IMRT for HN Cancer

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Outline
1. Why IMRT for HN cancer
2. Immobilization
3. Tissue segmentation
4. Treatment planning
5. Plan evaluation
6. Summary

Why IMRT for HN Cancer

• Complex anatomical region
  • Optic nerves, chiasm, eyes, lenses
  • Spinal cord, brainstem
  • Parotid glands
  • Oral cavity
  • Temporal lobes
  • Mandible, TMJ
  • Larynx, …

• Normal tissues and targets in close proximity
• Inadequate 3D planning techniques
  • No way to deliver concave dose distributions
• Absence of organ motion

Complex Anatomical Region
Inadequate Conventional Planning

- Opposed Laterals electron fields
- Off-cord
- Questionable dosimetry at photon-electron beam matchline

Absence of Organ Motion

- Little or no intra-fraction organ motion
- Inter-fraction setup uncertainty can be controlled with usual intervention

Indications and Contra-Indications

- Cooperative patients
  - No claustrophobia, resting tremors, etc.
- Reduce normal tissue complications
  - Conformal avoidance
- To escalate dose
  - Improve local-regional control
- Avoid unwanted field junctions

HN Immobilization

- GTV and CTV can be very different structures
- Maximize reproducibility
  - Head
  - Chin
    - Mandible
    - Oral cavity
  - Clavicals
    - Supraclavicular nodes
Immbolization Options
(“Active”)

• Masking system with Accuform custom neck mold
• Patient comfort and immobilization go hand-in-hand

Immbolization Options
(“Passive”)

• Locate isocenter in head or upper neck
• Generally, setup error within 3 mm can be achieved
  • 1 – 2 mm in the head and neck
  • 2 – 3 mm in the shoulder region
  

• However, some variability can be expected
  • Treatment plans should account for those effects
  

Expected Reproducibility
Aspects of Imaging

- Target volumes
- Normal tissues
- Image fusion

Target Volume Delineation

ICRU 50

Example for NPC

- GTV
  - Gross tumor on MRI and PE
- CTV
  - GTV + margin including, nasopharynx, retropharyngeal nodes, clivus, skull base, inferior sphenoid sinus, pterygoid fossae, parapharyngeal space, posterior nasal cavity and maxillary sinuses
- PTV
  - CTV + 3-5 mm

Consistent with ICRU Definitions

- GTV-T, GTV-N
- CTV-T, CTV-N1, CTV-N2, etc.

CT Anatomy – Head/Neck

Location of inferior brainstem and superior spinal cord
Use PRV (ICRU-62) for margin around spinal cord.
Before Planning Begins

- Is IMRT appropriate for this case?
- Where is the target?
- What are target doses & acceptable normal tissue doses?
  - What can be compromised?
- What is the plan?
  - Simultaneous integrated boost versus sequential cone down plans?

IMRT Planning

- Same primary target as with 3DCRT
- Regional therapy requires specific identification of nodes
- Simultaneous boost
  - Lower regional dose per fraction (e.g. GTV to 66Gy and nodes to 54Gy both in 30 fractions)
- Sequential boost
  - Same dose per fraction for GTV and nodes
  - Requires two plans

CT/PET Images


Multi-modality Image Fusion

- Participate in process before imaging takes place
  - Ensure same position
  - Understand setup/imaging limitations
- Talk with physician about site of interest
  - Location, pre- or post-op, etc.
- Communicate uncertainty of manually fused images
Physician Communication
(managing expectations)

- Isodose lines are not as smooth as 3DCRT
  - Increases dose heterogeneity, which may affect toxicity, tumor control probability
- You can not specify an isodose line to move by millimeters
  - IMRT planning is not like changing a block edge
- Hot/cold spot will fall within the target(s)

Issues with IMRT Treatments

- Time consuming planning process and quality assurance procedures
- Many factors in plan evaluation of uncertain significance
- Exchanges exposure of larger volumes of normal tissue to low doses for smaller volumes exposed to high doses

Tissue Inhomogeneity Corrections

- AAPM Report No. 85: Tissue Inhomogeneity Corrections for Megavoltage Photon Beams
- 4 – 10% error in relative density results in ~2% error in dose
- CT Streak artifacts can be locally significant
  - Do not normalize a plan to a point in this region
  - Little effect on DVH of large structures

Know Published Dose Limits
(understand what your physician will accept)

<table>
<thead>
<tr>
<th>Tissue</th>
<th>Maximal Dose (Gy)</th>
<th>Mean Dose (Gy)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain</td>
<td>60</td>
<td>-</td>
<td>Emami et al 1991</td>
</tr>
<tr>
<td>Brainstem</td>
<td>54</td>
<td>-</td>
<td>Emami et al 1991</td>
</tr>
<tr>
<td>Optic chiasm/nerve</td>
<td>54</td>
<td>-</td>
<td>Emami et al 1991</td>
</tr>
<tr>
<td>Retina</td>
<td>45</td>
<td>-</td>
<td>Emami et al 1991</td>
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<tr>
<td>Lung</td>
<td>12</td>
<td>-</td>
<td>Emami et al 1991</td>
</tr>
<tr>
<td>Parotid</td>
<td>50</td>
<td>25 - 30</td>
<td>Enneking et al 2003</td>
</tr>
<tr>
<td>Larynx</td>
<td>50</td>
<td>25 - 30</td>
<td>Stanford</td>
</tr>
<tr>
<td>Mandible</td>
<td>65</td>
<td>&lt; 30 – 45</td>
<td>Stanford</td>
</tr>
<tr>
<td>Spinal cord</td>
<td>45</td>
<td>-</td>
<td>Enneking et al 1991</td>
</tr>
</tbody>
</table>

*Recommend lowering these dose limits by 10% when concurrent chemotherapy is used.
IMRT Planning Parameters

• Dose/volume constraints
• Number of beams
• Beam orientation / Table angles
• Tuning structures
• Collimator angle
• Isocenter placement
• Beamlet size / Intensity levels
• Direct modification of intensity maps

Number of Beams

• More beams = Better plan?
• Generally Yes
  • But improvement can be marginal over 7 beams
  • Degree of improvement depends on tumor shape and proximity to critical structures

Beam Orientation

• Coplanar vs Non-coplanar
  • Ease of setup
  • Ease of planning
  • Speed of treatment

• Equi-spaced vs Selected angles
  • Entrance through table/immobilization device
Beam Orientation

Collimator Orientation

Collimator Orientation

Tuning Structure

- A structure added just for the purpose of treatment planning
- Provides additional control over the dose distribution in IMRT plans
- Reduce normal tissue dose
- Reduce/increase target dose

No collimator angle
With collimator angle
Leaf travel direction perpendicular to the brainstem/spinal cord
Tuning Structure

An added structure to be used in optimization

GTV 66 and CTV60

CTV54, but will accept a lower dose (32)
**Tuning Structure & Other Tools**
- Empirical tools can be very useful

**Isocenter Placement**

**Issues**
- Sometimes a better plan can be achieved by selective isocenter placement
  - Center of GTV vs center of all targets
  - Dosimetry and/or QA
  - Patient setup
  - Isocenter in region of reliable bony anatomy

**Isocenter Placement**

Choose a reliable anatomical reference point

**Modification of Intensity Map**

An option provided by some planning systems
Modification of Intensity Map

- Erase intensity over the RT Eye in all fields

HN IMRT with Sclav Nodes

- Treating nodes in IMRT
  - Eliminates junction issues
  - Requires extra care to immobilize shoulders
  - Do not treat the supraclav nodes through the shoulders

- Treating nodes with AP field
  - Requires a method to match the IMRT fields
  - Not advised for node positive cases
  - If possible, include SCV field in IMRT optimization

IMRT Including Sclav Nodes

- Tissue depth in BEV can change with shoulder position
- Unnecessary dose to the shoulders
50% isodose line on IMRT plan – SCV match line is 2-3 mm inferior

Matching IMRT to AP Sclav
Cold match

Matching IMRT to AP Sclav
Single isocenter

Matching IMRT to AP Sclav
Feathered match-line

Matching IMRT to AP Sclav
Feathered match-line
Final Comments on Planning

• Beam energy
  • Higher energy PA beam can help to cover Sclav nodes and reduce posterior hot spots
• Skin dose
  • Immobilization masking systems can act as a bolus to produce a severe skin reaction
• Opposed beam are “ok”

When The Plan is Finished

• Review the plan with your physician!
• Talk through the plan with the physician
  • What is good and bad about this plan?
  • Why did you use those beam angles?
  • Why underdose parts of the target?
  • Why can’t you spare more normal tissue?
• Intrude on the physician’s decision making process

About Plan Evaluation

• Maximal point doses may exceed normal tissue tolerance
• Review the DVH
  • Determine how much of the critical structure volume receives a dose that exceeds the specified limit
  • In many cases, it only correlates to a few voxels and may be acceptable

About Plan Evaluation

• Hot and cold spots must be identified using the isodose curves on a slice-by-slice basis
• The decision on hot spots should be individualized based on other clinical considerations
  • Previous treatments the region
  • Medical co-morbidities and the use of concurrent chemotherapy
Parting Thoughts

- The risk of secondary malignancies is not zero
  - Relative to co-morbidity and the patient’s life style
- Setup uncertainty changes the position and magnitude of hot spots
- Recurrences are mainly in the high-dose regions
- Refinements and new techniques in the IMRT technique are ongoing
- Real-time adaptive IMRT based-on tumor changes is still in the future

Be prepared to make difficult decisions