Calculation of Contra-lateral Lung Doses in Thoracic IMRT: An Experimental Evaluation

Deborah Schofield, Laurence Court, Aaron Allen, Fred Hacker, Maria Czerminska

Department of Radiation Oncology
Dana Farber / Brigham and Women’s Cancer Center
Overview

- **Background on Mesothelioma**
  - The disease
  - Why use IMRT?
  - Should IMRT be used?
  - Why is the accuracy of calculated lung dose important?

- **Experiment**
  - Equipment and planning techniques
  - Constraints and calculated lung dose
  - Setup
Overview

- Experimental Results
  - Control Plans
  - IMRT plans
  - In-field vs Out of Field Points

- Conclusions
Background on Mesothelioma
Mesothelioma

- Largely fatal disease
- Median Survival : 12 months
- No clear standard of care
Extra-Pleural Pneumonectomy  
(EPP)

- Patients with disease limited to the chest are candidates for EPP.

- After EPP, 80% of patients will experience disease progression.

- Even with a tri-modal effort (EPP, chemotherapy and traditional radiation therapy), the 5 year survival rate is only 14%.

- More aggressive treatment (including the possibility of using IMRT) needs to be pursued.
Why Use IMRT?

- CTV is very large (contoured from the apex of the lung to the upper abdomen).

- Boost regions often desired.

- Dose painting / Differential Dosing can be used
Why Use IMRT?

- Large number of normal structures in the region
  ex. spinal cord, liver, heart, contralateral lung and kidney, GI Tract and esophagus

- Delivering high doses to the CTV while maintaining normal structure tolerance is nearly impossible with conventional RT.
Mesothelioma CTV

Superior

Central
Mesothelioma Normal Structures
Should IMRT be used in the Thoracic Region?

- IMRT is not typically used in the thorax due to possible interplay between patient and leaf motion.

- IMRT on a mesothelioma patient following EPP is a special case.

- Typically have small amount of respiratory motion in these patients.
Why is Calculated Lung Dose Important?

- Mesothelioma patients undergoing IMRT following EPP have only one remaining lung.

- Normal lung constraints used in patients with two lungs are thought to be too high for this subset of patients.
Why is Calculated Lung Dose Important?

- In particular, IMRT may give large volumes of the lung small doses of radiation which may not be modeled well by traditional dose calculation algorithms.

- If the lung dose is too high, radiation induced pneumonitis may occur resulting in death.
Experiment
Equipment for Planning and Delivery

- TPS: Eclipse (Varian)

- Energy: 6X

- Heterogeneity Corrections: Modified Batho

- Linac: Varian 21Ex

- Sliding window IMRT
Prescription

CTV to 54 Gy in 30 fx (1.8 Gy/fx)

Boost region to 60 Gy in 30 fx (2.0 Gy/fx)

Lung Metrics

<table>
<thead>
<tr>
<th>Mesothelioma</th>
<th>Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td>MLD: &lt;=9 Gy</td>
<td>MLD: 15-17 Gy</td>
</tr>
<tr>
<td>V5: &lt;60%</td>
<td>V5: N/A</td>
</tr>
<tr>
<td>V20: &lt;20%</td>
<td>V20: 20%</td>
</tr>
</tbody>
</table>
## Planning Techniques

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of Plans</th>
<th>Number of Degrees Free from Entrance Beams on the Contra-lateral Side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>5</td>
<td>160°</td>
</tr>
<tr>
<td>Group B</td>
<td>4</td>
<td>80° - 90°</td>
</tr>
</tbody>
</table>
Beam Arrangement

160° free from Entrance beams
Sample Mesothelioma Plans
- Two control plans were also evaluated

- Control Plan 1 consisted of an AP/PA plan that would irradiate the entire thorax of the phantom (40 x 40cm field sizes).

- Control Plan 2 consisted of an AP/PA plan that would only irradiate the ipsilateral side of the phantom’s thorax.
Control Plans

40x40 Control

Ipsilateral Control

Field Edge
Obtaining Calculated Lung Doses

- All 11 plans (9 IMRT + 2 Control) were applied to a Rando Torso Phantom and Doses Calculated.

- Doses to 10 co-planar points in the contralateral lung were identified.
10 Points Evaluated
Experimental Setup

- MOSFETs were placed at the 10 points in the contralateral lung of the Rando torso phantom.

- The phantom was setup using a Laser System and then irradiated.

- The dose at each of the 10 points, for each beam, was recorded.
Results
The mean difference between Eclipse and Experimental Results for each group of plans was determined as well as the Standard Error of the Mean.

A negative value indicates that Eclipse was cold (underestimated lung dose) compared to the experimental results.
Overall Difference for Groups A and B

% Difference Between Eclipse and Experiment

Negative Values Indicate Eclipse is cold compared to measured values
Is there a Difference Between The Accuracy for In-Field vs Out of Field Points?

- Group B results showed better agreement between calculated and measured. Is this due to more of the lung being within the field?

- For each beam, the points were divided into in-field or out of field.

- Points within the jaws but under MLC’s were considered in-field.
In-Field vs Out of Field
Group A

% Difference for Group A
In Field vs Out of Field

% Difference

+/- SEM

Infield
Out of Field

-60
-50
-40
-30
-20
-10
0
10
20
30

-60
-50
-40
-30
-20
-10
0
10
20
30
In-Field vs Out of Field
Group B

% Difference for Group B
Infield vs Out of Field
Comparison of Infield and Out of Field for IMRT Plans

- For both groups of Plans, there was a significant difference between the accuracy of Eclipse Calculated Dose for In-field vs Out of Field Points.

- Do the Control plans show the same results?
Conclusions
Summary

Eclipse adequately models infield lung dose.

Eclipse results for scatter/out of field lung dose can be off by up to 50%.

This error should be considered when evaluating lung metrics especially when using IMRT to lower lung dose.

While IMRT for mesothelioma was specifically studied here, these results can be applied to IMRT for any thorax case.
What Do We Do With This Information?

- Tests are currently being conducted to determine how accurately Monte Carlo results agree with the experimental findings.

- If accurate, Monte Carlo DVH’s will be generated to determine the impact on the lung metrics.
The End