Respiratory Motion Management and Image Guidance in Lung Cancer Radiotherapy

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IGRT and Motion Management in Lung Cancer: Why?

• Lung Cancers are challenging to outline!
• Lung Cancers and Patients Move!
• Lung Cancers and Patients Change Shape!
Talk Outline

• Improving the Basics
• Pre Treatment
• On Treatment
  • Motion Management
  • Image Guided RT
Improving the Basics!
Starting with the Basics

• Lung Q/A Meeting @ SJIO
  • Weekly MDT meeting of Consultant Clinical Oncologists, Consultant Radiologists, Dosimetrists, Physicists, Radiographers and SpRs.
  • Review all radical/SABR contours and any difficult cases
  • Review all planned lung RT cases
  • Review any on treatment problems eg CBCT
  • Discuss any unexpected toxicity
Starting with the Basics

• Better 3D CRT
  • Correct for tissue heterogeneity!- NOT UK
  • Use Type B Model if available
    • Models than in a approximate way consider changes in lateral electron transport
  • Dedicated Lung Dosimetrist/Physicists
• Use published dose limits for lungs and be prepared to accept acute toxicity.

Don’t be Nihilistic!!!
Pre-Treatment Need Better Target Definition
Identifying the GTV

• Many studies have shown considerable variation in GTV contouring between clinicians

• This can be improved by:
  • Training/Having a friendly radiologist!
  • Routine use of IV Contrast
  • PET/CT
Where’s the tumour?
**PET/CT Fusion**

- Significant potential benefit by reducing RT volumes

- However:
  - False positive uptake in post-obstructive inflammation
  - Histological correlation of PET findings with pathology are lacking

PET/CT Fusion

CT based GTV

PET-CT based GTV
4D-CT Simulation

- 4DCT = 4\textsuperscript{th} dimension = time
- Basically uses an external surrogate of chest wall motion and links this to a long acquisition CT scan
- These images are then reconstructed into multiple CT datasets that represent the phases of breathing
- Why?
  - Standard free breathing helical scanning is inaccurate for moving targets
  - Allow quantification of tumour +/- OAR motion = PATIENT SPECIFIC MARGINS
Helical CT vs. 4DCT
4DCT
Patient Specific Margins
Generating your PTV using 4DCT

**Standard Method**
- CTV
- GTV
- PTV

**SJIO Method**
- GTV
- GTV
- GTV
- GTV
- ITV
- PTV

**NKI Method**
- PTV
- GTV
- GTV
- GTV

4D PET/CT

Movie courtesy of Dr Katy Clarke St James’s Institute of Oncology
On-Treatment-Motion Management
Motion Management

• Most Important is to quantify it first!

• If motion significant >0.5-1.0cm need to address it

• Lots of methods!
Motion Management

- Simple - Allow for it in your planning

Standard Method

- CTV
- GTV
- PTV

SJIO Method

- GTV_{EXH}
- GTV_{MID}
- GTV_{INH}
- ITV
- PTV

NKI Method

- PTV
- GTV

Leeds Cancer Centre
Motion Management

• Simple – Restrict it
Motion Management

• Gating and Tracking

Gating Method

Tracking Method

GTV
PTV
RT BEAM ON
GTV
PTV
RT BEAM ON
GTV
PTV
RT BEAM ON
GTV
PTV
RT BEAM ON
GTV
PTV
MV Orthogonal Imaging

• Traditionally orthogonal MV images were used to match to the “tumour”

• However, poor quality images.
  • Can’t see tumour reliably
  • Often matching to a surrogate…… or at least trying to!
  • Can only detect gross changes in tumour volume/anatomy
MV Orthogonal Imaging

- MV Portal Imaging is POOR
- Likely we have missed tumours due to;
  - Collapse
  - Re-expansion
  - Changes in tumour motion
  - Response/Progression
MV Orthogonal Images

- Only suitable for short course palliative RT where
  - Are looking to detect a gross systematic error
  - Larger margins are used to account for this uncertainty
  - Bony match is a reasonable surrogate
  - No close OARs that are close to tolerance
CLINICAL SITE

Lung IGRT Pathway

INTENT

Palliative

PLANNING

CT Simulation Recommended (Level 0a)

TREATMENT

≤5 Fractions

>5 Fractions

IGRT METHOD

IMAGE 1ST FRACTION ONLY WITH PLANAR IMAGING MATCHING TO BONE OR CARINA (Level 1a)

IMAGE USING OFFLINE PATHWAY WITH PLANAR IMAGING MATCHING TO BONE OR CARINA (Level 1b+1c) OR IF AVAILABLE VOLUMETRIC IMAGING MATCHING TO TARGET (Level 2b + 2c)
Volumetric Imaging- CBCT
Volumetric Imaging with kV Cone Beam CT (CBCT)

- Provides CT “like” images whilst patient is on the treatment couch.
- Not diagnostic quality
- Similar to a Slow CT scan
Volumetric Imaging with kV Cone Beam CT (CBCT)

• BUT…
  • For lung cancers CBCT is able to visualise parenchymal tumours easily
  • Slow CT equivalent and therefore can detect motion
  • Can detect collapse/re-expansion
Volumetric Imaging - CBCT
MV CT with Tomotherapy
IGRT with implanted fiducials

- Metals fiducials can be placed near or in lung tumours
  - Percutaneously
  - Trans-bronchially
- Visualised with kV fluoroscopy/CBCT
- This allows accurate localisation
- Can allow tracking eg Cyberknife or gating (RTTS/BrainLab)
IGRT with Fiducials

- Gating and Tracking
IGRT with implanted fiducials

• Advantages:
  • Real time tumour tracking ensures dose delivered to target as patient breathes
  • Can reduce Treatment Volumes

• Disadvantages:
  • Complications of fiducial placement
  • Can image tumour or OARs directly
  • Fiducials can move
4D Cone Beam CT
Real Time Tracking with CBCT

• Currently in development
• Can acquire a CBCT during a VMAT delivery
• Can the real-time kV images be used to track anatomy or fiducials?
Lung IGRT Pathway

**Radical**

CT Simulation Required (Level 0a)
IV Contrast Recommended for all lesions close to mediastinum or brachial plexus (Level 0b)
4DCT Recommended for all tumours with significant motion (eg >0.5cm in any direction) especially for lung SABR (Level 0c)

**Treatment**

- 3DCT with Conventional Fractionation
- More Complex RT (eg IMRT / Boost) or Margin Reduction
- Hypofractionation eg SABR

**IGRT Method**

- **Image Using Offline Pathway**
  - with Volumetric Imaging Matching to Target (i.e. Level 2b, 2c +/-2d+2e)
  - Planar Imaging only for ParaVertebral/Pancoast Tumour Matching to Reliable Bony Surrogate (i.e. Level 1b, 1c +/-1d+1e) with Regular Volumetric Imaging (eg weekly) to Detect Changes in Internal Anatomy (eg Lung Collapse)

- **Image Using Online Pathway**
  - with Volumetric Imaging Matching to Target or Marker(s) Implanted in or Near Target (i.e. Level 2d+2e)

- **Image Using Online Pathway**
  - with Volumetric Imaging Matching to Target or Marker(s) Implanted in or Near Target.
  - Consider Repeat Imaging After Shifts and at End of Treatment (>1 image per treatment i.e. Level 3a)
  - Consider Monitoring for Intra-Fraction Changes (i.e. Levels 3a + 3b)
Conclusion

• Lung RT is improving!!!
  • Better Target Definition
  • Patient Specific Margins
  • Manage Motion if required
  • Ensure Accurate Delivery

= BETTER OUTCOMES
Questions?
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