Published in final edited form as:

Ann Thorac Surg. 2012 September ; 94(3): 895–901. doi:10.1016/j.athoracsur.2012.04.091.

Characteristics Associated With the Use of Nonanatomic Resections Among Medicare Patients Undergoing Resections of Early-Stage Lung Cancer

Anthony W. Kim, MD, Frank C. Detterbeck, MD, Daniel J. Boffa, MD, Roy H. Decker, MD, Pamela R. Soulos, MPH, Laura D. Cramer, PhD, and Cary P. Gross, MD

Section of Thoracic Surgery, Department of Therapeutic Radiology and Radiation Oncology, Department of General Internal Medicine, and Cancer Outcomes, Public Policy, and Effectiveness Research (COPPER) Center, Yale Comprehensive Cancer Center, Yale School of Medicine, Yale University, New Haven, Connecticut

Abstract

Background—Racial disparities in access to surgical resection for treatment of early-stage non-small-cell lung cancer (NSCLC) are well documented. However it is unclear how race, clinical, and hospital characteristics affect the surgical approach among patients undergoing resection.

Methods—Using the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER)/Medicare linked database, we identified patients 67 years of age or older diagnosed with stage I NSCLC who underwent surgical resection from 2000 to 2007. Surgical approach was categorized as lobectomy or segmentectomy (anatomic) versus wedge resection (nonanatomic). We used logistic regression to identify the association between demographic, clinical, and hospital factors and the use of nonanatomic resections.

Results—There were 8,986 patients in the sample (mean age, 75 years; 53% women); 12.8% underwent nonanatomic resection. The use of nonanatomic resection increased significantly, from 11.0% in 2000 to 15.9% in 2007 ($p = 0.008$). In multivariable analysis, race was not associated with the receipt of nonanatomic resection. Factors associated with the use of nonanatomic resections included age greater than 80 years (odds ratio [OR], 1.51; 95% confidence interval [CI], 1.15–1.98), T1a primary tumor status, chronic obstructive pulmonary disease (COPD) (OR, 1.81; 95% CI, 1.55–2.12), and volume of hospital lung resections performed (highest versus lowest hospital volume, OR, 1.58; 95% CI, 1.23–2.04). More nonanatomic resections were performed in 2007 than in 2000 (OR, 1.73; 95% CI, 1.27–2.37). After stratifying by tumor size, the temporal trend in the use of nonanatomic resection remained significant only among patients with tumors greater than 3 cm.

Conclusions—Since 2000, the use of nonanatomic resections in stage I NSCLC has increased, most significantly among patients with larger tumors. After adjusting for clinical factors, there was no relation between race and type of surgical resection.

Anatomic resections for the treatment of non-small-cell lung cancer (NSCLC) in the form of lobectomy or segmentectomy (anatomic resection) are technically more challenging than nonanatomic wedge resections (nonanatomic resection). Although segmentectomies officially are sublobar resections, they still require division of the vascular and bronchial structures, which distinguishes them from nonanatomic sublobar resections. Nonanatomic

resections generally are regarded oncologically as an inferior form of definitive treatment [1, 2]. The American College of Chest Physicians and the National Comprehensive Cancer Network guidelines recommend anatomic resection for the majority of patients with NSCLC except under specific circumstances such as poor pulmonary function [3, 4]. The use of nonanatomic resections for treatment of lung cancer outside these guidelines is unclear.

Race may be 1 factor that accounts for differences in the receipt of anatomic versus nonanatomic resections. Multiple factors are thought to account for racial disparities in lung cancer care, including limited access to care, patient misperceptions, and biases that exist in the delivery of lung cancer care [5–10]. Several studies have demonstrated that black patients are less likely to receive surgical resection for lung cancer [7, 9, 10]. However it is unclear whether disparities persist in the type of resection among patients who do receive surgical therapy. Billmeier and colleagues [11] recently reported that there is no difference in surgical management of black and white patients with early-stage NSCLC.

In addition to race, other sociodemographic, clinical, and provider-related factors may affect the type of resection given for lung cancer. Age may influence the type of operation offered; other investigators have previously reported that nonanatomic resection is more commonly performed in elderly patients [12, 13]. Specific clinical factors, such as a history of severe lung disease and stroke, have been shown to be predictive of differences in surgical resection [11]. Provider characteristics such as hospital volume of procedures performed have been shown to be a surrogate marker of higher quality of care [14–16]. Although an association between hospital volume and type of resection has not been established, it is reasonable to hypothesize that hospitals with higher volume might be more likely to perform anatomic resections.

A gap in knowledge exists regarding why certain individuals with NSCLC undergo nonanatomic resections versus anatomic resections. The specific factors affecting the delivery and receipt of nonanatomic resections have yet to be delineated. The objective of this study was to assess patterns in the surgical approach to stage I NSCLC in the Medicare population and to determine whether specific characteristics such as race were associated with the receipt of nonanatomic resection in this population.

Material and Methods

Data Source

The National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) program data linked to the Medicare claims database was used for this investigation. The SEER program collects cancer incidence and survival information from population-based cancer registries encompassing 28% of the US population [17]. Patient-level information includes sociodemographic characteristics as well as cancer type, stage, tumor size, lymph node involvement, and histologic subtype. Each patient's zip code or census tract, or both, has been linked to US census data to provide ecological estimates of socioeconomic status [7]. Additional information includes health maintenance organization enrollment, Part B status, and patient date of death. Medicare claims for health care services for patients in the database who are 65 years of age or older are available through the linked SEER-Medicare database. These files include the Part A Medicare Provider Analysis and Review file and Part B Carrier and Outpatient Claims files.

Study Sample

The sample consisted of patients 67 to 94 years of age with stage I NSCLC diagnosed from 2000 through 2007 who underwent surgical resection within 6 months of diagnosis. The cancer sites investigated were lung and bronchus according to the International

Classification of Diseases for Oncology, Third Edition (ICD-O-3) coding system. Only patients for whom this was their first cancer diagnosis and who were not diagnosed with a second cancer (other than lung cancer) during the study period were included. Patients were excluded if they had an unknown month of diagnosis, were diagnosed based on autopsy or death certificate, or were not continuously enrolled in fee-for-service Medicare Parts A and B for the entire study period (24 months before diagnosis through 6 months after diagnosis). Patients who received nonanatomic resections associated with other primary operations for lung cancer such as chest wall resection or pneumonectomy were excluded.

Construction of Variables

Clinical factors included receipt of a flu vaccination in the 24 months before diagnosis (an accepted marker for access to health care), performance of pulmonary function tests (PFTs) or a ventilation-perfusion (V/Q) scan in the 6 months before operation, performance of invasive staging within 3 months before operation, hospital admission for chronic obstructive pulmonary disease (COPD), number of days in hospital the year before diagnosis, and individual comorbid conditions. Tumor factors included histologic type, size of tumor, number of nodes examined, and year of diagnosis. Provider factors included hospital teaching status, volume of lung resections performed, and type of surgeon (thoracic versus nonthoracic). The hospital volume of resections performed and the division into quintiles were based on the total number of pulmonary operations performed among lung cancer patients diagnosed from 1998 to 2007. Operations performed by surgeons self-reporting in the specialty of cardiac procedures were not included as thoracic surgeons but as nongeneral thoracic surgeons in the analysis.

Comorbid conditions were identified by searching all claims in the 3 through 24 months before diagnosis. Only ICD-9 diagnosis codes that appeared at least twice in outpatient or physician claims billed more than 30 days apart or that corresponded to a hospital claim were counted. Conditions recommended by Elixhauser and associates [18] that we previously found to be significantly associated with survival were incorporated as candidate covariates.

The main outcome measure was the receipt of anatomic versus nonanatomic resection. Patients who underwent both anatomic and nonanatomic resections were included in the anatomic resection group. The type of surgical treatment received was ascertained using the Healthcare Common Procedure Coding System and ICD-9 procedure codes. The specific types of surgical approaches ascertained included lobectomy and segmentectomy (anatomic resections) and wedge resection (nonanatomic resections). A distinction between open or video-assisted thoracoscopic surgery (VATS) was not made.

Statistical Analysis

We assessed the association between all covariates and the receipt of nonanatomic resections using χ^2 tests. Multivariable logistic regression was then performed using a stepwise forward regression approach to determine which factors were independently associated with receipt of nonanatomic resection. All analyses were performed using SAS software, version 9.2 (SAS Institute Inc, Cary, NC). The Yale Human Investigation Committee determined that this study did not constitute human subjects research.

Results

There were 8,986 patients identified with stage I NSCLC who fulfilled our inclusion criteria. The mean age was 75 ± 5 years and 53% were women. The majority of patients underwent anatomic resection (87.2%) and the remainder underwent nonanatomic resection (12.8%)

(Table 1). The use of nonanatomic resection increased significantly over time, from 11.0% in 2000 to 15.9% in 2007 ($p = 0.008$). After stratifying by tumor size (< 2 cm, 2 to 3 cm, and > 3 cm), the use of nonanatomic resections increased from 2000 to 2007 in all tumor sizes, but this trend was significant only among patients with tumors greater than 3 cm ($p = 0.04$) (Fig 1). The use of nonanatomic resection for smaller tumors did not increase significantly during the same period. In the multivariable analysis, more wedge resections were performed in 2007 than in 2000 (OR, 1.73; 95% CI, 1.27–2.37).

In the bivariate analysis, race was associated with the receipt of a nonanatomic resection ($p < 0.001$) (Table 1). However the pairwise comparison of the receipt of wedge resections between the 14.5% of black patients and the 13% of white patients was not significant. In the multivariable analysis, race was not associated with the receipt of a nonanatomic resection (Table 2). In both bivariate and multivariable analysis, advanced age was associated with the increased use of nonanatomic resections (OR for 80 – 84 years versus 67– 69 years, 1.51; 95% CI, 1.15–1.98; 85 years, 1.91; 95% CI, 1.31–2.82). Although some other sociodemographic factors were associated with the receipt of a nonanatomic resection on bivariate analysis (Table 1), they were not associated with nonanatomic resections in multivariable analysis.

Clinical factors significantly associated with the receipt of nonanatomic resections in bivariate analysis included hospital admission for COPD in the year before resection, hospital admission from all causes in the previous year, receipt of flu vaccine, PFT testing, V/Q scans, and invasive mediastinal staging (each $p < 0.05$) (Table 1). Among the 31 comorbid conditions, 9 conditions were significant and 2 additional conditions were marginally significant. Of the 11 comorbid conditions with unadjusted p values less than 0.10, only COPD was found to be significantly associated with receipt of nonanatomic resections after adjusting for the other factors (Table 2). In multivariable analysis, performance of V/Q scans (OR, 1.56; 95% CI, 1.55–2.12) was associated with the receipt of nonanatomic resections.

In terms of tumor characteristics, patients with smaller tumor size were significantly more likely to undergo nonanatomic resections ($p < 0.001$). After stratifying by tumor size, the temporal trend in the use of nonanatomic resection remained significant only among patients with tumors larger than 3 cm. Patients undergoing nonanatomic resections also had fewer lymph nodes examined ($p < 0.001$).

Among provider factors, bivariate analysis demonstrated that patients whose resections were performed at a hospital performing a higher volume of resections ($p < 0.001$) or whose procedures were not performed by a thoracic surgeon ($p = 0.02$) were more likely to undergo nonanatomic resections (Table 1). In the multivariable analysis, the highest quintile for hospital volume was the only provider prognostic factor for nonanatomic resection (OR, 1.58; 95% CI, 1.23–2.04) (Fig 2). The absolute number of hospitals decreased from lowest to highest quintile of lung resection volume. The percentage of teaching hospitals, urban hospitals, and patients treated by a thoracic surgeon, however, increased with quintile of volume (data not shown).

A subgroup analysis was performed, focusing on age, COPD diagnosis, and tumor size, which were all independently associated with nonanatomic resections. Patients 80 years of age or older underwent nonanatomic resection more often than did patients younger than 80 years of age, and the same was true among patients with COPD and those without (Fig 3). The greatest disparity occurred among patients with the smallest tumors (< 2 cm). Among patients with COPD, 28% of patients younger than 80 years of age versus 35% of patients older than 80 years of age received anatomic resections ($p = 0.06$). Among patients without

COPD, 14% of patients younger than 80 years of age versus 24% of patients 80 years of age or older received anatomic resections ($p < 0.001$).

Comment

Since 2000, the use of nonanatomic resections has risen among Medicare beneficiaries with NSCLC. The findings of this study build upon previous observations regarding the use of nonanatomic resections [19–21]. Specifically, although the temporal trend in the use of nonanatomic versus anatomic resections was consistent across the range of different primary tumor sizes, this trend was statistically significant only among tumors larger than 3 cm. The increase in nonanatomic resections may have been partly caused by the wider adoption of the VATS platform as a whole. Given the technically easier nature of nonanatomic resections compared with anatomic resections, it is possible that VATS nonanatomic resections contributed more to the increase of nonanatomic resections relative to anatomic resections. However it was not the original intent of this investigation to examine the differences between open and VATS procedures.

Racial disparities in access to surgical resection for patients with early-stage lung cancer have been well documented [7, 9,10]; however we found that race was not significantly associated with the type of surgical resection performed. Billmeier and coworkers [11] recently reported that although black patients may be less likely to receive operations after a diagnosis of early-stage NSCLC, once resection is initiated factors other than race are associated with the decision to proceed with sublobar versus lobar resection. Our findings parallel this observation but also show that other factors may affect the decision-making process in offering nonanatomic resections.

In this study, age (< 80 and ≥ 80 years) had a strong relationship with the increased use of nonanatomic resection. Other studies have shown that age is related to poorer survival and an increased use of nonanatomic resection [12, 13, 22]. Advanced age may be thought to be associated with increased comorbidities, but when adjusting for these and other clinical factors, including COPD, the lone Elixhauser condition associated with nonanatomic resections, it was still strongly associated with the receipt of nonanatomic resections.

Conventionally, hospital volume of procedures performed has been thought to be a proxy for quality, as measured by better outcomes such as complications or perioperative mortality [14–16]. Our findings contradict this—namely, that hospitals that perform a higher volume of procedures perform more nonanatomic resections, which is not what is recommended by clinical guidelines. This recommendation has been called into question for patients with stage Ia disease by some authors [12, 20, 23–25]. However this does not appear to explain the increased use of wedge resection in hospitals that perform more resections because neither teaching hospital status nor operations performed by thoracic surgeons were prognostic for the performance of a nonanatomic resection. Furthermore it is unlikely that the hospitals performing more resections operate on a disproportionately sicker case mix of patients because we adjusted for age and comorbidity in our models.

The increased use of nonanatomic resections may be the consequence of medical reimbursement [11]. The frequent use of nonanatomic resections may be what transforms a “high-volume” hospital into a “highest-volume” hospital. Additionally, the technically less challenging nature of nonanatomic resections leads to faster operations and earlier discharges, which may be a more economically attractive alternative to administrators. To a surgeon working in a resource-based relative-value-unit scale system, performing multiple nonanatomic resections versus 1 anatomic resection may result in greater productivity [26].

Irrespective of the reason behind the increased use of nonanatomic resections at hospitals that perform more resections, it appears that this observation is contradictory to previous reports associating higher volume and better quality [14–16], although similar contentions that volume may not, in fact, be an accurate measure of quality have been made recently [27]. Interestingly, among the studies evaluating the volume versus quality relationship for lung cancer operations, examinations of only anatomic resections have been performed [14–16]. Given the lack of technical sophistication associated with nonanatomic resections, it may be reasonable to assert that the volume versus outcome argument should be refined to provide more granular analyses when different types of surgical therapy can be offered for disease.

COPD was the only clinical factor found to be significantly associated with receipt of a nonanatomic resection. Cardiopulmonary risk factors have often been cited as reasons for pursuing nonanatomic resections as definitive treatment for NSCLC because of concerns that the patient is unable to tolerate an anatomic resection [12, 25]. From the data presented in this study, it appears that the preservation of pulmonary parenchyma rather than concerns of taxing the cardiac system may be the dominant rationale for performing nonanatomic resections. Also in this particular study, the use of V/Q scanning, which is a test typically used in patients with limited pulmonary function, was found to be significantly associated with the use of nonanatomic resections, suggesting that it may serve as a surrogate indicator for severity of pulmonary disease.

One of the significant limitations of a study based on Medicare claims is the lack of specific granular data such as the values of PFT results. Comprehensive reviews of the existing data in the literature show that PFT results are strong determinants of pulmonary resections [28, 29]. Another potential criticism of this study may be that segmentectomies were not grouped with nonanatomic resections as has been done in other studies [11,20, 23]. Although it is possible that the use of segmentectomies for larger lesions also increased during the study period, this issue was not examined. Because of the greater technical expertise required with anatomic resections over nonanatomic resections, segmentectomies and lobectomies were grouped together. Furthermore, examining the factors predictive of sublobar resections versus lobar resections was not the focus of this study.

Gaining a better understanding of the patterns of resection for early-stage lung cancer will be important because the number of resections is sure to increase in the future. Identifying these patterns may help to highlight the misapplication of nonanatomic resections among patients with larger tumors or among older patients without prohibitive comorbidities. Although it could be argued that the increase in nonanatomic resections may reflect a willingness to treat patients despite significant medical issues, alternative treatment approaches associated with similar outcomes argue against the use of nonanatomic resections.

Acknowledgments

This study was supported in part by the Ohse Research Grant, Department of Surgery, Yale School of Medicine and by a grant from the National Cancer Institute (1R01CA149045-01).

The authors acknowledge the efforts of the Applied Research Program, National Cancer Institute; the Office of Research, Development and Information, Centers for Medicare and Medicaid Services; Information Management Services, Inc; and the SEER program tumor registries in the creation of the SEER-Medicare database. This study used the SEER-Medicare linked database. The interpretation and reporting of this data are the sole responsibility of the authors.

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Fig. 1.
Frequency of nonanatomic resections from 2000 to 2007 grouped according to size of the primary tumor.

Fig. 2. Adjusted odds ratios for receipt of nonanatomic resection according to quintiles of hospital volume. The first quintile is the reference quintile.

Fig. 3.
Use of nonanatomic resection according to tumor size and chronic obstructive pulmonary disease (COPD) status.

Table 1

Unadjusted Analysis Comparing Use of Nonanatomic Resections Among Specific Subgroups According to Patient, Clinical, and Provider Factors^a

Variable	N	Percent Receiving Nonanatomic Resection	p Value
Overall	8,986	12.8	
<i>Sociodemographic Factors</i>			
Age (y)			
67–69	1,560	10.5	<0.001
70–74	2,994	11.9	
75–79	2,684	13.3	
80–84	1,362	15	
85	386	18.4	
Race			
White	8,174	13.1	<0.001
Black	401	14.5	
Other	411	5.4	
Marital Status			
Married	5,053	11.5	<0.001
Not married	3,636	14.1	
Unknown	297	19.5	
<i>Clinical Factors</i>			
Flu vaccination			
Yes	5,709	13.4	0.03
No	3,277	11.8	
Performance of pulmonary function tests			
Yes	7,375	12.2	0.001
No	1,611	15.5	
Performance of perfusion (V/Q) scan			
Yes	855	18.3	<0.001
No	8,131	12.2	
Invasive mediastinal staging in past 3 months			
Yes	715	9.2	0.003
No	8,271	13.1	
Number of days in hospital in previous year			
0	6,617	11.8	<0.001
1–10	1,870	14.7	
>10	499	18.8	
Number of comorbidities			
0	3,114	8.6	<0.001
1–2	4,050	13.3	
3	1,822	18.9	

Variable	N	Percent Receiving Nonanatomic Resection	p Value
Congestive heart failure			
Yes	894	19.1	<0.001
No	8,092	12.1	
Cardiac arrhythmias			
Yes	1,437	15.6	0.001
No	7,549	12.3	
Valvular disease			
Yes	665	15.6	0.02
No	8,321	12.6	
Peripheral vascular disorders			
Yes	1,344	16.8	<0.001
No	7,642	12.1	
Hypertension, uncomplicated			
Yes	5,286	13.5	0.02
No	3,700	11.8	
Chronic pulmonary disease			
Yes	2,934	19.8	<0.001
No	6,052	9.4	
Weight loss			
Yes	181	19.9	0.004
No	8,805	12.7	
Fluid/electrolyte disorder			
Yes	716	16.5	0.002
No	8,270	12.5	
Depression			
Yes	540	15.6	0.05
No	8,446	12.6	
Hospital Factors			
Hospital volume (number of patients undergoing resection)			
<18	1,673	14.2	<0.001
19–33	1,644	9.9	
34–55	1,635	12.6	
56–86	1,711	10.9	
87–309	1,719	15.1	
Unknown	604	16.6	
Resection performed by a thoracic surgeon			
Yes	4,219	12	0.02
No	4,767	13.6	
Tumor Factors			
Size of tumor (cm)			

Variable	N	Percent Receiving Nonanatomic Resection	<i>p</i> Value
0.1–2.0 (T1a)	3,237	21.1	<0.001
2.1–3.0 (T1b)	2,687	11.8	
3.1–5.0 (T2a)	2,228	5.7	
5.1–7.0 (T2b)	531	3.2	
>7.0 (T3)	238	<4.7 ^a	
Unknown	65	<17.0 ^a	
Number of lymph nodes examined			
0	1,291	55.1	<0.001
1–5	3,051	10.1	
6–10	2,008	2.4	
> 10	1,584	1.2	
Unknown	1,052	6	

^aOnly the factors and Elixhauser conditions that were significantly associated with receipt of nonanatomic resection are reported. AIDS/HIV, paralysis, drug abuse, and psychoses were significant but are not reported because of the Centers for Medicare and Medicaid Services (CMS) prohibition against publication of cell sizes < 11 patients.

Table 2Factors Associated With Nonanatomic Resections in Multivariable Analysis^a

Variable	Odds Ratio	95% CI		p Value
		Lower	Upper	
Age (y)				<0.003
67–69	1.00	...	...	
70–74	1.14	0.90	1.45	
75–79	1.26	0.99	1.61	
80–84	1.51	1.15	1.98	
85	1.92	1.31	2.82	
Race				<0.001
White	1.00	...	...	
Black	1.18	0.83	1.69	
Other	0.28	0.16	0.51	
Performance of perfusion (V/Q) scan				<0.001
Yes	1.56	1.22	1.98	
No	1.00	...	...	
Chronic pulmonary disease				<0.001
Yes	1.81	1.55	2.12	
No	1.00	...	...	
Hospital volume by number of operations				<0.001
< 18	1.00	...	...	
19–33	0.87	0.67	1.13	
34–55	1.06	0.82	1.38	
56–86	0.92	0.71	1.19	
87–309	1.58	1.23	2.04	
Unknown	0.83	0.60	1.14	
Size of tumor (cm)				<0.001
0.1–2.0 (T1a)	1.00	...	...	
2.1–3.0 (T1b)	0.58	0.49	0.69	
3.1–5.0 (T2a)	0.25	0.20	0.32	
5.1–7.0 (T2b)	0.17	0.10	0.29	
>7.0 (T3)	0.11	0.04	0.32	
Unknown	0.21	0.07	0.64	
Number of Lymph Nodes Examined				<0.001
0	1.00	...	...	
1–5	0.09	0.08	0.11	
6–10	0.02	0.02	0.03	
> 10	0.01	0.01	0.02	
Unknown	0.05	0.04	0.07	

^aModel also adjusted for SEER registry ($p < 0.001$) and year of diagnosis ($p = < 0.001$).

CI = confidence interval.