Data from The Society of Thoracic Surgeons General Thoracic Surgery database: The surgical management of primary lung tumors

Daniel J. Boffa, MD,[a] Mark S. Allen, MD,[b] Joshua D. Grab,[c] Henning A. Gaissert, MD,[d] David H. Harpole, MD,[e] and Cameron D. Wright, MD[d]

Earn CME credits at http://cme.ctsnetjournals.org

Objective: Our objective was to investigate the surgical management of primary lung cancer by board-certified thoracic surgeons participating in the general thoracic surgery portion of The Society of Thoracic Surgeons database.

Methods: We identified all pulmonary resections recorded in the general thoracic surgery prospective database from 1999 to 2006. Among the 49,029 recorded operations, 9033 pulmonary resections for primary lung cancer were analyzed.

Results: There were 4539 men and 4494 women with a median age of 67 years (range 20–94 years). Comorbidity affected 79% of patients and included hypertension in 66%, coronary artery disease in 26%, body mass index of 30 kg/m^2 or more in 25.7%, and diabetes mellitus in 13%. The type of resection was a wedge resection in 1649 (18.1%), segmentectomy in 394 (4.4%), lobectomy in 6042 (67%), bilobectomy in 357 (4.0%), and pneumonectomy in 591 (6.5%). Mediastinal lymph nodes were evaluated in 5879 (65%) patients; via mediastinoscopy in 1928 (21%), nodal dissection 3722 (41%), nodal sampling in 1124 (12.4%), and nodal biopsy in 729 (8%). Median length of stay was 5 days (range 0–277 days). Operative mortality was 2.5% (179 patients). One or more postoperative events occurred in 2911 (32%) patients.

Conclusion: The patients in the general thoracic surgery database are elderly, gender balanced, and afflicted by multiple comorbid conditions. Mediastinal lymph node evaluation is common and the pneumonectomy rate is low. The length of stay is short and operative mortality is low, despite frequent postoperative events.

The operative mortality of pulmonary resection for lung cancer reported by several national databases (4%–5%) is substantially higher than that indicated in recent reports from databases that only include operations performed by dedicated thoracic surgeons (2%).[1-3] Although incompletely studied, clinical training and board certification are thought to affect outcomes of surgical procedures.[4] To further examine this hypothesis, we queried the general thoracic surgery portion of The Society of Thoracic Surgeons (GTS-STS) database to study the patient population, types of procedures being performed, and short-term outcomes of patients undergoing pulmonary resection for primary lung cancer by board-certified thoracic surgeons.

From the Department of Thoracic and Cardiovascular Surgery, Cleveland Clinic, Cleveland, Ohio[a]; the Division of General Thoracic Surgery, Mayo Clinic School of Medicine, Rochester, Minn[b]; The Duke Clinical Research Institute, Duke University, Durham, NC[c]; The Department of General Thoracic Surgery, Massachusetts General Hospital, Boston, Mass[d]; and the Department of General Thoracic Surgery, Duke University, Durham, NC.[e]

Read at the Eighty-seventh Annual Meeting of The American Association for Thoracic Surgery, Washington, DC, May 5-9, 2007.

Received for publication May 4, 2007; revisions received July 20, 2007; accepted for publication July 26, 2007.

Address for reprints: Mark S. Allen, MD, Mayo Clinic School of Medicine, Division of General Thoracic Surgery, Mayo Clinic, 200 First St, SW, Rochester, MN 55905 (E-mail: allen.mark@mayo.edu).

J Thorac Cardiovasc Surg 2008;135:247-54

0022-5223/$34.00

doi:10.1016/j.jtcvs.2007.07.060

Abbreviations and Acronyms

GTS-STS = General Thoracic Surgery portion of The Society of Thoracic Surgeons database
ACS = American College of Surgeons
ACGME = Accreditation Council for Graduate Medical Education
AJCC = American Joint Committee on Cancer
ASA = American Society of Anesthesia
CCACS = Commission on Cancer report from the American College of Surgeons
DCRI = Duke Clinical Research Institute
GTS-STS = General Thoracic Surgery portion of The Society of Thoracic Surgeons database
HIPAA = Health Insurance Portability and Accountability Act
STS = The Society of Thoracic Surgeons
VATS = video-assisted thoracic surgery

Patients and Methods

The Society of Thoracic Surgeons (STS) has maintained a prospective database of patients undergoing cardiothoracic surgery in the United States since 1987.[5] In 1999 the database was expanded to include data for general thoracic surgery operations. Submission to the database is voluntary and not restricted to members of the STS. Thus far, 225 surgeons have contributed to the database. The group consists of 220 (97%) board-certified thoracic surgeons, 4 (1.8%) surgeons who are in a thoracic surgery residency program accredited by the Accreditation Council for Graduate Medical Education (ACGME), and 1 (0.4%) who is not board certified in thoracic surgery. The institutional review board of each participating site has approved the use of the database for research.

Data are harvested from participants on a yearly basis, and each participant received a quality report and the opportunity to amend missing or aberrant data. Data submissions are checked for completeness as well as compliance with preset limits on individual data fields. Harvested data are maintained and analyzed within the Duke Clinical Research Institute (DCRI) in full compliance with the Health Insurance Portability and Accountability Act (HIPAA) of 1996. Variables are collected on a data form that includes information about patient demographics, medical history, surgical procedures, cancer staging, and outcome (http://www.ctsnet.org/file/ThoracicDCFV2_07_Nonannotated.pdf).

Between January 1999 and July 2006, a total of 49,029 operations were entered into the GTS-STS database, including 9077 pulmonary resections for primary lung cancer. Patients without data for age, gender, or surgery date were excluded from the present study. We also excluded patients with a recorded age of 17 years or less and more than100 years. These requirements excluded 44 patients; thus 9033 patients were examined. Additional limits were imposed on individual data fields to exclude analysis of highly improbable data. We excluded body mass index data if the recorded height was less than 97 cm, forced expiratory volume in 1 second data if less than 5% of predicted, diffusion capacity of carbon monoxide data if less than 10% of predicted, and data for operative time if less than 10 minutes. Missing data were excluded from calculations. Postoperative complications occurring during the same hospitalization as the resection were defined by the STS database guidelines.[5] Operative mortality is defined as death during the same hospitalization for the pulmonary resection or within 30 days of the procedure. Cancer staging was done in accordance with the American Joint Committee on Cancer (AJCC).[6]

For categorical variables, the prevalence was calculated from the patient records with complete data for each respective variable. For continuous variables, median values are given with the range. To estimate the annual lung resection volume among GTS-STS database participants, we averaged the number of lobectomies done per year for primary lung cancer for each participant.

TABLE 1. Characteristics of the patients undergoing pulmonary resection (n = 9033) for bronchogenic carcinoma

Variable: No. of patients with data (% of 9033)	
Age: n = 9033 (100%)	Median 67 y (range 20–94 y)
Gender: n = 9033 (100%)	
Male	4539 (50.2%)
Female	4494 (49.8%)
Race: n = 8887 (98.4%)	
White	7760 (87.3%)
African American	624 (7%)
Asian	136 (1.5%)
Hispanic	118 (1.3%)
Other	249 (2.8%)
Body mass index: n = 8038 (89%)	Median 26.4 (range 15–77)
FEV_1 predicted: n = 6799 (75%)	Median – 77.5% (range 14%–200%)
DLCO predicted: n = 5455 (60%)	Median – 70% (range 12%–169%)

FEV_1, Forced expiratory volume in 1 second; *DLCO,* diffusion capacity of carbon monoxide.

Results

The median age was 67 years (range 20–94 years). There were 4539 (50.2%) men and 4494 (49.8%) women. The majority of operations (87.3%) were performed on white patients; African Americans accounted for 7% of the patients. Patient characteristics are shown in Table 1.

A smoking history was present in 7645 (87%) patients and the median tobacco exposure was 45 pack-years (range 1–210 pack-years). Before the operation, 4218 (55%) patients had stopped smoking for at least 1 year, whereas 2207 (28.6%) patients were still smoking within 2 weeks of their operation (Table 2).

Pulmonary function tests were available on 7344 (84%) patients. Preoperative forced expiratory volume in 1 second was available for 6799 (75%) patients and was a median of 78% of predicted (range 14%–200%). Diffusion capacity of carbon monoxide was recorded in 5455 (60%) patients and was a median of 70% of predicted (range 12%–169%) (Table 1).

TABLE 2. Comorbidities (n = 9033)

Comorbidity: No. of patients with data (% of 9033)	Affected patients (%)*
Hypertension: 6977 (77%)	4571 (66%)
Coronary artery disease: 6794 (75%)	1782 (26%)
Diabetes mellitus: 8768 (97.1%)	1142 (13%)
Peripheral vascular disease: 6749 (74.7%)	767 (11.4%)
Cerebral vascular event: 8669 (96%)	685 (7.9%)
Congestive heart failure: 6722 (74%)	296 (4.4%)
Renal insufficiency: 8901 (98.5%)	217 (2.4%)
Preoperative chemotherapy: 6787 (75.1%)	1097 (16%)
Preoperative radiotherapy: 6770 (75%)	800 (11.8%)
Prior thoracic surgery: 6773 (75%)	1290 (19%)
Body mass index > 30: 8038 (89%)	2067 (25.7%)
History of smoking: 8793 (97.3%)	7645 (87%)
Quit >12 mo before resection	4218 (54.6%)
Quit between 30 d and 12 mo before resection	884 (11.4%)
Quit between 14 and 30 d before resection	417 (5.4%)
Quit 0-14 d before resection	2,207 (28.6%)
Pack-years of smoking	Median 45 (range 1–210)
Zubrod score: 8334 (92%)	
0	3598 (43%)
1	4079 (49%)
2	489 (5.9%)
3	136 (1.6%)
4 or 5	32 (<0.1%)
ASA category: 8117 (90%)	
I	208 (2.6%)
II	2,267 (28%)
III	4927 (60.7%)
IV	711 (8.8%)
V	4

ASA, American Society of Anesthesiology. *The percentage of patients with data for each variable (noted in left column) that are affected by each comorbidity (noted in right column).

TABLE 3. Pulmonary resections (n = 9033)

Type of resection	No. of patients (%)*	Median operative time, min (range)
Pneumonectomy	591 (6.5%)	199 (10–700)
Bilobectomy	357 (4.0%)	189 (35–499)
Lobectomy	5,957 (66%)	159 (10–840)
Sleeve lobectomy	85 (0.9%)	246 (49–548)
Segmentectomy	394 (4.4%)	155 (26–379)
Single wedge resection	1,275 (14%)	90 (10–799)
Multiple wedge resections	374 (4.1%)	90 (20–634)

*Percentage of the 9033 resections in the database.

At least one comorbidity was present in 7173 (79%) of patients. The most prevalent comorbidities were hypertension (66%) and coronary artery disease (26%) (Table 2). A Zubrod score of 0 or 1 was present in 92% of patients. Conversely, 70% (5642) of patients were in American Society of Anesthesia (ASA) class III or greater. The median body mass index was 26.4 kg/m^2 (range 15- 2 kg/m^2); 25.7% of patients had a body mass index greater than 30 kg/m^2.

Preoperative chemotherapy was given to 557 (6.2%) patients and 373 (4.1%) received preoperative radiotherapy. Prior thoracic surgery had been performed in 1290 (19%), but only 293 (4.3%) resections were considered as a reoperative procedure (implying that other procedures did not involve the hemithorax of the resection being reported to the database).

The procedure was considered elective in 7971 (93%) and urgent or emergency in 610 (7%). The types of procedures are listed in Table 3. Operative time (skin incision to skin closure) was available for 7833 (87%) patients. The median operative time was 152 minutes (range 10-840 minutes) and varied with the type of resection (Table 3). The surgical approach consisted of thoracotomy in 6087 patients (70%), video-assisted thoracic surgery (VATS) in 2429 (28%), and others in 230 (2%). Lobectomy was performed via VATS in 1040 patients or 20% of all lobectomies. Over the past 3 years the percentage of lobectomies performed by VATS has increased (21.6% in 2004, 28.6% in 2005, and 32% in 2006).

The median number of lobectomies for lung cancer performed per year per participant was 31.4 (range 1–128) (Figure 1). Four (7%) participants performed fewer than 7 resections per year, 8 (14%) performed more than 7 but fewer than 17 resections per year, and 47 (79%) centers performed 17 or more resections per year.

Mediastinal lymph nodes were evaluated in 5879 (65%) patients: via mediastinoscopy in 1928 (21%), nodal dissection 3722 (41%), nodal sampling in 1124 (12.4%), and nodal biopsy in 729 (8%).

Complete pathologic surgical stage was recorded in 4864 (54%) resections and is listed in Table 4. A T stage was available in 7369 (82%): T0 in 61, T1 in 3493, T2 in 2921, T3 in 493, and T4 in 401. An N stage was recorded in 6936 (77%): N0 in 5155, N1 in 1020, N2 in 740 (10.7%), and N3 in 21. Of note, 177 of the N2-positive patients received induction chemotherapy, 133 received induction radiother-

GTS

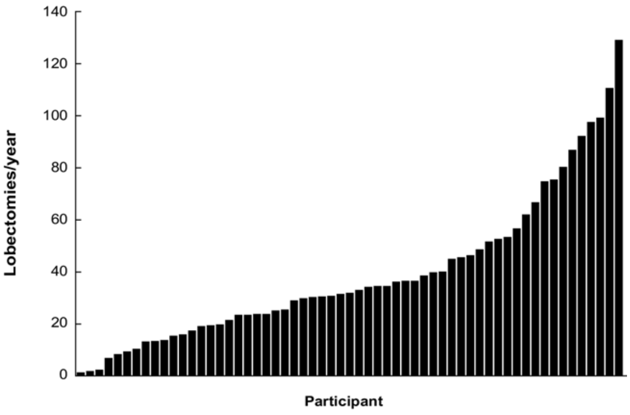

Figure 1. Participant lobectomy volume. The average number of lobectomies for primary lung cancer submitted to the GTS-STS per year *(y-axis)* was determined for each of the 59 participants *(x-axis)*. The STS database refers to the registered party as a "participant." Each participant may therefore consist of a hospital, a surgical department, a group practice, or an individual surgeon.

apy, and 125 received both. M stage was listed for 5022 resections (56%). A total of 188 resections took place in patients with M1 disease.

At least 1 postoperative complication was recorded in 2911 (32%) patients. The most common complications included atrial arrhythmia necessitating treatment in 964 (10.7%), prolonged air leak (>7 days) in 722 (8%), pneumonia in 351 (3.9%), reintubation in 306 (3.4%), or atelectasis in 325 (3.6%) (Table 5). Perioperative blood transfusion was recorded in 647 (7%) patients. The median length of stay was 5 days (range 0–277 days).

In-hospital mortality information was available for 8905 (98.6%) patients. Overall, 161 (1.8%) patients died in the hospital after the operation. Thirty-day mortality information was available in 7843 patients, and 178 (2.3%) died within 30 days of the operation. Operative mortality was 2.5% (197/7840). Mortality varied by surgical procedure (Table 6).

TABLE 4. Pathologic surgical stage (n = 4864)

AJCC stage	No. of patients (%)*
0	16 (0.3%)
IA	1,952 (40.1%)
IB	1,277 (26.2%)
IIA	182 (3.7%)
IIB	498 (10.2%)
IIIA	454 (9.3%)
IIIB	228 (4.7%)
IV	257 (5.3%)

AJCC, American Joint Commission on Cancer. *Prevalence among the patients with complete data for pathologic stage (n = 4864).

TABLE 5. Complications

Complication	Affected patients (%)*
Atrial arrhythmia requiring treatment	964 (10.7%)
Air leak > 5 d	722 (8%)
Pneumonia	351 (3.9%)
Atelectasis requiring bronchoscopy	325 (3.6%)
Reintubation	306 (3.4%)
Other pulmonary event	319 (3.5%)
Urinary tract infection	129 (1.4%)
New renal failure requiring treatment or doubling creatinine	125 (1.4%)
Adult respiratory distress syndrome	99 (1.1%)
Tracheostomy	103 (1.1%)
Initial ventilator support > 48 h	76 (0.8%)
Ventricular arrhythmia requiring treatment	71 (0.8%)
Ileus	72 (0.8%)
Sepsis	71 (0.8%)
Bleeding requiring reoperation	66 (0.7%)
Bronchopleural fistula	27 (0.3%)
Pulmonary embolus	34 (0.4%)
Myocardial infarction	37 (0.4%)
Deep venous thrombosis requiring treatment	41 (0.5%)
Empyema	29 (0.3%)
Wound infection	26 (0.3%)
Central neurologic event	47 (0.5%)
Recurrent laryngeal nerve paresis	20 (0.2%)
Chylothorax	50 (0.6%)
Delerium tremens	25 (0.3%)
Other	736 (8.1%)

*Prevalence within total resection population (n = 9033).

Discussion

The patients in the general thoracic portion of the STS database undergoing pulmonary resection for primary lung cancer are predominately white, evenly split between men and women, and commonly affected by comorbid conditions. Previous database studies of surgical resection for lung cancer have found patients to be of similar age and ethnic background, with similar comorbidities, but to have shown a stronger male predominance. In the Commission on Cancer report from the American College of Surgeons (CCACS) about patients who underwent surgical resection for lung cancer, there were 55% men versus 45% women.

The prevalence and duration of smoking is consistent with the patient population with non–small cell lung cancer. However, more than a quarter of patients smoked within 2 weeks of their resection. Although continued smoking has been reported to increase complications after pulmonary resection, the optimal smoke-free interval remains unclear.[7,8] Ideally, with database maturation a more complete

GTS

TABLE 6. Mortality by resection type

Procedure	In-hospital mortality	Thirty-day mortality	Operative mortality
All resections	1.8% (161/8905)*	2.3% (178/7843)	2.5% (197/7840)
Lobectomy (including sleeve)	1.4% (86/5957)	1.8% (93/5242)	2% (101/5234)
Bilobectomy	3.4% (12/353)	3.4% (11/322)	4% (13/322)
Pneumonectomy	4.3% (25/586)	5.3% (27/512)	6.2% (32/512)
Segmentectomy	1.6% (6/384)	2.9% (10/347)	2.9% (10/347)
Wedge resection	2% (32/1625)	2.6% (37/1425)	2.7% (39/1425)

*Number of reported deaths/number of resections with mortality data.

data analysis will be able to yield an evidence-based recommendation on whether or not to postpone pulmonary resection in current smokers.

Lobectomies were the most common type of lung cancer resection, 20% of which were approached minimally invasively via VATS.[9] This high proportion of VATS may reflect the selective participation in the GTS-STS database.

The current pneumonectomy rate of 6.5% is less than half the rate of 13.3% reported by the CCACS study.[2] Although patient selection and surgical staging may influence the pneumonectomy rate, advanced oncologic knowledge allows for tailoring of the appropriate resection and reduces the number of unnecessary pneumonectomies.

Operative volume of the hospital in which resection is performed has been demonstrated to be important factor toward patient outcome.[10] In the study by Bach and associates,[1] the 30-day mortality for pulmonary resection was 6% in centers that performed 14 or fewer thoracic procedures per year whereas it was only 3% in centers that performed more than 19 procedures. More recently, Little and colleagues[2] found the transition in outcomes associated with low- and high-volume centers to occur at much higher hospital volumes. The 30-day mortality rate among hospitals performing 90 or fewer resections was 4.8% compared with 3.2% among hospitals with more than 90 resections. Birkmeyer and coworkers,[11] who reviewed Medicare claims data from 1998 to 1999, found adjusted mortality of 6.1% for institutions that performed fewer than 7 lobectomies per year, 5.6% for those that did between 7 and 17, and 5.0% for those that did more than 17 per year. Our nonadjusted 30-day mortality of 2.3% and nonadjusted in-hospital mortality of 1.8% are far below these figures; however, in the current study, since participants average 39 $\pm$ 28 lobectomies per year, very few participants were in the low-volume group.

The prevalence of preresection mediastinoscopy of 21% in the present study is slightly lower than that of the CCACS study (27%).[2] One mechanism to gauge the success of clinical and surgical staging before resection is prevalence of "unsuspected" N2 disease or the failure to identify N2 disease before performing a lung resection for cancer. Among two large series of mediastinoscopy performed before resection, 5% to 8% of patients were found to have metastasis to N2 nodes that were not identified by mediastinoscopy.[12,13] The rate of pathologic N2 disease in the current study is 740/6936 (10.7%), and 435 of these patients received preoperative therapy. The status of N2 lymph nodes is known to be an important prognostic factor that is dependent on the extent of mediastinal lymph node evaluation. Although the rate of mediastinal lymph node evaluation in the current study (65% of the operations) is substantially higher than the rate of 48.1% reported to occur at community cancer centers by Little and associates,[2] N2 status was not adequately determined in a considerable number of patients.

The stage distribution among patients undergoing resection in the current study is similar to that reported by the American College of Surgeons (ACS) National Cancer Database during a similar time period.[14] In the current report, 66.3% of the patients were in stage I compared with 59.5% in the ACS study. Mediastinal lymph nodes were evaluated less frequently in the ACS study (57.8%) than in our study (65%), raising the possibility that the ACS patients may have been understaged. However, with just over half of our patients staged in accordance with AJCC guidelines, it is difficult to make meaningful comparisons to other database reports. A significant factor contributing to the paucity of staged patients was the absence of M stage in 3128 resections. Although the majority of patients were likely to have M0 disease, it was not possible to generate an accurate stage without recorded data.

The median length of stay after pulmonary resection is typically reported around 9 days.[1,15] The patients in the present study had considerably shorter hospital stays (median 5 days). Although complications certainly prolong the length of stay, many other factors, including cultural and economic, which are unrelated to the patient's recovery from surgery, can affect the duration of hospitalization. Thus comparison among different database reports is difficult.

The majority of patients were highly functional (Zubrod score of $\leq$1 in 92% of patients); however, the ASA classi-

GTS

TABLE 7. All databases compared

	STS data (current study)	CCACS survey (Little et al[2])	NIS dataset (Mequid et al[18])	SEER–Medicare database and NIS (Bach et al[1])	NSQIP (Harpole et al[17])	NHDS (Memtsoudis et al[15])
Years	1999–2006	2001	1998–2003	1985–1996	1991–1995	1988–2002
Mortality defined	Hospital or 30-d	30-d	Hospital mortality	30-d	30-d	Hospital mortality
Total resections	9033	11,668	50,867	2118	3,516	512,758
All resections	2.5% (7859)	5.2% (11,668)	3.8%	4%	NA	4.8%
Lobectomy	2% (5234)	4.5% (7,869)	3.3%	NA	4.0% (2949)	NA
Bilobectomy	4% (322)	NA	NA	NA	NA	NA
Pneumonectomy	6.2% (512)	8.5% (1,507)	9.4%	NA	11.5% (567)	NA
Segmentectomy	2.9% (347)	NA	3.3%	NA	NA	NA
Wedge resection	2.7% (1,425)	4.9% (1,737)	NA	NA	NA	NA
Median LOS (d)	5			9		10.8 (1–358)

STS, The Society of Thoracic Surgeons; *CCACS,* Commission on Cancer of the American College of Surgeons; *NIS,* Nationwide Inpatient Sample; *SEER,* Surveillance Epidemiology and End Results; *NSQIP,* National Veterans Affairs Quality Improvement Program; *NHDS,* National Hospital Discharge Survey; *NA,* not available; *LOS,* length of stay.

fication was elevated in the majority, with 70% of patients having ASA class III disease or higher. Although ASA class was not designed to predict anesthesia or operative risk, an increasing ASA class has recently been shown to predict mortality after pulmonary resection.[16] Our database includes a high percentage of patients with other comorbidities. Therefore, this patient mix would be expected to have a higher morbidity and mortality than the "average" patient.

Mortality after pulmonary resection has recently been evaluated in several large databases: The National Veterans Affairs Surgical Quality Improvement Program (3516 patients), The National Hospital Discharge Survey (512,758 patients), the CCACS 2001 Patient Care Evaluation (11,668 patients), and the Nationwide Inpatient Sample (2118 patients) (Table 7).[1,2,15,17] Among these reports, the 30-day mortality for all lung resections ranged from 4% to 5.4%, for lobectomy 4% to 4.5%, and for pneumonectomy 8.5% to 11.5%. All of these values are considerably higher than the mortality reported in the present study. Several factors attributable to the surgeon and hospital have been shown to influence the perioperative outcome after pulmonary resection for bronchogenic carcinoma. As previously mentioned, hospital volume may be an important determinant of outcome. The type of hospital (teaching versus private) also may influence outcome.[18] The training and experience of the surgeon also are thought to influence operative mortality. Lung cancer resections by dedicated thoracic surgeons have previously been reported to offer advantages over those performed by less specialized surgeons.[19,20] This finding is consistent with reports in other surgical areas such as foregut surgery,[4] colorectal surgery,[21] and vascular surgery,[22] where subspecialty training has been shown to decrease operative mortality and morbidity. The current study re-emphasizes this fact. The operative mortality for pulmonary resections by board-certified thoracic surgeons in the GTS-STS database is approximately half that reported by databases populated with resections performed by less specialized surgeons.

This report does have several limitations. Most important are insufficient data limits and the lack of a formal audit, which allow nonsensical data to persist in the database. As with all noncompulsory databases, the potential exists for incomplete submissions as well as for centers with poor outcomes to abstain from participating. The STS database needs to develop a robust data verification system to reduce the nonsensical data and ensure completeness. The current report is the first from the GTS-STS database and has led to several clarifications that ideally will improve the quality and quantity of collected data. This does not represent a majority of pulmonary resections in the United States. Although participation in the GTS-STS database has been increasing every year, the data collected for the first 6 months of 2006 (1646 resections) represent only approximately 7% of the total resections performed in the United States during this time period.

In conclusion, the GTS-STS database is a useful platform to evaluate the surgical management of lung cancer by board-certified thoracic surgeons. The patient demographics and comorbid afflictions appear similar to those in larger reports from national databases. STS surgeons are likely to evaluate mediastinal lymph nodes but less likely to perform a pneumonectomy. The operative mortality is low and length of stay is short despite numerous postoperative events. Long-term survival of this group of patients awaits maturation of the database.

References

1. Bach P, Cramer L, Schrag D, Downey R, Gelfand S, Begg C. The influence of hospital volume on survival after resection for lung cancer. *N Engl J Med.* 2001;19:181-8.

2. Little A, Rusch V, Bonner J, Gaspar LE, Green MR, Webb WR, et al. Patterns of surgical care of lung cancer patients. *Ann Thorac Surg*. 2005;80:2051-6.
3. Allen M, Darling G, Pechet T, Mitchell JD, Herndon JE 2nd, Landreneau RJ, et al. Morbidity and mortality of major pulmonary resections in patients with early-stage lung cancer: initial results of the randomized, prospective ACOSOG Z0030 trial. *Ann Thorac Surg.* 2006;81: 1013-20.
4. Callahan M, Christos P, Gold H, Mushlin A, Daly J. Influence of surgical subspecialty training on in-hospital mortality for gastrectomy and colectomy patients. *Ann Surg.* 2003;238:629-39.
5. Society of Thoracic Surgeons. 2007. (Accessed February 27, 2007, at www.sts.org/sections/stsnationaldatabase.)
6. AJCC cancer staging manual. 5th ed. New York: Springer; 1997.
7. Nakagawa M, Tanaka H, Tsukuma H, Kishi Y. Relationship between the duration of the preoperative smoke-free period and the incidence of postoperative pulmonary complications after pulmonary surgery. *Chest.* 2001;120:750-10.
8. Barrer R, Shi W, Amar D, Thaler HT, Gabovich N, Bains MS, et al. Smoking and timing of cessation: impact on pulmonary complications after thoracotomy. *Chest.* 2005;127:1977-83.
9. McKenna R, Houck W, Fuller C. Video-assisted thoracic surgery lobectomy: experience with 1,100 cases. *Ann Thorac Surg.* 2006;81: 421-6.
10. Birkmeyer JD, Stukel TA, Siewers AE, Goodney PP, Wennberg DE, Lucas FL. Surgeon volume and operative mortality. *N Engl J Med.* 2003;349:2117-27.
11. Birkmeyer J, Stukel T, Siewers A, Goodney P, Wennberg D, Lucas F. Surgeon volume and operative mortality in the United States. *N Engl J Med.* 2003;349:2117-27.
12. Lemaire A, Nikolic I, Petersen T, Haney JC, Toloza EM, Harpole DH Jr, et al. Nine-year single center experience with cervical mediastinoscopy: complications and false negative rate. *Ann Thorac Surg.* 2006; 82:1185-90.
13. Hammoud Z, Anderson R, Meyers B, Guthrie TJ, Roper CL, Cooper JD, et al. The current role of mediastinoscopy in the evaluation of thoracic disease. *J Thorac Cardiovasc Surg.* 1999;118:894-9.
14. Cancer facts and figures 2006. American Cancer Society, 2006. (Accessed 2006, at www.cancer.org.)
15. Memtsoudis S, Besculides M, Zellos L, Patil N, Rogers S. Trends in lung surgery: United States 1988 to 2002. *Chest.* 2006;130:1462-70.
16. Falcoz P, Conti M, Brouchet L, Chocron S, Puyraveau M, Mercier M, et al. The Thoracic Surgery Scoring System (Thoracoscore): risk model for in-hospital death in 15,183 patients requiring thoracic surgery. *J Thorac Cardiovasc Surg.* 2007;133:325-32.
17. Harpole D, DeCamp M, Daley J, Hur K, Oprian CA, Henderson WG, et al. Prognostic models of thirty-day mortality and morbidity after major pulmonary resection. *J Thorac Cardiovasc Surg.* 1999;117:969-79.
18. Meguid R, Brooke B, Chang D, Yang S, Are surgical outcomes for lung cancer resections improved at academic institutions. Proceedings of the 43rd Annual Meeting of The Society of Thoracic Surgeons; 2007 Jan 28-31; San Diego.
19. Silvestri G, Handy J, Lackland D, Corley E, Reed C. Specialists achieve better outcomes than generalists for lung cancer surgery. *Chest.* 1998;114:675-80.
20. Goodney P, Lucas F, Stukel T, Birkmeyer J. Surgeon specialty and operative mortality with lung resection. *Ann Surg.* 2005;24:179-84.
21. Dorrance H, Docherty G, O'Dwyer P. Effect of surgeon specialty interest on patient outcome after potentially curative colorectal cancer surgery. *Dis Colon Rectum.* 2000;43:492-8.
22. Pearce W, Parker M, Feinglass J, Ujiki M, Manheim L. The importance of surgeon volume and training in outcomes for vascular surgical procedures. *J Vasc Surg.* 1999;29:768-78.

Discussion

Dr David R. Jones *(Charlottesville, Va).* I have no conflict of interest. I would like to congratulate Dr Boffa and his coauthors on a nicely presented study. Although the GTS-STS database was established in 1999, its subsequent acceptance into the general thoracic surgical community has occurred at a surprisingly slow pace. In fact, as noted by the authors, data included in this study likely represent less than 5% to 7% of all pulmonary resections performed in the United States. Therefore, this inaugural report from Dr Boffa and his colleagues on data harvested from the database is a welcome contribution to the literature. I say this because, finally, board-certified general thoracic surgeons are tracking and now presenting their results, which is in stark contrast to other databases such as CCACS, the National Hospital Discharge Survey, and others, which include outcomes from non–board-certified thoracic surgeons.

Dr Boffa has highlighted the contemporary operation type, morbidity, and mortality associated with surgical treatment of primary lung cancer in the United States today. These results demonstrate that our morbidities, and specifically our mortality rates, for resection of primary lung cancer are almost half of those reported by studies using other databases. These splendid results were achieved with a median length of stay of only 5 days and pneumonectomy rates of 6.5%, both far lower than what had previously been reported.

I have three questions for the authors. Inasmuch as one of the primary charges given the thoracic surgeon is to assure accurate staging of their patient's disease before the operation, I was surprised to see that the incidence of preresection mediastinoscopy in your series was only 21%. Do you have any idea why this number is so low, and is it possible that it is artificially low owing to the inherent limitations of such a study as this? Did some patients have a mediastinoscopy at a separate setting perhaps, which may not have been captured as a true preresection mediastinoscopy?

Second, inasmuch as several groups have shown that hospital case volume may affect overall survival after resection of lung cancer, how do you think that your results fit into that literature as we know it today?

Finally, one of the biggest criticisms of any data retrieved from the GTS-STS database is that there is no mechanism to audit this self-reporting data. You mention this in the limitations of your study. What effect do you think this has on your study and what is being done to correct this potential bias for those in the audience who may wish to join the database?

Dr Boffa. Thank you, Dr Jones. We were a bit surprised by the low mediastinoscopy rate. As you suggested, this could be a phenomenon of the database not capturing mediastinoscopy taking place before the resection. The STS database is a procedure-oriented database more than a patient-oriented database. As procedures are entered into the database, patient identifiers are exchanged for a unique Duke identifier. Although the mechanism is such that the same patient should be given the same Duke identifier on multiple admissions, it is quite possible that we are missing mediastinoscopies that were performed preoperatively.

One parameter that has been used to look at the accuracy of preoperative staging is unsuspected N2 disease. In the current study, 10.4% of patients were found to have N2 disease in their final pathology report. Approximately half of the patients with N2-positive disease had received induction therapy. Therefore, the prevalence of unsuspected N2 nodal disease was somewhere between 5% and 10% (as neoadjuvant may have been given for reasons other than N2 disease). The rate of unsuspected N2 disease is similar to the rate reported from two large series of mediastinoscopies by Duke and Washington University in St Louis.

The clinical importance of unsuspected N2 disease is entirely dependent on the extent of mediastinal lymph node evaluation. You never are surprised by a bill if you never check the mailbox. The STS surgeons evaluated mediastinal lymph nodes in 65% of resections, which is higher than the rate reported by the American College of Surgeons Commission on Cancer (CCACS) in 2005.

As to the impact on volume, we have generated a curve representing all the lobectomies in the database distributed over the annual lobectomy volume of the submitting participants. We observed that the lobectomies were pretty evenly distributed across participants that average between 20 and 100 lobectomies per year. Therefore, although I believe volume is almost certainly a factor, the GTS-STS database represents a wide array of practice volumes.

Finally, the lack of a formal audit is definitely a concern. This has been discussed at database meetings and the hope is to incorporate a formal audit much like the one that is in place in the cardiac database. Until an audit is implemented, however, this will remain a valid criticism.