The State of Radiotherapy Physics Through the Eyes of a Quality Auditor

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Brief Background

• Originated through agreement between AAPM and CRTS

• Founded in 1968 to monitor institution participation in clinical trials

• Funded continuously by NCI as structure of cooperative group programs have changed

• Now 38 years of experience of monitoring institutions and reporting findings to study groups and community
Why do we do this?

We have an NCI grant to:

1. Assure NCI and cooperative groups that institutions participating in clinical trials deliver prescribed doses that are comparable and consistent.

2. Help institutions to make any corrections that might be needed.

3. Report findings to the community.
Only QA Office with relationships with all study groups.
Clinical Trial Participants

- Number of Active Institutions – 1435
- 2864 megavoltage machines
- 7279 active megavoltage beams
RPC QA Audit Techniques

- On-site Dosimetry Review Visits
- Remote Reviews
- - TLD Program
- - Phantom Program
- - Off-site Dosimetry Reviews
- - Patient Dosimetry Reviews
- - Benchmark case Reviews
- - QA Program Reviews
RPC Verification of Institutions’ Delivery of Tumor Dose

- Reference calibration (NIST traceable)
- Correction Factors:
  - Field size & shape
  - Depth of target
  - Transmission factors
  - Treatment time

Tumor Dose

- Evaluated by RPC Dosimeters
- Evaluated by RPC visits and chart review
- Evaluated by RPC phantoms
The Thermoluminescent Dosimetry (TLD) Program

- Largest of its kind in operation (> 30 years)
- Verifies dose output and energy on megavoltage units (>9100 beams in 2006).
- Measure consistency of institutions based on TLD history
- Provides independent audit of the output as required by many states
- Other similar programs
Country participating in the IAEA/WHO TLD service
National QA network or participant in international network other than IAEA
QA network co-operating with IAEA

Data from J. Izewska
13 institutions visited recently to resolve TLD problems
RPC Phantoms

Pelvis

Thorax

H&N IMRT

SRS Head

Liver
Number of H&N Phantom Mailings

![Bar chart showing the number of H&N phantom mailings from 2001 to 2006. The chart indicates the number of phantoms mailed for different years and categories, with the largest increase in 2004.](chart.png)
Plan vs. Treatment
Examples of Failures
# Phantom Results

<table>
<thead>
<tr>
<th>Phantom</th>
<th>H&amp;N</th>
<th>Prostate</th>
<th>Thorax</th>
<th>Liver</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irradiations</td>
<td>217</td>
<td>55</td>
<td>25</td>
<td>4</td>
</tr>
<tr>
<td>Pass</td>
<td>146</td>
<td>41</td>
<td>14</td>
<td>2</td>
</tr>
<tr>
<td>Fail</td>
<td>57</td>
<td>14</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>Under analysis or</td>
<td>12</td>
<td>13</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>at institution</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unevaluable</td>
<td>12</td>
<td>3</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Year introduced</td>
<td>2001</td>
<td>2004</td>
<td>2004</td>
<td>2005</td>
</tr>
<tr>
<td>Failure Rate</td>
<td>34%</td>
<td>27%</td>
<td>14%</td>
<td>-</td>
</tr>
</tbody>
</table>
On-Site Dosimetry Review Visit

• The only completely independent comprehensive radiotherapy quality audit in the USA and Canada
  
  – Identify errors in dosimetry and QA program and suggest methods of improvements.
  
  – Collect and verify dosimetry data needed to review patient charts.
  
  – Improve quality of patient care for all patients.
On-Site Dosimetry Review Visit

~1435 institutions participating in clinical trials

visited  |  not visited yet
---------|-----------------|
Institutions: 728  |  707
Patient accrual: 20,130  |  1,095
(95%)  |  (5%)

Prioritization schema focuses our visit resources where the majority of the patients are treated!
Reference Calibration

BEAM CALIBRATION
PROJECTION POST TG-51

Percent within Criterion

TG-21 Implementation

TG-51 Implementation

YEAR

## On-Site Dosimetry Review Visit

<table>
<thead>
<tr>
<th>Errors Regarding</th>
<th>Percent of Institutions Receiving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review QA Program</td>
<td>(84%)</td>
</tr>
<tr>
<td>*Photon Depth Dose</td>
<td>(30%)</td>
</tr>
<tr>
<td>Switch to TG-51</td>
<td>(24%)</td>
</tr>
<tr>
<td>*Wedge Transmission</td>
<td>(24%)</td>
</tr>
<tr>
<td>*Electron Calibration</td>
<td>(22%)</td>
</tr>
<tr>
<td>*Photon Calibration &amp; FSD</td>
<td>(24%)</td>
</tr>
<tr>
<td>*Off-axis Factors</td>
<td>(16%)</td>
</tr>
</tbody>
</table>

*70% of institutions received at least one of the significant dosimetry recommendations.
# On-Site Dosimetry Review Visit for TLD Problems

**Clinac 23EX**  
Reason: Electron output low for two energies

<table>
<thead>
<tr>
<th>E</th>
<th>TLD Before</th>
<th>TLD Visit</th>
<th>Ion chamber Visit</th>
<th>Compounding Individual errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 MeV</td>
<td>0.948</td>
<td>0.961</td>
<td></td>
<td>0.963</td>
</tr>
<tr>
<td>20 MeV</td>
<td>0.943</td>
<td>0.942</td>
<td></td>
<td>0.946</td>
</tr>
</tbody>
</table>

1. Dosimetry system comparison (- 0.1 %)  
2. Incorrect barometric pressure (+ 1.3%)  
3. Incorrect $N_{d,w}K_{ecal}$ for parallel plate chamber (- 2.0%)  
4. Use of % Ion for $d_{ref}$ to $d_{max}$ correction (-2.9 to -5.4%)
Over 500 errors and 85 lapses in QA programs were identified at institutions visited by the RPC during this past 5 year period.
Water or muscle - does it matter?

The RPC has received a number of comments about the question on our TLD forms that asks if the institution calibrates to water or muscle. Several callers were concerned that they needed to report their calibration in the same medium as is used by the RPC to report dose. Others asked for the converse; for the RPC to report dose in the same medium as used by their institution for calibration.

The medium used for reporting dose is not necessarily the same as the medium in which the beam output is measured. TG-51 requires that beam output be measured in water, and many institutions report the calibration that way. In other words, they describe the output as 1.00 cGy to water per MU under reference conditions. However, quite a few institutions apply a 1% correction at the time of calibration, and adjust the treatment unit output to 1.00 cGy to muscle per MU under reference conditions. The RPC database indicates that 35% of the institutions report their calibration to muscle and the remaining 65% to water.

We would like institutions to indicate on the TLD forms how their beams are calibrated, not how patient doses are described. If a 1% correction is applied at the time of beam calibration, you should check the box for "muscle". Otherwise you should check "water", even if you apply the 1% correction when calculating MU settings for patient treatments.
Ongoing Communications with Community

1. Via the web site and email
2. AAPM newsletter
3. Workshops, Posters, oral talks and publications
4. Phone (713) 745-8989
Redundancy
Vigilance
Resolution
Time
Support
There is no other organization within the USA and Canada that serves as a National Resource for the Radiation Oncology Community like the RPC does.