Safety and efficacy of video-assisted versus conventional lung resection for lung cancer

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Objective: We sought to evaluate the use of video-assisted thoracoscopy among patients with lung cancer and its safety and effectiveness relative to conventional resection.

Methods: A cohort study (1994–2002) was conducted by using the Surveillance, Epidemiology, and End-Results Medicare database. Video-assisted thoracoscopy and conventional resection were hypothesized to be equivalent in terms of risks of death. Equivalency was defined by a confidence interval of 0.72 to 1.28 for the odds of 30-day death and 0.89 to 1.11 for the hazard of death, corresponding to a difference of no more than 1% for 30-day mortality and 5% for 5-year survival, respectively.

Results: Among 12,958 patients who underwent segmentectomy or lobectomy (mean age, 74 ± 5 years), 6% underwent video-assisted thoracoscopy. The use of video-assisted thoracoscopy increased from 1% to 9% between 1994 and 2002. Compared with those who underwent conventional resection, patients who underwent video-assisted thoracoscopy more frequently had smaller tumors ($P < .001$) and stage I disease ($P = .03$), underwent lymphadenectomy ($P < .001$), and were cared for by higher-volume surgeons ($P < .001$) and at higher-volume hospitals ($P < .001$). After adjusting for differences in patient, cancer, management, and provider characteristics, the odds of early death were not significantly different between patients undergoing video-assisted thoracoscopy and those undergoing conventional resection, although equivalency was not demonstrated (adjusted odds ratio, 0.93; 95% confidence interval, 0.57–1.50). The hazard of death was equivalent for video-assisted thoracoscopy and conventional resection (adjusted hazard ratio, 0.99; 95% confidence interval, 0.90–1.08).

Conclusions: Video-assisted thoracoscopy was uncommonly used to manage lung cancer, although its use has increased over time. Video-assisted thoracoscopy and conventional resection were equivalent in terms of long-term survival.

Although an increasing body of evidence supports the use of video-assisted thoracoscopy (VATS) in lung cancer management,^{1–16} it is unclear how widely it is being used. Additionally, it is unknown whether the safety and effectiveness of this relatively new procedure is equivalent to that of open thoracotomy.

New technology and therapeutic interventions can offer advantages over standard treatment without compromising well-established safety and efficacy benchmarks, but determining whether 2 competing therapies are equivalent is methodologically challenging. Standard hypothesis testing cannot prove equivalence, even when the outcomes of 2 treatments are not significantly different. A well-accepted

method of evaluating equivalency is a noninferiority randomized trial: a study designed to rule out the possibility of prespecified, clinically important differences in outcomes between treatment groups.¹⁷ Because the feasibility of a randomized trial of VATS versus conventional resection has been questioned, a noninferiority-based analysis of observational data might be informative.

Using a nationally representative tumor registry linked to Medicare claims and a noninferiority-based analytic framework, we described the use and associated outcomes of VATS among patients with lung cancer who underwent segmentectomy or lobectomy. We hypothesized that the safety (30-day case fatality) and effectiveness (long-term survival) of VATS and conventional resection would be equivalent. Clinically important differences of 1% for 30-day case fatality and 5% for 5-year survival were specified a priori.

MATERIALS AND METHODS

The Surveillance, Epidemiology, and End-Results (SEER) Medicare database was used to perform a retrospective cohort study of patients given diagnoses of lung cancer from 1994 through 2002. SEER captures approximately 14% of incident malignancies in the United States. Tumor registry data have been linked to claims data among SEER patients who were Medicare beneficiaries. The utility, quality, and validity of the SEER-Medicare database have been described previously.¹⁸ The University of Washington Institutional Review Board approved this study and waived consent.

Among 191,024 patients given diagnoses of lung cancer from 1994 through 2002, the following sequential exclusions were made: patients

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Abbreviations and Acronyms

CI	= confidence interval
HCPCS	= Healthcare Common Procedure Coding System
LOS	= length of stay
SEER	= Surveillance, Epidemiology, and End-Results
VATS	= video-assisted thoracoscopy

given diagnoses at autopsy/death ($n = 4379$), patients who did not undergo segmentectomy or lobectomy ($n = 170,258$), patients less than 66 years old ($n = 1370$), diagnosis of a second malignancy between 3 months before and 6 months after lung cancer diagnosis ($n = 812$), and patients with only part A or part B, concurrent health maintenance organization enrollment, or both between 1 year before and 6 months after lung cancer diagnosis ($n = 1247$). These exclusions were made to ensure the accuracy and completeness of claims data when used for the purposes of research, and the specific reasons for the exclusions have been described previously.¹⁹

Outcomes included long-term survival, death within 30 days of the operation, length of stay (LOS), and Medicare expenditures. Death data were available through the Medicare Enrollment Database with follow-up through 2005. LOS and Medicare expenditure information were available from the Medicare Provider Analysis and Review file. Costs were defined by the actual dollar amount paid by Medicare to the hospital (expenditures) rather than hospital charges and adjusted for inflation by using the Consumer Price Index for Medical Care.

Patient and disease characteristics were available through the SEER registry, and management and provider information was available through Medicare claims. Indicators of low income or education were based on the lowest quartiles of median income and proportion with a high-school education within a given zip code. Geography was defined by the SEER registry where the patient was diagnosed. Residence refers to the population size of the area where the patient lived. Claims within the carrier and outpatient files in the year before diagnosis were used to ascertain the Klabunde-modified Charlson Comorbidity Index.²⁰ Tumor size, stage (American Joint Committee on Cancer, sixth edition), and histology were based on all available information within 4 months of diagnosis. The use of mediastinal staging modalities was ascertained by using claims defined by the Healthcare Common Procedure Coding System (HCPCS) and present within the carrier claims files, outpatient files, or both. Resection type, radiation therapy, and chemotherapy were defined by using the carrier claim files with relevant HCPCS; by using the outpatient files with relevant HCPCS codes, International Classification of Diseases (Ninth Revision) procedure codes, and Revenue Center Codes (Appendix 1); or both. Hospital teaching status was determined by linkage to Medicare hospital files. Volume measurements reflected average yearly provider volume among SEER-Medicare patients but not total provider volume.²¹ A dichotomous variable was created to indicate higher-volume providers based on those within the highest quartile of volume.

STATA (Special Edition 9.2; StataCorp, College Station, Tex) was used for all statistical analyses. Continuous and categorical variables were compared by using a t test for independent samples and the χ^2 test, respectively. The Kaplan-Meier method was used to obtain unadjusted survival estimates. A priori designated potential confounders included patient (age, sex, race, and comorbidity index), cancer (stage, histology, and tumor size), management (mediastinoscopy, mediastinal lymphadenectomy, and neoadjuvant therapy), and provider (surgeon volume and hospital volume and teaching status) characteristics. The analytic strategy was to sequentially add groups of variables to regression models to better understand how these variables might confound unadjusted comparisons. Cox propor-

tional-hazards models were used to evaluate the relationship between approach to resection and overall survival while providing adjustment for potential confounders. Survival time was defined as the interval between the date of diagnosis and the date of death or censoring. The proportional-hazards assumption was tested by using Schoenfeld residuals. In the event the assumption was not satisfied, extended (stratified) Cox regression models were used. Logistic regression models were used to examine the relationship between approach to resection and 30-day mortality while providing adjustment for potential confounders. Linear regression was used to evaluate the relationship between approach to resection and LOS and expenditures while providing adjustment for potential confounders. Because the distributions of LOS and expenditures were not normal, both variables were log transformed, and geometric means were reported. All multivariable regression models adjusted for clustering at the hospital level.

Confidence interval (CI) inspection was used to conduct a noninferiority-based analysis. Because regression models estimate relative risk, prespecified noninferiority risk differences were expressed in terms of relative risk by using the conventional resection group's outcomes as baseline. CIs defining equivalence were 0.72 to 1.28 for the odds of early death and 0.89 to 1.11 for the hazard of death, corresponding to a difference of no greater than 1% for 30-day mortality and 5% for 5-year survival, respectively. Derived CIs falling within these ranges indicated equivalence. If the upper bounds of the derived CIs exceeded the upper bounds of the predetermined equivalency intervals, then inferiority could not be excluded. Similarly, if the lower bounds of derived CIs exceeded the lower bounds of prespecified equivalency intervals, then superiority could not be excluded.

RESULTS

Between 1994 and 2002, 12,958 patients with lung cancer underwent segmentectomy or lobectomy performed by 1600 surgeons at 781 hospitals. Six percent of patients underwent VATS resection by 7% of surgeons and at 13% of hospitals. The frequency of VATS use increased over time among patients, surgeons, and hospitals (Figure 1).

Patients who underwent VATS or open resection were dissimilar in many ways (Table 1). Compared with patients who underwent conventional resection, those who underwent VATS were older (76 vs 74 years, $P < .001$); more commonly lived in the West (61% vs 42%, $P < .001$) or

FIGURE 1. Temporal trends in the use of video-assisted thoracoscopy (VATS) among patients, surgeons, and hospitals.

TABLE 1. Patient and disease characteristics by approach to resection

	All (n = 12,958)	Open (n = 12,237)	Thoracoscopic (n = 721)	P value*
Age, y (%)				<.001
66–70	27	27	21	
71–75	34	34	32	
76–80	26	26	28	
81–85	11	11	16	
≥86+	2	2	5	
Mean ± SD	74 ± 5	74 ± 5	76 ± 6	<.001
Male sex (%)	51	51	45	.01
Race (%)				.10
White	89	89	92	
Black	5	5	4	
Other	5	5	5	
Missing	<1	<1	<1	
Income (%)				<.001
Lowest quartile	24	24	14	
Missing	4	4	3	
Education (%)				<.001
Lowest quartile	24	24	18	
Missing	4	4	3	
Marital status (%)				<.001
Unmarried	38	38	41	
Missing	4	4	1	
Geography (%)				<.001
West	43	43	61	
East	21	21	33	
Midwest	23	23	4	
South	13	13	2	
Residence (%)				<.001
Metropolitan	87	87	96	
Urban	6	6	2	
Rural	8	8	2	
Prior malignancy (%)	23	23	29	<.001
Comorbidity index (%)				.40
0	54	54	52	
1	30	30	30	
2	11	11	11	
≥3	6	6	7	
Histology (%)				<.001
NSCLC				
Adenocarcinoma	56	56	64	
Squamous	29	29	23	
Large cell	5	5	3	
Undifferentiated	2	2	2	
NOS	3	3	2	
SCLC	1	2	1	
Other	4	4	5	
Stage (%)				.01
I	61	61	65	
II	12	12	9	
IIIA	7	7	5	
IIIB	4	4	6	
IV	3	3	4	
Missing	13	13	11	

TABLE 1. Continued

	All (n = 12,958)	Open (n = 12,237)	Thoracoscopic (n = 721)	P value*
Size				
Mean ± SD, cm	3.3 ± 2.0	3.3 ± 2.0	2.8 ± 1.6	<.001
>3 cm (%)	40	41	29	<.001
Missing (%)	5	5	3	
Location (%)				.16
RUL	31	31	31	
RML	5	5	5	
RLL	18	18	18	
LUL	28	29	28	
LLL	15	16	15	
Missing	3	3	3	

SD, Standard deviation; NSCLC, non-small cell lung cancer; NOS, histology not otherwise specified; SCLC, small cell lung cancer; RUL, right upper lobe; RML, right middle lobe; RLL, right lower lobe; LUL, left upper lobe; LLL, left lower lobe. *P value for tests comparing thoracoscopic and open resection.

metropolitan areas (96% vs 86%, $P < .001$); more commonly had a prior malignancy (29% vs 22%, $P < .001$), stage I disease (65% vs 61%, $P = .03$), or adenocarcinoma (64% vs 55%, $P < .001$); and were less frequently in low-income (14% vs 25%, $P < .001$) or low-education (18% vs 24%, $P < .001$) strata. The mean tumor size was significantly smaller among patients who underwent VATS (2.8 vs 3.4 cm, $P < .001$). No significant differences in the distribution of race or comorbidity index were observed.

Perioperative management varied by approach to resection (Table 2). Compared with those in the conventional resection group, patients in the VATS group more often underwent mediastinal lymphadenectomy (45% vs 26%, $P < .001$) and neoadjuvant therapy (8% vs 6%, $P < .001$). During the period when claims for positron emission tomography were available (1998–2002), patients undergoing VATS more often underwent positron emission tomography (51% vs 29%, $P < .001$). Those in the VATS group less frequently received adjuvant therapy (15% vs 20%, $P < .001$). There was no significant difference in the use of mediastinoscopy between groups.

Provider characteristics also varied by approach to resection (Table 2). Compared with those who underwent conventional resection, patients who underwent VATS were cared for by a higher proportion of higher-volume surgeons (92% vs 75%, $P < .001$) and more frequently at higher-volume (88% vs 75%, $p < 0.001$) and teaching (84% vs 63%, $P < .001$) hospitals.

In the unadjusted analysis VATS was associated with significantly higher 5-year overall survival rates compared with those after conventional resection (48% vs 44%, $P = .02$), although 30-day mortality rates were not significantly different (3.2% vs 3.6%, $P = .53$). VATS was associated with shorter LOS (4 vs 8 days, $P < .001$) but higher Medicare expenditures (\$20,519 vs \$19,786, $P = .008$).

TABLE 2. Management and provider characteristics by approach to resection

	All (n = 12,958)	Open (n = 12,237)	Thoracoscopic (n = 721)	P value*
Staging (%)				
PET†	30	30	51	<.001
Mediastinoscopy	16	16	17	.49
Neoadjuvant therapy (%)	6	6	8	<.001
Mediastinal lymphadenectomy (%)	27	26	45	<.001
Adjuvant therapy (%)	20	20	15	<.001
Higher-volume surgeon (%)	76	75	92	<.001
Missing	1	1	1	
Higher-volume hospital (%)	76	75	88	<.001
Missing	2	2	2	
Teaching institution (%)	64	63	84	<.001
Missing	2	2	2	

PET, Positron emission tomography. *P value for tests comparing thoracoscopic and open resection. †Calculated among the 1998–2002 cohort.

After adjustment, the odds of 30-day death were not significantly different when comparing VATS with open resection, although equivalency was not established based on noninferiority criteria (Table 3). In models evaluating survival, the hazards of death for VATS and open resection were equivalent in the fully adjusted model. In an exploratory analysis VATS and open resection were also equivalent in terms of the hazards of lung cancer cause-specific death (adjusted hazard ratio, 0.99; 95% CI, 0.88–1.11; non-inferiority bounds, 0.86–1.14). VATS was associated with a significantly shorter LOS compared with conventional resection (adjusted risk difference, –5 days; 95% CI, –7 to –2 days), although Medicare expenditures were not significantly different (adjusted risk difference, \$290; 95% CI, –\$1603 to \$2182). Adjustment for all measured variables (eg, income and education) had no substantial bearing on any of the findings from the primary analyses. Sensitivity analyses with 3 different methods of propensity scoring (ie, adjustment matching, stratification, and regression) yielded results that were largely similar to those of our primary analysis.

Finally, a stratified analysis was conducted to explore whether VATS and conventional resection were equivalent in terms of survival when performed by different provider types (Table 4). VATS was at least as effective as conventional resection when performed by higher-volume surgeons or at higher-volume and teaching hospitals. When performed by lower-volume surgeons or at lower-volume or nonteaching hospitals, point estimates suggested higher hazards of death associated with VATS, although this apparent association was not statistically significant.

DISCUSSION

The goals of this investigation were to describe the use and associated outcomes of VATS resection for lung cancer and evaluate whether this minimally invasive approach to pulmonary resection was as safe and effective as the standard. VATS was infrequently used for cancer management,

although its use increased over time. The risks of early death after VATS were not significantly different from those after conventional resection, although equivalency could not be confirmed. After adjustment, VATS was as effective as conventional resection in terms of long-term survival. VATS might have been inferior to open resection when performed by lower-volume surgeons and hospitals.

Several reasons might explain the infrequent use of VATS for lung cancer management. Surgeons might be uncomfortable performing VATS because of insufficient training or experience with this minimally invasive procedure. Some surgeons might believe that there is an insufficient level of evidence to confirm the safety and efficacy of VATS compared with standard resection and might be skeptical about its purported benefits. In the setting of malignancy in particular, surgeons might demand higher levels of evidence than they might for benign conditions. This notion might explain the relatively slow adoption of a laparoscopic approach to colon cancer resection,²² despite rapid adoption of laparoscopy for conditions such as symptomatic cholelithiasis, obesity, and gastroesophageal reflux.^{23–25} The lack of operating room resources or staff might also be a barrier to the use of VATS.

Several lines of evidence support the notion that VATS is at least as safe as conventional resection. By avoiding rib spreading, muscle splitting, and the use of a retractor, VATS is believed to result in less pain, earlier ambulation, fewer postoperative complications, and possibly fewer early deaths. Consistent with this claim, several reports show lower rates of postoperative complications associated with VATS when compared with conventional resection.^{1,6,16} Equivalent risks of early death were not demonstrated in this study for several possible reasons. First, most investigations, including this one, were probably underpowered to exclude the possibility of small prespecified differences in rare events, such as death.²⁶ Alternatively, large variability in risks of early death might reflect actual variability in outcomes rather than statistical noise. If true, this explanation

TABLE 3. Multivariable analysis of safety and effectiveness of VATS relative to conventional resection

	HR _{survival} (95% CI)	Equivalence interval
VATS vs conventional		
Unadjusted	0.89 (0.79–0.99)	
Add patient characteristics	0.85 (0.76–0.95)	
Add cancer characteristics	0.91 (0.81–1.02)	
Add management characteristics	0.96 (0.85–1.07)	
Add provider characteristics	0.99 (0.88–1.11)	
Adjust for clustering	0.99 (0.90–1.08)	0.89–1.11
	OR _{30-d mortality} (95% CI)	Equivalence interval
VATS vs conventional		
Unadjusted	0.84 (0.53–1.35)	
Add patient characteristics	0.77 (0.48–1.24)	
Add cancer characteristics	0.81 (0.50–1.31)	
Add management characteristics	0.82 (0.51–1.31)	
Add provider characteristics	0.93 (0.58–1.48)	
Adjust for clustering	0.93 (0.57–1.50)	0.72–1.28

Patient characteristics are age, sex, race, and Charlson Comorbidity Index. Cancer characteristics are histology, stage, and tumor size of greater than 3 cm. Management characteristics are mediastinoscopy, mediastinal lymphadenectomy, and neoadjuvant therapy. Provider characteristics are higher-volume surgeon, higher-volume hospital, and teaching institution. Values are adjusted for clustering at the hospital level. The hazard ratio (*HR*) of death is shown. The odds ratio (*OR*) approximates relative risk when the outcome is rare. *VATS*, video-assisted thoracoscopy; *CI*, Confidence interval.

would suggest that the quality of a VATS procedure is unnecessarily variable, perhaps by provider. This possibility could not be further explored because there were too few events among the relatively few patients who underwent VATS by a low-volume surgeon or at a low-volume hospital.

VATS and conventional resection were equivalent in terms of long-term survival, but 2 caveats are worthy of mention. A key concern regarding the use of VATS is that enthusiasm over minimally invasive surgery and its purported benefits might come at the expense of oncologic principles of pulmonary resection: dissecting and ligating individual bronchovascular structures, obtaining negative margins, and performing adequate intraoperative staging of mediastinal lymph nodes. Although it has been demonstrated that an oncologic resection is possible with VATS,^{9,14,22,27} there remains concern that not all surgeons who perform VATS adhere to these principles. Although this dataset did not provide an opportunity to evaluate the appropriateness of a VATS operation, it did allow for indirect examination of clinically important departures from

TABLE 4. Stratified regression analysis evaluating provider influence on VATS outcomes

	Lower-volume surgeon	Higher-volume surgeon
VATS vs conventional		
Adjusted HR* (95% CI)	1.42 (0.94–2.17)	0.96 (0.87–1.06)
	Lower-volume hospital	Higher-volume hospital
VATS vs conventional		
Adjusted HR* (95% CI)	1.13 (0.84–1.54)	0.97 (0.88–1.07)
	Nonteaching hospital	Teaching hospital
VATS vs conventional		
Adjusted HR* (95% CI)	1.13 (0.88–1.45)	0.96 (0.87–1.06)

VATS, Video-assisted thoracoscopy; *HR*, hazard ratio; *CI*, confidence interval.
*Adjusted for patient, cancer, management, and provider characteristics and clustering. Equivalence interval = 0.89 to 1.11.

standard oncologic principles measured in terms of patient survival. Even though the overall analysis supported the equivalence of a VATS approach, stratified analyses suggested higher risks of death associated with VATS when performed by low-volume surgeons. Although volume might have been a requisite for achieving equivalent outcomes with VATS, a more likely explanation is that it was a surrogate for appropriately performed VATS resections. The findings from this study are consistent with the notion that VATS was at least as good as conventional resection but only to the extent that VATS was performed according to appropriate oncologic principles. A second caveat is that this study was not a randomized noninferiority trial and is therefore subject to the usual limitations of an observational study, including unmeasured confounding (patient selection factors known or suspected to affect outcomes and possibly result in bias).

Findings from this investigation are consistent with prior descriptions of an association between VATS and shorter LOS^{1,3} but challenge the notion that shorter LOS results in cost savings. Shorter LOS is plausibly explained by less pain, earlier ambulation, and fewer complications after a VATS resection,^{1,6,16} and if true, these benefits would reasonably be expected to translate into cost savings. One explanation for why there were no observed cost savings associated with VATS is that Medicare expenditures were likely related to an episode of care (ie, hospitalization for lung cancer resection) rather than specific attributes of that care, such as type of operation performed, LOS, or frequency of adverse events. Had expenditures for subsequent care (beyond the index hospitalization) been evaluated and adverse event rates truly been lower for VATS, then cost savings might have been observed. Also, although it appears that shorter

LOS might not have resulted in cost savings for Medicare, it is likely that hospitals profited from patients who spent less time in the hospital. VATS might have been associated with shorter LOS because surgeons who commonly perform VATS might also frequently use clinical pathways and algorithms expediting postoperative care.²⁸ It would be important to know how much of the association between VATS and shorter LOS is explained by the use of such pathways because these algorithms might also be applicable to patients who undergo open resection. Unfortunately, the limitations of the dataset precluded a more detailed health economic analysis.

This study had a number of limitations. Because Medicare claims were created for administrative rather than research purposes, we were unable to measure important clinical variables, such as lung function, performance status, and severity of underlying comorbidities. This might have resulted in inadequate risk adjustment and possibly biased our noninferiority-based analyses. Although clinical databases, such as the one maintained by the Society of Thoracic Surgeons, likely allow for better risk adjustment, the SEER-Medicare database more likely provides a nationally representative description of patterns of care and associated outcomes, at least at this time. Yet even the SEER-Medicare database might be somewhat limited in its generalizability if patterns of care and outcomes are different for patients 65 years and younger or those enrolled in health maintenance organizations or other health plans. However, because the median age of lung cancer is 70 years²⁹ and Medicare provides health care coverage for 97% of elderly Americans, SEER-Medicare data might very well be generalizable. Finally, missing data varied by approach to resection (17% for standard resection and 13% for VATS) and might have biased our results. Because patients with missing covariate data had lower survival rates (40% vs 45%, $P < .001$) and were excluded from the analysis, outcomes associated with the standard resection group might have been too optimistic in the case-complete analysis. Any such bias might have resulted in VATS appearing equivalent to conventional resection when in truth VATS might have been associated with better outcomes.

The findings from this study have several implications for clinical practice, surgical education, policy, and future research. In counseling patients on the risks and benefits of pulmonary resection, results from this study can be cited as additional evidence, limitations notwithstanding, supporting the equivalency of VATS and standard resection in terms of effectiveness. Because there might be variability in VATS outcomes across surgeons and hospitals, greater efforts should be taken to mandate standardized VATS training within cardiothoracic training programs. Additionally, hospitals and organizations might choose to require credentialing of surgeons in the appropriate use of VATS. Given the limitations of this and other studies, future investigations

would ideally confirm the equivalence of VATS and standard resection in a randomized noninferiority trial. The feasibility of such a trial has been questioned on the basis of sample size and lack of clinical equipoise among individual surgeons.²⁷ Demonstrating noninferiority in terms of safety will not likely be feasible because it would require 13,888 patients to demonstrate a 1% difference in 30-day mortality rates. In contrast, 2982 patients would be needed to demonstrate a 5% difference in overall survival rates. Given the high incidence of lung cancer, a multicenter approach might be a realistic option if equipoise were to exist. The feasibility of conducting multicenter noninferiority trials in surgical oncology has been demonstrated previously in the setting of operable colon cancer.³⁰ In the interim, prospective observational studies should aim to re-evaluate the noninferiority of VATS by using clinical data for risk adjustment and quantify its purported benefits by using validated metrics for quality of life and functional status.

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APPENDIX 1. Billing codes used to define staging and therapy

Resection											
HCPCS	32480	32484	32663								
Chemotherapy											
HCPCS	95549	96400	96404	96406	96410	96412	96414	96420	96420	96422	96423
	96425	96440	96445	96450	96542	96545	C9017	J0182	J8510	J8530	J8560
	J8610	J899	J9000	J9001	J9010	J9045	J9060	J9062	J9070	J9080	J9090
	J9091	J9092	J9093	J9094	J9095	J9096	J9097	J9170	J9180	J9181	J9182
	J9190	J9201	J9206	J9208	J9230	J9250	J9260	J9265	J9280	J9290	J9291
	J9350	J9360	J9370	J9375	J9380	J9390	J9999	Q0083	Q0084	Q0085	Q0125
	Q0127	Q0128	Q0129	S0178	S0182	S9329	S9330	S9331			
ICD-9	V58.1	V66.2	V67.2	99.25							
RCC	0331	0332	0335								
Radiation therapy											
HCPCS	31643	77300	77301	77305	77310	77315	77321	77326	77327	77328	77331
	77332	77333	77334	77336	77370	77380	77381	77399	77401	77402	77403
	77404	77406	77407	77408	77409	77411	77412	77413	77414	77416	77417
	77418	77419	77420	77425	77427	77430	77431	77432	77470	77499	77520
	77522	77523	77525	77750	77761	77762	77763	77781	77782	77783	77784
	77799	C1716	C1717	C1718	C1719	C1720	C1790	C1791	C1792	C1793	C1794
	C1795	C1796	C1797	C1798	C1799	C1800	C1801	C1802	C1803	C1804	C1805
	C1806	C2616	G0126	G0173							
ICD-9	V58.0	V66.1	V67.1	92.20	92.21	92.22	92.23	92.24	92.26	92.27	9.28
	92.29	92.30	92.31	92.32	92.33	92.39					
PET											
HCPCS	G0125	G0126	G0210	G0211	G212	G0234	78810				
Mediastinoscopy											
HCPCS	39400										
Mediastinal lymphadenectomy											
HCPCS	38746										

HCPCS, Healthcare Common Procedure Coding System; ICD-9, International Classification of Diseases, Ninth Revision; RCC, Revenue Center Codes; PET, positron emission tomography.