Position Verification in Radiotherapy

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Overview

- Reasons to verify
- Methods
- Case studies
  - Prostate
  - Bladder
  - Lung
  - Oesophagus
- Summary
Why verify?

Treatment process assumes simulation is representative of the average target position and that daily position is reproducible.

In reality there is positioning variability due to:
- bony anatomy set-up error
- internal organ position
- machine parameters

Compensated for by using generic population based margins from CTV to PTV.

Studies show that using treatment verification reduces errors and allows the use of smaller population based margins in that department.
Types of error

- **Systematic error**
  - Generally introduced at planning and therefore propagated throughout treatment
  - Patient moving between CT scan and marking tattoos
  - Interobserver variability in contouring
  - Pb/MLCs in wrong position
  - Planning and treating the wrong site

- **Random error**
  - Daily variable movements – internal and external!
  - Mis-interpreting set-up instructions
  - Worse in prone, overweight or poorly immobilised patients
  - Critical if delivering short hypofractionated treatments

Equipment available in Leeds:

- Elekta Synergy™ kV CBCT x 2
- Elekta iview AmSi flat panel EPIDS x 10
How do we verify?

- **Conformal XRT Delivery**
  - 2D
  - Bony landmark verification
    - Standard #1 ± 2 ± 3
  - Patient re-positioning to compensate for geometric errors

- **2/3D IGRT**
  - 2/3D IGRT
  - Target volume verification
    - #1 – 3 and weekly

**Correction Strategy**

- **Systematic errors**
  - 3 - 10mm tolerance dependant on site
  - 75% of average error measured over at least 2 fractions corrected

- **Random Errors**
  - Correction only employed if errors are exceeding margins
  - Online correction 100% of error
- Are bony surrogates adequate to verify position?
- Do 2D images tell us anything else?

Case Study 1 Prostate
Planning scan and #1-4 CBCT images
Case study 1 Prostate
DRR and #1-4 EPI’s

Case study 2 Bladder – setup error

<table>
<thead>
<tr>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anatomic displacement relative to the field edge</td>
</tr>
<tr>
<td>Horizontal (mm)</td>
</tr>
<tr>
<td>Vertical (mm)</td>
</tr>
<tr>
<td>Rotation (degrees)</td>
</tr>
</tbody>
</table>
But some problems we can’t see without CBCT…

Case Study 3 - Peripheral Lung Tumour
Case study 3 – Peripheral lung tumour

Margins

Margin calculation for radical NSCLC patients planned using slow CT including a correction of systematic errors after 3 fractions from the mean of the first three measurements

<table>
<thead>
<tr>
<th>Uncertainty</th>
<th>Mediastinal</th>
<th>Non-mediastinal</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PA (mm)</td>
<td>RL (mm)</td>
<td>SI (mm)</td>
</tr>
<tr>
<td>Σset-up</td>
<td>0.84</td>
<td>1.54</td>
<td>2.63</td>
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<tr>
<td>Σsystematic</td>
<td>2.6</td>
<td>2.9</td>
<td>4.2</td>
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<tr>
<td>σset-up</td>
<td>0.57</td>
<td>2.27</td>
<td>2.91</td>
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<tr>
<td>σcombined</td>
<td>5.0</td>
<td>5.5</td>
<td>5.8</td>
</tr>
</tbody>
</table>

CTV-PTV margin (Semi-diameter r)

- Previous Margin: PTV = GTV + 1.5 cm around the primary tumour and 0.5 cm around involved lymph nodes laterally. Cranio-caudal margin is PTV + 2.0 cm (dependant on respiration)
Slow CT to 4DCT

- Slow CT obtained on GE lightspeed as 4D not feasible.
- Bexley Wing = Siemens scanner = 4DCT feasible
- 1st 4D CT patient scanned August 2008
- Need CBCT to verify

Case study 4 – 4DCT
4DCT - #3 and #4

Case Study 5 - Oesophagus
Summary

- There is still a role for standard 2D verification
- CBCT is our method of choice in some sites
  - Lung
  - Bladder
  - Oesophagus