Mesothelioma XRT: From Old School to New School

A brief walk down memory lane at UCLA
Sherri Alexander, RTT CMD
Thanks

Michael Selch MD
Percy Lee MD
Amar Kishan MD
Sharon Qi, Phd
Julie Kang, MD
Objectives

- Demonstrate the original 3d planning technique from yesteryear
- Show the progression of the technique through time
- Discuss IMRT planning
- Understand the increase in control rates through the advent of advanced techniques.
Meso is rare, but highly lethal form of lung cancer

- Approximately 3300 cases diagnosed per year
- Thought to be caused by asbestos exposure
- These patients have a poor prognosis, with a median survival ranging from six to 18 months depending on the stage of the disease at the time of diagnosis.
- Multimodality treatment, surgery, chemo, XRT
Extraplueral Pneumonectomy (EPP) and Lung sparing pleurectomy/decortication (P/D)

Both are viable surgical options

P/D has recently emerged as the standard surgery (our Lung Surgeon has been doing this type if surgery for a long time, as opposed to the EPP)

That leaves the intact lung which presents problems as we attempt to treat the “pleural bed” so to speak
Surgery

EPP

P/D
Historical Progression

* Initially simmed Prone only, for PA/AP photon fields and PA electron field
* Then simmed Prone and Supine for the addition of matching electron blocks for the photon blocked area (hoping to treat more Pleura and still leave some lung utility)
* Then simmed Supine for Tomo IMRT
Simulated on CT Sim
Used independent Jaws
Full 20 cm superiorly
Inf border down to bottom of T10 (majority of lung)
Ipsilateral border allowed to flash to include all of scar, medial border to include whole spinal column and mediastinum
Insert Calc points at Sup and Inf Cord, Curvature causes hot spots, Insert D1/2 point
Draw MLC for lateral chest wall blocking, try to include as much scar as possible
Draw Middle lung block (leave approx. 2 cm border from lung edges)...
PTV was not drawn at this point in our history
Calc Points/Depth
Calculation Deliberations

* Decision needs to be made about the location of the D1/2 Calc point
  * Near bone? Near lung?
  * Too close to the block?
  * Does it result in too high of a max on cord?
  * Do we need to calculate to a different point? Different normalization/Weighting
* Rx to D1/2 Max cord dose 5314.3 cGy
* Rx to D= 10cm (from Post) Max cord is 5195.4 cGy
Post Electron Field
Post E Field Energy
Prone Only, Plan Sum
Prescribed to D1/2
Prone Only, Sum Plan
Prescribed or Normalized to another calc point
At this point in the history, a PTV was not drawn.
Paradigm Shift

Adding Electron boosts to the blocked photon field

- Faculty Physician added matching electron blocks to treat the blocked part of the photon field.
- Introduces the needs for Supine and Prone positioning
- Introduces more uncertainty of positioning and matching of fields.
Draw Electron Block to match photon island block
Matching Can be Fun!
Are you a Virgo?
Note the 45Gy and higher cloud around the periphery of the matched fields.
Electron boost
Rx

* Generally use 12 Mev to get deep enough but not fly through the lungs
* Prescribe to 36 Gy instead of 45 Gy to attempt preserve some lung function
* (physicians have to sleep at night too!!)
Plan Sum, What are we getting

- There are many uncertainties with the plan sum
- Positioning variations
- Is the plan sum accurate with Supine and Prone data sets?
- Is the hot spot in the same location daily?
- Is the spine in the same curvature/location?
Calculate to D/12 vs D 10cm

Rx to D1/2 50% IDL

Rx to D10 =10 50% IDL
5Fld Plan Sum showing 20Gy dose cloud
Switched to IMRT

- Simulated supine only, arms up
- Marked all scars and drain sites with wire
- Motion management techniques were not utilized at this time
- Ipsilateral lung contour was expanded by 1 cm and contracted by 0.5 cm, then added to create PTV, which was then extended down to bottom of L1 or L2 vertebra, and pulled out in individual slices to include the scar
Common PTV
Volume = 2800 cc’s
Inferior Border Comparison
Anecdotal discussion of patterns of failure with Thoracic Surgeon/Oncologist revealed failure in the posterior diaphragmatic interface, quite inferiorly.

Inferior borders were brought down past the kidneys to include all of that potential space.
Challenging Much????
Ipsilateral Lung Sparing
Not difficult at all!
IMRT Parameters (Tomo)

* Helical Tomo Therapy HD Dynamic Jaw
* Pitch .287 - .443, 2.5cm Jaw size
* Optional directional blocking on Contra Lateral Lung
* Goal V100% PTV $\geq$ 95%, with cord max < 45Gy, Total Lung Less PTV V20Gy < 30% and Total mean lung < 18Gy, Ipsilateral Lung V20 < 60%, Heart V 50% < 50%, Liver V 30Gy < 1000 ccs, Each Kidney D12Gy < 33% and Each Kidney mean < 10 Gy
## Plan Quality Report

### Lung

<table>
<thead>
<tr>
<th>Site</th>
<th>Lt Lung</th>
</tr>
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<tbody>
<tr>
<td>Dose</td>
<td>1.8 Gy  x 25 = 45 Gy Total</td>
</tr>
</tbody>
</table>

### PTV

<table>
<thead>
<tr>
<th>DVH Goal Achieved</th>
<th>DVH Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>V100%</td>
<td>95.0 %</td>
</tr>
</tbody>
</table>

### DVH Goals

<table>
<thead>
<tr>
<th>Organ</th>
<th>DVH Goals</th>
<th>Achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Lung</td>
<td>V &lt; 20 Gy</td>
<td>&lt; 30 %</td>
</tr>
<tr>
<td></td>
<td>Mean Dose</td>
<td>&lt; 18 Gy</td>
</tr>
<tr>
<td>Ipsil Lung</td>
<td>V &lt; 20</td>
<td>&lt; 60 %</td>
</tr>
<tr>
<td>Contra Lung</td>
<td>V &lt; 5 Gy</td>
<td>&lt; 50 %</td>
</tr>
<tr>
<td>Heart</td>
<td>V &lt; 22.5 of 45 Gy</td>
<td>&lt; 50 %</td>
</tr>
<tr>
<td>Liver</td>
<td>1000 CC &lt;30Gy</td>
<td>&lt; 1000 cc</td>
</tr>
<tr>
<td>Rt Kidney</td>
<td>D12Gy &lt;33 %</td>
<td>&lt; 12 Gy</td>
</tr>
<tr>
<td></td>
<td>Mean &lt;10 Gy</td>
<td>&lt; 10 Gy</td>
</tr>
<tr>
<td>Lt Kidney</td>
<td>D12Gy &lt;33 %</td>
<td>&lt; 12 Gy</td>
</tr>
<tr>
<td></td>
<td>Mean &lt;10 Gy</td>
<td>&lt; 10 Gy</td>
</tr>
<tr>
<td>Small Bowel</td>
<td>V &lt; 45 Gy</td>
<td>&lt; 150 cc</td>
</tr>
<tr>
<td></td>
<td>V &lt; 45 Gy</td>
<td>&lt; 5 %</td>
</tr>
<tr>
<td>Stomach</td>
<td>V &lt; 45 Gy</td>
<td>&lt; 50 cc</td>
</tr>
<tr>
<td>Cord</td>
<td>Max Dose</td>
<td>&lt; 45 Gy</td>
</tr>
<tr>
<td>Esophagus</td>
<td>Mean Dose</td>
<td>&lt; 24 Gy</td>
</tr>
</tbody>
</table>
Our PTV
EPP PTV
IMRT 20Gy
IMRT Hotspot 50 Gy
In our one of our own retrospective studies, the PTV coverage was compared between 3D and IMRT planning techniques.

In the study with 8 cases, the average % PTV coverage was 37.9 ± 23.8% for the 3D cases and 94.9% ± 0.5% for the IMRT/Tomo cases.

The HI (D5%/D95%) for the 3D plans was 9.0 ± 11.0 and for IMRT/Tomo was 1.1 ± 0.1.
Another larger (46 pts.) retrospective study showed V100% to PTV and mean doses of 91.1% vs. 47.9% and 47.9 Gy and 36 Gy respectively. The overall max and PTV max doses were quite similar. The mean dose and V20Gy for Ipsilateral and Total lung were significantly higher for Tomo/IMRT plans, while keeping the Mean Lung Dose < 20Gy and V20 Less than 30%.
Evaluation of 3D-Conformal versus Tomotherapy Plans for Mesothelioma Patients following Lung Preserving Pleurectomy/Decortication

INTRODUCTION

To evaluate the dosimetric matrix such as Homogeneity Index (HI) and the PTV coverage when going from conventional 3D planning to IMRT Tomotherapy planning for intact lung mesothelioma.

MATERIALS AND METHODS

Eight mesothelioma patients were planned using Varian Eclipse 15.5 treatment planning system (TPS) and a Tomotherapy TPS. PTV at the planning target volume from CTV of the primary tumor region with an average range from 0.12 cm to 0.3 cm to the planning target volume for AP/PA photon fields were designed, utilizing 15MV beams, with MLC blocking, including the soft area. Contour shells are placed directly to 0.2 cm per level. Fields are prescribed at 5 cm depth to avoid severe hot spots. Matching electron fields were targeted to fill the shaded photon region with an energy ranging from 0.12 cm to 0.3 cm to the planning target volume for AP/PA fields. A further electron field is selected posteriorly to treat the inferior mesophrenic angle (IMA). For Tomotherapy TPS planning occlusion factors were used to ensure the IMA was not intentionally included in the PTV volume. shielded region is centered. In this study, the isodose lines were determined at 95% and average dose of 2.0 Gy. The total beam size, including minimum and other organs were centered at Dmax. The dose volume histogram (DVH) and other important parameters of the plans were compared and analyzed against the Tomotherapy plans. Homogeneity index (HI) is defined as the dose received by 95% volume of the PTV (D95)/Dmax.

RESULTS

Tomotherapy yielded better PTV coverage for all cases and lower HI. The mean PTV covered by 95 Gy (D95) standard deviation for the 3D plans was 37.5 ± 5.2. The average PTV coverage for Tomotherapy plans was 44.5 ± 5.5. The average HI for the 3D conformal plan was 3.0 ± 1.1, while the average HI for the Tomotherapy plan was 1.6 ± 0.3.

CONCLUSION

Tomotherapy greatly improves PTV coverage for the PTV and the HI for the PTV over traditional 3D planning for intact mesothelioma radiation treatment. Further investigation is recommended to determine if this leads to possible improvement in disease progression or recurrence.
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<thead>
<tr>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
<th>Column 4</th>
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</thead>
<tbody>
<tr>
<td>Data 1</td>
<td>Data 2</td>
<td>Data 3</td>
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<tr>
<td>Data 13</td>
<td>Data 14</td>
<td>Data 15</td>
<td>Data 16</td>
</tr>
</tbody>
</table>

**Notes:**
- Column 1: Description of Item 1
- Column 2: Description of Item 2
- Column 3: Description of Item 3
- Column 4: Description of Item 4
## OAR DVH comparison

<table>
<thead>
<tr>
<th>OAR</th>
<th>3D</th>
<th>IMRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart (LST)</td>
<td>mean 41.2</td>
<td>28.3</td>
</tr>
<tr>
<td>Heart (RST)</td>
<td>mean 18.4</td>
<td>19.1</td>
</tr>
<tr>
<td>Cord</td>
<td>Max dose 48.4</td>
<td>40.6</td>
</tr>
<tr>
<td>Esophagus</td>
<td>mean 39.4, max 46.9</td>
<td>30.2, 49.8</td>
</tr>
<tr>
<td>OAR</td>
<td>3D</td>
<td>IMRT</td>
</tr>
<tr>
<td>-------------------------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>Stomach (LST) mean</td>
<td>24.8</td>
<td>22.5</td>
</tr>
<tr>
<td>* Stomach (RST) mean</td>
<td>1.23</td>
<td>9.0</td>
</tr>
<tr>
<td>* Liver (LST) mean</td>
<td>3.97</td>
<td>10.9</td>
</tr>
<tr>
<td>* Liver (RST) mean</td>
<td>12.4</td>
<td>22.2</td>
</tr>
<tr>
<td>* Liver (RST) V30Gy</td>
<td>4.4</td>
<td>1.4</td>
</tr>
<tr>
<td>* Liver (RST) V30Gy</td>
<td>24.3</td>
<td>29.8</td>
</tr>
<tr>
<td>* Ipsilateral kidney</td>
<td>1.2</td>
<td>6.7</td>
</tr>
<tr>
<td>Contra Kidney mean</td>
<td>0.33</td>
<td>3.2</td>
</tr>
</tbody>
</table>
Tomotherapy Improves Local Control and Changes Failure Patterns in Locally Advanced Malignant Pleural Mesothelioma

Kishan, et al
Toxicity

- Incidence of fatigue, acute upper gastrointestinal toxicity, pulmonary toxicity, skin toxicity, and esophageal toxicities were NOT significantly different between the two groups.
- One patient in each group had grade 3 toxicity and both required hospitalization with a prolonged course of corticosteroids.
Patterns of Failure

- Local control was significantly higher with IMRT (2 years)
- Overall survival and out of field control were not significantly different between the two groups
- Median time to local failure was 19 months vs 10.9 months with IMRT and 3D CRT respectively
Woot woot!

* Bottom line is that with IMRT we can give more dose to the Pleura with similar OAR values/means as 3D CRT
* So now we are able to give a greater fighting chance to those people that we treat while we cause the side effects that we cause.
* I am able to sleep better at night knowing this!
* Such a thrill to see the progress in such leaps and bounds
Discussion

* We are currently still modifying and adjusting the planning parameters, hoping to get more efficient plan delivery times as well a planning time...
* Trying different pitches and jaw sizes to help (attempting to bring the plan delivery down, currently 21-24 mins for 180 cGy/day)
* Can we attempt a higher dose? 50.4 cGy??
Other techniques

- Other facilities have done 8 field static beam IMRT planning
- Other facilities have used VMAT planning (intact lung)
- Some facilities are suggesting protons
Currently investing the utility of Pre-Op XRT

Thought process is similar to the concept of Pre-Op XRT for rectal Ca

Often is delay from XRT to surgery, causing impaired local control and overall survival

Princess Margaret showed favorable results with NeoAdjuvant XRT and Extra Pulmonary Pleurectomy

We are trying to see if we can do it in the P/D setting
Can I interrupt?
I don't mean to cause a scene
But you are boring

BLAH BLAH BLAH.
A haiku
Thanks!

Questions? Comments?
Fissures
What about the fissures?