Sublobar resection compared with stereotactic body radiation therapy and ablation for early stage non–small cell lung cancer: A National Cancer Database study

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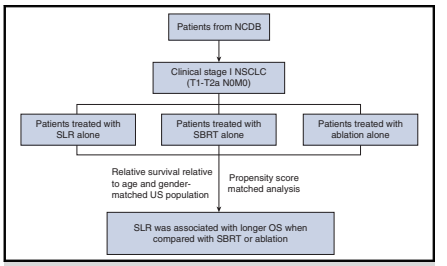
ABSTRACT

Objectives: To compare the overall survival (OS) outcomes of sublobar resection (SLR) with stereotactic body radiation therapy (SBRT) or ablation for patients with early stage non–small cell lung cancer (NSCLC).

Methods: Patients with clinical stage I (T1-T2aN0M0) NSCLC from 2004 to 2014 who were treated with SLR, SBRT, or ablation as the sole treatment were identified from the National Cancer Database. OS was estimated using the Kaplan–Meier method and evaluated by log-rank test, univariate and multivariate Cox proportional hazard regression, and propensity score–matched analysis. Relative survival analyses compared with age- and sex-matched US population were performed.

Results: A total of 53,973 patients were identified. The 1-, 2-, 3-, and 5-year relative survival rates were 96%, 90%, 84%, and 71% for SLR (n = 30,451); 93%, 78%, 65%, and 46% for SBRT (n = 22,134); and 90%, 73%, 58%, and 37% for ablation (n = 1388). Propensity score matching resulted in 9967 patients in the SBRT group versus 9967 in the SLR group and 1062 patients in the ablation group versus 1984 in the SLR group. After matching, both SBRT (hazard ratio, 1.559; 95% confidence interval, 1.497-1.623; $P < .001$) and ablation (hazard ratio, 1.906; 95% confidence interval, 1.730-2.101; $P < .001$) were associated with shorter OS when compared with SLR. These results persisted in patients with tumor size ≤2 cm.

Conclusions: Preliminary results suggest SLR may be associated with longer OS in patients with early-stage NSCLC compared with SBRT or ablation. Future prospective, randomized, controlled clinical trials comparing these treatments are needed to confirm these results. (J Thorac Cardiovasc Surg 2020;160:1350-7)



SLR was associated with longer OS when compared with SBRT or ablation.

CENTRAL MESSAGE

Our results suggest SLR may be associated with increased OS in patients with early-stage NSCLC compared with SBRT or ablation.

PERSPECTIVE

The major finding of our study is that SLR may be associated with longer OS in patients with early-stage NSCLC compared with SBRT or ablation, and the difference persisted after propensity score matching and in patients with tumor size ≤2 cm. Our study is the largest performed to date comparing SLR with SBRT or ablation in patients with stage I non–small cell lung cancer.

See Commentaries on pages 1358, 1359, 1361.

Lung cancer is the leading cause of cancer mortality. The estimated number of new cases of lung cancer that will be diagnosed in the United States in 2019 is 228,150, and the estimated number of deaths due to lung cancer is 142,670.[1] As 1 of the 2 main subtypes of lung cancer, non–small cell lung cancer (NSCLC) accounts for 85% of all cases.[2] Fifteen percent of NSCLC are diagnosed at stage I with an overall 5-year survival rate of 54%.[3] For standard-risk operable patients with stage I NSCLC, the primary treatment is surgical resection with lobectomy.[4] In greater-risk but operable patients, sublobar resection (SLR) is indicated to preserve lung function. There is

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Abbreviations and Acronyms

CI = confidence interval
FORDS = Facility Oncology Registry Data Standards
HR = hazard ratio
NCDB = National Cancer Database
NSCLC = non–small cell lung cancer
OS = overall survival
PSM = propensity score-matched
RFA = radiofrequency ablation
SBRT = stereotactic body radiation therapy
SEER = Survival, Epidemiology, and End Results
SLR = sublobar resection
VATS = video-assisted thoracoscopic surgery

mounting evidence that SLR when applied to the appropriate patient population can provide not only excellent oncologic results but also equivalent survival to lobectomy.[5] For patients with poor cardiopulmonary function, advanced age, or other comorbidities, alternative minimally invasive therapies have recently emerged as curative options, including stereotactic body radiation therapy (SBRT) and ablation. With evidence of tumor control rates and survival outcomes similar to surgery, SBRT is regarded as standard management for inoperable stage I NSCLC.[6,7] More recently, the introduction of ablation therapy has expanded treatment opportunities.

Although lacking in long-term follow-up, several case series and small clinical trials have demonstrated the feasibility, safety, and effectiveness of ablation and SBRT for the treatment of stage I NSCLC.[8-11] However, comparative studies of SLR to SBRT or ablation are scarce and limited in cohort size and study quality. Some studies have found no survival differences between SLR and ablation or SBRT,[12-17] whereas others have found that SLR is associated with longer OS when compared with ablation or SBRT.[18-23] Given these contradictory results, our study aimed to compare the overall survival (OS) of patients receiving SLR only versus those who received ablation or SBRT as the sole treatment for stage I NSCLC in a large national cohort.

METHODS

Data Source

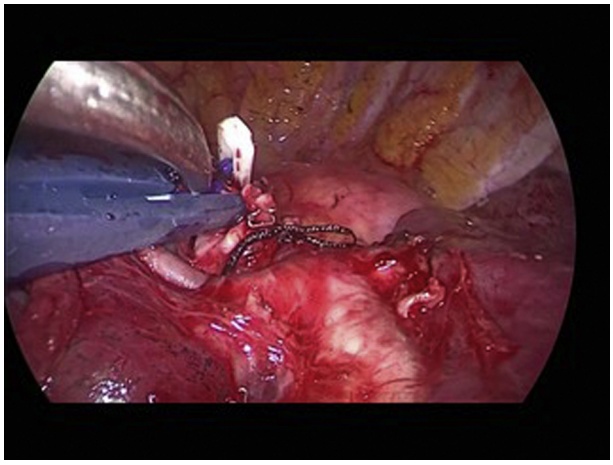
The National Cancer Database (NCDB) is a large database that is prospectively acquired and maintained by the American College of Surgeons' Commission on Cancer and the American Cancer Society. The database draws on information gathered from Commission on Cancer–accredited cancer centers nationwide and currently captures 70% of all diagnosed malignancies in the United States annually. The data set includes detailed information on patient characteristics, disease parameters, treatment information, and outcomes. The American College of Surgeons and the Commission on Cancer have not verified and are not responsible for the analytic or statistical methodology employed or the conclusions drawn from these data by the investigator. Institutional review board approval is waived for the use of NCDB data.

Study Population

The primary objective of this study was to estimate the difference in OS between patients treated with SLR (Video 1) versus ablation or SBRT for primary clinical stage I NSCLC according 8th American Joint Committee on Cancer stage edition. Patients with American Joint Committee on Cancer T1 through T2a tumors, lymph node-negative (N0), nonmetastatic (M0), primary NSCLC who received either ablation (Facility Oncology Registry Data Standards [FORDS] code 12, 15)[24] or SLR (FORDS codes 21–22) or SBRT (FORDS codes 41-43) from 2004 to 2014 were included. According to Participant Use Data File, FORDS code 12 represents laser ablation or cryosurgery, 15 local tumor destruction not otherwise specified, 21 wedge resection, 22 segmental resections including lingulectomy, 41 stereotactic radiosurgery not otherwise specified, 42 LINAC (ie, linear accelerator) radiosurgery, and 43 Gamma Knife. Patients who received chemotherapy, immune therapy, or hormone therapy were excluded. The study cohort is summarized in Figure 1. Patient demographics and disease characteristics included age, sex, race, year of diagnosis, facility type, facility location, insurance status, income (median household income in the patient's zip code of residence), education level (percentile without high school graduation in the patient's zip code of residence), metro versus urban/rural residence, Charlson–Deyo comorbidity index score, tumor size (in millimeters), histology, pathologic grade, 30-day unplanned hospital readmission, and type of treatment.

Statistical Analysis

Demographic and clinicopathologic characteristics were compared between patients treated with SLR and those treated with SBRT or ablation using the χ^2 test or Student t test. Patients' comorbidity was evaluated by the Charlson–Deyo score. The Charlson–Deyo score (0, 1, 2, or 3) was assigned per NCDB guidelines based how many comorbid conditions were reported and their relative severity. Propensity score–matched (PSM) analysis based on factors significant on univariable Cox regression analysis for OS and logistic regression for receipt of SLR versus ablation or SBRT was performed. PSM analyses were performed using the MatchIt package of the



VIDEO 1. Segmental resection for the non–small cell lung cancer in the posterior segment of left upper lobe. Video available at: https://www.jtcvs.org/article/S0022-5223(19)41497-9/fulltext.

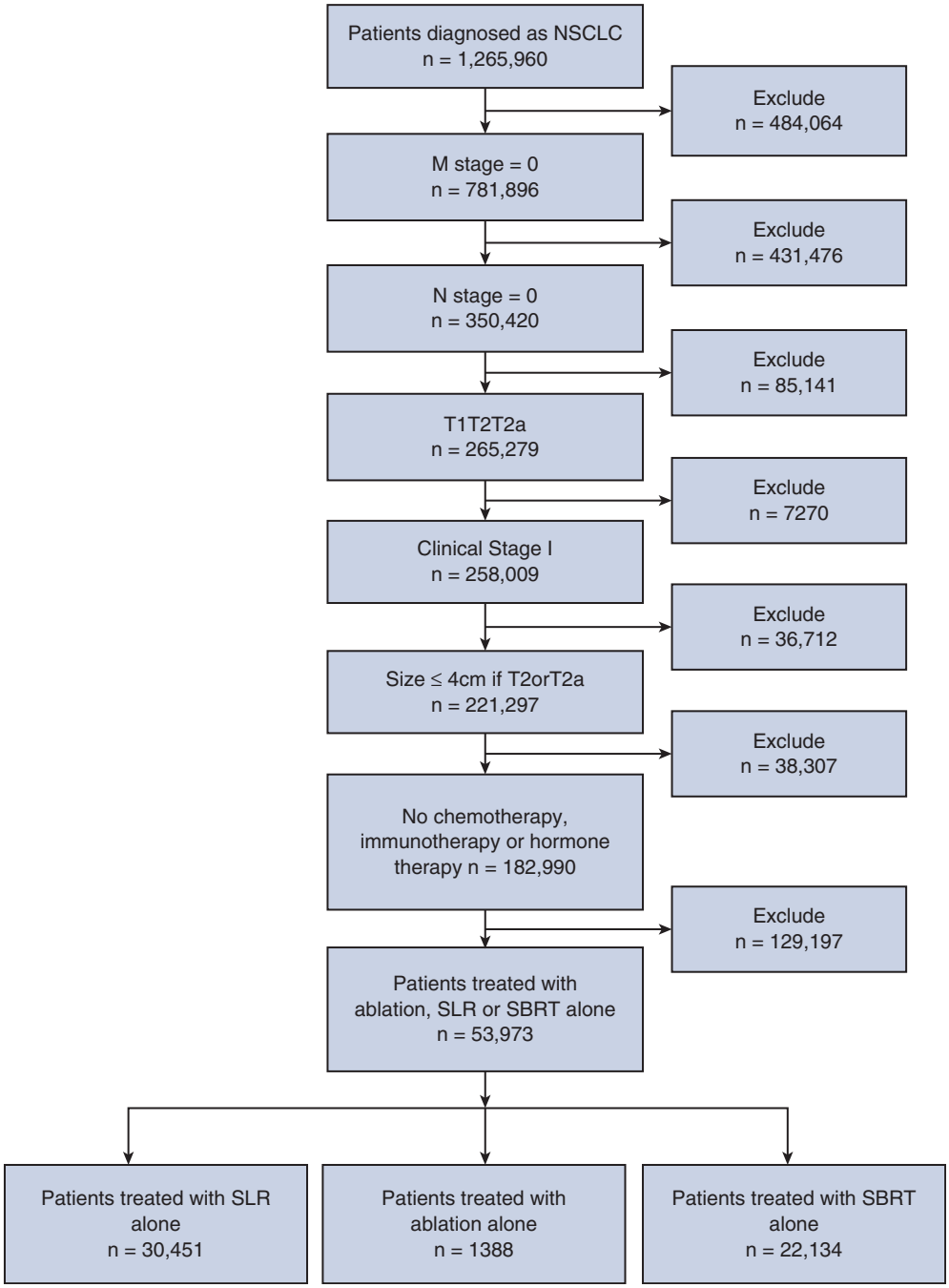


FIGURE 1. Flowchart of patient selection. Patients diagnosed as clinical-stage I NSCLC according to the AJCC 8th edition of staging between 2004 and 2014 and treated with SBRT, ablation, or SLR as their sole treatment were included. Patients with unknown treatment status or treated with chemotherapy, immunotherapy, or hormone therapy were excluded. *NSCLC*, Non–small cell lung cancer; *SLR*, sublobar resection; *SBRT*, stereotactic body radiotherapy.

R program, version 2.15.1 (R Foundation for Statistical Computing, Vienna, Austria). One-to-two or one-to-one matching without replacement was completed using the nearest-neighbor match on the logit of the propensity score for treatment approach. All subsequent analyses were performed on PSM cohorts. OS of matched groups were estimated using the Kaplan–Meier method and evaluated by log-rank test. All analyses were performed using SPSS 22.0 (IBM Corp, Armonk, NY). Survival of the NSCLC patient cohort relative to the expected survival in the age-, sex-matched general US population stratified by treatment method was analyzed with the strs commend in STATA/SE 13 (Stata Corporation, College Station, Tex) as detailed in an article in *The Stata Journal* by P. W. Dickman and E. Coviello.[25] Information on the yearly age- and sex-matched segments of the US population was extracted from the US Census Bureau (www.census.gov), and information on mortality among the same population subgroups was obtained from the Centers for Disease Control and Prevention (www.cdc.gov) in September 2019.

RESULTS

A total of 53,973 patients with stage I NSCLC, including 30,451 who received SLR, 22,134 SBRT, and 1388 ablation met our inclusion criteria. The median age of the entire cohort was 73 years, and the median follow-up was 32.3 months. A summary of demographic and clinicopathologic characteristics is shown in Table E1. After SLR, 1042 of 23,528 (4.4%) surgical patients with pathologic staging data available migrated to pathologic stage II or greater.

Unadjusted Kaplan–Meier survival curves for the unmatched groups are shown in Figure 2. The median OS time for the entire cohort was 53.1 months (95% confidence interval [CI], 52.4-53.8 months). The 1-, 2-, 3-, and 5-year OS rates were 92%, 82%, 73%, and 56% for the SLR group; 84%, 64%, 47%, and 26% for the ablation group; and 87%, 68%, 53%, and 32% for the SBRT group. The 1-, 2-, 3-, and 5-year relative survival rates were 96%, 90%, 84%, and 71% for SLR; 90%, 73%, 58%, and 37% for ablation; and 93%, 78%, 65%, and 46% for SBRT (Figure 3).

Compared with SLR, patients treated with ablation or SBRT were older, and more patients had squamous cell carcinoma. In addition, more patients treated with SBRT had Charlson–Deyo score of 0 and were diagnosed after 2009 from non-metropolitan regions, and treated in facility located in central US when compared with SLR. More patients treated with ablation had Charlson–Deyo score of 2 when compared with SLR.

Logistic and Cox regression analyses were performed to select important variables to be included in PSM analyses (Tables E2-E5). Propensity matching based on age, sex, race, year of diagnosis, facility type, facility location, insurance status, income, education level, residence, Charlson–Deyo score, tumor size, histology, and pathologic grade resulted in 9967 patients in both SBRT and SLR groups (1:1 ratio), and 1062 patients in the ablation group versus 1984 in the SLR group (1:2 ratio). Covariates were well balanced as shown in Figure E1 and Tables E6 and E7. After matching, the 30-day posttreatment unplanned hospital readmission rate among patients treated with SLR was greater than SBRT (4.0% vs 0.4%, $P < .001$). There was no significant difference in 30-day posttreatment

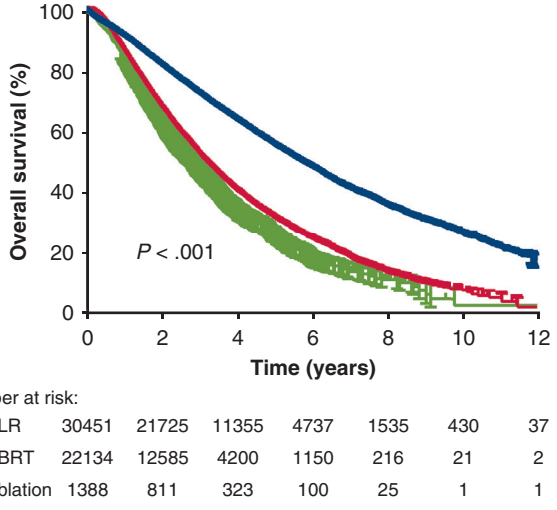


FIGURE 2. Comparison of overall survival among the treatment groups before PSM. Before matching, there was significant difference in the overall survival among 3 treatment groups ($P < .001$), with median survival of 68.8 months for SLR, 33.9 months for ablation, and 38.2 months for SBRT group. *SLR*, Sublobar resection; *SBRT*, stereotactic body radiotherapy.

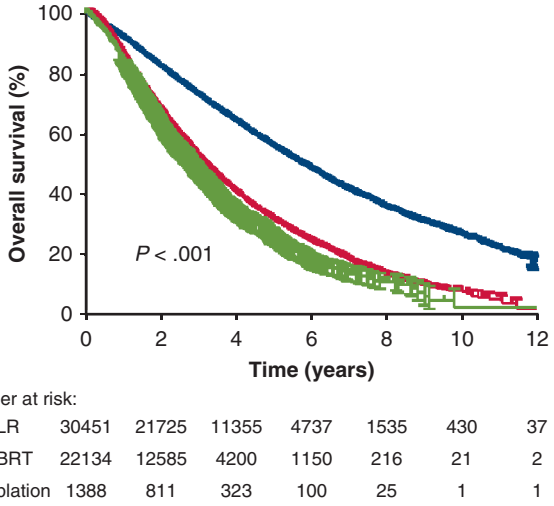


FIGURE 3. Comparison of relative survival among the treatment groups. After adjusting for the general survival of the US population of same age and race, the SLR group showed longer survival than SBRT and ablation. *SLR*, Sublobar resection; *SBRT*, stereotactic body radiotherapy.

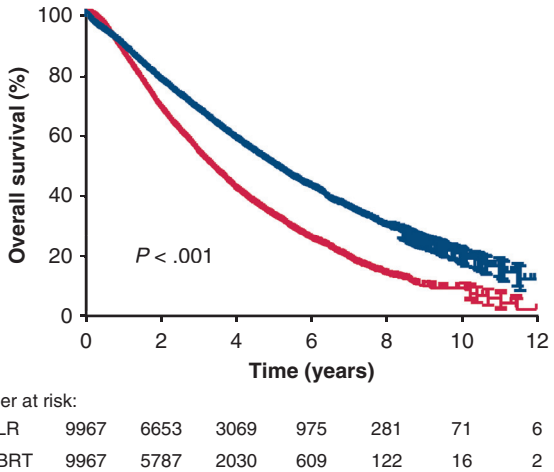


FIGURE 4. Comparison of overall survival between matched SBRT and SLR groups. After matching, the SLR group was associated with longer overall survival than SBRT group. *SLR*, Sublobar resection; *SBRT*, stereotactic body radiotherapy.

unplanned hospital readmission rate between the SLR and ablation groups ($P = .238$). Kaplan–Meier survival curves for the matched groups are displayed in Figures 4 and 5 and Figure E2. After matching, both SBRT (median, 40.5 vs 60.4 months; hazard ratio [HR], 1.559; 95% CI, 1.497-1.623; $P < .001$) and ablation (median, 33.5 vs 58.9 months; HR, 1.906; 95% CI, 1.730-2.101; $P < .001$) were associated with shorter OS when compared with SLR. Both wedge resection (HR, 0.668; 95% CI, 0.640-0.697; $P < .001$) and segmental resection (HR, 0.529; 95% CI, 0.488-0.573; $P < .001$) were associated with longer OS when compared with SBRT, whereas patients treated with segmental resection had longer median survival time than those treated with wedge resection (71.4 vs 58.0 months; $P < .001$). The HR was lower in video-assisted thoracoscopic surgery (VATS) (median, 66.3 months; HR, 0.554; 95% CI, 0.516-0.595; $P < .001$) than open surgery (median, 60.2 months; HR, 0.654; 95% CI, 0.619-0.692; $P < .001$) when compared with SBRT (Table E8).

For patients with tumor size $\leq$2 cm, PSM resulted in 5647 patients in the SBRT group versus 5699 in the SLR group, and 692 patients in the ablation group versus 1303 in the SLR group. The hazard of mortality remained increased for patients treated with ablation (median, 39.1 vs 66.2 months; HR, 1.962; 95% CI, 1.732-2.223; $P < .001$) or SBRT (median, 45.0 vs 67.5 months; HR, 1.626; 95% CI, 1.538-1.720; $P < .001$) when compared with SLR (Figures E3 and E4 and Table E8).

DISCUSSION

Given the preliminary result of relative survival and PSM analysis using NCDB, our study found that SLR may be associated with increased survival in patients with stage I NSCLC compared with SBRT or ablation (Figure 6). Few studies have compared SLR with SBRT or ablation, and results from these investigations have been equivocal.[12-23] Some studies suggest that SLR provides longer OS and/or better local control than ablation or SBRT,[18-23] whereas others report insignificant difference in OS.[12-17] We propose several explanations for these inconclusive results. First, current studies are likely underpowered, with the largest comparative study using the Survival, Epidemiology, and End Results (SEER) database consisting of only 75 patients with stage I NSCLC treated with ablation.[14] For comparison with SBRT, the largest study using NCDB included 5887 patients treated with SBRT before 2010, which was outdated.[20] Second, studies comparing treatments include confounding variables or use different threshold criteria for patient inclusion.[12,14] Third, meta-analyses use diverse cohorts with very different patient demographics and tumor characteristics, limiting the reliability of their conclusions.[5,21] Consequently, no definite conclusion has been reached as to the effectiveness of SLR when compared with ablation or SBRT for early-stage NSCLC.

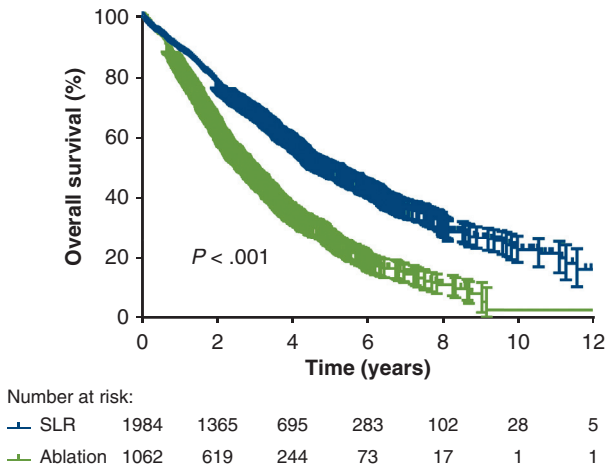


FIGURE 5. Comparison of overall survival between matched ablation and SLR groups. After matching, the SLR group was associated with longer overall survival than ablation group. *SLR*, Sublobar resection.

Over the 10-year period of the study, the most rapidly evolving aspect of clinical staging for NSCLC is the question of how to best assess nodal status. Although position emission tomography and endobronchial ultrasound have improved staging accuracy,[26] treatment has also evolved. Lobectomy has remained the standard treatment of early-stage lung cancer with SLR reserved as an option for high-risk patients. The use of VATS increased 5-fold in the Centers of Medicare/Medicaid population in United States between 2006 and 2014.[27] The dosage range in SBRT was 30 to 66 Gy in 2 to 8 fractions.[21] Both radiofrequency ablation (RFA) and percutaneous cryoablation were recommended to treat tumors smaller than 3 cm. Unlike RFA, recommended for peripheral tumors, percutaneous cryoablation was considered for central tumors.[28] The use of adjuvant chemotherapy showed benefit for stage II NSCLC but was of unproven benefit for stage I NSCLC.[29]

The OS of the SLR group in our study (1-, 2- year OS rates: 92%, and 82%) is consistent with a SEER study using a national cohort of patients with early-stage NSCLC who underwent SLR (1-, 2- year OS rates: 93% and 81%).[23] Long-term survival data in the literature for SLR of early-stage NSCLC are limited by study sizes and population heterogeneity with OS rates ranging between 64% and 85%, 61% and 73%, and 43% and 62% at 2, 3, and 5 years, respectively.[15,17,20,23,30]

PSM analyses had been performed to compare the OS of SBRT and SLR for patients with stage I NSCLC in some previous retrospective studies, including the ones using the SEER database and NCDB.[16,17,20,23,30,31] Puri and colleagues[20] enrolled patients diagnosed between

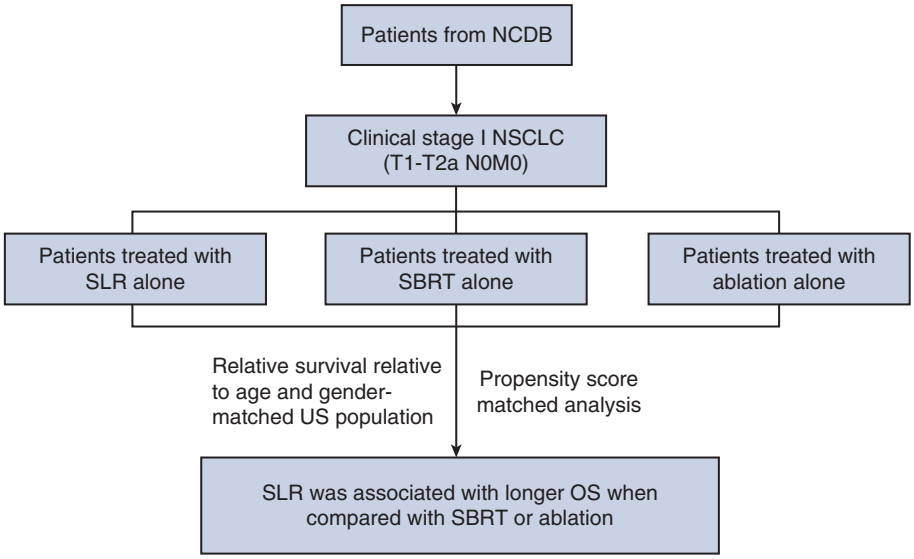


FIGURE 6. PSM and relative survival analysis showed increased OS for SLR group compared to SBRT or ablation group. *NCDB*, National Cancer Database; *NSCLC*, non–small cell lung cancer; *SLR*, sublobar resection; *SBRT*, stereotactic body radiotherapy; *OS*, overall survival.

1998 and 2010 from NCDB, and yielded 4555 pairs of SBRT versus SLR. They demonstrated that the median survival is longer in SLR than SBRT with (48.3 vs 33.9 months) or without PSM (62.3 vs 33.1 months).[20] A retrospective cohort study of the SEER database comparing SLR and SBRT for elderly patients (≥66 years) found that OS was better in the SLR group for both patients with tumor sized <2 cm (HR, 1.80; 95% CI, 1.33-2.43; $P < .001$) and <5 cm (HR, 1.92; 95% CI: 1.62–2.26; $P < .001$).[23] Our study provided the latest national database study comparing these 2 treatments. Given the significant changes over the past 10 years in clinical staging and surgical techniques, we compared SBRT with segmental and wedge resection separately and found patients treated with segmental resection had better OS than wedge resection and both were associated with longer OS than SBRT. We also compared SBRT with different approaches of SLR and found that the HR was lower in VATS than open resection when compared with SBRT. One potential explanation for the longer survival outcomes of SLR compared with SBRT is that patients choosing surgery undergo a lymph node dissection, which is potentially therapeutic as well as diagnostic (improved staging).

A secondary finding of our study is that SLR was associated with longer OS in patients with early-stage NSCLC compared with ablation, and the difference persisted after propensity score matching and in patients with tumor size ≤2 cm. These results are consistent with 2 of the larger comparative studies in the literature by Ambrogi and colleagues[19] and Alexander and colleagues,[18] which compared RFA (n = 62 and 56, respectively) with SLR (n = 59 and 28, respectively) for patients with stage I NSCLC. Both studies found worse survival outcomes for RFA when compared with resection. Notably, 2 other studies, limited by their smaller cohort sizes, reported no OS difference between ablation and SLR but observed a trend toward poorer survival outcomes for ablation.[12,13]

In contrast to our study, Kwan and colleagues[14] showed no significant difference in survival between matched thermal ablation and SLR cohorts. These disparate findings can be accounted for by several factors. First, our study used larger cohorts from 2004 to 2014 with 1388 patients treated with ablation, whereas the study by Kwan and colleagues was limited to patients from 2007 to 2009 and only included 75 patients in the ablation group. Second, 17 of 69 patients in Kwan and colleagues' ablation group underwent adjuvant radiation therapy. Previous studies suggested an additive benefit of external radiation therapy to ablation.[32-34] To limit confounding factors, we only included patients who underwent ablation as the sole treatment in our study. Third, our study had a longer follow-up period than that of Kwan and colleagues (median, 32.3 vs 16.7 months).

The present study has several limitations. Similar to other large databases, the NCDB lacks specific variables such as detailed histology, pretreatment imaging features, lung function, and specific indications for treatment or cause-specific mortality. In this study, patients with adenocarcinoma were more likely to receive SLR over ablation or SBRT. It is likely those adenocarcinomas with

some unique features (probably ground-glass opacity containing lesions on computed tomography scan) were more likely to be offered surgery based on expectations of better outcomes. It is also probable that radiologists and interventional therapists are not sure of the efficacy of energy delivery in these air-containing lesions and are thus reluctant to offer ablation and SBRT to such patients. Comorbidity scores were used as proxies for these variables, consistent with established methods in the literature.[35] However, more patients treated with SBRT had Charlson–Deyo score of 0 when compared with SLR. We believe there are other unmeasured covariates, such as severity of comorbid disease, cardiopulmonary functions, and cognitive impairment, that may have biased the results. Many of the patients undergoing ablative therapies and SBRT have significant comorbidities and limited cardiopulmonary function, making them nonoperative candidates and more likely to have noncancer causes leading to mortality. Although we attempted to compensate for this by performing relative survival on age- and sex-matched US population as well as showing difference in survival on long-term follow-up up to 5 and even 10 years, the observed survival benefit may be exaggerated. We also want to emphasize that although the study results showed superiority of SLR over ablation or SBRT, it does not exclude the value of ablation or SBRT in certain circumstances. Second, NCDB provides codes for ablation that do not distinguish among specific technologies, limiting the ability to differentiate survival outcomes based on modality. Alternative codes including electrocautery/fulguration (FORDS code 13), and laser excision (FORDS code 24) were clearly distinguished from ablation and were not included in the analysis. Third, because data on recurrence were unavailable, we could not compare progression-free survival among treatment groups. Fourth, to compare the efficacy of SLR with ablation or SBRT directly, we excluded patients who received other kinds of anticancer treatments. It is uncertain whether these treatments were superior when combined with the modalities studied in this paper. Lastly, although the cohorts were matched with PSM analysis, there are inherent biases due the retrospective nature of the study (eg, patient exclusion due to missing data) that can only be avoided with a prospective randomized control trial. Despite these limitations, our study is the largest performed to date comparing SLR with ablation or SBRT in patients with stage I non-small cell lung cancer.

CONCLUSIONS

Preliminary results suggest that SLR may be associated with increased survival in patients with stage I NSCLC compared with SBRT or ablation. Despite PSM and relative survival analyses used in this study, unrecorded variables such as cardiopulmonary function probably play an important role in treatment selection and may affect survival. Future prospective, randomized, controlled clinical trials comparing these treatments are needed to confirm these results.

Conflict of Interest Statement

Authors have nothing to disclose with regard to commercial support.

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Key Words: non–small cell lung cancer, sublobar resection, stereotactic body radiation therapy, ablation

THOR

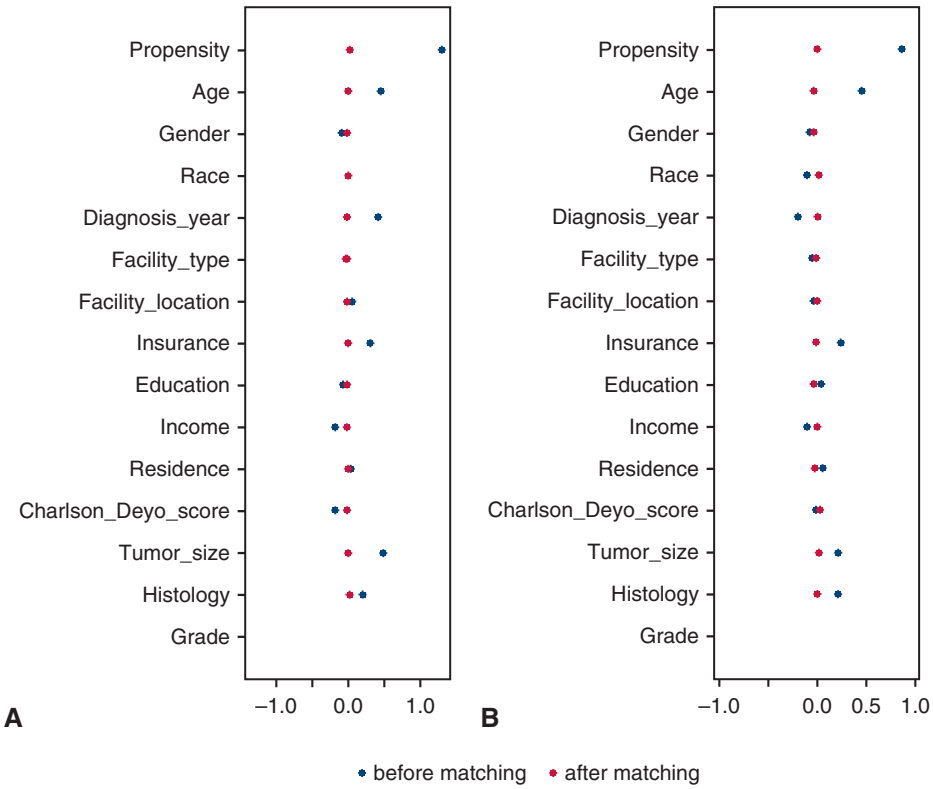

FIGURE E1. A, Standardized differences of means showing well balanced covariates between SBRT and SLR groups after PSM. B, Standardized differences of means showing well balanced covariates between ablation and SLR groups after PSM.

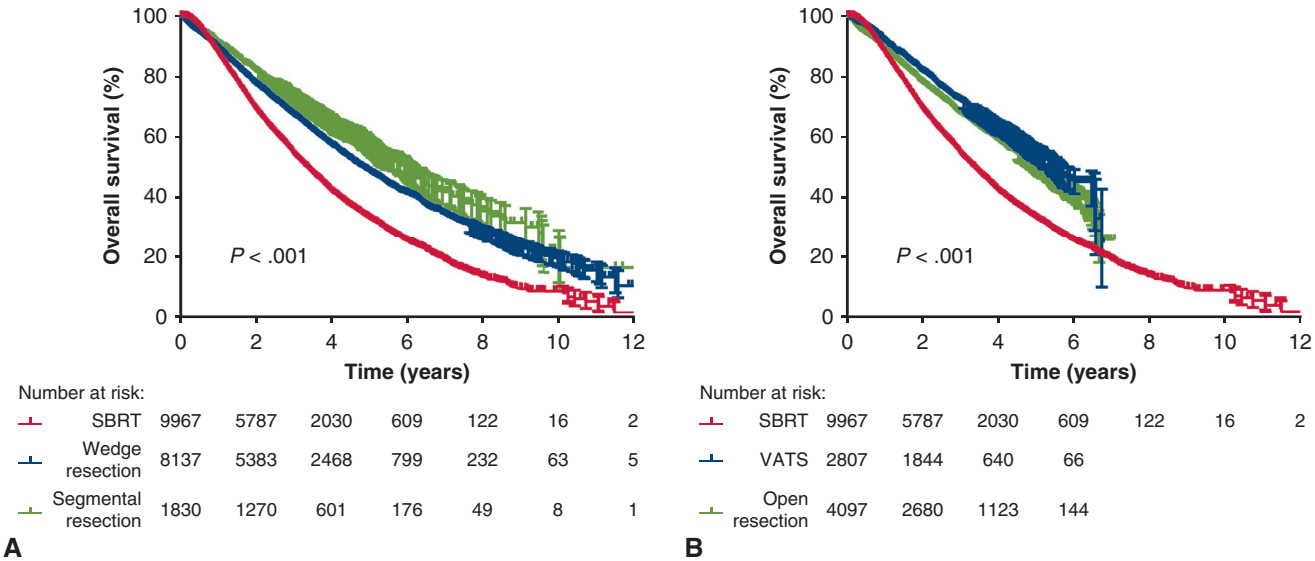

FIGURE E2. A, Comparison of overall survival among matched wedge resection, segmental resection, and SBRT groups. Both wedge resection and segmental resection group were associated with longer overall survival when compared with SBRT. B, Comparison of overall survival among VATS, open resection, and SBRT groups. Both VATS and open resection group were associated with longer overall survival when compared with SBRT. *SBRT*, Stereotactic body radiotherapy; *VATS*, video-assisted thoracoscopic surgery.

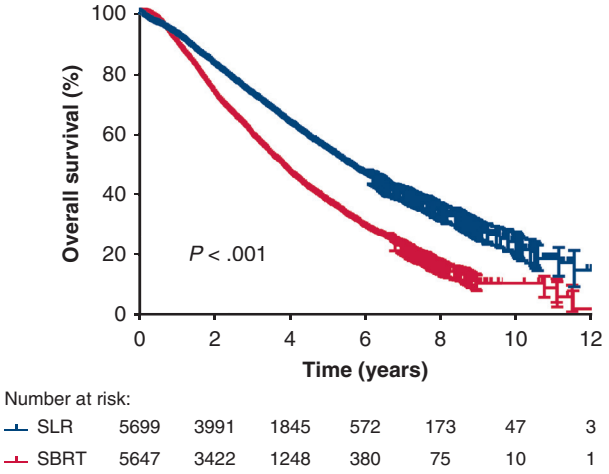

FIGURE E3. Comparison of overall survival between matched SBRT and SLR groups for patients with tumor size ≤2 cm. After matching, the SLR group was associated with longer overall survival than SBRT group for patients with tumor size ≤2 cm. *SLR*, Sublobar resection; *SBRT*, stereotactic body radiation therapy.

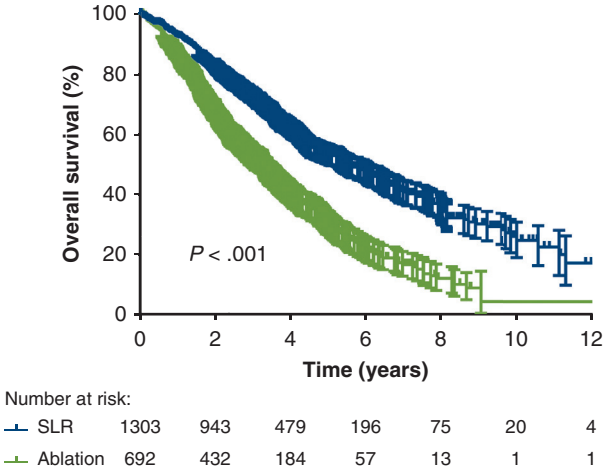

FIGURE E4. Comparison of overall survival between matched ablation and SLR groups for patients with tumor size ≤2 cm. After matching, the SLR group was associated with longer overall survival than ablation group for patients with tumor size ≤2 cm. *SLR*, Sublobar resection.

TABLE E1. Demographic and clinicopathologic characteristics

Variable	No. patients (%) SLR (n = 30,451)	Ablation (n = 1388)	SBRT (n = 22,134)	*P* value
Age, y, median ± SD; range, 4-90 y	70 ± 10	74 ± 9	74 ± 9	<.001
Sex				<.001
Male	12,726 (41.8)	627 (45.2)	10,085 (45.6)	
Female	17,725 (58.2)	761 (54.8)	12,049 (54.4)	
Race				.067
White	27,529 (90.4)	1291 (93.0)	19,957 (90.2)	
Non-white	2721 (8.9)	86 (6.2)	2014 (9.1)	
Missing data	201 (0.7)	11 (0.8)	163 (0.7)	
Year of diagnosis				<.001
2004-2009	11,257 (37.0)	649 (46.8)	4356 (19.7)	
2010-2014	19,194 (63.0)	739 (53.2)	17,778 (80.3)	
Facility type				<.001
Academic/research program	12,128 (39.8)	643 (46.3)	9033 (40.8)	
Nonacademic program	18,220 (59.8)	739 (53.2)	13,098 (59.2)	
Missing data	103 (0.3)	6 (0.4)	3 (0.0)	
Facility location				<.001
Eastern	15,151 (49.8)	740 (53.3)	9574 (43.3)	
Central	11,343 (37.3)	503 (36.2)	10,048 (45.4)	
Western	3854 (12.7)	139 (10.0)	2509 (11.3)	
Missing data	103 (0.3)	6 (0.4)	3 (0.0)	
Primary payer				<.001
Not insured	322 (1.1)	11 (0.8)	155 (0.7)	
Private insurance	7106 (23.3)	206 (14.8)	2790 (12.6)	
Government insurance	22,719 (74.6)	1154 (83.1)	18,948 (85.6)	
Missing data	304 (1.0)	17 (1.2)	241 (1.1)	
Education				<.001
≥21%	4259 (14.0)	173 (12.5)	3087 (13.9)	
13%-20.9%	7632 (25.1)	336 (24.2)	6048 (27.3)	
7%-12.9%	10,352 (34.0)	527 (38.0)	7867 (35.5)	
≤7%	7847 (25.8)	333 (24.0)	4997 (22.6)	
Missing data	361 (1.2)	19 (1.4)	135 (0.6)	
Income				<.001
≤$38,000	4774 (15.7)	216 (15.6)	3947 (17.8)	
$38,000-$47,999	6440 (21.1)	374 (26.9)	5713 (25.8)	
$48,000-$62,999	8007 (26.3)	326 (23.5)	6205 (28.0)	
≥$63,000	10,855 (35.6)	453 (32.6)	6126 (27.7)	
Missing data	375 (1.2)	19 (1.4)	143 (0.6)	
Residence				<.001
Metropolitan area	24,763 (81.3)	1033 (74.4)	17,743 (80.2)	
Urban/rural	4667 (15.3)	232 (16.7)	3825 (17.3)	
Missing data	1021 (3.4)	123 (8.9)	566 (2.6)	
Charlson–Deyo score				<.001
0	13,999 (46.0)	661 (47.6)	12,770 (57.7)	
1	11,318 (37.2)	461 (33.2)	5884 (26.6)	
≥2	5134 (16.9)	266 (19.2)	3480 (15.7)	
Tumor size, mm, median ± SD	17.4 ± 7.6	19.4 ± 7.8	21.5 ± 8.1	<.001
Histology				<.001
Adenocarcinoma	16,799 (55.2)	642 (46.3)	10,172 (46.0)	
Squamous cell carcinoma	7609 (25.0)	432 (31.1)	7549 (34.1)	
Others	5295 (17.4)	92 (6.6)	766 (3.5)	
NOS	748 (2.5)	222 (16.0)	3647 (16.5)	

(Continued)

TABLE E1. Continued

Variable	No. patients (%) SLR (n = 30,451)	Ablation (n = 1388)	SBRT (n = 22,134)	*P* value
Grade				<.001
Well and moderately differentiated	19,227 (63.1)	351 (25.3)	5486 (24.8)	
Poorly and undifferentiated	8242 (27.1)	260 (18.7)	4311 (19.5)	
Unknown, high-grade dysplasia	2982 (9.8)	777 (56.0)	12,337 (55.7)	
30-d unplanned hospital readmission				<.001
No unplanned readmission	28,916 (95.0)	1294 (93.2)	21,876 (98.8)	
Unplanned readmission	1105 (3.6)	56 (4.0)	99 (0.4)	
Missing data	430 (1.4)	38 (2.7)	159 (0.7)	

SLR, Sublobar resection; *SBRT*, stereotactic body radiotherapy; *SD*, standard deviation; *NOS*, not otherwise specified.

TABLE E2. Factors associated with receipt of SBRT versus SLR by logistic regression

Variable	Univariate		Multivariate	
	OR	*P* value	OR	*P* value
Age, y, median ± SD; range, 4-90 y	1.051 (1.049-1.054)		1.042 (1.039-1.045)	<.001
Sex				
Male	1.000 (Ref)		1.000 (Ref)	
Female	0.858 (0.828-0.888)	<.001	1.015 (0.968-1.065)	.538
Race				
White	1.000 (Ref)			
Non-white	1.021 (0.961-1.085)	.5		
Year of diagnosis				
2004-2009	1.000 (Ref)		1.000 (Ref)	
2010-2014	2.394 (2.299-2.493)	<.001	3.154 (2.983-3.335)	<.001
Facility type				
Academic/research program	1.000 (Ref)		1.000 (Ref)	
Nonacademic Program	0.965 (0.932-1.000)	.049	0.978 (0.931-1.027)	.373
Facility location				
Eastern	1.000 (Ref)		1.000 (Ref)	
Central	1.402 (1.351-1.455)	<.001	1.568 (1.489-1.652)	<.001
Western	1.03 (0.974-1.090)	.301	1.283 (1.188-1.385)	<.001
Primary payer				
Not insured	1.000 (Ref)		1.000 (Ref)	
Private insurance	0.816 (0.670-0.993)	.042	0.867 (0.669-1.124)	.283
Government insurance	1.733 (1.429-2.101)	<.001	1.138 (0.881-1.471)	.322
Education				
≥21%	1.000 (Ref)		1.000 (Ref)	
13%-20.9%	1.093 (1.032-1.158)	.002	1.154 (1.063-1.253)	.001
7%-12.9%	1.048 (0.993-1.108)	.091	1.262 (1.156-1.377)	<.001
≤7%	0.879 (0.829-0.931)	<.001	1.287 (1.161-1.425)	<.001
Income				
≤$38,000	1.000 (Ref)		1.000 (Ref)	
$38,000-$47,999	1.073 (1.015-1.134)	.012	1.009 (0.931-1.093)	.827
$48,000-$62,999	0.937 (0.888-0.989)	.018	0.847 (0.778-0.923)	.001
≥$63,000	0.683 (0.648-0.719)	<.001	0.576 (0.522-0.634)	<.001
Residence				
Metropolitan area	1.000 (Ref)		1.000 (Ref)	
Urban/rural	1.144 (1.091-1.199)	<.001	0.887 (0.830-0.948)	.002
Charlson–Deyo score				
0	1.000 (Ref)		1.000 (Ref)	
1	0.57 (0.548-0.593)	<.001	0.551 (0.522-0.581)	<.001
≥2	0.743 (0.707-0.781)	<.001	0.643 (0.602-0.688)	<.001
Tumor size, mm	1.066 (1.064-1.069)	<.001	1.062 (1.059-1.066)	<.001
Histology				
Adenocarcinoma	1.000 (Ref)		1.000 (Ref)	
Squamous cell carcinoma	1.638 (1.574-1.706)	<.001	1.482 (1.406-1.563)	<.001
Others	0.239 (0.221-0.259)	<.001	0.136 (0.123-0.151)	<.001
NOS	8.052 (7.415-8.744)	<.001	4.441 (3.987-4.947)	<.001
Grade				
Well and moderately differentiated	1.000 (Ref)		1.000 (Ref)	
Poorly and undifferentiated	1.833 (1.748-1.922)	<.001	1.49 (1.407-1.577)	<.001
Unknown, high-grade dysplasia	14.5 (13.793-15.243)	<.001	18.128 (16.998-19.333)	<.001

OR, Odds ratio; *SD*, standard deviation; *NOS*, not otherwise specified.

TABLE E3. Cox regression analyses of overall survival of patients treated with SLR or SBRT

Variable	Univariate		Multivariate	
	HR	*P* value	HR	*P* value
Treatment				
SLR	1.000 (Ref)		1.000 (Ref)	
SBRT	1.945 (1.896-1.995)	<.001	1.568 (1.518-1.620)	<.001
Age, y, median ± SD; range, 4-90 y	1.033 (1.032-1.035)	<.001	1.022 (1.020-1.024)	<.001
Sex				
Male	1.000 (Ref)		1.000 (Ref)	
Female	0.7 (0.683-0.717)	<.001	0.768 (0.748-0.788)	<.001
Race				
White	1.000 (Ref)		1.000 (Ref)	
Non-white	0.878 (0.839-0.920)	<.001	0.916 (0.873-0.962)	<.001
Year of diagnosis				
2004-2009	1.000 (Ref)			
2010-2014	0.995 (0.969-1.022)	.723		
Facility type				
Academic/research program	1.000 (Ref)		1.000 (Ref)	
Nonacademic program	1.146 (1.117-1.176)	<.001	1.074 (1.045-1.104)	<.001
Facility location				
Eastern	1.000 (Ref)		1.000 (Ref)	
Central	1.182 (1.151-1.213)	<.001	1.063 (1.033-1.093)	<.001
Western	0.95 (0.912-0.990)	.015	0.941 (0.901-0.983)	.006
Primary payer				
Not insured	1.000 (Ref)		1.000 (Ref)	
Private insurance	0.882 (0.758-1.027)	.107	0.874 (0.747-1.022)	.092
Government insurance	1.477 (1.273-1.715)	<.001	1.016 (0.870-1.186)	.844
Education				
≥21%	1.000 (Ref)		1.000 (Ref)	
13%-20.9%	1.029 (0.988-1.071)	.17	1.001 (0.958-1.047)	.959
7%-12.9%	0.958 (0.921-0.996)	.031	0.975 (0.929-1.022)	.292
≤7%	0.854 (0.819-0.890)	0	0.946 (0.894-1.000)	.05
Income				
≤$38,000	1.000 (Ref)		1.000 (Ref)	
$38,000-$47,999	0.985 (0.947-1.023)	.433	0.959 (0.919-1.002)	.059
$48,000-$62,999	0.929 (0.894-0.965)	<.001	0.947 (0.904-0.992)	.021
≥$63,000	0.775 (0.746-0.804)	<.001	0.881 (0.836-0.929)	<.001
Residence				
Metropolitan area	1.000 (Ref)		1.000 (Ref)	
Urban/rural	1.19 (1.152-1.230)	<.001	1.033 (0.996-1.071)	.084
Charlson–Deyo score				
0	1.000 (Ref)		1.000 (Ref)	
1	1.073 (1.043-1.103)	<.001	1.143 (1.110-1.178)	<.001
≥2	1.408 (1.361-1.456)	<.001	1.389 (1.340-1.439)	<.001
Tumor size, mm	1.036 (1.034-1.037)	<.001	1.02 (1.018-1.022)	<.001
Histology				
Adenocarcinoma	1.000 (Ref)		1.000 (Ref)	
Squamous cell carcinoma	1.474 (1.433-1.516)	<.001	1.182 (1.147-1.218)	<.001
Others	0.767 (0.732-0.803)	<.001	0.924 (0.879-0.970)	.002
NOS	1.611 (1.545-1.680)	<.001	1.129 (1.078-1.182)	<.001
Grade				
Well and moderately differentiated	1.000 (Ref)		1.000 (Ref)	
Poorly and undifferentiated	1.496 (1.451-1.542)	<.001	1.242 (1.203-1.284)	<.001
Unknown, high-grade dysplasia	1.532 (1.487-1.578)	<.001	1.082 (1.043-1.122)	.001

HR, Hazard ratio; *SLR*, sublobar resection; *SBRT*, stereotactic body radiotherapy; *SD*, standard deviation; *NOS*, not otherwise specified.

TABLE E4. Factors associated with receipt of ablation versus SLR by logistic regression

Variable	Univariate		Multivariate	
	OR	*P* value	OR	*P* value
Age, y, median ± SD; range, 4-90 y	1.051 (1.044-1.057)	<.001	1.049 (1.041-1.057)	<.001
Sex				
Male	1.00 (Ref)		1.00 (Ref)	
Female	0.871 (0.782-0.971)	.013	0.951 (0.837-1.082)	.449
Race				
White	1.00 (Ref)		1.00 (Ref)	
Non-white	0.674 (0.540-0.841)	.013	0.867 (0.669-1.123)	.279
Year of diagnosis				
2004-2009	1.00 (Ref)		1.00 (Ref)	
2010-2014	0.668 (0.599-0.744)	<.001	0.888 (0.780-1.011)	.073
Facility type				
Academic/research program	1.00 (Ref)		1.00 (Ref)	
Nonacademic program	0.765 (0.687-0.852)	<.001	0.893 (0.783-1.018)	.091
Facility location				
Eastern	1.00 (Ref)		1.00 (Ref)	
Central	0.908 (0.809-1.019)	.102	1.025 (0.890-1.179)	.735
Western	0.738 (0.614-0.888)	<.001	0.876 (0.707-1.086)	.228
Primary payer				
Not insured	1.00 (Ref)			
Private insurance	0.849 (0.458-1.572)	.602		
Government insurance	1.487 (0.813-2.720)	.198		
Education				
≥21%	1.00 (Ref)		1.00 (Ref)	
13%-20.9%	1.084 (0.899-1.307)	.399	1.283 (1.019-1.617)	.034
7%-12.9%	1.253 (1.052-1.494)	.012	1.719 (1.352-2.184)	<.001
≤7%	1.045 (0.866-1.260)	.647	1.743 (1.321-2.299)	<.001
Income				
≤$38,000	1.00 (Ref)		1.00 (Ref)	
$38,000-$47,999	1.284 (1.081-1.524)	.004	1.191 (0.961-1.475)	.11
$48,000-$62,999	0.9 (0.755-1.073)	.239	0.645 (0.510-0.815)	<.001
≥$63,000	0.922 (0.782-1.088)	.339	0.584 (0.455-0.749)	<.001
Residence				
Metropolitan area	1.00 (Ref)		1.00 (Ref)	
Urban/rural	1.192 (1.030-1.379)	.018	1.025 (0.857-1.227)	.784
Charlson–Deyo score				
0	1.00 (Ref)		1.00 (Ref)	
1	0.863 (0.764-0.974)	.017	0.891 (0.772-1.029)	.116
≥2	1.097 (0.948-1.270)	.212	1.111 (0.933-1.322)	.238
Tumor size, mm	1.033 (1.026-1.040)	<.001	1.024 (1.015-1.032)	<.001
Histology				
Adenocarcinoma	1.00 (Ref)		1.00 (Ref)	
Squamous cell carcinoma	1.486 (1.311-1.683)	<.001	1.445 (1.244-1.678)	<.001
Others	0.455 (0.365-0.567)	<.001	0.225 (0.176-0.289)	<.001
NOS	7.766 (6.557-9.198)	<.001	3.998 (3.212-4.976)	<.001
Grade				
Well and moderately differentiated	1.00 (Ref)		1.00 (Ref)	
Poorly and undifferentiated	1.728 (1.469-2.033)	<.001	1.347 (1.125-1.612)	.001
Unknown, high-grade dysplasia	14.273 (12.510-16.284)	<.001	18.185 (15.602-21.195)	<.001

OR, Odds ratio; *SD*, standard deviation; *NOS*, not otherwise specified.

TABLE E5. Cox regression analyses of overall survival of patients treated with ablation or SLR

Variable	Univariate		Multivariate	
	HR	*P* value	HR	*P* value
Treatment				
Sublobar resection	1.000 (Ref)		1.000 (Ref)	
Ablation	2.284 (2.140-2.437)	<.001	2.038 (1.887-2.202)	<.001
Age, y, median ± SD; range, 4-90 y	1.037 (1.035-1.039)	<.001	1.029 (1.026-1.031)	<.001
Sex				
Male	1.000 (Ref)		1.000 (Ref)	
Female	0.665 (0.643-0.688)	<.001	0.738 (0.712-0.764)	<.001
Race				
White	1.000 (Ref)		1.000 (Ref)	
Non-white	0.865 (0.812-0.921)	<.001	0.951 (0.889-1.017)	.141
Year of diagnosis				
2004-2009	1.000 (Ref)		1.000 (Ref)	
2010-2014	0.795 (0.767-0.824)	<.001	0.874 (0.842-0.908)	<.001
Facility type				
Academic/research program	1.000 (Ref)		1.000 (Ref)	
Nonacademic program	1.236 (1.194-1.280)	<.001	1.104 (1.064-1.146)	<.001
Facility location				
Eastern	1.000 (Ref)		1.000 (Ref)	
Central	1.2 (1.158-1.244)	<.001	1.109 (1.067-1.152)	<.001
Western	0.977 (0.925-1.031)	.394	0.956 (0.903-1.013)	.128
Primary payer				
Not insured	1.000 (Ref)		1.000 (Ref)	
Private insurance	0.781 (0.647-0.942)	.01	0.768 (0.633-0.932)	.008
Government insurance	1.367 (1.137-1.644)	.001	0.921 (0.760-1.117)	.404
Education				
≥21%	1.000 (Ref)		1.000 (Ref)	
13%-20.9%	1.046 (0.990-1.105)	.109	1.035 (0.976-1.098)	.255
7%-12.9%	0.947 (0.898-0.998)	.042	0.978 (0.918-1.042)	.494
≤7%	0.81 (0.765-0.857)	<.001	0.917 (0.852-0.987)	.021
Income				
≤$38,000	1.000 (Ref)		1.000 (Ref)	
$38,000-$47,999	0.959 (0.909-1.011)	.119	0.948 (0.894-1.005)	.072
$48,000-$62,999	0.905 (0.859-0.953)	<.001	0.947 (0.890-1.007)	.084
≥$63,000	0.735 (0.699-0.772)	<.001	0.862 (0.804-0.925)	<.001
Residence				
Metropolitan area	1.000 (Ref)		1.000 (Ref)	
Urban/rural	1.264 (1.209-1.321)	<.001	1.057 (1.006-1.109)	.027
Charlson–Deyo score				
0	1.000 (Ref)		1.000 (Ref)	
1	1.245 (1.199-1.293)	<.001	1.161 (1.116-1.208)	<.001
≥2	1.628 (1.556-1.703)	<.001	1.412 (1.347-1.482)	<.001
Tumor size, mm	1.032 (1.030-1.034)	<.001	1.02 (1.017-1.022)	<.001
Histology				
Adenocarcinoma	1.000 (Ref)		1.000 (Ref)	
Squamous cell carcinoma	1.45 (1.396-1.506)	<.001	1.122 (1.077-1.168)	<.001
Others	0.816 (0.774-0.860)	<.001	0.902 (0.853-0.954)	<.001
NOS	1.572 (1.449-1.706)	<.001	1.026 (0.937-1.122)	.58
Grade				
Well and moderately differentiated	1.000 (Ref)		1.000 (Ref)	
Poorly and undifferentiated	1.494 (1.440-1.550)	<.001	1.291 (1.241-1.343)	<.001
Unknown, high-grade dysplasia	1.09 (1.032-1.152)	.002	0.995 (0.932-1.062)	.877

HR, Hazard ratio; *SD*, standard deviation; *NOS*, not otherwise specified.

TABLE E6. Demographic and clinicopathologic characteristics of patients treated with SLR or SBRT after matching

Variable	No. patients (%) SLR (n = 9967)	SBRT (n = 9967)	*P* value
Age, y, median ± SD; range, 40-90 y	73 ± 9	73 ± 9	.266
Sex			.875
Male	4409 (44.2)	4420 (44.3)	
Female	5558 (55.8)	5547 (55.7)	
Race			.606
White	9067 (91.0)	9046 (90.8)	
Non-white	900 (9.0)	921 (9.2)	
Year of diagnosis			.432
2004-2009	2355 (23.6)	2308 (23.2)	
2010-2014	7612 (76.4)	7659 (76.8)	
Facility type			.977
Academic/research program	3762 (37.7)	3760 (37.7)	
Nonacademic program	6205 (62.3)	6207 (62.3)	
Facility location			.509
Eastern	4167 (41.8)	4087 (41.0)	
Central	4575 (45.9)	4631 (46.5)	
Western	1225 (12.3)	1249 (12.5)	
Primary payer			.600
Not insured	97 (1.0)	85 (0.9)	
Private insurance	1505 (15.1)	1483 (14.9)	
Government insurance	8365 (83.9)	8399 (84.3)	
Education			.989
≥21%	1422 (14.3)	1429 (14.3)	
13%-20.9%	2660 (26.7)	2639 (26.5)	
7%-12.9%	3526 (35.4)	3530 (35.4)	
≤7%	2359 (23.7)	2369 (23.8)	
Income			.884
≤$38,000	1704 (17.1)	1743 (17.5)	
$38,000-$47,999	2455 (24.6)	2454 (24.6)	
$48,000-$62,999	2865 (28.7)	2862 (28.7)	
≥$63,000	2943 (29.5)	2908 (29.2)	
Residence			.630
Metropolitan area	8215 (82.4)	8189 (82.2)	
Urban/rural	1752 (17.6)	1778 (17.8)	
Charlson–Deyo score			.504
0	5195 (52.1)	5277 (52.9)	
1	3047 (30.6)	3001 (30.1)	
≥2	1725 (17.3)	1689 (16.9)	
Tumor size, mm, median ± SD	20.3 ± 8.3	20.3 ± 7.7	.476
Histology			.109
Adenocarcinoma	5263 (52.8)	5287 (53.0)	
Squamous cell carcinoma	3463 (34.7)	3501 (35.1)	
Others	725 (7.3)	640 (6.4)	
NOS	516 (5.2)	539 (5.4)	
Grade			.838
Well and moderately differentiated	4785 (48.0)	4820 (48.4)	
Poorly and undifferentiated	3238 (32.5)	3200 (32.1)	
Unknown, high-grade dysplasia	1944 (19.5)	1947 (19.5)	
30-d unplanned hospital readmission			<.001
No unplanned readmission	9564 (96.0)	9928 (99.6)	
Unplanned readmission	403 (4.0)	39 (0.4)	

SLR, Sublobar resection; *SBRT*, stereotactic body radiotherapy; *SD*, standard deviation; *NOS*, not otherwise specified.

TABLE E7. Demographic and clinicopathologic characteristics of patients treated with SLR or ablation after matching

Variable	No. patients (%) SLR (n = 1984)	Ablation (n = 1062)	*P* value
Age, y, median ± SD; range, 40-90 y	73 ± 8	74 ± 9	.06
Sex			.412
Male	866 (43.6)	480 (45.2)	
Female	1118 (56.4)	582 (54.8)	
Race			.974
White	1847 (93.1)	989 (93.1)	
Non-white	137 (6.9)	73 (6.9)	
Year of diagnosis			.218
2004-2009	808 (40.7)	457 (43.0)	
2010-2014	1176 (59.3)	605 (57.0)	
Facility type			.478
Academic/research program	792 (39.9)	438 (41.2)	
Nonacademic program	1192 (60.1)	624 (58.8)	
Facility location			.942
Eastern	963 (48.5)	515 (48.5)	
Central	793 (40.0)	429 (40.4)	
Western	228 (11.5)	118 (11.1)	
Primary payer			.484
Not insured	17 (0.9)	8 (0.8)	
Private insurance	327 (16.5)	158 (14.9)	
Government insurance	1640 (82.7)	896 (84.4)	
Education			.755
≥21%	231 (11.6)	132 (12.4)	
13%-20.9%	471 (23.7)	258 (24.3)	
7%-12.9%	758 (38.2)	409 (38.5)	
≤7%	524 (26.4)	263 (24.8)	
Income			.584
≤$38,000	304 (15.3)	174 (16.4)	
$38,000-$47,999	513 (25.9)	290 (27.3)	
$48,000-$62,999	471 (23.7)	247 (23.3)	
≥$63,000	696 (35.1)	351 (33.1)	
Residence			.479
Metropolitan area	1614 (81.4)	875 (82.4)	
Urban/rural	370 (18.6)	187 (17.6)	
Charlson–Deyo score			.787
0	971 (48.9)	507 (47.7)	
1	666 (33.6)	361 (34.0)	
≥2	347 (17.5)	194 (18.3)	
Tumor size, mm, median ± SD	18.6 ± 8.0	18.8 ± 7.6	.409
Histology			.069
Adenocarcinoma	1040 (52.4)	533 (50.2)	
Squamous cell carcinoma	590 (29.7)	330 (31.1)	
Others	174 (8.8)	77 (7.3)	
NOS	180 (9.1)	122 (11.5)	
Grade			.381
Well and moderately differentiated	609 (30.7)	301 (28.3)	
Poorly and undifferentiated	421 (21.2)	228 (21.5)	
Unknown, high-grade dysplasia	954 (48.1)	533 (50.2)	
30-d unplanned hospital readmission			.238
No unplanned readmission	1910 (96.3)	1013 (95.4)	
Unplanned readmission	74 (3.7)	49 (4.6)	

SLR, Sublobar resection; *SD*, standard deviation; *NOS*, not otherwise specified.

TABLE E8. Cox regression analyses of overall survival of patients after propensity score matching

Treatment	Overall			Tumor ≤2 cm		
	Median survival, mo	HR	*P* value	Median survival, mo	HR	*P* value
SLR vs ablation						
SLR	58.9 (54.4-63.5)	1.00 (Ref)	<.001	66.2 (63.4-69.0)	1.00 (Ref)	<.001
Ablation	33.5 (30.6-36.5)	1.906 (1.730-2.101)		39.1 (35.3-42.9)	1.962 (1.732-2.223)	
SLR vs SBRT						
SLR	60.4 (58.6-62.3)	1.00 (Ref)	<.001	67.5 (64.9-70.1)	1.00 (Ref)	<.001
SBRT	40.5 (39.4-41.5)	1.559 (1.497-1.623)		45.0 (43.5-46.6)	1.626 (1.538-1.720)	
Subgroup analysis						
SBRT	40.5 (39.4-41.5)	1.00 (Ref)		45.0 (43.5-46.6)	1.00 (Ref)	
Wedge resection	58.0 (56.0-59.9)	0.668 (0.640-0.697)	<.001	64.3 (61.4-67.2)	0.640 (0.604-0.679)	<.001
Segmental resection	71.4 (66.5-76.4)	0.529 (0.488-0.573)	<.001	77.5 (68.2-86.9)	0.482 (0.426-0.546)	<.001
SBRT		1.00 (Ref)			1.00 (Ref)	
VATS	66.3 (61.4-71.2)	0.554 (0.516-0.595)	<.001	70.4 (65.2-75.6)	0.523 (0.474-0.577)	<.001
Open surgery	60.2 (57.5-62.9)	0.654 (0.619-0.692)	<.001	65.1 (60.9-69.2)	0.64 (0.592-0.692)	<.001
Other or unknown	55.4 (52.6-58.2)	0.685 (0.648-0.723)	<.001	61.1 (56.6-65.7)	0.653 (0.605-0.706)	<.001

HR, Hazard ratio; *SLR*, sublobar resection; *SBRT*, stereotactic body radiotherapy; *VATS*, video-assisted thoracoscopic surgery.