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Original Research

LUNG CANCER

Use of New Treatment Modalities for Non-small Cell Lung Cancer Care in the Medicare Population

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Background: **Many older patients with early stage non-small cell lung cancer (NSCLC) do not receive curative therapy. New surgical techniques and radiation therapy modalities, such as video-assisted thoracoscopic surgery (VATS), potentially allow more patients to receive treatment. The adoption of these techniques and their impact on access to cancer care among Medicare beneficiaries with stage I NSCLC are unknown.**

Methods: **We used the Surveillance, Epidemiology and End Results-Medicare database to identify patients with stage I NSCLC diagnosed between 1998 and 2007. We assessed temporal trends and created hierarchical generalized linear models of the relationship between patient, clinical, and regional factors and type of treatment.**

Results: **The sample comprised 13,458 patients with a mean age of 75.7 years. The proportion of patients not receiving any local treatment increased from 14.6% in 1998 to 18.3% in 2007. The overall use of surgical resection declined from 75.2% to 67.3% ($P < .001$), although the proportion of patients undergoing VATS increased from 11.3% to 32.0%. Similarly, although the use of new radiation modalities increased from 0% to 5.2%, the overall use of radiation remained stable. The oldest patients were less likely to receive surgical vs no treatment (OR, 0.12; 95% CI, 0.09-0.16) and more likely to receive radiation vs surgery (OR, 13.61; 95% CI, 9.75-19.0).**

Conclusion: **From 1998 to 2007, the overall proportion of older patients with stage I NSCLC receiving curative local therapy decreased, despite the dissemination of newer, less-invasive forms of surgery and radiation.**

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Abbreviations: EBRT = external beam radiation therapy; HGLM = hierarchical generalized linear model; HRR = hospital referral region; IMRT = intensity-modulated radiation therapy; NSCLC = non-small cell lung cancer; SBRT = stereotactic body radiation therapy; SEER = Surveillance, Epidemiology and End Results; VATS = video-assisted thoracoscopic surgery

Surgery and radiation can be curative in stage I non-small cell lung cancer (NSCLC); untreated patients with stage I NSCLC have a 5-year survival of only 6% compared with an overall survival of 43% to 73% for all patients with stage I cancer.[1-3] Curative therapy should be offered to all patients for whom it is clinically appropriate. However, up to 20% of patients with early stage NSCLC have been described as medically inoperable.[4] Although new technologies have disseminated into clinical practice over the past decade, it is unknown whether these have led to increased access to treatment.

Video-assisted thoracoscopic surgery (VATS) reduces the morbidity of lung cancer surgery and improves quality of life for patients with lung cancer.[5,6] It is unknown how adoption of VATS is affecting access to surgical resection in older persons with NSCLC; that is, VATS may have been adopted primarily for the treatment of patients who traditionally would have received open surgery, resulting in no net increase in the use of surgical resection. Alternatively, the adoption of VATS on the population level may have increased the proportion of patients receiving surgery.

Stereotactic body radiation therapy (SBRT) uses multiple radiation beams and sophisticated accounting for motion to deliver biologically effective doses of radiation several times higher than standard external beam radiation therapy (EBRT).[7] Intensity-modulated

radiation therapy (IMRT) is a method of radiation planning that decreases normal tissue exposure.[8] It is also unclear whether these new radiation modalities are associated with an increased proportion of patients receiving radiation therapy or whether the new modalities are merely replacing existing modalities without any net gain in access to treatment.

Materials and Methods

Overview

We analyzed the Surveillance, Epidemiology and End Results (SEER)-Medicare data set for 1998 to 2007 to ascertain trends in the treatment of patients with stage I NSCLC. We used The Dartmouth Atlas of Health Care hospital referral regions (HRRs) to group patients into areas of similar health-care utilization. We constructed separate models to identify patient and regional factors independently associated with each radiation modality and to assess trends over time, and we estimated separate models to assess whether residence in an area of high VATS use was associated with surgical resection. The Yale Human Investigation Committee determined that this study did not constitute human subjects research.

Data Source and Study Population

The SEER-Medicare database links data from the SEER registries, covering 28% of the US population, with Medicare claims.[9] We identified patients aged 67 to 94 years diagnosed with stage I NSCLC between 1998 and 2007, using the American Joint Committee on Cancer stage variable in SEER prior to 2004 and the derived American Joint Committee on Cancer variable in SEER in 2004 and later. Patients were excluded if they had an unknown month of diagnosis, a prior cancer diagnosis, a second cancer diagnosis (other than lung cancer) during the study period, or a diagnosis based on autopsy specimen or death certificate or if they were not continuously enrolled in fee-for-service Medicare Parts A and B from 24 months prior to diagnosis through 12 months after diagnosis.

Construction of Variables

The primary independent variable was treatment modality. Patients were assigned to treatment groups based on Medicare claims and the following hierarchy: surgery, SBRT/proton therapy, IMRT, and EBRT. We selected the following patient variables a priori as factors that might influence decisions regarding treatment: age, sex, race, urban vs rural residence, marital status, and income. Clinical variables included comorbidity, tumor size, histology (e-Appendix 1), receipt of chemotherapy or invasive mediastinal staging, prior receipt of the influenza vaccine, admission for COPD exacerbation in the year prior to diagnosis, and life expectancy. We used Healthcare Common Procedure Coding System and *International Classification of Diseases, Ninth Revision*, codes to identify treatments and invasive staging (e-Appendix 2).

US Department of Agriculture rural-urban continuum codes were used to classify patient area of residence. Comorbidity was assessed in two ways. First, Medicare claims for service in the previous 24 months through 3 months prior to diagnosis were used to identify the comorbid conditions recommended by Elixhauser et al,[10] which we previously determined to be significantly associated with survival. *International Classification of Diseases, Ninth Revision*, codes were used if they appeared on an inpatient claim or two or more outpatient or physician claims billed >30 days apart. Second, we created a variable to indicate whether a patient had been admitted for a COPD exacerbation in the year prior to diagnosis. A dichotomous variable to indicate whether a claim had been submitted for influenza vaccine for service in the previous 24 months through 3 months prior to diagnosis was created; this variable has been used previously as a marker for health-care system access.[11,12]

We used HRRs to examine geographic variation in the use of VATS.[13] In patients receiving a diagnosis in 2002 and later, we calculated the percentage of surgery patients in each HRR (with at least 20 surgical patients) who underwent VATS. We also examined the following HRR variables: hospital bed and physician density, Centers for Medicare & Medicaid Services Hospital Compare technical process quality measures composite quality score (for acute myocardial infarction, congestive heart failure, and pneumonia in 2007), percentage of Medicare enrollees with one or more ambulatory visits, percentage of doctors in primary care specialty, percent mortality among non-health maintenance organization participants, and overall Medicare expenditures per beneficiary.[14] We also constructed a dichotomous variable to indicate whether each patient's state of residence required a certificate of need to construct new radiation facilities.

Statistical Analysis

We summarized patient demographic, clinical, and utilization characteristics according to treatment group (no treatment, surgery, IMRT, EBRT, or SBRT/proton therapy) and calculated the number of patients per physician and per HRR and the percentage of patients in each treatment group for each year (1998-2007). Rather than assume that patient treatment was independent of the physician and geographic region, we examined the degree to which variance in treatment was attributable to each of these factors using hierarchical generalized linear models (HGLMs).[15] Because of the technical difficulties in estimating polytomous HGLMs, we estimated a series of logistic HGLMs. We modeled receipt of surgery using no treatment as the reference category and receipt of IMRT, EBRT, or SBRT/proton therapy using surgery as the reference category. To avoid overfitting and to assess the relationship between HRR factors and treatment, we estimated a series of two-level logistic HGLMs, one for each HRR factor and each treatment group, and included those that were significant ($P<.05$) in the corresponding full models. Finally, to assess any attenuating effect of the use of VATS, we conducted a subgroup analysis, extending these models to include a variable representing the percentage of patients receiving VATS, restricting this final analysis to the subset of HRRs for which VATS information was available. To account for calendar time, all models

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