Patient Setup Imaging in RT: Getting the Most Bang for your Buck

Olivier Morin, PhD

Comprehensive Cancer Center
San Francisco, CA

Saturday, April 2nd, 2011
UCSF Annual Course
St. Regis Hotel, San Francisco, CA

Presentation Outline

- Errors in RT.
- Radiographic films in RT.
- On-board digital imaging.
  - EPID, Tomosynthesis and Cone Beam CT.
- Clinical applications.
  - Prostate, H&N and lungs.
- New imaging development.

Main Errors in RT

- Gross errors
- Anatomy acquisition
- Target delineation
- Patient Setup
- Anatomy changes
- Patient or organ movement
- Dose delivery

PTV was proposed to assure tumor coverage despite these 3 error types

With improved setup

Hypothetical Patient Examples

Patient A
- Relaxed
- Good overall health
- No serious pain

Patient B
- Nervous
- Good overall health
- No serious pain

Patient C
- Nervous
- Poor overall health
- Highly symptomatic

Setup Errors

-1.0 0 1.0 [cm]

fractions %

-1.0 0 1.0 1.0 [cm]

Systematic Random
Hypothetical Patient Examples

- Patient D
  - Relaxed
  - Good overall health
  - No serious pain

- Weight loss
  - Mask no longer fits

Are we giving these four patients the same quality of treatment?

Modalities for Management of Patient Setup Errors

- Portal imaging with radiographic films (2D).
- Portal imaging with electronic portal imaging device (2D).
- Cone Beam CT (3D).
- Others (Tomosynthesis, 4D CBCT, US, etc.).

Films vs. Digital Modalities

Radiographic Films:
- Good spatial resolution (fine grain).
- Poor bone contrast (up to 8 MU).
- Difficult to incorporate in the digital record system.
- Won’t go away tomorrow (QA, backup, etc.).
- Not accepted as an IGRT method by RTOG.

Films in RT (“Film Age”)

<table>
<thead>
<tr>
<th>Stock</th>
<th>1990</th>
<th>2011</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastman Kodak (EK)</td>
<td>39.13</td>
<td>3.4</td>
<td>-91</td>
</tr>
<tr>
<td>Perkin Elmer (Flat panel manufacturer)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
All new treatment machines are equipped with on-board digital imaging.

In-Room Imaging Options with EPID

Projections

- 20°-60° arc
- Multiple tomograms

Lung Digital Tomograms

| 20°, 5 sec, 1.2 MU | 40°, 10 sec, 2.4 MU | 60°, 20 sec, 3.6 MU | EPI, 2 sec, 2 MU |

Dose, Time, Motion blurring

Tomograms with 40 degree arc provide the best overall performance.

Presentation Outline

- Errors in RT.
- Radiographic films in RT.
- On-board digital imaging.
  - EPID, Tomosynthesis and Cone Beam CT.
- Clinical applications.
  - Prostate, H&N and lungs.
  - New imaging development.

Using Digital Tomograms

- Lung: 40°, 2 cGy
- H&N: 40°, 0.6 cGy
- Prostate: 40°, 0.6 cGy

- Agreement of < 2 mm obtained at all treatment sites (prostate, HN and lungs) compared with CBCT.
- Position of the isocenter is important for the clinical utility of the Tomograms and the specificity of the alignment.

Prostate Patient Setup

Current:
- Gold markers implanted in the prostate.
- All patients aligned every day with 2D EPID.

Investigational:
- Fiducial-less imaging. 3D CBCT performed everyday. Alignment on soft-tissue and dosimetric evaluation of surrounding OARs.

H&N Patient Setup

Current:
- Patient alignment using bony landmarks.
- Weekly imaging (CBCT or EPID).
- Verification of gross anatomical changes (3D).

Investigational:
- Patient specific correction strategies.
- Evaluation of the dosimetric impact of anatomical changes.

Patient Setup Strategies (H&N)

<table>
<thead>
<tr>
<th>IGRT Strategy</th>
<th>%IG</th>
<th>Frequencies Errors &gt; 3 mm</th>
<th>Frequencies Errors &gt; 5 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>No imaging</td>
<td>0</td>
<td>72</td>
<td>37</td>
</tr>
<tr>
<td>Imaging first fraction only</td>
<td>3</td>
<td>79</td>
<td>47</td>
</tr>
<tr>
<td>Mean of five fraction</td>
<td>15</td>
<td>58</td>
<td>26</td>
</tr>
<tr>
<td>Weekly imaging</td>
<td>20</td>
<td>60</td>
<td>31</td>
</tr>
<tr>
<td>First five fraction + weekly</td>
<td>31</td>
<td>50</td>
<td>27</td>
</tr>
<tr>
<td>Imaging every other fraction, running mean</td>
<td>50</td>
<td>29</td>
<td>11</td>
</tr>
</tbody>
</table>

Lung Patient Setup

Current:
- Large margins (up to a few cm).
- Margins based on 4DCT (MIP).
- Weekly imaging (CBCT or EPID)?

Investigational:
- Patient specific correction strategies (daily ?).
- Carina vs. bony anatomy for setup.

Investigational:
- New On-board Imaging Technology
  - Stationary Tomosynthesis Array for Radiotherapy (STAR)
    - High-current cold CNT cathode technology
  - 4 x 18 cold x-ray sources

Reference: Yom et al., 14th World Conference on Lung Cancer, 2011
Clinical Applications with STAR

- Periodic image verification
- Real-time tracking


In Summary

- The age of radiographic films for patient setup has passed.
- Portal imaging is a good first order correction for prostate and H&N. Probably not for lungs.
- Correction strategies for setup errors (modality and frequency) are not only site but also patient dependent.
- Tomosynthesis may be a good alternative to CBCT for lung setup but more development is needed.

Acknowledgments

UCSF
- Jean Pouliot
- Michelle Aubin
- Martina Descovich
- Sue Yom
- Vivian Weinberg
- Neil Kirby
- Christine Malfatti
- Complete team of therapists

Siemens
- Ali Bani-Hashemi
- Jonathan Maltz
- Bijumon Gangadharan
- Ajay Paidi
- Supratik Bose