Outcomes of Positive and Suspicious Findings in Clinical Computed Tomography Lung Cancer Screening and the Road Ahead

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Abstract

Rationale: Future optimization of computed tomography (CT) lung cancer screening (CTLS) algorithms will depend on clinical outcomes data.

Objectives: To report the outcomes of positive and suspicious findings in a clinical CTLS program.

Methods: We retrospectively reviewed results for patients from our institution undergoing lung cancer screening from January 2012 through December 2018, with follow-up through December 2019. All exams were retrospectively rescored using Lung-RADS v1.1 (LR). Metrics assessed included positive, probably benign, and suspicious exam rates, frequency/nature of care escalation, and lung cancer detection rates after a positive, probably benign, and suspicious exam result and overall. We calculated time required to resolve suspicious exams as malignant or benign. Results were broken down by subcategories, reason for positive/suspicious designation, and screening round.

Results: During the study period 4,301 individuals underwent a total of 10,897 exams. The number of positive (13.9%), suspicious (5.5%), and significant incidental (6.4%) findings was significantly higher at baseline screening. Cancer detection and false-positive rates were 2.0% and 12.3% at baseline versus 1.3% and 5.1% across subsequent screening rounds, respectively. Baseline solid nodule(s) 6 to 8 mm were the only probably benign findings resulting in lung cancer detection within 12 months. New solid nodules 6 to <8 mm were the only LR category 4A (LR4A) findings falling within the LR predicted cancer detection range of 5–15% (12.8%). 38.5% of LR4A cancers were detected within 3 months.

Conclusions: Modification of the definition and suggested workup of positive and suspicious lung cancer screening findings appears warranted.

Keywords: lung; cancer; screening; CTLS; LCS

In March 2021, the United States Preventive Services Task Force (USPSTF) expanded their lung cancer screening recommendation to include individuals aged 50 to 80 years with at least a 20 pack-year smoking history who currently smoke or quit within the past 15 years (1). This recommendation will nearly double the population eligible for computed tomography (CT) lung cancer screening (CTLS) to 15 million. Currently, fewer than 5% of qualified Americans are enrolled in a CTLS program (2). Achieving a
50% screening rate for the expanded eligible population could increase CTLS volume at many institutions by 2,000% or more. In anticipation of this dramatic increase in screening volume, institutions performing CTLS and developing reporting systems need to provide updated patient and physician education materials and look for strategies to eliminate unnecessary follow-up imaging and precisely target advanced imaging and invasive procedures.

The USPSTF encourages CTLS-eligible individuals to engage in a shared decision-making (SDM) visit with their ordering healthcare provider (1, 3). Many current CTLS SDM decision aids contain National Lung Screening Trial (NLST)-based information; however, the International Early Lung Cancer Action Program and others demonstrated that increasing the NLST positive nodule size threshold safely improves the performance of CTLS (4–9). Current reporting systems and guidelines, such as Lung-RADS v1.1 (LR) and the National Comprehensive Cancer Network (NCCN) Guidelines Lung Cancer Screening, have adopted this larger positive nodule size threshold, resulting in increased positive predictive values (PPVs) and decreased false-positive rates (FPRs) in clinical practice (10, 11).

Additionally, in contrast to the NLST, LR defines a subset of positive findings termed “suspicious,” which warrant consideration of invasive diagnostic procedures and advanced imaging (positron emission tomography [PET]/CT). LR classifies these types of findings as category 4 (LR4), with 3 subcategories (A/B/X). According to LR, LR4A exams are “suspicious,” with an estimated malignancy rate of 5–15%, whereas LR4B and LR4X exams are “very suspicious” with an estimated malignancy rate >15%. LR recommends follow-up imaging in 3 months for LR4A exams, with PET/CT a consideration. For LR4B and LR4X findings, additional/advanced imaging and/or tissue sampling is recommended. LR distinguishes suspicious findings from other positive findings termed “probably benign” and designated as category 3 (LR3), with an estimated malignancy rate of <2%. The malignancy estimates and management recommendations for LR categories are primarily based on expert consensus and/or data from research trials such as the NLST (12). Going forward, clinical outcomes data will be needed to optimize the tools/systems necessary for safe and effective lung cancer screening.

We report the nature and outcomes of positive and suspicious CTLS exams using current clinical standards to provide a reference data point/benchmark for CTLS programs, SDM visits/decision aids, and future CTLS guidelines/reporting systems. A novel CTLS reporting system is proposed on the basis of these clinical outcomes data.

**Methods**

This retrospective single-center study was institutional review board–approved with waiver of informed consent. We assessed consecutive individuals from our institution who underwent clinical CTLS from January 1, 2012 through December 31, 2018 with follow-up through December 31, 2019. All individuals met NCCN lung cancer screening eligibility criteria as previously described (11). All exams were performed on ≥64-row multidetector CT scanners at 100 kV and 30–100 mA.

Image interpretation was performed by radiologists credentialed in CTLS reporting with LR (13). LR1 and LR2 exams were negative. LR3 and LR4 (A/B/X) exams were positive. LR4 (A/B/X) exams were suspicious. All patients with LR4 findings were referred for consultation with a pulmonologist. The specific steps taken to investigate a suspicious exam result were left to the consulting pulmonologist and patient without a proscribed follow-up algorithm. Exams from January 2012 through July 2014 were reported with the original version of Lung-RADS developed at Lahey Clinic in 2011; exams from August 2014 through December 2018 were reported with Lung-RADS v1.0 (14, 15). All exams were reclassified to Lung-RADS v1.1 (LR) as needed (10). Significant incidental findings (LR Category S) were defined as new/unknown, unexpected findings warranting dedicated clinical/imaging evaluation before the next CTLS exam (13). Exams with infectious/inflammatory findings were reported as LR2i to enable analysis separate from other LR2 exams. Patients with mediastinal/hilar lymph nodes >1 cm and 1.5 cm without other suspicious findings were categorized as LR3 and LR4X, respectively.

The overall lung cancer detection rate (CDR), PPV (LR3/LR4), suspicious (LR4) predictive value (SPV), probably benign (LR3) predictive value (3PV), FPR, false negatives, and time to cancer diagnosis were analyzed per screening round, with T0 representing the baseline/prevalence exam and T1, T2, T3, and T4+ reflecting the annual/incidence exams. Metrics were assessed at 12 months unless stated otherwise. The next screening round was defined as the exam performed 11+ months (≥353 d) after a negative exam. Interval studies performed to resolve positives were not included in this analysis, except in determining which positives were false. Combined incidence (T1+) and overall (T0+) results were reported by LR4 category (A/B/X) and eventual diagnostic outcome (benign vs. lung cancer) after a suspicious exam. True positives required lung cancer diagnosis without an intervening negative exam. All other positives were considered false. False negatives occurred when lung cancer was diagnosed fewer than 365 days after a negative exam. PPV, SPV, and 3PV were defined as the percentage of positive, suspicious, and probably benign exams resulting in lung cancer diagnoses, respectively. False positives divided by negative outcomes constituted FPR (16–18).

Benign outcomes after a suspicious exam result were determined by subsequent negative (LR1/LR2) interval exams or tissue sampling with benign histology. Lung cancer was diagnosed by positive pathology or presumed to be present in patients unable to undergo invasive procedures and meeting institutional criteria for lung cancer including nodule growth, PET/CT assessment, and multidisciplinary consensus. Diagnosis date was defined as the date of positive pathology or, for presumed lung cancer, the date of oncology consultation that first documented clinical stage and diagnosis. Treatment date was defined as date of surgery, stereotactic radiotherapy (SBRT), or first day of chemotherapy or combined-modality therapy. 

P values for numerical/continuous variables were calculated using analysis of variance; P values for categorical variables were determined using the chi-square test except in cases with fewer than five events, for which Fisher exact test was used. Confidence intervals (95% CI) were calculated using the binomial exact method. For all statistical analyses, the significance level for differences was set at P ≤ 0.05.

**Results**

A total of 4,301 qualified individuals from our institution underwent a total of 10,897...
CTSLS exams during the study interval. A total of 2,682 (62.4%) had at least one annual exam, and 1,144 (26.5%) completed at least four annual rounds of screening. Average age was 63.1 years, and average smoking history was 48.5 pack-years. Most individuals were male (55.6%), had quit smoking (52.6%), and met NCCN Group 1 eligibility criteria (79.8%) (11). Average quit duration was 9.7 years (ST1), and average follow-up was 3.1 years.

Positive (13.9%; 95% CI, 12.9 – 15.0%), suspicious (5.5%; 95% CI, 4.8 – 6.2%), and significant incidental (6.4%; 95% CI, 5.7 – 7.2%) findings were significantly higher at the baseline round of screening (Table 1). No significant differences existed among annual (T1+) examinations with two exceptions of doubtful clinical significance: significant incidental findings were slightly higher in the T1 round versus the T2 round (2.7% vs. 1.8%), and infectious/inflammatory findings were slightly higher in the T4+ round versus the T3 round (5.8% vs. 8.4%) (Figure 1). Incomplete (LR0) exams were rare, occurring four times (0.04% overall), as were false-negative exams, occurring 11 times (0.1% overall). Nine false negatives occurred within the LR2i group, yielding a 1.2% lung cancer rate at 12 months. The overall 3PV was 0.7% (95% CI, 0.2 – 1.9%) with only one LR3 finding (solid nodule[s] 6 to <8 mm at baseline) resulting in lung cancer detected within 12 months. The overall SPV was 33.0% (95% CI, 28.8 – 37.5%) with subcategory SPVs of LR4A 21.2% (95% CI, 15.9 – 27.4%), LR4B 54.2% (95% CI, 46.3 – 61.9%), and LR4X 20.5% (95% CI, 12.4 – 30.8%) (Table 2). Only

Figure 1. Distribution of computed tomography lung cancer screening exam results by screening round. *Significantly different from one other round. **Significantly different from all other rounds.
one LR4A finding (new solid nodule 6 to <8 mm) fell within the LR4A predicted SPV range of 5–15% (12.8%; 95% CI, 4.3–27.4%), with the remaining LR4A findings SPV’s ranging from 16.7% (endobronchial nodule; 95% CI, 0.4–64.1%) to 30.0% (part-solid nodule[s] ≥ 6 mm with solid component 6 to <8 mm; 95% CI, 6.7–65.2%). All LR4B findings had SPVs significantly exceeding 15%, ranging from a minimum of 46.2% (growing solid nodule ≥ 8 mm; 95% CI, 30.1–62.8%) to a maximum of 75.0% (part-solid nodule with a solid component ≥ 8 mm; 95% CI, 34.9–96.8%). Lymph nodes with minimum dimension ≥ 15 mm had a below-expected SPV of 5% (95% CI, 0.1–24.9%). Excluding these lymph nodes increased the LR4X SPV to 25.4% (95% CI, 15.3–37.9%).

A total of 62.8% and 93.3% of lung cancers detected after a suspicious exam were diagnosed within 3 months and 12 months, respectively (LR4A, 38.5% and 86.5%; LR4B, 76.6% and 96.8%; LR4X, 61.1% and 94.4%) (Figure 2). Overall, 65.2% of lung cancers were diagnosed within 6 months and 84.8% within 1 year of the CTLS exam (ST2). The overall (T0 +) mean and median times to lung cancer diagnosis after a suspicious exam were 193 and 87 days, respectively.

The rate of PET/CT and invasive procedures performed to evaluate a suspicious exam before cancer diagnosis was significantly lower among individuals eventually determined to have benign findings (41.4% and 13.4%) versus those diagnosed with cancer (79.9% and 90.9%) (ST3). The overall rate that an individual without lung cancer in the study population underwent an invasive procedure was 0.9%.

LR4X patients diagnosed with cancer had the highest percentage of SCLC (16.7%) and squamous cell (27.8%) histology (ST4) and largest average cancer size (2.6 cm) (ST5). Overall survival for cancers in the LR4X group was inferior to those found in both the LR4A and LR4B groups (SF1).
those with LR4B findings (SPV 20.5% vs. 54.2%), when cancer is diagnosed the LR4X group has the poorest survival. This is likely due to a higher rate of aggressive histologies (squamous and SCLC) in the LR4X group (ST4). Presumably, these histologies more commonly present with “additional suspicious features” not defined by LR4A or LR4B. However, a host of benign conditions can also display “additional suspicious features,” lowering the SPV of LR4X versus LR4B.

**LR Discrepancies/Gaps**

Only one of the LR3 category findings resulted in lung cancer detected within 12 months despite standard follow-up imaging obtained at 6 months. Reclassification of the other LR3 category findings as LR2 may reduce unnecessary interval imaging (Table 3). All but one of the LR4A category findings had a higher SPV than the LR predicted rate of 5–15%, with nearly 40% of LR4A lung cancers in our cohort diagnosed within 3 months. This suggests a standard 3-month follow-up recommendation for LR4A may be too liberal (Table 3). The SPV of LR4X cases (excluding lymph nodes > 15 mm) of 24.5% more closely approximates the LR4A rate of 21.2% than the LR4B rate of 54.2%, questioning LR descriptively differentiating LR4X (very suspicious) from LR4A (suspicious). The fact that LR4A, LR4X, and LR4B all have SPVs in excess of 15% would appear to obviate the need for any subcategorization of LR4.

How to classify findings characteristic of infection/inflammation and enlarged lymph nodes in the lung cancer stations (mediastinal/hilar) is not sufficiently addressed by LR. Despite our institutional policy of delaying CTLS for 12 weeks after resolution of symptoms and/or treatment of pulmonary infection and multiple reminders of the need to be asymptomatic before imaging, we observed a remarkably consistent LR2i rate of 6–8% across all rounds of screening, similar to other clinical reports (19). These findings are more common than both probably benign and suspicious findings. LR2i most commonly reflects multifocal areas of tree-in-bud nodularity that resolve on follow-up imaging or wax and wane over multiple exams. Although there were nine false-negative cancers within the LR2i group, this represents an overall malignancy rate of just over 1%. At 12 months we found no lung cancer among individuals with mediastinal/hilar lymph nodes between 10 and 15 mm in the absence of other positive findings. For mediastinal/hilar lymph nodes 15 mm or greater in short axis, the malignancy rate of 5% was the lowest rate of all individual suspicious findings assessed. Finally, no

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**Figure 2.** Overall time from suspicious (Lung-RADS v1.1 category 4 [LR4]) exam to lung cancer (top) or benign (bottom) diagnosis.
A proposed reporting system, the RLS System, which accounts for these clinical observations and addresses LR gaps, is provided (Figure 3). The RLS System recommendations for follow-up imaging are based on the clinically observed cancer diagnosis rates within the updated categories. As compared with LR, some findings would not require interval imaging, such as new ground-glass nodules. Other findings would prompt specialist evaluation rather than confirmation imaging at 3 months, such as a part-solid nodule with a >6 mm solid component due to a higher likelihood of cancer than predicted by LR. Based on this single-center data set, the proposed RLS System would reduce the overall number of scans performed in a lung cancer screening program, while prompting more rapid workup of those most likely to have a new lung cancer. This has the potential to improve both patient outcomes and cost effectiveness.

**Limitations**
The generalizability of our results is limited, as our data are drawn from a single institution screening a relatively homogeneous patient population. Fifteen percent of cancers diagnosed included those presumed to be present in patients deemed medically unsafe for biopsy and empirically treated with SBRT (20).

| LR Category | Category Findings | Cases (n) | Prevalence (%) | Lung Cancer at 12 mo (n) | Observed (%) | 95% CI (%) | Estimated by LR (%) | Observed vs. Estimated |
|-------------|-------------------|----------|----------------|------------------------|-------------|------------|---------------------|------------------------|
| Negative    | No lung nodules, nodule(s) w/flat or characteristically benign calcifications | 2,784 | 25.5 | 1 | <0.1 | 0–0.2 | <1 | √ |
| Benign      | Solid nodule(s) < 6 mm at baseline, solid nodule(s) < 4 mm new, part-solid nodule(s) < 6 mm total diameter at baseline, nonsolid nodule(s) (GGN) < 30 mm at baseline, nonsolid nodule(s) (GGN) slowly growing, nodules unchanged for >3 mo | 6,320 | 58.0 | 1 | <0.1 | 0–0.09 | <1 | √ |
|             | Findings characteristic of infection/inflammation* | 782 | 7.2 | 9 | 1.2 | 0.5–2.2 | N/A | N/A |
| Probably benign | Lymph nodes 10–15 mm without pulmonary nodules* | 7,102 | 65.2 | 10 | 0.1 | 0.07–0.3 | <1 | √ |
| Suspicious  | Solid nodule(s) > 6 to <8 mm at baseline | 203 | 1.9 | 4 | 2.0 | 0.5–5.0 | 1–2 | √ |
|             | New solid nodule(s) 4 to <6 mm | 146 | 1.3 | 6 | 0.0 | 0–2.5 | - | - |
|             | Part solid nodule(s) > 6 mm total diameter w/solid component < 6 mm | 47 | 0.4 | 0 | 0.0 | 0–7.6 | - | - |
|             | New part-solid nodule(s) < 6 mm total diameter | 35 | 0.3 | 0 | 0.0 | 0–10.0 | - | - |
|             | Nonsolid nodule(s) (GGN) < 30 mm at baseline CT | 1 | 0.0 | 0 | 0.0 | 0–97.5† | - | - |
|             | New GGN | 21 | 0.2 | 0 | 0.0 | 0–16.1 | - | - |
|             | Total LR3 | 544 | 5.0 | 4 | 0.7 | 0.2–1.9 | - | - |
| Suspicious  | Solid nodule(s) > 8 to <15 mm at baseline | 80 | 0.7 | 20 | 25.0 | 16.0–35.9 | 5–15 | - |
|             | Growing nodule(s) < 8 mm | 23 | 0.2 | 4 | 17.4 | 5.0–38.8 | - | - |
|             | New solid nodule(s) 6 to <8 mm | 39 | 0.4 | 5 | 12.8 | 4.3–27.4 | - | - |
|             | Part solid nodule(s) > 6 mm w/solid component > 6 to <8 mm | 10 | 0.1 | 3 | 30.0 | 6.7–65.2 | - | - |
|             | Part solid nodule(s) w/new or growing <4-mm solid component | 54 | 0.5 | 12 | 22.2 | 12.0–36.0 | - | - |
|             | Endobronchial nodule(s) | 6 | 0.1 | 1 | 16.7 | 0.4–64.1 | - | - |
| Very        | Solid nodule(s) > 15 mm at baseline | 212 | 1.9 | 45 | 21.2 | 15.9–27.4 | - | - |
| Very        | New solid nodule(s) > 8 mm | 62 | 0.6 | 30 | 48.4 | 35.5–61.4 | - | - |
|             | Growing solid nodule(s) > 8 mm | 39 | 0.4 | 18 | 46.2 | 30.1–62.8 | - | - |
|             | Part-solid nodule(s) with solid component > 8 mm | 8 | 0.1 | 6 | 75.0 | 34.9–96.8 | - | - |
|             | Part-solid nodule(s) w/new or growing > 4 mm solid component | 24 | 0.2 | 12 | 50.0 | 29.1–70.9 | - | - |
|             | Total LR4A | 168 | 1.5 | 91 | 54.2 | 46.3–61.9 | - | - |
|             | Lymph nodes > 15 mm without pulmonary nodules* | 20 | 0.2 | 1 | 5.0 | 0.1–24.9 | N/A | N/A |
|             | LR 3 or 4 nodules w/findings increasing cancer risk | 63 | 0.6 | 16 | 25.4 | 15.3–37.9 | >15 | √ |
|             | Total LR4X | 83 | 0.8 | 17 | 20.5 | 12.4–30.8 | - | - |

**Definition of abbreviations:** CI = confidence interval; CT = computed tomography; GGN = ground-glass nodules; LR = Lung-RADS v1.1; N/A = not applicable.

*Not currently part of LR.
†Unreliable CI.
### Figure 3. Proposed reporting system. CTLS = computed tomography lung cancer screening; PET/CT = positron emission tomography/computed tomography; TBD = to be determined.

| RLS Category | Findings | Prevalence | Lung Cancer @ 12 Months | Recommendation |
|--------------|----------|------------|--------------------------|-----------------|
| **Baseline** |          |            |                          |                 |
| Negative     | 1        | • No findings | 4.7% (95% CI 0.1%<br>– 9.1%) | Non-surgical     |
| Benign       | 2        | • Solid nodule(s) ≤ 6 mm &
               | 6.4% (95% CI<br>0.1%–6.9%) | 6 month CTLS2 |
|              |          | • Part-solid nodule(s) &
               | 7.3% (95% CI<br>0.1%–7.9%) | 6 month CTLS2 |
|              |          | • Lymph node(s) ≤ 10 mm &
               | 5.7% (95% CI<br>0.1%–6.1%) | 6 month CTLS2 |
|              |          | • Non-solid nodule(s) &
               | 6.8% (95% CI<br>0.1%–7.1%) | 6 month CTLS2 |
|              |          | • Lymph node(s) > 10 mm &
               | 6.9% (95% CI<br>0.1%–7.2%) | 6 month CTLS2 |
|              |          | • Non-solid nodule(s) &
               | 7.0% (95% CI<br>0.1%–7.4%) | 6 month CTLS2 |
| **Probable** | 3        | • Solid nodule(s) @ baseline &
               | 4.7% (95% CI<br>0.1%–5.0%) | Non-surgical     |
| Suspicous    | 4        | • Solid nodule(s) &
               | 4.7% (95% CI<br>0.1%–5.0%) | Non-surgical     |
|              |          | • Baseline &
               | 4.7% (95% CI<br>0.1%–5.0%) | Non-surgical     |
|              |          | • New &
               | 4.7% (95% CI<br>0.1%–5.0%) | Non-surgical     |
|              |          | • Growing &
               | 4.7% (95% CI<br>0.1%–5.0%) | Non-surgical     |
|              |          | • Baseline &
               | 4.7% (95% CI<br>0.1%–5.0%) | Non-surgical     |
|              |          | • New &
               | 4.7% (95% CI<br>0.1%–5.0%) | Non-surgical     |
|              |          | • Growing &
               | 4.7% (95% CI<br>0.1%–5.0%) | Non-surgical     |
|              |          | • Baseline &
               | 4.7% (95% CI<br>0.1%–5.0%) | Non-surgical     |
|              |          | • New &
               | 4.7% (95% CI<br>0.1%–5.0%) | Non-surgical     |
|              |          | • Growing &
               | 4.7% (95% CI<br>0.1%–5.0%) | Non-surgical     |
|              |          | • Baseline &
               | 4.7% (95% CI<br>0.1%–5.0%) | Non-surgical     |
|              |          | • New &
               | 4.7% (95% CI<br>0.1%–5.0%) | Non-surgical     |
|              |          | • Growing &
               | 4.7% (95% CI<br>0.1%–5.0%) | Non-surgical     |
|              |          | • Baseline &
               | 4.7% (95% CI<br>0.1%–5.0%) | Non-surgical     |
|              |          | • New &
               | 4.7% (95% CI<br>0.1%–5.0%) | Non-surgical     |
|              |          | • Growing &
               | 4.7% (95% CI<br>0.1%–5.0%) | Non-surgical     |
|              |          | • Baseline &
               | 4.7% (95% CI<br>0.1%–5.0%) | Non-surgical     |
|              |          | • New &
               | 4.7% (95% CI<br>0.1%–5.0%) | Non-surgical     |
|              |          | • Growing &
               | 4.7% (95% CI<br>0.1%–5.0%) | Non-surgical     |
|              |          | • Baseline &
               | 4.7% (95% CI<br>0.1%–5.0%) | Non-surgical     |
|              |          | • New &
               | 4.7% (95% CI<br>0.1%–5.0%) | Non-surgical     |
|              |          | • Growing &
               | 4.7% (95% CI<br>0.1%–5.0%) | Non-surgical     |

Although this raises the potential for overestimating lung cancer prevalence, more than 30% of these patients subsequently experienced pathology-proven regional/distant lung cancer recurrence, a rate exceeding that observed in patients with pathology-proven lung cancer at initial diagnosis (21). However, low numbers of patients treated with SBRT without biopsy preclude assessment of survival differences at this time. However, although all patients with suspicious findings were recommended to undergo consultation with a pulmonologist, the next steps in each patient’s care were customized on the basis of exam findings, physician experience, patient preference, patient performance level, and a variety of other factors rather than a preset algorithm. This limits the generalizability of our results to institutions without access to lung cancer specialists. Finally, because of the low positive rate of CTLS, particularly during annual rounds of screening, a larger number of exams would be useful to confirm the prevalence and malignancy rates of each LR finding within the probably benign and suspicious categories.

**Conclusions**

The outcomes of positive and suspicious CTLS findings in clinical practice differ meaningfully from those reported by the NLST and predicted by current CTLS reporting systems. To account for these differences and in anticipation of an oncoming USPSTF eligibility expansion-driven increase in CTLS volume, we propose a novel CTLS reporting system designed to improve clinical outcomes by accelerating the workup of those most likely to have cancer while reducing the overall number of scans performed. A multi-institutional validation study is planned.

**Author disclosures** are available with the text of this article at www.atsjournals.org.
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