IROC Houston's Proton Beam Validation for Clinical Trials

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Proton QA Audit Components

• Goal: ensure proton centers deliver consistent, comparable dose for clinical trials & follow NCI/AAPM recommendations

• Remote
  – Annual TLD audit of beam calibrations
  – Anthropomorphic proton phantom audits

• On-site
  – Dosimetry review site-visit
Output Audits

- TLD used to monitor beam output annually – verification of TRS 398 protocol
- TLD placed in acrylic blocks, institutions provide own water-equivalent buildup
- OSLD also investigated
- Characterizable response at center of modulation
TLD Output Audits

Proton Beam TLD/Inst

Date
Which calibration protocol is recommended for proton beams?

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>20%</td>
<td>1. AAPM TG 21</td>
<td></td>
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<tr>
<td>20%</td>
<td>2. AAPM TG 43</td>
<td></td>
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<tr>
<td>20%</td>
<td>3. AAPM TG 51</td>
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<td>20%</td>
<td>4. IAEA TRS 277</td>
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<td>20%</td>
<td>5. IAEA TRS 398</td>
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Correct Answer:

• 5: IAEA TRS 398

Per recommendations by NCI and AAPM Ad-hoc advisory group in 2012

Ref: NCI. Guidelines for the Use of Proton Radiation Therapy in NCI-Sponsored Cooperative Group Clinical Trials: RPC; 2012.

Phantom Irradiation Audits

- 5 proton phantoms: prostate, spine, lung, head, liver
  - Prostate, head: simple, spherical target geometry
  - Spine: field matching
  - Lung, liver: motion included
  - Liver: 2 targets
Phantom Irradiation Audits

- Phantoms made from proton-equivalent plastics
Phantom Irradiation Audits

- Phantoms contain TLD and radiochromic film – used for absolute and relative dose comparison with treatment plan
## Phantom Irradiation Audits

- 91 proton phantoms irradiated, analyzed

<table>
<thead>
<tr>
<th></th>
<th>Prostate</th>
<th>Spine</th>
<th>Lung</th>
<th>Head</th>
<th>Liver</th>
<th>TOTAL</th>
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<tbody>
<tr>
<td>Total Irradiations</td>
<td>35</td>
<td>16</td>
<td>20</td>
<td>16</td>
<td>4</td>
<td>91</td>
</tr>
<tr>
<td># Passed</td>
<td>25</td>
<td>13</td>
<td>15</td>
<td>16</td>
<td>2</td>
<td>71</td>
</tr>
<tr>
<td>Pass Rate</td>
<td>71%</td>
<td>81%</td>
<td>75%</td>
<td>100%</td>
<td>50%</td>
<td>78%</td>
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Why are different plastics required for proton phantoms relative to photon phantoms?

<table>
<thead>
<tr>
<th>20%</th>
<th>1. Photon plastics are too heavy</th>
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<tbody>
<tr>
<td>20%</td>
<td>2. To match tissue HU-RLSP curve</td>
</tr>
<tr>
<td>20%</td>
<td>3. Proton plastics are cheaper</td>
</tr>
<tr>
<td>20%</td>
<td>4. Different dosimeters are used</td>
</tr>
<tr>
<td>20%</td>
<td>5. Proton plastics are deformable</td>
</tr>
</tbody>
</table>
Correct Answer:

• 2: To match tissue HU-RLSP curve

Many plastics used for our photon phantoms do not fall on the tissue-equivalent conversion curve for proton therapy

On-site Proton Dosimetry Audits

• Institutions visited after routinely treating patients for 6 months, no fewer than 3 disease sites

• Each delivery modality has separate audit requirement – must each be reviewed
  – Scattering
  – Uniform Scanning
  – Spot Scanning/PBS
On-site Proton Dosimetry Audits

• Review:
  – Absolute calibration
    • Ion chamber in water
  – Dosimetry for reference and patient fields
    • 2D ion chamber array, MLIC
  – IGRT
    • Film on cube
  – CT-RLSP
    • Tissue-equivalent phantom
  – Treatment planning procedures
  – Machine & patient-specific QA
On-site Proton Audit Results

• Common site visit recommendations:
  – QA (66 rec’s)
    • Expected to improve when AAPM Task Group 224 (proton machine QA) is published
  – CT Number/RLSP conversion (11 rec’s)
    • Most discrepancies observed at high CT #s, a few at low CT #s
  – Very few recommendations for beam output, delivery
Summary

• TLD
  – Output measurements within ±5% over past several years
  – Will transition to OSLD in the near future

• Phantoms
  – Phantom pass rates improving
  – Motion, OARS, multiple targets prove challenging

• On-site Dosimetry Review
  – Very few dosimetry recommendations
  – Many QA recommendations
Questions?