Lung Cancer Imaging

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Disclosures

• None
Objectives

• To review the status of lung cancer screening in the U.S.A. and Canada
• To review the image guided diagnosis and staging of lung cancer
• To review the imaging findings of post-treatment effects and discuss surveillance
Overview

• Screening
• Diagnosis
• Staging
• Follow-up
Lung Cancer Screening

• No screening program in place in Canada

• US Preventative Services Task Force (USPSTF) recommends annual low dose CT (LDCT) for high risk population age 55 – 80
  – Active smokers or quit within the last 15 years with ≥ 30 pack year smoking history
  – Otherwise “healthy”: asymptomatic with no significant comorbidities that would preclude the individual from undergoing therapy with curative intent (including lung surgery)
Lung Cancer Screening

- USPSTF recommendations are based on National Lung Screening Trial (NLST) which showed 16% reduction in lung cancer mortality in this high risk population who underwent annual LDCT screening

- Nonetheless, the majority of lung cancer deaths cannot be prevented by screening and smoking cessation remains the most effective strategy for mortality reduction
Lung Cancer Screening in Canada

• No program currently in place in any province, but ...
  – BC Cancer Agency has reviewed scientific evidence for high risk screening and is preparing business case for implementation
  – Canadian Task Force on Preventive Health Care is currently reviewing lung cancer screening guidelines. The published updated recommendation statement is expected in 2016.
Incidental Pulmonary Nodules

• Pulmonary nodules are a common incidental finding on CT
• Differential diagnosis is broad and includes
  – Infection, Inflammation
  – Hemorrhage, Vascular lesions
  – Fibrosis, Neoplasm (benign and malignant)
Incidental Pulmonary Nodules

• Fleischner Society Guidelines
  – Multidisciplinary international society for thoracic imaging which publishes position papers on diagnosis and management of diseases of the chest
  – Published guidelines for management of incidental solid and subsolid pulmonary nodules
  – Guidelines are for “incidental” nodules only and don’t apply if they may be related to underlying disease, e.g.:
    • Known or suspected malignancy
    • Young patients (<35y)
    • Unexplained fever (may be related to infection)
Malignancy risk:
- < 4 mm: <1%
- 4-7 mm: 1%
- 8-20 mm: 15%
### Fleischner Guidelines - Solid Nodules

<table>
<thead>
<tr>
<th>Nodule Size (mm)</th>
<th>Low-Risk Patient</th>
<th>High-Risk Patient</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤4</td>
<td><strong>No follow-up needed</strong></td>
<td>Follow-up CT at 12 mo; if unchanged, no further follow-up</td>
</tr>
<tr>
<td>&gt;4–6</td>
<td>Follow-up CT at 12 mo; if unchanged, no further follow-up</td>
<td>Initial follow-up CT at 6–12 mo then at 18–24 mo if no change</td>
</tr>
<tr>
<td>&gt;6–8</td>
<td>Initial follow-up CT at 6–12 mo then at 18–24 mo if no change</td>
<td>Initial follow-up CT at 3–6 mo then at 9–12 and 24 mo if no change</td>
</tr>
<tr>
<td>&gt;8</td>
<td>Follow-up CT at around 3, 9, and 24 mo, dynamic contrast-enhanced CT, PET, and/or biopsy</td>
<td>Same as for low-risk patient</td>
</tr>
</tbody>
</table>

MacMahon et al. Radiology 2005 237:2, 395-400
Fleischner Guidelines - Subsolid Nodules

• Adenocarcinoma spectrum
• Solid component → higher risk
• No difference in management based on smoking status (increasing incidence in non-smokers)
• Nodules followed for a longer period due to slower growth
### Fleischner Guidelines - Subsolid Nodules

<table>
<thead>
<tr>
<th>Nodule Type</th>
<th>Management Recommendations</th>
<th>Additional Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solitary pure GGNs</td>
<td><strong>≤5 mm</strong>  No CT follow-up required</td>
<td>Obtain contiguous 1-mm-thick sections to confirm that nodule is truly a pure GGN</td>
</tr>
<tr>
<td></td>
<td>&gt;5 mm  Initial follow-up CT at 3 months to confirm persistence then annual surveillance CT for a minimum of 3 years</td>
<td>FDG PET is of limited value, potentially misleading, and therefore not recommended</td>
</tr>
<tr>
<td>Solitary part-solid nodules</td>
<td>Initial follow-up CT at 3 months to confirm persistence. If persistent and solid component &lt;5 mm, then yearly surveillance CT for a minimum of 3 years. If persistent and solid component ≥5 mm, then biopsy or surgical resection</td>
<td>Consider PET/CT for part-solid nodules &gt;10 mm</td>
</tr>
<tr>
<td>Multiple subsolid nodules</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pure GGNs ≤5 mm</td>
<td>Obtain follow-up CT at 2 and 4 years</td>
<td>Consider alternate causes for multiple GGNs ≤5 mm</td>
</tr>
<tr>
<td>Pure GGNs &gt;5 mm without a dominant lesion(s)</td>
<td>Initial follow-up CT at 3 months to confirm persistence and then annual surveillance CT for a minimum of 3 years</td>
<td>FDG PET is of limited value, potentially misleading, and therefore not recommended</td>
</tr>
<tr>
<td>Dominant nodule(s) with part-solid or solid component</td>
<td>Initial follow-up CT at 3 months to confirm persistence. If persistent, biopsy or surgical resection is recommended, especially for lesions with &gt;5 mm solid component</td>
<td>Consider lung-sparing surgery for patients with dominant lesion(s) suspicious for lung cancer</td>
</tr>
</tbody>
</table>

Naidich et al. Radiology 2013 266:1, 304-317
Diagnosis

• Percutaneous image-guided biopsy
  – Usually CT, may be US in some cases
  – Peripheral or anterior mediastinal lesions
  – Lesions > 1 cm
  – Lesions in lower lung technically more difficult due to larger respiratory excursion
• Bronchoscopic guided biopsy
  – Direct or under EBUS
  – Endobronchial or central lesions
Preparing a Patient for Lung Biopsy*

• Medications
  – No need to hold ASA, NSAIDs
  – Hold Plavix for 5 days pre-biopsy
  – Hold last dose of LMWH pre-biopsy
  – Hold Fondaparinux, Dabigatran 3-5 days pre-biopsy
• Obtain coagulation studies
  – PLT ≤ 50 → requires transfusion
  – INR > 1.5 → requires normalization prior to procedure
  – aPTT → may require correction to < 1.5x control
• Obtain eGFR
  – In case contrast is required

* From Society of Interventional Radiology Standards of Practice Committee, there may be institutional, practitioner and patient-related variability in practice
Complications of Lung Biopsy

- **Pneumothorax**: 20-25%
  - 5-10% require chest tube
  - Higher risk in emphysema, central lesions, smaller lesions

- **Pulmonary hemorrhage**:
  - 5% hemoptysis, 25% perilesional opacity (self resolving)

- **Air embolism**
  - Rare (<0.1%), potentially fatal

- **Tumour seeding along biopsy tract**
  - Rare (<0.1%), 4% of mesothelioma
  - Wide en bloc resection

- **Death**: 0.15%
Post biopsy pneumothorax

Post biopsy perilesional hemorrhage

Pre

Post
Staging

- **7th edition (2009) of TNM staging for lung cancer**
  - Small, non-small cell lung cancers and bronchopulmonary carcinoids are staged using the same system
  - Updated to correlate with the most current (retrospective) data on disease survival
- Staging is useful for informing prognosis and guiding/monitoring therapy, but is limited
  - Based on retrospective data
  - Reliability and accuracy of imaging and contribution of PET in clinical staging not addressed
  - Does not account for tumour biology
- Ultimately treatment and prognosis are determined by prospective clinical trials
Staging: Tumour (T) Designation

- Determined by tumour size, locoregional invasion

<table>
<thead>
<tr>
<th>Size</th>
<th>T designation</th>
<th>5 year survival (NSCLC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \leq 2 \text{ cm} )</td>
<td>T1a</td>
<td>77%</td>
</tr>
<tr>
<td>&gt; 2 - ( \leq 3 \text{ cm} )</td>
<td>T1b</td>
<td>71%</td>
</tr>
<tr>
<td>&gt; 3 - ( \leq 5 \text{ cm} )</td>
<td>T2a</td>
<td>58%</td>
</tr>
<tr>
<td>&gt; 5 - ( \leq 7 \text{ cm} )</td>
<td>T2b</td>
<td>49%</td>
</tr>
<tr>
<td>&gt; 7 \text{ cm} )</td>
<td>T3</td>
<td>35%</td>
</tr>
<tr>
<td>Invasive*</td>
<td>T4</td>
<td>22%+</td>
</tr>
</tbody>
</table>

* mediastinum, trachea/carina, vertebral bodies or satellite nodule(s) ipsilateral to the main tumour but in another pulmonary lobe

+ satellite nodule(s) ipsilateral to the main tumour but in another pulmonary lobe
Local Invasion in Superior Sulcus Tumours

- CT and PET/CT are mainstays of staging
- MRI may be a helpful adjunct in assessing extent of local chest wall invasion such as in superior sulcus (Pancoast) tumours

Normal Anatomy

Superior sulcus tumour with chest wall and vertebral invasion
Local Invasion in Superior Sulcus Tumours
Staging: Nodal (N) Designation

- Lymph nodes on anatomical imaging are deemed pathological if ≥ 1 cm in maximum short axis diameter
  - Presence or absence of fatty hilum or low attenuation suggesting necrosis are less reliable features than size
  - False negatives: metastasis in normal sized nodes
  - False positives: benign enlarged nodes (reactive hyperplasia, inflammation)
  - Sensitivity, specificity: 45-80%
- PET, EBUS-guided FNA offer improved diagnostic accuracy
Ipsilateral hilar (N1) adenopathy

Contralateral (N3) adenopathy
Staging: Metastasis (M) Designation

- Common sites of lung cancer metastasis
  - Lung
  - Liver
  - Adrenal
  - Bone
  - Brain
- Small cell lung cancer has propensity for early metastasis
- M Designation:
  - Intrathoracic mets (M1a)
    - Contralateral malignant lung nodules
    - Malignant pleural dissemination/effusion
    - Malignant pericardial dissemination/effusion
  - Extrathoracic mets (M1b)
Intrathoracic Metastases (M1a)

Cavitating contralateral metastases from a RUL primary
Intrathoracic Metastases (M1a)

Malignant pleural dissemination
Extrathoracic Metastases (M1b)

Liver mass: benign or met?
- Further evaluation:
  - Liver protocol CT/MRI
  - PET/CT
  - Biopsy

Adrenal nodule: benign or met?
- Most are benign
- Further evaluation:
  - Adrenal protocol CT/MRI
  - PET/CT
  - Biopsy
Extrathoracic Metastases (M1b)

Obvious brain mets on CT

More subtle brain mets on MRI
Lung Cancer Imaging - PET

Sharon Gershony MD
UBC Radiology and Nuclear medicine Resident
BCCA Indications for FDG-PET in the Clinical Management of Adult Cancer Patients:

**Lung** (non-small cell lung cancer)

1. Undiagnosed solitary lung nodule in patients at high risk from trans-thoracic needle biopsy
2. Staging of patients with clinical Stage I and IIA lesions
3. Staging of potentially resectable Stage IIB and III disease
4. Planning for radical radiotherapy
5. Staging prior to resection of solitary lung metastasis

NOTE: No defined indications exist for bronchial carcinoid or small cell lung cancer.
Other cancers given specific clinical indications, as approved by the BC Cancer Agency, on an individual basis.

It is well recognized in clinical practice that there may be clinical scenarios that do not meet specific guidelines but where expert medical opinion indicates the procedure could have a major impact on patient management. PET scan referrals in these cases will be reviewed on an individual basis by physician representatives from the appropriate Provincial Tumor Group and the Functional Imaging department.

If approved by consensus, the patient will be offered participation in the study.

http://www.bccancer.bc.ca/PPI/PET/indications.htm
SOLITARY PULMONARY NODULE
Follow-up

• Response to treatment
  – Tumour burden
  – Treatment complications

• Surveillance
Follow-up – Response to Treatment

Recurrence in LLL following right pneumonectomy. This was treated with stereotactic radiotherapy.

7 months post treatment

15 months post treatment
Follow-up – Response to Treatment
Response to Treatment - Complications

- Radiation Toxicity
  - Radiation pneumonitis
  - Radiation fibrosis

- Chemotherapy Toxicity
  - Lung toxicity
Radiation Toxicity

Radiation pneumonitis
• 1-6 months after completion of RT
• Doses typically > 20Gy
• Ground glass opacities or consolidation sharply bounded by the treatment area
• May resolve radiographically or may progress to fibrosis

Radiation fibrosis
• 6-12 months after completion of RT, with progression up to 2 years
• Volume loss, scarring/consolidation and traction bronchiectasis sharply bounded by the treatment area
Chemotherapy Toxicity

Bleomycin Toxicity
Surveillance

• Surveillance regimen at discretion of treating oncologist
  – Surveillance regimen recommended by the American College of Chest Physicians (2013):
    • CT every 6 months x 2 years, annually thereafter (Stage I/II NSCLC)
  – Surveillance regimen followed by Dr. Sophie Sun (med onc):
    • Stage I/II (potentially curative)
      – CXR every 3-4 months
      – Annual CT
    • Stage III/IV
      – CXR surveillance
      – CT PRN based on symptoms
Questions/Discussion

• Useful links for lung cancer screening:
  – cancerview.ca
  – canadiantaskforce.ca
Thank you for your attention