Percutaneous CT-Guided Biopsy of Small Pulmonary Nodules

Jo-Anne O. Shepard, MD

Challenges and Opportunities

- LCS detects smaller nodules at early stages
- Increasing numbers of “actionable” nodules for evaluation
- Older patients with significant co-morbidities
  - Technical difficulty
  - Risk factors
- More treatment options
  - VATS, SBRT, ablative therapy

Who should be biopsied?

- Not all nodules require biopsy:
  - High pre-test probability of malignancy
  - Persistent or growing nodules
  - PET positive nodules
  - Surgical candidate

Who should be biopsied?

- Surgical candidate:
  - Small lesion deep in lobe, cannot wedge out
  - Patient needs to know to consent
  - High-risk candidate, requiring pre-op diagnosis
- Non-surgical candidate:
  - Pre-treatment diagnosis
  - Low pre-test probability for lung cancer
    - Infection
    - Benign nodule
    - Lymphoma or metastasis

Confirm pre-operative diagnosis

- 42 yo non-smoker
- Part solid/part gg nodule
- Stable for 2 years
- Suspicious morphology
- Adenocarcinoma at biopsy
- VATS wedge resection

Multiple primary tumors

- 72 yo Male
- History of micropapillary thyroid cancer and s/p resection of thymoma
- Metastatic thymoma at biopsy
Diagnosis of lymphoma

- 64 yo Male
- Remote history of treated MALT lymphoma
- New left hilar mass
- Negative bronchoscopy
- Large B-cell lymphoma at biopsy
- Treated with chemotherapy

Management of non-surgical patient

- 78 yo Female
- Limited pulmonary function
- Multiple groundglass nodules
- Growing dominant nodule in RUL
- Adenocarcinoma at biopsy
- Treated with RFA

Differentiate infection from tumor

- 71 yo Male
- Squamous cell ca of the parotid gland
- Cryptococcus neoformans infection identified on bx
- Treated with fluconazole

Confirm benign diagnosis

- 60 yo Heavy smoker
- Slowly enlarging nodule
- Suspicious benign lesion, R/O lung cancer
- Hamartoma confirmed at biopsy
- No further treatment

Planning neo-adjuvant therapy

- 40 yo Male
- Primary anterior mediastinal mass
- Primary pericardial synovial sarcoma at biopsy
- Neo-adjuvant therapy (radiation and chemo) and resection

Targeted therapy

- 55 yo Female
- Malignant adenocarcinoma progressed with conventional chemotherapy
- Metastatic tumour with KRAS mutation identified on bx
- Targeted therapy
(Relative) Contraindications

- Bleeding diathesis
- Pulmonary hypertension
- Pneumonecctomy
- Severe emphysema/bullous disease
- Near diaphragm
- Near major vascular structure
- Uncooperative patient

How to improve diagnostic yield...

- Pre-procedure planning of biopsy route
- Immobilize patient in scanner
- Local analgesia and conscious sedation
- Single pleural puncture
- Angling gantry
- Core biopsies: Aspirates and core biopsies
- On-site cytopathology
- Specimen handling: Cytology, histology, flow cytometry, molecular testing, microbiology

PET/CT: Functional imaging to localize a lesion

Patient Positioning

- Most stable in supine or prone position
- Decubitus position less stable, higher PTX rate
- Posterior approach always preferable
  - Wider interspaces
  - Less lung motion
  - No intervening vessels or breast tissue
  - Greater muscle layer
  - Patient cannot see needles
  - Recover in supine position

Choosing an Access Route

- Avoid bullae
- Avoid traversing lung if possible
- Avoid fissures

Choosing an Access Route

- Avoid chest wall vessels: internal mammary artery, subclavian, and axillary vessels
Choosing an Access Route
- Avoid medium to large pulmonary vessels
- Align needle tangential to aorta

Coaxial Technique
- 19 gauge introducer
- 22 gauge aspirating needle
- Single pleural puncture
- Multiple specimens
- Core biopsy as needed

Angling the Gantry

Core Biopsy
- Provides tissue for histology
- Benign lesions
- Lymphoma
- Molecular markers
- No increase in complications

Crossing the Chest Wall and Pleura
- Advance needle incrementally in chest wall to pleura
- Scan and correct
- Cross pleura ONCE in a single brisk manner

Bonniez PM: AJR 1997: 169:661-666
Repositioning the Needle in the Lung

Coaxial Technique

Handling of Specimens
On-site Cytopathology
- Aspirates
- Washings/cell block
- Cores
- Special stains
- Flow cytometry
- Cultures
- Molecular Profiling

How to decrease complications....
- Careful patient selection
  - PFTs, EF, RVSP, CPAP, etc
- Normal coagulation
- Suppress coughing, talking, moving
- Single pleural puncture, avoid fissures
- Aspirate PTX before removing needle
- Dependent precautions without delay
- Quiet recumbent recovery
- Nasal oxygen

Dependent Precautions
- Patient placed biopsy side down
- Dependent lung hypoventilated
- Decreases PTX

Moore II, et al
Radiology 1990: 176:733-735
Post Procedure Care

- Biopsy side down
- Instruct not to talk, laugh, cough, etc.
- Nasal oxygen
- Monitor hemodynamics and oxygen saturation
- CXRs at 1 hr and 3 hrs
- Discharge if no complication

Diagnostic Yield

- Nodule factors
  - Size
  - Density
  - Location
- Technical factors
  - Aspirate
  - Core
  - Length of needle path


- 198 pts
- Accuracy related to size, morphology and location
- Size
  - <5 mm: 92% (95% CI 87.9–98.0), >5 mm: 98% (95% CI 96.5–100)
- Morphology
  - Solid: 99.3%, Mixed 84.6%, Subsolid 66.6%
- Location
  - Upper 84.2%, Lower 85.3%, Lingular/middle 90.9%
- In 75% of false negative biopsies, needle was outside the lesion on reconstructions


- 98 pts
- Size: GGO and needle length
- GGOe; 90-99% vs >99% no significance
- Size mm  Sensitivity  Accuracy
  - <5  97  97
  - 5-10 97 97
  - >10 97 97
- Overall 97 97
- GGOe: 99
- Yield not affected by needle length
- PTX 16%, Mild hemoptysis 14%


- 83 pure GGOs, 20 g cutting needle
- Mean size 12.1 mm
- Final diagnosis undetermined in 16 lesions, no specimen in 1 lesion
- Diagnostic accuracy 95% (63–66)
- 4 nondiagnostic lesions were smaller, deeper and in lower lobe
- High diagnostic yield for pure GGOs with core

L v. et al. Diagnostic accuracy of CT-guided core biopsy of ground-glass opacity pulmonary lesions. AJR N98; 160:234–239

- 50 pts, GGO and core
- Size: 2 cm vs ≥2 cm
- GGO >0% vs ≥0-90%
- Overall diagnostic accuracy 91%
- Sensitivity and accuracy not significantly different between groups of lesion size and GGO components
- PTX 18%, CT 2%, mild hemoptysis 13%
Localization of small nodules for VATS

- Methylene blue
- Lipiodol
- Technetium labeled tracer
- Hook wire
- Neuroembolization coils “fuzzy wires”
- Gold fiducial markers: Extension of coaxial technique

COMPLICATIONS OF PNAB

- Pneumothorax 10-20%
- Chest tube 1-7%
- Bleeding 5%
- Hemoptysis 3.4%^a
- Air embolism <0.1%
- Death 0.02%
- Tumor seeding -----  

Klein JS. Radiol Clinics North America 2000; 38: 23  
^a Bay et al, Chest 2002;121:1521-1528

How to decrease complications....

- Careful patient selection
  - PFTs, EF, RV, CPAP, etc
- Normal coagulation
- Suppress coughing, talk, moving
- Single pleural puncture, avoid fissures
- Aspirate PSN before removing needle
- Dependent precautions before delay
- Quiet recumbent recovery
- Nasal oxygen

Management of PTX

- During procedure
  - Small - conservative mgmt
  - Moderate - Large - ASPIRATE
- Post procedure
  - Dependent position
  - Naloxone
  - Serial CXRs
- Large or symptomatic
  - Chest tube

Aspirating a Pneumothorax

Delayed Pneumothorax

1 hr
3 hrs
Hemoptysis

- Minor during procedure
  - Suppress cough
  - Abort procedure if persists
- Minor post-procedure
  - Biopsy side down
- Severe post-procedure
  - Bronchoscopy and suction
  - Double lumen tube

Hemothorax

Air Embolism

- Rare 0.07%
- Cavitary or vascular lesions
- Prevention
  - Cross as little lung as possible
  - Avoid pulmonary veins
  - Prevent coughing/motion
- Treatment
  - 100% oxygen
  - Keep recumbent

Air Embolism Mechanism

Tumor Seeding

- Exceedingly rare with fine needles
- More commonly seen with large cutting needles
- Certain tumors are more likely to implant, i.e. thymoma

Summary

- Small pulmonary nodules present special challenges
- Careful patient selection and attention to technique yields high diagnostic accuracy and low complication rate
References

- JVIR 2014; 25:340-346
- Journal of Thoracic Oncology January 2012. Vol 7, Number 1
- European Journal of Radiology 79 (2011) e85-e89

References

- AJR: 192, March 2009. 629-644
- AJR:190, January 2008. 234-239
- Journal of Radiology 68 (2013) e43-e48
- Chest Radiology (2013) 118:1071-1081
- AJR: 201, November 2013
- Clinical Radiology (2008) 63, 272-277