Lung-RADS™
Pushing the Limits

Maria Daniela Martin, MD
Jeffrey P. Kanne, MD
Lynn S. Broderick, MD
Ella M. Kazerooni, MD
Cristopher A. Meyer, MD
Background

- Lung Imaging Reporting and Data System (Lung-RADS™) was developed by the American College of Radiology.
- Modeled after BI-RADS™.
- Meets CMS requirements for a standardized reporting and management system.
- Serves as data collection tool to facilitate outcome monitoring.
- Currently in its first iteration.
Objectives

• Identify through clinical cases gray areas and ambiguous situations that arise while using Lung-RADS.
• Propose solutions for these circumstances, focusing on classification and management of findings.
1. Eligibility

How Would You Manage This Nodule?

80-year-old M will turn 81 years old in 3 months. Has a new 5 mm solid nodule.

<table>
<thead>
<tr>
<th>Category</th>
<th>Category Descriptor</th>
<th>Category</th>
<th>Findings</th>
<th>Management</th>
<th>Probability of Malignancy</th>
<th>Estimated Population Prevalence</th>
</tr>
</thead>
</table>
| Probably Benign | Probably benign finding(s) - short term follow up suggested; includes nodules with a low likelihood of becoming a clinically active cancer | 3        | solid nodule(s):  
≥ 6 to < 8 mm at baseline OR  
new 4 mm to < 6 mm  
part solid nodule(s):  
≥ 6 mm total diameter with solid component < 6 mm OR  
new < 6 mm total diameter  
non solid nodule(s) (GGN) ≥ 20 mm on baseline CT or new | 6 month LDCT | 1-2%                      | 5%                 |
## Screening Eligibility

At 81 years old, this patient will no longer qualify for lung cancer screening

<table>
<thead>
<tr>
<th>Organization</th>
<th>Current Eligibility Criteria</th>
</tr>
</thead>
</table>
| • American College of Chest Physicians  
  • American Society of Clinical Oncology  
  • American Cancer Society  
  • American Lung Association  
  • American Thoracic Society  
  • CMS +  
  • USPSTF *                      | • ≥ 55 years old **up to** 74 years old  
                                          + 77 years old  
                                          * 80 years old  
                                          • Smoked ≥ 30 pack-years  
                                          • Quit smoking < 15 years ago               |
| • National Comprehensive Cancer Network  
  (NCCN)                                | • ≥ 55 -74 years old  
                                          • Smoked ≥ 30 pack-years  
                                          • Quit smoking < 15 years ago  
                                          OR  
                                          • ≥ 50 years old  
                                          • smoked ≥ 20 pack-years and 1 more risk factor (other than second-hand smoke) including: radon or occupational exposure, cancer history, history of lung cancer in first-degree relative, disease history (COPD or pulmonary fibrosis) |
| • American Association for Thoracic Surgery  
  (AATS)                              | • ≥ 55 -79 years old  
                                          • Smoked ≥ 30 pack-years  
                                          OR  
                                          • Lung cancer survivors starting 5 years after treatment until age 79  
                                          OR  
                                          • ≥ 50 years old,  
                                          • Smoked ≥ 20 pack-years  
                                          • 5% risk of developing a lung cancer in the next 5 years (COPD, environmental/occupational exposure, prior cancer/radiation therapy, genetics, or family history) |

* U.S. Preventive Services Task Force  
+ Centers for Medicare & Medicaid Services
Teaching Points

- Many organizations advocate CT lung cancer screening.
- Eligibility criteria vary depending on the organization.
- 80 years is the upper age limit and only for USPSTF.
- Those who do not meet CMS criteria will not be covered by Medicare (up to 77 years old).
What Can You Do For This Patient?

• Can manage similarly but outside of the screening program.
• Management of older patients is controversial: benefits vs. risks (life expectancy, comorbidities, etc.)
• Make clear recommendations: when to follow up and most importantly when to stop monitoring.
# If Phased Out of Screening… Should You Use Lung-RADS or Fleischner?

<table>
<thead>
<tr>
<th>Lung-RADS</th>
<th>Fleishner&lt;sup&gt;1,2&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Published in 2014</td>
<td>Published in 2005* and 2013*</td>
</tr>
<tr>
<td>Based on newer data from lung cancer screening trials</td>
<td>Based on older data, pending review</td>
</tr>
<tr>
<td>Developed for the management of nodules in the setting of lung cancer screening</td>
<td>Developed for the management of incidently detected nodules</td>
</tr>
<tr>
<td>Adressed how to manage nodules that are new or growing</td>
<td>Does not address how to manage nodules that are new or growing</td>
</tr>
<tr>
<td>All nodule types are included</td>
<td>Separate guidelines for solid and subsolid nodules</td>
</tr>
</tbody>
</table>

### Teaching Point

For the reasons underlined above, Lung-RADS recommendations are more appropriate to follow in this case.

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* Guidelines for Management of Small Pulmonary Nodules Detected on CT Scans: A Statement from the Fleischner Society
* Recommendations for the Management of Subsolid Pulmonary Nodules Detected at CT: A Statement from the Fleischner Society
Vague Symptoms: Screening vs. Routine CT

- 63 F with mass detected at baseline screen → small cell carcinoma.
- Retrospective review of the chart after diagnosis revealed complaints of cervicalgia.
- Screening should be reserved for patients without symptoms attributable to lung cancer. Even vague symptoms suspicious for pathology (weight loss, fatigue) should prompt routine CT.
How Would You Categorize and Manage This Nodule?

Baseline Screen - 76 F with a 21 x 16 (19) mm nodule

<table>
<thead>
<tr>
<th>Category</th>
<th>Category Descriptor</th>
<th>Findings</th>
<th>Management</th>
<th>Probability of Malignancy</th>
<th>Estimated Population Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspicious</td>
<td>Findings for which additional diagnostic testing and/or tissue sampling is recommended</td>
<td>solid nodule(s)</td>
<td>chest CT with or without contrast, PET/CT and/or tissue sampling depending on the *probability of malignancy and comorbidities. PET/CT may be used when there is a ≥ 8 mm solid component.</td>
<td>&gt; 15%</td>
<td>2%</td>
</tr>
<tr>
<td>4B</td>
<td></td>
<td>≥ 15 mm OR new or growing, and ≥ 8 mm part solid nodule(s) with: a solid component ≥ 8 mm OR a new or growing ≥ 4 mm solid component</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4X</td>
<td>Category 3 or 4 nodules with additional features or imaging findings that increases the suspicion of malignancy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: The probability of malignancy is estimated based on the size and characteristics of the nodule.
• Version 1.0 of Lung-RADS does not address categorizing a nodule present on an examination before baseline screen.
• Growth = increase > 1.5 mm.
• This nodule, by growth, would fall under Category 4B

<Probability of Malignancy>
> 15%.

• Do you think this nodule is malignant after 12 years?
Not Everything That Grows is Cancer

• Growth of a solid nodule is assessed by volume doubling time (VDT) \(^3\).

<table>
<thead>
<tr>
<th>VDT in Days</th>
<th>Growing Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 20</td>
<td>Inflammatory/Infectious</td>
</tr>
<tr>
<td>&lt; 100 (range of 20 – 400)</td>
<td>Malignant</td>
</tr>
<tr>
<td>&gt; 400</td>
<td>Benign</td>
</tr>
</tbody>
</table>

• VDT helps determine malignant potential\(^3\).
• VDT formula based on axial dimensions and time between studies \(\rightarrow\) many online calculators available.
• Mesenchymal tumors and granulomatous lesions can grow very slowly and lack definitively benign features (reference).

VDT = 948 days

Biopsy proven hamartoma. Nodule grew and lacked definitively benign features (e.g. macroscopic fat or benign calcifications). Remote history of testicular cancer prompted the biopsy.
Knowing that VDT = 5.2 years, would you manage nodule differently?

- This is an excellent example to use the *
- *Footnote 9: 4B management based on probability of malignancy (patient evaluation, patient preference, and risk of malignancy).
Teaching Points

• Lung-RADS provides guidelines and is not absolute.
• Use all resources available to propose management options appropriate to each case (VDT, prior exams, online assessment tools).

• Possible solutions for future versions of Lung-RADS include:
  • Address comparison of baseline LDCT to prior exams.
  • Categorization of a large nodule as benign at baseline based on behavior over time (volume doubling time).
65 F with baseline screen CT in 2016. A comparison CT from 2012 is available. **How would you categorize and manage?**

<table>
<thead>
<tr>
<th>Category</th>
<th>Findings</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>≥ 6 to &lt; 8 mm at baseline OR new 4 mm to &lt; 6 mm</td>
<td>6 month LDCT</td>
</tr>
<tr>
<td></td>
<td>part solid nodule(s)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 6 mm total diameter with solid component &lt; 6 mm OR new &lt; 6 mm total</td>
<td></td>
</tr>
<tr>
<td></td>
<td>diameter</td>
<td></td>
</tr>
<tr>
<td></td>
<td>non solid nodule(s) (GGN) ≥ 20 mm on baseline CT or new</td>
<td></td>
</tr>
<tr>
<td>4A</td>
<td>≥ 8 to &lt; 15 mm at baseline OR growing &lt; 8 mm OR new 6 to &lt; 8 mm</td>
<td>3 month LDCT; PET/CT may be used</td>
</tr>
<tr>
<td></td>
<td>part solid nodule(s):</td>
<td>when there is</td>
</tr>
<tr>
<td></td>
<td>≥ 6 mm with solid component ≥ 6 mm to &lt; 8 mm OR</td>
<td>a ≥ 8 mm solid component</td>
</tr>
<tr>
<td></td>
<td>with a new or growing &lt; 4 mm solid component</td>
<td></td>
</tr>
<tr>
<td></td>
<td>endobronchial nodule</td>
<td></td>
</tr>
</tbody>
</table>

Nodule was classified as 4X (new large solid component).

Footnote 4) Growth: an increase in size of > 1.5 mm.
Footnote 10) Category 4X – Nodules with additional findings that increase suspicion of lung cancer (spiculation, GGN* that doubles in size in 1 year, enlarged lymph nodes, etc.)

* GGN = Ground-glass Nodule
Teaching Points

- X definition on Lung-RADS is flexible and includes: nodule with spiculations, GGN* that doubles in size in 1 year, enlarged lymph nodes, etc.
- Use your judgement and experience to “X” a nodule that you are convinced is cancer.
Definition of Growth

• Growth of subsolid nodules may manifest as increase in size, attenuation, development of a solid component, or enlarging solid component\(^3\) (increase in mass).
• Currently, the footnote definition of nodule growth in Lung-RADS is only related to change in size.
• Category 4 implies growth by development of a solid component, or enlarging solid component.
• Future iterations will likely clarify the concept of growth.

This nodule was an adenocarcinoma. Although size did not change, density did. There are also mild spiculations.
Teaching Point

• Remember that growth also includes increase in density or a new or enlarging solid component.
2.2 Nodules – Sub-solid nodules growth

What does slowly growing mean to you?

- Currently, growth is defined as an increase in size of > 1.5 mm.
  - It does not address solid vs. sub-solid.
  - “Slowly growing” is not defined.

- VDT varies greatly between nodule type.

<table>
<thead>
<tr>
<th>Benign Appearance or Behavior</th>
<th>Nodule Growth</th>
<th>VDT (in days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 solid nodule(s):</td>
<td>&lt; 6 mm</td>
<td>2.2</td>
</tr>
<tr>
<td>now &lt; 4 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>part solid nodule(s):</td>
<td>&lt; 6 mm, stable, unchanged screening</td>
<td></td>
</tr>
<tr>
<td>Non solid nodule(s) (GGN):</td>
<td>&lt; 20 mm OR</td>
<td></td>
</tr>
<tr>
<td>≥ 20 mm and unchanged or slowly growing</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category</th>
<th>VDT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid</td>
<td>20 – 400</td>
</tr>
<tr>
<td>Part-solid</td>
<td>300 – 450</td>
</tr>
<tr>
<td>Pure ground-glass</td>
<td>600–900 (widely variable)</td>
</tr>
</tbody>
</table>
• If GGOs persist, they are preinvasive lesions sufficiently often to warrant surveillance\textsuperscript{2}.

• VDT of GGO is much longer than solid and part-solid nodules - on the order of years.

• It has been reported that an increase in length of maximal diameter $> 1.72$ mm is needed to identify true growth of a GGO\textsuperscript{5}.

77-year-old M, on surveillance for contralateral NSCLC.
Teaching Points

• VDT of GGO is much longer than solid and part-solid nodules.
• Remember to compare GGO to the oldest scans as an interval longer than 1 year may be required to detect a change.
• Future versions of LungRads could include a definition of slow (addressing change over periods longer than 1 year).
How would you categorize this 23 x 19 mm nodule found at baseline? No priors.

Ground-glass ≥ 20 mm

<table>
<thead>
<tr>
<th>Category 3 or 4 nodules with additional features or imaging findings that increase the suspicion of malignancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>• We had a poll amongst several thoracic radiologist who rated this nodule as almost all categories listed below.</td>
</tr>
<tr>
<td>• Greatest controversy related to how to measure solid component.</td>
</tr>
<tr>
<td>• However, they <strong>all agreed</strong> that it looks like an adenocarcinoma, which allows use of the X modifier, and recommendations at your discretion.</td>
</tr>
<tr>
<td>• Some advocated f/u CT in 3 months to assess for change (most conservative approach, related to overdiagnosis).</td>
</tr>
<tr>
<td>• Some were more aggressive and recommended biopsy or resection, which is valid, as it looks like a cancer.</td>
</tr>
<tr>
<td>• Path -&gt; Adenocarcinoma with mucinous component.</td>
</tr>
</tbody>
</table>

- 3
- 2
- 3
- 4A
- 4B
Teaching Point

• Regardless of the category, X modifier allows you to target the recommendations based on your experience, taking into account patients’ comorbidities, etc.
Scar or Adenocarcinoma?

Scar

All nodules need to be evaluated in multiple planes!

Adenocarcinoma
Category 3 Nodule Becomes Smaller but Denser How Would You Manage?

- Lung-RADS does not address nodules that decrease in size.
- Footnote 12 “All Category 3 and 4A nodules that are unchanged on interval CT should be coded as category 2, and returned to screening in 12 months”.
- We suggest that increase in density should be considered as a change.
- Temporary regression of malignant lung nodules can be seen in lung cancers\(^3,6\).
- Felt to be related to development of a fibrous component and subsequent collapse of the fibrosis\(^3\).
- Continued surveillance is required.
Teaching Points

- Remember that cancer growth may not be fully exponential, and they may decrease in volume at some point.
- The most accurate assessment in this case would be to measure the mass of the nodule (volume and density).
- Continued surveillance through screening is suggested.
How Would You Categorize This Nodule?

Intrapulmonary lymph node (IPLN)
• IPLN are well circumscribed, smoothly marginated, in contact or closely related to the fissure, most commonly triangular (A,B,D), polygonal (C), or oval, often with a septal attachment\(^7\) (D, E).

• Notice how they can become engorged when edema is present (same patient: D&E).

• Several studies based on lung cancer screening trials have shown that IPLN (perifissural nodules) have no malignant potential\(^7,8\).
Nodules with Features of IPLN

- Management is controversial - contradicts clinical practice for radiologists who do not routinely follow-up when characteristic findings are present.
- Lung-RADS management developed due to potential for confusion with early lung cancers.
- Given their usual small size, most IPLN fall under Category 2 (same management as Category 1).

Footnote 11: Nodules with features of an IPLN should be managed by mean diameter and the 0-4 numerical category classification.
Teaching Points

• By size, management of IPLN will nearly always be the same (category 1 and 2).
• A multireader study could be conducted evaluating the degree of agreement for recognition of IPLN.
• If high agreement can be achieved, future iterations could allow documenting IPLN in the report and assigning a Category 1, as IPLN are a normal finding.
Airway Lesions: Real or Mucus Plugging?

- Mucus plugging is common in smokers and former smokers and can mimic endobronchial lesions.

- If strictly followed → multiple 3 month LDCTs every time a new mucus plug is identified.
59 F with new endobronchial lesion compared to CT 4 months earlier performed for other reasons.

Helpful clues to identify secretions include:

- Dependent location (layering)
- Low/water density
- Presence of gas within secretions

None of these was present in this case.

The patient was brought back the same day and repeat scanning was performed after vigorous coughing, indicating the filling defect was a mucus plug.

Teaching Points

- Consider asking the patient to vigorously cough before screening CT
- If in doubt, manage as endobronchial nodules
- If there are multiple CTs showing waxing and waning mucus plugs, use clinical judgement to avoid unnecessary scans
Incidental (Potentially) Significant Findings Other than Lung Cancer

<table>
<thead>
<tr>
<th>Category</th>
<th>Category Descriptor</th>
<th>Findings</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other</td>
<td>Clinically Significant or Potentially Clinically Significant Findings (non lung cancer)</td>
<td>S modifier - may add on to category 0-4 coding</td>
<td>As appropriate to the specific finding</td>
</tr>
</tbody>
</table>

- Rate of incidental findings needing additional evaluation = 10.2% at baseline and 7.5% overall in the National Lung Cancer Screening Trial\textsuperscript{9}.
- “Clinically significant” definition not clear.
- Until Lung-RADS includes specific recommendations, practices should develop or adopt management guidelines.
- We encourage use of ACR white papers on management of incidental findings on CT\textsuperscript{10,11} and ACR Select TM.
What Could be Included and How Often?

- Include as S:
  - Findings that may lead to a health benefit if a behavior is modified.
  - Findings that will lead to adverse outcome if not further evaluated or treated.
- There is no value to adding an S modifier for the same finding in subsequent scans.

<table>
<thead>
<tr>
<th>Finding</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronary arterial calcifications (CAC)</td>
<td>S → Although studies based on lung cancer screening trials showed CAC are predictive of future all-cause mortality and cardiovascular events, others question if CAC scoring will be clinically useful</td>
</tr>
<tr>
<td>Langerhans cell histiocytosis</td>
<td>S → Although uncommon, can be seen in smokers. May lead to a health benefit if patient stops smoking</td>
</tr>
<tr>
<td>Any findings that can be interpreted as malignant such as a solid mass including mediastinal, kidney, and liver</td>
<td>S → Follow ACR white papers for further work-up and management</td>
</tr>
<tr>
<td>Thyroid nodules</td>
<td>Follow ACR white paper guidelines. Only give S if the nodule warrants further work up and has not already been evaluated</td>
</tr>
<tr>
<td>Benign findings (e.g., mediastinal duplication cyst)</td>
<td>Leave in body of the report. S for a finding that does not warrant follow up will lead to confusion and potential harm and cost from unnecessary testing</td>
</tr>
<tr>
<td>Emphysema</td>
<td>CONTROVERSIAL. Not routinely encouraged to report as an S → very common finding in smokers and unlikely to change management</td>
</tr>
</tbody>
</table>
Returning Back to Screening: What Does Yearly Mean?

- Although not clarified on Lung-RADS, ACR recommends that 12 months should be counted from the day of the scan that prompted the follow up. This refers to the annual date based on their first lung cancer screening CT (in this case, Oct 2016).
- This topic is controversial. Many believe that there will be likely no change in less than a year, so the 12 months should be counted from the last scan (Jan 2016).
- Future Lung-RADS iterations will likely clarify this recommendation.

Footnote 12: Category 3 and 4A nodules that are unchanged on interval CT should be coded as category 2, and individuals returned to screening in 12 months.

When should the next CT be performed?

- Although not clarified on Lung-RADS, ACR recommends that 12 months should be counted from the day of the scan that prompted the follow up. This refers to the annual date based on their first lung cancer screening CT (in this case, Oct 2016).
- This topic is controversial. Many believe that there will be likely no change in less than a year, so the 12 months should be counted from the last scan (Jan 2016).
- Future Lung-RADS iterations will likely clarify this recommendation.
Recent Infection:
What Lung-RADS Category?

2 months prior, had symptoms of pneumonia.

Spiculated part-solid nodule, smaller than consolidation on chest radiograph.

- Recent infection or other inflammation not addressed by Lung-RADS.
- We categorized it as 3 - probably benign with 6 months follow-up.
- Rationale:
  - Nodule was smaller *but*
  - Not resolved.
  - Right upper lobe location.

Teaching Points

- Patients with symptoms or recent infection should not be scanned.
- This patient was scanned 2 months after an episode of pneumonia. Future iterations can address a timeframe of no symptoms prior to CT.
- Remember that cancers can become a little smaller before further growth.
Cavitary Nodules

- No clear guidelines for the management of cavitary nodules.
- Lung cancer, pulmonary Langerhans cell histiocytosis nodules, infection, and some metastases can be cavitary.
- Should probably manage similar to solid nodules
- Use the X modifier if high suspicion for malignancy.
Patients with Prior Lung Cancer

• Previous lung cancer
  → 3% annual risk of developing new lung cancer.
  → Peak recurrence incidence 2-3 years after treatment\textsuperscript{14}.

• AATS* recommends
  – 4 years of CT surveillance after surgery AND
  – Annual LDCT screening starting 5 years after treatment until age 79.

• USPSTF and CMS do not address previous lung cancer.
• Lung-RADS provides a modifier (C). Categories coded as usual.

\begin{tabular}{|c|c|c|}
\hline
Prior Lung Cancer & Modifier for patients with a prior diagnosis of lung cancer who return to screening & \textbf{C} \\
\hline
\end{tabular}

*American Association for Thoracic Surgery
Patients with Non-Lung Malignancy

• Current recommendations do not address patients treated for malignancies with low risks of recurrence (e.g. early stage breast or prostate cancer or low-grade lymphoma).

Should an eligible patient 18-months out from treated stage 1 breast cancer be screened for lung cancer?

• We believe that screening may be appropriate for patients more likely than not to be alive within the next 5 years.
Conclusions

- Lung-RADS is a very helpful guideline that allows consensus in reporting and management in lung cancer screening.
- Several topics remain unclear, but will likely be addressed in future iterations.
- We proposed solutions to several areas of ambiguity based on current literature and our collective experience.
- As we gather data from lung cancer screening and continue to learn about nodules and cancer behavior, Lung-RADS will evolve to best serve our patients.

Thank you!


References


Contact: Maria Daniela Martin mmartin3@uwhealth.org