Imaging for Radiation Treatment Planning

Craig W. Stevens, M.D., Ph.D.
Professor and Chief
Division of Radiation Oncology
H. Lee Moffitt Cancer Center

Reginald F. Munden M. D., D. M. D.
Associate Professor
Department of Diagnostic Imaging
M.D. Anderson Cancer Center
Thanks!

- AAPM
- James Balter
- Reggie Munden
- Ken Forster
- Lung Team at MDACC

- Please remember I’m just a RadOnc!
New technology requires careful attention to detail
Mesothelioma
Isodose Distributions

50 Gy

30 Gy
Extrapleural Pneumonectomy:
IMRT Survival & Nodal Stage

N0

Median 20 mo
2 year 47%
3 year 36%

N1 / N2

p = 0.090
Patient Characteristics

• 12/04-8/05: 13 patients treated with IMRT
• All patients underwent EPP
• 12 received intra-operative heated cisplatin (IOHC)*
• 12 received cisplatin/alimta*, median 3 cycles

* IOHC and adjuvant chemotherapy not used at MD Anderson

Elizabeth Baldini, M.D.
Toxicity following RT

- Grade 4/5 Radiation Pneumonitis: 46% (6/13)
  - 4 patients died
  - 2 are stable on steroids off ventilatory support
- Median time to onset of RP: 30 days (r, 5-57)
Summary

• Imaging will grow in importance in radiation oncology
• Technology will help our patients
• Efficacy and side effects will improve
• Careful attention to detail will be required to optimally implement new technologies
Imaging Questions for Radiation Oncology Today

• What is the Stage?

• Where is the tumor?
  – Where is the edge?
  – Which nodes are likely involved?

• When is the tumor within my fields?

• How does the tumor change shape during Rx?
  – Second-to-second
  – Day-to-day
Imaging Questions for Radiation Oncology Tomorrow

• Does the tumor or normal tissue change shape during Rx?
  – Adaptive radiotherapy

• How do we image biology?
  – Tumor?
  – Normal tissue function/risk?
Who will help answer these questions?

• Radiologists have different questions
  – Is this cancer?
  – Does it involve nodes?
  – What is the stage?
  – Can I bill for this test?

• Radiologic physicists have different questions
  – Does the machine work correctly?
  – Are there new technologies to help with the first 4 questions?
Who will help answer these questions?

• YOU

• Radiobiologists

• The occasional radiation oncologist
Imaging Questions for Radiation Oncology Today

• What is the Stage?
  – Really the purview of diagnostic

• Where is the tumor?
  – Where is the edge?
  – What is the best technology to determine this?
    • Disease specific
    • May need multiple modalities
Imaging in Lung Cancer
Assessing Gross Tumor Volume
Effect of Window/Level

Lung Window (W1000/L-300)  Mediastinal Window (W340/L25)

What about out of plane spiculations?
Imaging in Lung Cancer
Assessing Gross Tumor Volume
Contouring
Imaging in Lung Cancer
Normal Anatomy: Abnormal
Imaging in Lung Cancer
Normal Anatomy: Abnormal
Imaging in Lung Cancer
Normal Anatomy: Abnormal
Imaging in Lung Cancer
Normal Anatomy: Abnormal

Lymphoma
Imaging in Lung Cancer
Normal?
High Riding Paratracheal Recess
Superior Aortic Recess
Transverse and Oblique Sinus
Oblique Sinus
Pericardial Recess
Lymph node ??
Pericardial Recess
Pericardial Recess
Imaging Questions

• How well do we train Radiation Oncologists in anatomy or imaging?
• Do they know the pitfalls of the imaging modalities?
  – Do they understand MRI flatness?
    • Might be important for radiosurgery!!
  – Do they understand how US can deform targets?
  – Do they understand PET or PET/CT?
    • Voxel size? Duration of scan? Setup?
  – How will you train them in any new technology?
Assessing Gross Tumor Volume
Imaging in Lung Cancer
Assessing Gross Tumor Volume
CT-then-PET Registration
PET-CT
CT/PET

- CT image is for attenuation correction, but can be diagnostic
- All in the eyes of the beholder
- Will improve staging even compared to PET
Staging – PET/CT
Staging – PET/CT
Radiation Injury of the Lung Fibrosis
Radiation Injury of the Lung
Recurrence
Imaging Questions for Radiation Oncology Today

• When is the tumor within my fields?
  – Tumor motion, mostly respiratory
  – 4D CT
  – Gating, though internal fiducials work best
  – Does motion change during Rx?
    • Infection
    • Response to Rx
    • How often should we re-measure motion?
      – Who would most benefit?

• How does the tumor change shape during Rx?
  – Second-to-second
  – Day-to-day
Lung Tumors Move
Lung Tumors Move

Coronal source1
Ex: 1344
Se: 100
A: 57.1

DFOV 50.0cm
STND Ph:0%

R 2 5 0

1.0/
kv 120
mA 150
Rot 0.50s/Cli
2.5mm /2.5sp
Tilt: 0.0
02:05:40 PM
W = 1415 L = -310

MDACC002 Sagittal source1
Ex: 1344
F 617685 Se: 100
Jul 19 2004 R: 100.1

DFOV 50.0cm
STND Ph:0%

L A
2 2
5 5
0 0

1.0/
kv 120
mA 150
Rot 0.50s/Cli
2.5mm /2.5sp
Tilt: 0.0
02:05:40 PM
W = 1415 L = -310

Tinsu Pan
Problems with gating using external fiducials

Helen Liu
Intrafractional fiducial trajectory
4DCT
Gated Motion (2 Different Days)
Imaging Questions for Radiation Oncology Tomorrow

- Does the tumor or normal tissue change shape during Rx?
  - Adaptive radiotherapy
    - Need to replan to account for changes in tumor
    - What about normal tissue?
    - How do you account for motion (or changes in motion) in a way that physicians understand? 4D DVH?
    - Certainly rectums are thankful for IGRT
      - will adaptive be better?
      - What about lungs?
    - How do you account for these changes with IMRT or protons?
    - How do doses add together?
Imaging Questions for Radiation Oncology Tomorrow

• How do we image biology?
  – Tumor?
    • SUV?
    • MR Spectroscopy?
    • Hypoxia, other markers?
  – Normal tissue function/risk?
    • Interpatient differences
      – Radiosensitivity
      – Underlying disease
      – Pretreatment vs. post treatment imaging
    • Can Dose/function histograms be developed?
Accounting for lung biology
Voxel-by-voxel ventilation

Thomas Guerrero, M.D., Ph.D.
Ventilation loss due to Radiation

Radiation dose distribution

4D CT derived ventilation

Week 0

Week 2

Week 7
Summary

- Imaging will grow in importance in radiation oncology
- Technology will help our patients
- Efficacy and side effects will improve
- Careful attention to detail will be required to optimally implement new technologies