Has IMRT delivery improved in the last 5 years?

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Purpose:
To determine whether institutions that participate in clinical trials are delivering IMRT more accurately today than they were when the RPC auditing program began in 2001.

Methods and Materials:
A malable anthropomorphic IMRT head and neck phantom was irradiated 572 times by 416 institutions. Some institutions irradiated multiple times. Institutions imaged the phantom, planned an IMRT treatment, performed their routine IMRT QA checks, and irradiated the phantom according to their plan. The phantom contained inimageable structures representing a planning target volume (PTV) close to an organ at risk (OAR), simulating an oropharyngeal tumor and the spinal cord. The phantom also contained a secondary PTV that simulated peripheral nodes. TLDs were placed in each structure and a set of orthogonal radiochromic film (axial and sagittal planes) intersected in the primary PTV. The following criteria were used to evaluate the measurements: TLD/institution dose – ≤ 7%; distance-to-agreement in the high dose gradient region near the OAR – ≥ 4 mm. The current failure rate was compared to the failure rate in 2005 to determine if IMRT delivery has improved over the past few years. The results for all institutions were also analyzed by looking for correlations between the failure rates and type of accelerator, treatment planning systems, and IMRT technique at the institution.

Results:
Between 2001 and June 2008, the head and neck phantom was irradiated by 416 institutions for a total of 572 irradiations. As of June 2008, 135 of the irradiations failed the criteria for an overall pass rate of 75%.

The following table shows the average TLD and film results from the 572 irradiations.

<table>
<thead>
<tr>
<th>Criteria Failed</th>
<th>Pass Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLD/institution dose</td>
<td>≤ 7%</td>
</tr>
<tr>
<td>Distance-to-agreement region</td>
<td>≥ 4 mm</td>
</tr>
</tbody>
</table>

The following histograms show the spread of the results from the TLD in the PTVs and the spread of the DTA results. A negative DTA means that the institution delivered dose posteriorly into the spinal cord beyond the plan and a positive DTA means that the delivered dose fell off faster than the planned dose.

The following shows the results for linear accelerator manufacturer, treatment planning system and IMRT technique.

<table>
<thead>
<tr>
<th>Manufacturer/TPS</th>
<th>Pass Rate</th>
<th>Attempts</th>
<th>Dose</th>
<th>DTA</th>
<th>Dose and DTA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Varian/Eclipse</td>
<td>80</td>
<td>50</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Varian/Pinnacle</td>
<td>79</td>
<td>56</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

The following shows the same results through mid 2008. Some of the overall improvement is believed to be due to improvements in Pinnacle software to better model round end leaves. The Varian/Eclipse combination has also shown an improvement for which the reasons are not clear.

Conclusions:
Institutions interested in participating in NCI sponsored IMRT protocols appear to be delivering IMRT more accurately today than they were several years ago. One of the reasons for this is improved modeling capabilities in treatment planning systems. One of the most common treatment machine/planning system combinations has shown an improvement in pass rates since a new version of software became available. However, this does not explain all of the improvement. Other reasons could include more care taken at the time of phantom irradiation and increased knowledge in the medical physics community of how to appropriately commission IMRT systems. Though there has been improvement, there is still room for more. 24% of the irradiations are still failures. Adequate IMRT quality assurance and commissioning is essential now as always.

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References:


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