

A National Analysis of the Complications, Cost, and Mortality of Percutaneous Lung Ablation

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ABSTRACT

Purpose: To perform a national analysis of the safety and cost of percutaneous image-guided lung malignancy ablation.

Materials and Methods: Using the National (Nationwide) Inpatient Sample, we evaluated complications, need for further intervention, in-hospital mortality, length of hospitalization, and hospital charges for patients undergoing inpatient percutaneous image-guided lung ablation in the United States during the period 2007–2011. Additionally, an analysis of the relationship between specific patient factors, procedural complications, and mortality was performed.

Results: The study group consisted of 3,344 patients, including 2,072 (61.9%) patients treated for primary lung carcinomas and 1,277 (38.1%) patients treated for pulmonary metastatic disease. In-hospital mortality occurred after 43 (1.3%) ablation procedures. A Charlson comorbidity index score ≥ 4 was associated with higher mortality (odds ratio [OR], 2.84; 95% confidence interval [CI], 1.16–6.91). Pneumothorax was the most common complication (38.4%), followed by pneumonia (5.7%) and effusion (4.0%). Neither pneumothorax nor chest tube insertion was associated with higher in-hospital mortality rates (pneumothorax, OR, 1.10; 95% CI, 0.59–2.04, and chest tube insertion, OR, 1.45; 95% CI, 0.78–2.68). Surgical reintervention via thoracoscopy or thoracotomy occurred in 31 cases (0.9%). Median length of hospitalization was 1 day (interquartile range, 1–3 d), and median hospital charges were \$22,320 (interquartile range, \$13,705–\$43,026).

Conclusions: Percutaneous image-guided lung ablation of primary and metastatic disease has an acceptable safety profile, and surgical reintervention is rarely required. The most frequent complications of percutaneous lung ablation were not associated with increased in-hospital mortality.

ABBREVIATIONS

CCI = Charlson comorbidity index, CCS = Clinical Classifications Software, CI = confidence interval, COPD = chronic obstructive pulmonary disease, ICD-9 = International Classification of Diseases, 9th Revision, IQR = interquartile range, NIS = National (Nationwide) Inpatient Sample, NSCLC = non-small cell lung cancer, OR = odds ratio, SBRT = stereotactic body radiation therapy

More than 224,000 cases of lung and bronchial malignancy were diagnosed in the United States in 2014 (1). These neoplasms are the leading cause of cancer-related mortality for men and women with nearly 160,000 estimated deaths in 2014 (1). Additionally, the lung is the second most common site of metastatic disease from

extrathoracic malignancies, with up to 20% of these patients harboring only pulmonary metastases (2). Although surgical resection is the mainstay of treatment in stage I and II non-small cell lung cancer (NSCLC) and select cases of metastatic disease to the lung, medical comorbidities or poor pulmonary reserve preclude operative intervention in many patients (3). Untreated, these individuals have grim prognoses and limited therapeutic options. Percutaneous ablation and stereotactic body radiation therapy (SBRT) have gained increasing international acceptance as treatment modalities for nonsurgical candidates. Percutaneous thermal ablation is a minimally invasive alternative to surgical resection in appropriately selected patients with small primary pulmonary malignancy or limited metastatic disease, with an acceptable safety profile and oncologic efficacy (4–18).

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Despite the growing acceptance of pulmonary thermal ablation, reported rates of complications vary considerably. Rates of pneumothorax after percutaneous lung ablation range from 11% to 52% based on a literature review by Hiraki et al (2). Fatal complications after radiofrequency (RF) ablation of lung tumors led the US Food and Drug Administration to issue a public statement regarding deaths after RF ablation (2). Additionally, the relationship between frequently seen lung ablation complications and in-hospital mortality has not been evaluated. The purpose of this study was to perform a national analysis of the complications, mortality, and cost of percutaneous image-guided lung ablation using the National (Nationwide) Inpatient Sample (NIS).

MATERIALS AND METHODS

Patient Population

The NIS database for 2007–2011 was purchased from the Health Care Utilization Project of the Agency for Healthcare Research and Quality (Rockville, Maryland). The NIS is a hospital discharge database that represents 20% of all inpatient admissions to nonfederal hospitals in the United States. We selected all patients receiving percutaneous lung ablation (International Classification of Diseases, 9th Revision [ICD-9] procedure code 3224). Patients treated with open ablation were not included in the analysis. Using the NIS, 3,344 patients were identified to have undergone percutaneous lung ablation, and all of these patients were included for analysis. For each patient, the following demographic information was collected: age, gender, race (white vs nonwhite), elective versus nonelective admission, insurance status, and Charlson comorbidity index (CCI) score (19). Malignancy types were identified using Clinical Classifications Software (CCS) codes. The following malignancies identified: primary lung lesion (CCS 19–20), gastrointestinal primary (CCS12–18), genitourinary primary (CCS 25–34), head and neck primary (CCS 11), and melanoma (CCS 22). The following patient comorbidities were identified using ICD-9 and CCS codes: smoking (ICD-9 3051), asthma (CCS 128), coronary artery disease (CCS 101), and chronic obstructive pulmonary disease (COPD) (CCS 127).

Outcomes

The primary outcome of this study was in-hospital mortality. Additional outcomes studied included length of hospital admission and hospital charges (inflation adjusted for 2011). Inflation adjustments were calculated using the Bureau of Labor Statistics consumer price index calculator (<http://data.bls.gov/cgi-bin/cpiccalc.pl>). Complications studied included respiratory failure/arrest (ICD-9 51881, 7891, and 51884), pneumothorax (ICD-9 5120–5128), hemoptysis (ICD-9 7863), effusion (ICD-9

5111–5119), pneumonia (CCS 122), empyema (ICD-9 5100–5109), lung collapse (ICD-9 5180), and other postoperative respiratory complications (ICD-9 9973). We also reviewed the proportion of patients requiring the following additional procedures: thoracoscopy/thoracotomy (ICD-9 3402, 3431), transfusion (ICD-9 9904), and chest tube insertion (CCS 39). Finally, we analyzed for associations between the above-listed patient comorbidities, complications, required additional procedures, and in-hospital mortality.

Statistical Analysis

All categorical variables were compared with χ^2 test. All continuous variables were compared with Student *t* test. When determining which comorbidities, complications, and additional procedures were associated with mortality, odds ratio (OR) with corresponding 95% confidence interval (95% CI) was calculated. All data analysis was performed using the SAS-based statistical software package JMP V.9.0 (www.jmp.com; SAS Institute Inc, Cary, North Carolina).

RESULTS

Patient Population

The mean age of the treated cohort was 68.3 years \pm 31.0. Of treated patients, 1,738 (52.1%) were women, and 2,607 (88.5%) were white. Payment for 2,328 (69.5%) cases was via Medicare, and payment for 76 (2.3%) cases was via Medicaid. Primary lung cancer was treated in 2,072 (61.9%) patients, and pulmonary metastases were treated in 1,277 (38.1%) patients. COPD was the most common underlying comorbidity, found in 1,243 patients (37.1%). Median CCI score was 4 (interquartile range [IQR], 3–5). These data are summarized in **Table 1**.

Outcomes and Complications

In-hospital mortality occurred in 43 patients undergoing lung ablation (1.3%). Of these patients, 38 (1.8%) were treated for primary lung cancers, and 5 (0.4%) were treated for metastatic disease to the lung. In-hospital mortality was significantly elevated in primary lung treatment sessions ($P = .0002$). Median length of hospitalization after percutaneous lung ablation was 1 day (IQR, 1–3 d). Median hospital charges were \$22,320 (IQR, \$13,705–\$43,026). Pneumothorax was the most common complication of lung ablation and occurred in 1,286 (38.4%) cases. Chest tubes were placed in 1,069 (31.9%) patients. Respiratory failure was observed in 118 (3.5%) cases. Pneumonia complicated 190 (5.7%) procedures, and empyema occurred in 11 (0.3%) cases. Conversion to thoracoscopy/thoracotomy was required in only 31 cases (0.9%). These data are summarized in **Table 2**. Additionally, the prevalence of patient comorbidities and CCI score before procedures and the

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