Original Investigation

Low-dose Lung Cancer Screening at an Academic Medical Center: Initial Experience and Dose Reduction Strategies

Altan Ahmed, MD, MS, Nupur Verma, MD, Izabella Barreto, PhD, Tan-Lucien Mohammed, MD

Rationale and Objectives: Implementation of low dose computed tomography (LDCT) lung cancer screening programs has followed the demonstration of reduced lung cancer mortality in the National Lung Screening Trial and subsequent consensus screening recommendations. Here we aim to assess the initial results of a screening program at an academic medical center, to discuss the challenges of implementing such a program, and suggest strategies for reducing patient dose.

Materials and Methods: Retrospective review of all patients who underwent LDCT lung cancer screening at our institution between March 2015 and July 2016 was performed to assess the lung cancer detection rate, the spectrum of imaging findings (nodule or mass characteristics, degree of emphysema, etc.), and patient radiation dose indices.

Results: A total of 272 patients were screened during the study period. Approximately 50% ($n = 135$) were women. The lung cancer detection rate was 2.2% ($n = 6$). One patient underwent chemoradiation therapy, whereas the remainder underwent uneventful thoracoscopic resection. Approximately, 80% of screened patients met United States Preventative Services Task Force criteria for LDCT screening. The median pack-years of smoking was 42 pack-years. The mean volume CT dose index for the screening CTs was 3.12 mGy. Utilizing tube current modulation and iterative reconstruction, where available, resulted in lower patient doses.

Conclusion: Initial LDCT lung cancer screening at our institution yielded results similar to those of the National Lung Screening Trial. Thorough prescreening evaluation, joint decision-making, centralized coordination of screening-related care, and patient size conscious scanning protocols are critical elements of a safe and successful lung cancer screening program.

Key Words: Low-dose CT; lung cancer screening; cancer detection; dose reduction.

INTRODUCTION

Lung cancer is the leading cause of cancer death worldwide, accounting for an estimated 13% of new cancer diagnoses and 27% of all cancer deaths (1). Despite advances in medical and surgical intervention and imaging techniques, the overall 5-year survival rate for those diagnosed with lung or bronchial cancer is 17.8%, largely in part due to the advanced stage at diagnosis (2).

The development of effective lung cancer screening tools has remained challenging. Early studies of computed tomography (CT) demonstrated increased sensitivity for detecting lung cancer, but single-arm design precluded assessment of mortality benefit (3–6). The National Lung Cancer Screening Trial (NLST) demonstrated that lung cancer screening using low-dose computed tomography (LDCT) not only detected more nodules and cancers than conventional chest radiography, but that disease was discovered at an earlier stage than with conventional chest radiography, providing a survival benefit with 20% reduction in lung cancer-related mortality (7).

In December 2013, the United States Preventive Services Task Force recommended LDCT screening for lung cancer in individuals aged 55–80 with greater than 30 pack-years of smoking, who currently smoke, or have quit smoking within the last 15 years (8). This was followed in February 2015 by the Centers for Medicare & Medicaid Services (CMS) final approval to provide coverage for annual LDCT for lung cancer screening for high-risk individuals (9).

With growing evidence of the mortality benefit of LDCT for lung cancer screening and the rapid institution of screening programs nationwide, the need for standardization and uniformity in reporting and establishing a system that facilitates data tracking was evident. Building on the success of the Breast Imaging Reporting and Data System in mammographic imaging, the Lung-RADS structured reporting system was developed and implemented by the American College

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From the Department of Radiology, College of Medicine—University of Florida, PO Box 100374, Gainesville, FL 32610-0374. Received August 23, 2017; revised December 24, 2017; accepted December 24, 2017. **Address correspondence to:** A.A. e-mail: ahmeaf@radiology.ufl.edu

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of Radiology (10,11). By assigning a single score that is associated with a specific risk level and clear action recommendation to each screening examination, the ambiguity regarding management of imaging findings is greatly reduced.

Based on these experiences and resources, our tertiary referral center joined health-care systems across the country with implementation of an LDCT lung cancer screening program in March 2015. Here, we review our program experience and clinical findings in the initial cohort of 272 screened individuals.

MATERIALS AND METHODS

Study Population

This retrospective clinical study was performed with approval from our Institutional Review Board. Written informed consent was waived because of the retrospective nature of the study in accordance with institution policies. All patients who underwent lung cancer screening with LDCT between March 2015 and July 2016 at our institution were included in the study. The decision to image was made prior to this retrospective review and was based on current screening guidelines and referral from clinicians.

Computed Tomography Scan Acquisition

All lung cancer screening LDCT examinations were carried out using seven helical CT scanners with 16, 64, 160, or 320 rows of detectors, at hospital-based and freestanding imaging facilities. The acquisition protocols utilized scan parameters adapted from reduced-dose chest CT protocols as deemed necessary by CT technologists, taking into account beam and section collimations available in each scanner, as well as dose reduction capabilities. All scanners offered dose reduction by means of tube current modulation, while two scanners offered additional dose reduction with iterative reconstruction algorithms. All patients were scanned in the supine position during a single breath hold. The scan range extended from the thoracic inlet to the bottom of the lungs.

Data Abstraction

The electronic medical record and the picture archiving and communication system (PACS) (Visage Imaging, San Diego, CA) at our institution were accessed retrospectively to collect and analyze the demographics of patients undergoing screening, findings at screening (nodule or mass characteristics, degree of emphysema, presence of lymphadenopathy, Lung-RADS score, and incidental findings), results of diagnostic procedures obtained as a result of LDCT screening, and pathologic or surgical data if available. Examinations that did not include a Lung-RADS score were re-reviewed and assigned a score to meet standardized reporting at our institution. Incidental findings were considered significant if they required additional clinical evaluation or indicated the presence of a previously undiagnosed condition. Furthermore, scanner model, examination acquisition techniques (kVp, mAs), and dose metrics (volume CT dose index [$CTDI_{vol}$], DLP) were recorded for each patient.

Statistical Analysis

Descriptive statistics were applied to quantify the outcome of LDCT screening.

RESULTS

Patient Characteristics

Of the 272 individuals who underwent lung cancer screening with LDCT, 50% ($n = 135$) were female. The median age was 64 (range 29–82), and the median pack-years of smoking was 42 (range 0–160). Approximately 80% (n = 218) of screened individual met United States Preventive Services Task Force criteria for lung cancer screening. Of the 54 people who did not meet criteria, 6 were out of age range, 47 did not meet minimum pack years of smoking, and 1 person did not meet either criterion (Table 1).

Clinical Findings

A comparison chest CT was available in approximately 25% ($n = 69$) of screened individuals. The mean time between comparison and screening CT was approximately 25.6 months. The mean number of nodules characterized per examination was 0.83 (range 0–8). The number of patients with 0, 1, and 2 or greater nodules was 151, 68, and 53, respectively. The radiographic severity of emphysema was characterized as none, minimal, mild, moderate, or severe in 40.1%, 15.1%, 26.1%, 12.5%, and 6.2% of patients, respectively (Fig 1). Approximately 6.6% of individuals had lymphadenopathy by size criteria ($n = 18$). The distribution of assigned Lung-RADS scores was as follows: 0 (0.4%, $n = 1$), 1 (46.7%, $n = 127$), 2 (33.4%, $n = 91$), 3 (9.9%, $n = 27$), and 4 (9.6%, $n = 26$) (Fig 2, Table 2).

TABLE 1. Baseline Characteristics of the Screened Cohort

Demographic	
Mean age	64 (range 29–82)
Sex	
Female	135 (50%)
Male	137 (50%)
Mean smoking duration (pack-years)	42
History of malignancy*	
Yes	56 (21%)
No	216 (79%)
Met USPSTF screening criteria	
Yes	218 (80%)
No	54 (20%)

USPSTF, United States Preventive Services Task Force.
* ≥5 years prior to screening, excluding nonmelanoma skin cancer.