 2-tailed. Video-assisted thoracoscopic surgery use was mapped according to the 2015 boundaries of the VISN administrative areas.

### Results

#### Demographic Characteristics

After applying the inclusion and exclusion criteria, our study population included 11,004 procedures, including 8526 (77.5%) lobectomies and 2478 (22.5%) wedge resections. Overall, there...
were 7095 open lung resections (64.5%) and 3909 VATS resections (35.5%). Figure 1 displays the CONSORT diagram to obtain the study population for the VATS uptake analysis.

As expected in this veteran cohort with known or suspected lung cancer, patients were predominantly older males, with a median (interquartile range) age of 66.0 (61.0-72.0) years (Table). Age did not differ by open vs VATS surgical approach. However, there was significantly more benign disease among veterans undergoing VATS lung resections (346 of 3909 [8.9%]) than among those undergoing open lung resections (345 of 7095 [4.9%]) (odds ratio, 0.53; 95% CI, 0.45-0.62; P < .001). Of the 1325 VATS wedge resections, 281 (21.2%) were ultimately benign. In comparison, of the 1153 open wedge resections, 149 (12.9%) were benign.

**VATS Use and Uptake**

The proportion of VATS lung resections increased steadily from 15.6% in 2002 to 50.6% in 2015 (Figure 2) across the entire Veterans Health Administration system. Overall, there was a steady positive correlation between the proportion of cases completely using VATS and time (Pearson r = 0.97; 95% CI, 0.91-0.99; P < .001). Separated into 3 periods to illustrate use trends, the proportion of VATS cases was 20.5% (589 of 2873 procedures) during the introduction of VATS before 2008, 38.4% (1153 of 3018 procedures) from 2008 to 2011, and 44.5% (1432 of 3220) from 2012 to 2015 (P < .001).

Higher facility volume of lung resections was correlated with higher VATS use (Pearson r = 0.35; 95% CI, 0.15-0.52; P < .001). The rate of VATS uptake varied widely across VA regions (P < .001 by Wilcoxon signed rank test) (Figure 3). Even from 2012 to 2015, the most recent period for which data were available, VATS use varied widely across VISNs, from 11.7% in VISN 19 to 78.7% in VISN 20.

**Discussion**

In this national VA cohort, we document a gradual upward trend in VATS lung resections for known or suspected lung cancer in the national VA system over the last decade and a half. The adoption of VATS lobectomy has traditionally lagged within the VA compared with the private sector, as documented by the Society for Thoracic Surgeons (STS) General Thoracic Surgery database (GTSD). The proportion of VATS lobectomy has increased in the VA from 9% in 2004 to 12% in 2006 and 28% in 2010, and the proportion has increased in the STS GTSD from 22% in 2004 to 32% in 2006 and 45% in 2010. In 2015, we observed heavy adoption of VATS, with 51% of lobectomies completed thoracoscopically in the VA. By comparison, from 2010 to 2013, the proportion of VATS lobectomies in the STS GTSD was 55.0%.

Long-term lung cancer survival has also previously been poorer among veterans compared with nonveterans in the same source population. This is improving. A 2017 VA Central Cancer Registry analysis of veterans with clinical stage I non-small cell lung cancer treated with surgery or curative-intent radiation reported an improvement in the overall 4-year survival from 38.9% in 2001 to 53.2% in 2010, comparable with a 2014 non-VA cohort using Surveillance, Epidemiology, and End Results data. The VA Central Cancer Registry analysis did not identify a statistically significant overall 4-year survival benefit with the VATS approach after adjusting for age, race/ethnicity, chronic obstructive pulmonary disease diagnosis, comorbidities, treatment region, diagnosis year, histology, and stage. In subsequent analyses, we will investigate the mortality and survival rates of VATS compared with open lobectomy while adjusting for patient acuity in veterans with clinical stage I non-small cell lung cancer.

**Table. Study Population Characteristics**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. (%) Total Population (N = 11 004)</th>
<th>Open Lung Resections (n = 7095)</th>
<th>VATS Lung Resections (n = 3909)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, median (IQR), y</td>
<td>66.0 (61.0-72.0)</td>
<td>65.0 (60.0-72.0)</td>
<td>66.0 (61.0-72.0)</td>
</tr>
<tr>
<td>Male</td>
<td>10 587 (96.2)</td>
<td>6856 (96.6)</td>
<td>3731 (95.4)</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>8508 (83.2)</td>
<td>5498 (82.7)</td>
<td>3110 (84.0)</td>
</tr>
<tr>
<td>African American</td>
<td>1641 (15.9)</td>
<td>1093 (16.4)</td>
<td>548 (14.8)</td>
</tr>
<tr>
<td>Other</td>
<td>99 (0.9)</td>
<td>56 (0.8)</td>
<td>43 (1.1)</td>
</tr>
<tr>
<td>Benign disease</td>
<td>691 (6.3)</td>
<td>345 (4.9)</td>
<td>346 (8.9)</td>
</tr>
</tbody>
</table>

Abbreviations: IQR, interquartile range; VATS, video-assisted thoracoscopic surgery.
The Veterans Health Administration offers an integrated health care system to more than 9 million veterans nationally. It has every potential to deliver oncologic care that is at the level of or even superior to that in the private sector if high-quality preventive care is delivered and if cancers, including lung cancers, can be identified and treated appropriately at an early stage. Interestingly, in 2 large studies, the VA was shown to have a significantly greater percentage of early-stage diagnoses compared with the private sector and academic medical centers.

We observed substantial variation in VATS uptake across VA VISNs. Although variability in lung cancer treatment and outcomes across geographic regions and hospital types has been demonstrated in the Netherlands, a 2017 US study using the STS GTSD did not identify any geographic variations in 30-day risk-adjusted mortality and morbidity outcomes after lung cancer lobectomy (mixed open and VATS). The variation in VATS rates we observed is likely because of VISN-specific or facility-specific differences in infrastructure (eg, VATS equipment) and individual surgeon experience in

Figure 2. Proportion of Video-Assisted Thoracoscopic Surgery (VATS) Lung Resections Over Time

Figure 3. Map of Video-Assisted Thoracoscopic Surgery Uptake Over Time by Veterans Integrated Service Network

There were a total of 11,004 lobectomies and wedge resections for known or suspected lung cancer from January 2002 to December 2015. There was a steady correlation between the proportion of VATS lung resections and time ($r = 0.97$, 95% CI, 0.91-0.99; $P < .001$).

There were a total of 11,004 lobectomies and wedge resections for known or suspected lung cancer from January 2002 to December 2015. The map is limited to the continental United States for simplicity. The numbers on the map indicate Veterans Integrated Service Networks.
performing VATS lung resections. More research is needed to tease out region-specific and facility-specific factors that affect VATS uptake.

We also found that higher lung resection facility volume was correlated with higher VATS use. Although we did not have access to individual surgeon information, the difference in surgical approaches may be more accurately attributable to higher surgeon volume, as surgeon-specific volume is more critical than facility volume per se in affecting risk-adjusted outcomes. Importantly, our study highlights opportunities for improvement within the VA. Veterans Integrated Service Networks with low VATS use even in 2015 may benefit from hiring and supporting a minimally invasive thoracic surgeon. The VA system may also consider adopting centers of excellence and regionalized care for lung cancer operations. This needs further study.

Limitations
Our study has limitations, including its retrospective nature and reliance on clinical CDW data not originally collected for research purposes. In addition, the veteran population is predominantly male. We were unable to separate robotic lobectomies in this cohort because the appropriate procedural ICD codes are not available in CDW at date. If local practice within a VISN shifted to robotics, it is unclear how such a change would affect the observed trends. Although unlikely, a minority of lung resections in our cohort may have been robotic procedures that were incorrectly coded because of the lack of robotic ICD-9 codes. The uptake of robotic lung resections has increased since its widespread introduction into clinical practice in 2009 and 2010, most rapidly in the South. An estimated 20% or greater of all lobectomies are currently performed robotically (data not shown). The use of robotic lung resections in the VA is unknown and merits further study.

Conclusions
In conclusion, despite substantial variability across VA VISNs, minimally invasive lung resections have increased significantly within the VA system over the last 15 years, mirroring the private sector and surpassing 50% in 2015. More research is needed to elucidate the reasons behind the heterogeneous uptake of minimally invasive lung resections nationally.


