Review Article

A narrative review of lung cancer screening implementation: increasing utilization of evidence-based practice

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Contributions: (I) Conception and design: Both authors; (II) Administrative support: Both authors; (III) Provision of study materials or patients: Both authors; (IV) Collection and assembly of data: Both authors; (V) Data analysis and interpretation: Both authors; (VI) Manuscript writing: Both authors; (VII) Final approval of manuscript: Both authors.

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Abstract: Cancer is the second leading cause of death in the United States, with lung cancer causing more cancer deaths annually than any other primary site. The high mortality is, in part, due to the lack of symptoms during early stage disease. There is therefore a resultant delay in diagnosis until lung cancer has progressed to later stages, when fewer if any potentially curative options exist. Low-dose computed tomography (LDCT) scanning for screening of high-risk patients has been found to identify lung cancer at earlier stages, and this has corresponded both with an increase in curative intervention and a decrease in lung cancer mortality. Although lung cancer screening carries a relatively low risk of harm, it remains underutilized. The rates of eligible patients that undergo lung cancer screening varies regionally, with rates of screening ranging from less than 4% of eligible patients up to 18% in some states. This low rate of screening has persisted over the past few years despite recommendations for lung cancer screening from national and international organizations. Improving utilization rates requires identification of barriers to screening and strategies to resolve these barriers. As screening utilization rates increase, continued improvement in rates of early diagnosis and mortality from lung cancer would then be expected to follow.

Keywords: Lung cancer; screening; utilization; quality improvement

Received: 23 September 2020; Accepted: 30 October 2020; Published online: 18 November 2020.
doi: 10.21037/ccts-20-162
View this article at: http://dx.doi.org/10.21037/ccts-20-162

Introduction

Lung cancer is the leading cause of cancer deaths in the United States in both men and women, with an expected 135,720 deaths in 2020 (1). Overall 5-year survival for lung cancer is 20.5%, but not surprisingly, survival varies dramatically depending on the stage at diagnosis; 5-year survival for disease confined to the primary site is 59%, falling to 31.7% when regional lymph nodes are involved, with a dismal 5.8% 5-year survival when distant metastasis is present (2). Additionally, only a minority of patients are diagnosed with localized and regional disease: 17% and 22%, respectively. Diagnosis at an earlier stage is therefore attractive so that potentially curable disease can be identified before regional and distant metastatic spread. Volumetric computed tomography (CT) imaging allows for high resolution imaging, and The National Lung Screening Trial (NLST) showed a 20% reduction in mortality from lung cancer with low-dose computed tomography (LDCT) screening as compared with chest radiography after a median follow up of 6.5 years (3). Extended follow-up has confirmed a true prevention of lung cancer death as opposed to delaying time of death due to lead time bias (4). The recently published Nederlands-Leuvens Longkanker Screenings Onderzoek (NELSON) trial also demonstrated a lung cancer mortality reduction in both men and women who underwent CT scanning as opposed to no screening (5).

LDCT screening for high-risk patients is recommended by the U.S. Preventive Services Task Force (USPSTF) and

multiple professional organizations. Despite the results of the aforementioned trials and the recommendations of professional societies, less than 4% of eligible patients underwent LDCT screening in 2015, with some improvement in 2018, although the utilization rate remained low at 14.4% (6,7). The lack of widespread utilization is likely multi-factorial due to physician-related, patient-related, and health system-related barriers. Once barriers to screening are identified, strategies to overcome these can be implemented to improve screening rates. We present the following article in accordance with the Narrative Review reporting checklist (available at https://ccts.amegroups.com/article/view/10.21037/ccts-20-162/rc).

Methods

We searched PubMed using the keywords "lung cancer screening", "lung cancer screening implementation", and "smoking cessation" from January 1, 1990, to August 1, 2020. Systematic and narrative reviews, randomized clinical trials, retrospective and cohort studies written in English were evaluated for inclusion. North American guidelines were also included.

Efficacy of LDCT

Efforts to screen for lung cancer have been ongoing since the 1970s with randomized controlled trials evaluating the benefit of chest radiographs with or without sputum cytology obtained every 4 months (8-10). None of these trials resulted in a decrease in lung cancer mortality. CT scanning has the benefit of increased resolution and volumetric imaging. The National Cancer Institute (NCI) sponsored a large randomized controlled trial, the NLST, which enrolled 53,454 persons from 2002–2004 at high-risk for lung cancer to evaluate if screening with LDCT scanning would result in a mortality benefit compared with chest radiography (3). Patients were between 55 and 74 years of age with an at least 30 pack-year history of cigarette smoking and who were either current smokers or had quit no more than 15 years prior to randomization.

Participants underwent three annual screens, and suspicious findings were communicated to the patient and the patient's health care provider. The LDCT group had 95% adherence to the three rounds of screening, and the radiography group had a 93% adherence rate. The LDCT group had significantly more lung cancers diagnosed (RR: 1.13; 95% CI: 1.03–1.23), cancer was diagnosed at an earlier stage, and lung cancer mortality was decreased by 20%. The number needed to screen to prevent one lung cancer mortality was 320. LDCT positive screening tests did have a relatively high false positive rate, which have since fallen since the introduction of Lung Imaging Reporting and Data System (Lung-RADS) by the American College of Radiology in 2014; when Lung-RADS was retrospectively applied to the NLST the false positive rate fell from 26.6% to 12.8% (11). Extended follow up from the NLST with median follow-up times of 11.3 years for incidence and 12.3 years for mortality confirmed a mortality benefit with a number needed to screen of 303 which was similar to earlier results (4).

Multiple European studies were also conducted to assess the benefit of LDCT screening. Only one of these was sufficiently powered to demonstrate a mortality benefit, the NELSON trial in the Netherlands and Belgium. Results of this were recently published (5). This was a population-based, randomized controlled trial comparing LDCT screening with a control group that did not undergo any formal screening. Eligibility included current and former smokers if they had quit less than or equal to 10 years prior and had smoked at least 15 cigarettes daily for 25 years or at least 10 cigarettes for 30 years. From 2003–2006, 15,792 participants were randomized to no formal screening and LDCT screening at baseline with subsequent LDCT screening at year 1, year 3, and year 5.5 from the initial screening scan. Of the total participants, 13,195 were male. Lung cancers detected by screening were diagnosed at an earlier stage (58.6% stage IA or IB) compared with the control group (13.5% stage IA or IB). Lung cancer mortality was decreased by 24%. Subset analysis of the smaller number of women revealed decreased mortality of 33%.

Current recommendations

Following the results of the NLST, the USPSTF in 2013 recommended annual screening with LDCT in adults ages 55 to 80 years who had a 30 pack-year history and were either current smokers or have quit within the previous 15 years (12). These recommendations are currently being updated based on review of LDCT screening programs to identify the most efficient strategies to avoid lung cancer deaths and to maximize life-years gained; the draft recommendation is to screen adults ages 50 to 80 years who have a 20 pack-year smoking history and are either current smokers or have quit within the past 15 years (13).

Other professional organizations, such as the National

Comprehensive Cancer Network (NCCN) and the American College of Clinical Pharmacy (ACCP) have similar recommendations with some variance. The NCCN currently recommends screening for high-risk patients defined as ages 55 to 77 years and a greater than or equal to 30 pack-year history with smoking cessation less than 15 years or for patients 50 years or older with a greater than or equal to 20 pack-year history and an additional risk factor that increases the risk of lung cancer to greater than or equal to 1.3% based on a risk prediction calculator (14). The ACCP recommend annual screening with LDCT for asymptomatic adults 55 to 77 years who have smoked at least 30 pack-years and who are current smokers or have quit within the past 15 years (15). The Centers for Medicare and Medicaid Services (CMS) issued a determination of coverage for lung cancer screening, counseling, and shared decision making in 2015, with eligibility including patients aged 55 to 77 years who are asymptomatic, have a smoking history of at least 30 pack-years, and who are either current smokers or have quit within the prior 15 years (16).

Current utilization rates

Cigarette use is declining, but there are still an estimated 34 million current adult cigarette smokers with 94 million current or former smokers in the United States (17-19). Despite the benefits of diagnosis of lung cancer at an earlier stage and reduction in lung cancer mortality, widespread adoption of screening in high-risk patients has been slow. From the 2010 National Health Interview Survey (NHIS), 4.4% of patients who were former smokers at high-risk for lung cancer and 1.8% of current smokers at high-risk for lung cancer based on NLST criteria underwent a LDCT for screening purposes (20). The NLST results and subsequent 2013 USPSTF recommendation were released in the interim before the 2015 NHIS, in which Jemal and Fedewa found that the percentage of eligible patients who underwent LDCT screening the in the prior 12 months remained low, at 3.9%, without any significant increase in screening for any socioeconomic group (6). The Behavioral Risk Factor Surveillance System (BRFSS) is a population-based telephone survey from 10 states, and the 2017 survey was analyzed by Zahnd and Eberth. As increased insurance coverage for LDCT screening has been implemented, increased rates of screening were expected, but still only 14.4% of eligible high-risk patients had undergone LDCT screening (7). Participation varied by state with rates varying from 6.5% in Nevada to 18.1% in Florida.

Review of Medicare fee-for-service beneficiary data from 2015–2017 revealed that the highest utilization of screening was in 10 states, the majority of which were in the Northeast United States (21). Interestingly, none of these states had the highest lung cancer mortality or prevalence of current smokers. In addition, the states that did have the highest mortality and current smokers were in the Southeast United States and also had a population with the lowest socioeconomic status and were below the national median for LDCT utilization.

Barriers to utilization

Increased utilization requires physicians and health care providers to understand the benefits of screening, identify appropriate patients, and participate in shared decision-making and counseling. Patients at high-risk for lung cancer need to be aware of and understand the purpose of screening. Additionally, health care systems need to be accessible, and have screening infrastructure in place that is affordable and cost-effective.

Physician-related barriers

Despite the results of NLST being published in 2011, there is still a lack of understanding of the benefits of lung cancer screening amongst health care providers. Provider surveys have revealed that clinicians understand that tobacco use history is the major risk factor needed for screening. However, they were unaware of efficacy of LDCT screening regarding the decrease in mortality and the relatively low number needed to screen to prevent a cancer related death compared with other commonly performed screening tests such as mammography and colonoscopy. Providers were also unaware of coverage for screening by CMS and private insurers, with confusion of who exactly is eligible based on the differing recommendations from the organizations also a likely contributing factor (22-24). In addition, when primary care providers at different healthcare settings were surveyed, academic and community based providers were more likely to understand the purpose of screening than their colleagues at a safety-net hospital (25). Low provider awareness of lung cancer screening recommendations also has resulted in inappropriate ordering of chest radiographs instead of LDCT (26). A 2019 survey of internal medicine residents in Indianapolis found that although a majority were aware there was a lung cancer specific benefit to screening, they were not aware of the appropriate

demographic and smoking history combination for high-risk stratification (27).

Patient-related barriers

Patient awareness regarding LDCT screening represents another challenge. Simmons *et al.* reported on in-person focus groups of high-risk patients, and the majority of patients had no awareness of LDCT lung cancer screening (28). Once they were informed of lung cancer screening, some patients expressed a fear of bad results and costs associated with screening. A cohort of patients who had been referred for LDCT screening believed CT technology to be accurate and useful, and patients who had been referred but had not yet undergone scanning did express an intention to be screened in the future (29).

Patient characteristics such as medical comorbidities (COPD) and socioeconomic factors (age, race, insurance status) are also associated with LDCT utilization. Recent further analysis of the 2017 BRFSS survey to identify predictors of LDCT utilization was reported by Zgodic *et al.* (30). Patients were significantly statistically more likely to undergo screening for lung cancer if they were insured, had COPD, had a personal past medical history of cancer, self-reported poor health, and had a primary care provider. Patients aged 65–69 years also had increased screening rates compared with patients 55–64 years. A report from a safety net hospital in Massachusetts found their lung cancer screening rate to be 16.1%, with unscreened patients more likely to be older, African American, and with a lower median income (31). At the authors' institution with a well-established lung cancer screening program, LDCT utilization from the primary care network was 19%, with patients less likely to be screened being younger and white (unpublished data).

System-related barriers

Primary care providers in academic, community, and safety-net systems have all reported a lack of electronic medical record (EMR) notification for potential lung cancer screening candidacy as a barrier to increasing utilization (25). However, reliance on an EMR to generate appropriate notifications depends on the existence of accurate information. Modin *et al.* reviewed the EMR entries of 252 eligible patients referred to a regional lung cancer screening program, finding a 96.2% discordance between the pack-year history in the EMR with what was reported in the shared decision-making conversation (32). In that analysis, if the EMR had been relied upon for pack-year history, greater than half of the patients appropriately referred would have been deemed ineligible due to under-reporting of tobacco use.

Access to health care systems and appropriate referrals for different demographics of high-risk patients varies regionally. In addition to race and socioeconomic status, presence of mental illness and gender status has an effect on lung cancer screening utilization rates. Individuals with severe mental illness such as schizophrenia have earlier mortality than the general population for multiple causes, including cancer due to higher smoker prevalence and challenges navigating the health care system (33). A survey of 112 adults with schizophrenia revealed that 88% had seen a primary care provider within the past year in addition to monthly visits with a psychiatrist, 34% met the high-risk criteria for lung cancer screening, yet only half of the current smokers were advised to quit, one-third were offered assistance with smoking cessation, and 13% were referred for smoking cessation counseling (34). Transgender individuals also have a disproportionate higher risk of lung cancer, and data from their responses in the BRFSS were analyzed (35). Only 2.3% of transgender participants reported undergoing screening compared with 17.2% of cisgender participants despite similar eligibility.

As mentioned previously, the distribution of available lung cancer screening is not homogenous. In the review of Medicare fee for service data, regions with lower socioeconomic status, higher lung cancer mortality, and a higher prevalence of current cigarette smokers had utilization rates below the national median, and an increase of both certified lung cancer screening facilities and providers are needed in these regions (21).

Cost and cost-effectiveness has been a perceived barrier to increased utilization as reported in the aforementioned physician surveys. CMS issued a national coverage determination for Medicare coverage with no out-of-pocket expense for LDCT in high-risk patients in 2015, with private insurers also covering screening due to the USPSTF Grade B recommendation. However, follow up testing such as positron emission tomography (PET) scan and procedures such as biopsy are subject to insurance copayment and likely represent a barrier for some patients. Cost-effective analyses performed have found that LDCT screening is cost-effective, falling below the $100,000 per quality-adjusted life-year threshold, although these analyses presume a much higher utilization rate than

currently exists (36,37).

Strategies to increase utilization

The addition of an evidence-based practice into routine clinical use has historically been reported to take 17 years (38). Implementation science is a relatively new field that promotes the systematic incorporation of evidence-based practices into routine practice to improve the quality and effectiveness of health services and care (39). Interventions using implementation science aim to change behaviors at provider, patient, system, and policy levels (40). Increased utilization of evidence-based lung cancer screening is an ideal target for implantation science. From a policy perspective, recommendations for screening are in place from the USPSTF and other professional organizations. Funding for lung cancer screening and smoking cessation programs, especially in communities where lung cancer mortality and smoking prevalence is high, is vital. National and regional grants are available to increase lung cancer screening. As an example, the National Football League Crucial Catch program, in conjunction with the American Cancer Society, recently issued Community Health Advocates implementing National Grants for Empowerment and Equity (CHANGE) grants to eight underserved community health centers for the purpose of increasing smoking cessation and lung cancer screening (41).

Continued provider education regarding the benefits of lung cancer screening is required. Incorporation of evidence-based practice in cancer screening has been shown to succeed in primary care settings with Plan-Do-Study-Act programs (42), and can be tailored to different practices for lung cancer. Furthermore, accurate documentation of smoking history is needed to identify high-risk patients. Patient navigators to assist with determining lung cancer eligibility, shared decision making, and facilitate appointments with primary care providers have been shown to increase LDCT utilization in community health centers, supplementing the role of primary care providers (43).

Trials have shown that high-risk patients who have an understanding of cancer and screening can increase utilization. Educational curriculums developed in collaboration with local community leaders that are appropriately targeted at high-risk demographics in lower-education and rural settings in easy to read content and graphic visual aids have been shown to increase engagement and motivation amongst target community members (44). Current smokers who are interested in quitting smoking are a prime target for lung cancer screening. Training smoking cessation counselors to identify individuals eligible for screening and to educate them on the purpose of screening is feasible (45). Likewise, a randomized controlled trial examining tobacco quit lines from 13 states where the intervention group was given a visual patient decision aid on lung cancer screening found that this was superior to standard educational material and improved informed decision-making (46).

The National Lung Cancer Roundtable is a coalition of public, private, and volunteer organizations whose mission is to increase lung cancer survivors; a recent White Paper served as recommendations to software developers regarding improvements in EMRs for identification of high-risk patients and tracking lung cancer screening (47). Among the recommendations are incorporating referral information to radiology facilities with perform LDCT scans, accurate smoking history with a dynamic rather than static calculation, and documentation of shared decision-making.

Partnerships between provider services may be a useful way to increase access to underserved populations. Flores *et al.* reported on a pilot partnership between radiologists and psychiatrists to bridge gaps in access to lung cancer screening for those with mental illness; shared-decision making counseling was done in a trusted environment for the patients and referral for LDCT screening was streamlined with assistance from radiology (33). Group sessions are to be employed as patients were familiar with this format during monthly visits to discuss lung cancer screening and smoking cessation; for patients who opt to undergo LDCT screening, same-day screening or appointments for a block of time rather than a single time-slot are being offered. Programs like this have the potential to dramatically increase the low utilization rates especially in traditionally marginalized patient groups, and should programs like this succeed, this could be a model for implementation in other communities.

Availability of screening in underserved areas, especially in rural communities, can be increased if screening is able to go to the patients; Headrick *et al.* presented on a 12-month feasibility project on mobile lung screening within a 2-hour drive from Chattanooga, Tennessee (48). The prototype bus included a CT scanner, radiology technician, and a nurse practitioner for shared-decision making and counseling. The project was found to be economically viable, and 548 scans were done at 104 rural or homeless shelter sites in a 10-month period.

Conclusions

Screening for lung cancer in high-risk patients with LDCT results in a reduction in lung cancer mortality, with more cancers being diagnosed at an earlier stage where curative therapies can be applied. Despite this, only a small minority of eligible patients are actually undergoing screening and this is likely related to issues of physician knowledge, patient awareness and engagement, sociodemographic barriers, and systems barriers such as inadequate electronic health record-integrated decision support. Multi-level implementation strategies are needed to address these gaps and increase the utilization of CT screening in patients at high-risk for lung cancer. This is a critically important public health task that will ultimately decrease lung cancer related mortality.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the Guest Editor (Sandra Starnes) for the series "Lung Cancer Screening" published in *Current Challenges in Thoracic Surgery*. The article has undergone peer review.

Reporting Checklist: The authors have completed the Narrative Review reporting checklist. Available at https://ccts.amegroups.com/article/view/10.21037/ccts-20-162/rc

Conflicts of Interest: Both authors have completed the ICMJE uniform disclosure form (available at https://ccts.amegroups.com/article/view/10.21037/ccts-20-162/coif). The series "Lung Cancer Screening" was commissioned by the editorial office without any funding or sponsorship. RMVH reports personal fees from Intuitive Surgical, outside the submitted work. The authors have no other conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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doi: 10.21037/ccts-20-162
Cite this article as: Miller JA, Van Haren RM. A narrative review of lung cancer screening implementation: increasing utilization of evidence-based practice. Curr Chall Thorac Surg 2023;5:2.

