An update on the dosimetric accuracy of different treatment planning system algorithms in the IROC lung phantom

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IROC Lung phantom

- Assess dose in a heterogeneous environment
  - Following a clinical workflow
  - Moving phantom

- Dose assessment
  - 2 TLD in center of lung target (3 cm x 5 cm)
  - Film in 3 planes

- How accurate are current treatment planning systems?
There were systematic differences in dose calculation accuracy to the center of the target between different algorithms.
TLD Dose Findings (2013)

- Dose to the center of the target
- Measured doses systematically lower than calculated doses for S/C and AAA algorithms ($p<0.0001$)
- No significant difference between C/S AAA algorithms
- MC results looked good

- For C/S AAA algorithms:
  - No significant difference between IMRT (mean=0.963) and 3D CRT (mean=0.964) irradiations ($p=0.7$)
  - No significant difference between moving (mean=0.961) and static (mean=0.964) irradiations ($p=0.5$)
  - No significant trend versus irradiation date ($p=0.2$)
Status

Previous study
• Based on 304 irradiations
• All Monte Carlo results combined (n=32)
• No Acuros

Present day
• 965 irradiations
• Monte Carlo can be divided (n=89):
  – Multiplan (n=50)
  – Monaco (n=19)
  – iPlan (n=18)
• Acuros results (n=63)

How do the new results look
Particularly compared to historical values?
Measured/Calculated Dose to the centre of the target (TLD)

**Prior Results**
- AAA (n=98)
  - 0.959 (0.003)
- S/C (n=87)
  - 0.966 (0.002)
- MC (n=32)
  - 0.994 (0.005)
- Acuros
  - N/A

**Updated Results**
- AAA (n=417)
  - 0.962 (0.001)
- S/C (n=360)
  - 0.968 (0.001)
- MC (n=89)
  - 0.982 (0.003)
- Acuros (n=63)
  - 0.991 (0.004)

\(^1\text{Values corrected based on patient's status.}\)
\(^2\text{Uncorrected data for comparison.}\)
- Previously, there were trends but no significant differences between any S/C algorithm
- New results, similar trends, some significant:

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>N</th>
<th>Meas/Calc</th>
<th>St. Dev of mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>XiO</td>
<td>39</td>
<td>0.961*</td>
<td>0.004</td>
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<tr>
<td>Pinnacle</td>
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<td>Raysearch</td>
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<tr>
<td>Tomotherapy</td>
<td>53</td>
<td>0.977*</td>
<td>0.003</td>
</tr>
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</table>
Monte Carlo results: Measured/Calculated (TLD)

Prior Results
- N=32
  - 0.994 (0.005)
- 25/32 results were Multiplan

Updated Results
- Overall (n=89)
  - 0.982 (0.003)
- Multiplan (n=50)
  - 0.992 (0.005)
- Monaco (n=19)
  - 0.971 (0.007)
- iPlan (n=18)
  - 0.970 (0.004)
A few points

• Dose to center of target
  – 6 MV beam achieves electronic equilibrium

• Other IROC phantoms (homogeneous):
  – Average agreement between measurement and calculation:
    – within 1% (Ibbott G et al. Technol Ca Res Treat 2006;5:481)

• Differences between algorithms have been seen
  – MC recalculations of S/C
  – Larger irradiated volumes in SBRT lung tumors when CS/AAA plans recalculated with MC
    • (Li Int J Radiat Oncol Biol Phys; 84;508:2012)
Conclusion

- SC/AAA overestimate dose to center of target in IROC thorax phantom (3.5%)
- Issue for dose calculation accuracy (TG-65 goal: 1-2%)
- Potentially issue for dose reporting/prescribing
- Different Monte Carlo algorithms provided different levels of accuracy
- Many unknowns remain
- Acuros and Multiplan provide best accuracy
Thank You!

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