Educational Symposium: Planning, QA and the Role of Imaging and Localization in Head & Neck Cancer

Contouring, PTV and Organ at Risk Doses: A physician’s perspective

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Disclosures

• None
• No technology preferences.

Learning Objectives

• To review the physician’s role in radiation therapy treatment planning.
  ➤ Background
  ➤ Target volumes
  ➤ Organs at risk
  ➤ Dose trade-offs
  ➤ Planning process, when is it good enough?

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**Background**

- **H&N cancers**
  - 4% of all cancers/yr
  - 48,000 diagnoses
  - 12,000 deaths
  - Challenging disease
  - Multidisciplinary

**Post-operative radiotherapy**

**Treatment Hazard Ratios:**

<table>
<thead>
<tr>
<th></th>
<th>Overall Survival</th>
<th>All Patients</th>
<th>Chemoradiation better</th>
<th>Radiotherapy better</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EORTC</strong></td>
<td>334</td>
<td>0.703</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>RTOG</strong></td>
<td>416</td>
<td>0.838</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Combined</strong></td>
<td>750</td>
<td>0.776</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Bernier and Cooper, Head & Neck, 2005
Post-operative radiotherapy

- High risk patients benefit from the addition of chemotherapy
- Intermediate risk patients
  - RTOG 0920
  - PORT ± Cetuximab (250 mg/m² weekly X 11 weeks)

*PNI, LVI, single LN >3cm or ≥2LN (<6cm) with no ECE, close margin (<5mm), T3 or micro T4a, T2 OC with >5mm invasion

Survival by HPV status

<table>
<thead>
<tr>
<th>Group/Regimen</th>
<th>Time reported</th>
<th>HPV positive</th>
<th>HPV negative</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECOG Induction + CRT</td>
<td>2 yr</td>
<td>95%</td>
<td>62%</td>
<td>0.005</td>
</tr>
<tr>
<td>TROG 2.2 CRT + Tirpazamine</td>
<td>2 yr</td>
<td>94%</td>
<td>77%</td>
<td>0.007</td>
</tr>
<tr>
<td>DHANCA5 RT</td>
<td>5 yr</td>
<td>62%</td>
<td>26%</td>
<td>0.003</td>
</tr>
<tr>
<td>RTOG 0129 Accel vs Std CRT</td>
<td>3 yr</td>
<td>82%</td>
<td>57%</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Survival by HPV status

- Low risk: HPV pos, ≤ 10 pk-yrs
- HPV pos, > 10 pk-yrs, N0-N2a
- Intermediate risk (Everybody else!)
- High risk: HPV neg, > 10 pk-yrs
  HPV neg, ≤ 10 pk-yrs, T4
IMRT

<table>
<thead>
<tr>
<th>Study, year</th>
<th>Tumor site / N</th>
<th>Primary endpoint at 1 year</th>
<th>Outcome</th>
<th>IMRT vs. CRT</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pow, 2006</td>
<td>NPX / 51</td>
<td>Stim. Whole Saliva Flow</td>
<td>50% vs. 4.8%</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Kam, 2007</td>
<td>NPX / 60</td>
<td>RTOG/EORTC ≥Gr 2 Xerostomia</td>
<td>82% vs. 39%</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Nutting, 2009</td>
<td>OPX &amp; HPX 94</td>
<td>LENT/SOMA ≥Gr. 2 Xerostomia</td>
<td>74% vs. 40%</td>
<td>0.005</td>
<td></td>
</tr>
</tbody>
</table>

Comparative effectiveness and Safety of Head and Neck Radiotherapy: Review #20

- “Insufficient evidence to determine if 2DRT, 3DCRT, or IMRT confers any advantages when compared to each other in terms of local control and survival.”
- “IMRT is associated with a lower incidence of late xerostomia when compared to 3DCRT or 2DRT.”
- “Pts who received IMRT had improved QOL, with respect to late xerostomia.”

Samson DJ, et al Review #20, AHRQ May 2010

Radiotherapy Process for IGRT/IMRT

- Patient Assessment
- Patient set up and immobilization
- Imaging for RT Planning
- Contouring (Targets & OARs)
- Treatment Planning
- Data Transfer to RadOnc Information System
- Pre-Treatment Verification (i.e. IMRT QA)
- Image-Guidance and Localization
- Treatment Delivery
- Treatment Completion
- Follow up
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Target volumes

- Tumor volumes
  - Gross tumor volume
  - Clinical target volume
  - Planning target volume
- Normal structures
  - Structure itself (OAR)
  - Planning organ at risk volume (PRV)

Target volumes

- ITV = internal target volume
  - ITV = CTV + IM
- IM = internal margin
  - Motion due to physiology
- SM = set-up margin
  - Margin for technical factors
- PRV = planning organ at risk volume

Target Volumes

- RTOG atlases
  - H&N atlas provides CTVs for the N0/N1 neck
- No atlases per say…guidelines, tables
  - N positive neck or surgical patients (Gregoire)
  - CTV1, CTV2, CTV3
  - Location of disease, ECE, Skin, local extension
  - Chao, Ang, Eisbruch, Foote, Mendenhall, etc

http://www.rtog.org/CoreLab/ContouringAtlases/HN.aspx
Gregoire, Radiotherapy Oncol, 2006
Target volumes

- Target delineation is complex
- Targets and normal structures change and move during radiotherapy

Retrospective study
- 13 patients with weight loss and/or tumor shrinkage
- 2nd CT obtained at 19 fxns (+/- 6) out of planned 30 fxns

Hansen, IJROBP, 2006
Target volumes

- Dynamic MRI study of 22 H&N cancer pts
  - 9 OPX, 8 Larynx and 5 HPX
  - 4 re-irradiation patients
- Tumor motion and motion of normal structures was assessed (S-I and A-P)
- Quantify frequency of swallowing and displacement to determine PTV margins

<table>
<thead>
<tr>
<th>Target volumes</th>
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</tr>
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<tbody>
<tr>
<td>GTV</td>
<td>Soft Palate</td>
</tr>
<tr>
<td>Vocal Cord</td>
<td>Epiglottis</td>
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</table>
Target volumes

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Organs at Risk

- Lacrimal glands
- Lens
- Optic chiasm & nerves
- Orbit vs. Retina
- Pituitary gland
- Hypothalamus
- Spinal cord
- Brain
- Brainstem
- Parotid glands
- Submandibular glands
- Sublingual glands
- Oral cavity
- Lips
- Larynx
- Supraglottic larynx
- Constrictors
  - Superior, Middle, Inferior
- Esophagus
- Ears
- Cochlea, EAC, IAC, mastoid
- Thyroid gland
Organs at Risk

- **RTOG atlases**
  Brachial plexus (i.e. Hall)

- **No atlases per say...LOTs of anatomy books**
  Pharyngeal constrictors (Eisbruch)

http://www.rtog.org/CoreLab/ContouringAtlases/HN.aspx
Eisbruch, IJROBP, 2004

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**Emami guidelines**

**Quantitative Analysis of Normal Tissue Effects in the Clinic (QUANTEC)**

Emami B IJROBP, 1991
QUANTEC, Vol 76 (3) IJROBP 2010
Critical organ sparing RT?

- Cord sparing
- Parotid sparing
- Larynx sparing
- Pharyngeal constrictor sparing?
- Submandibular sparing?
- Brachial plexus sparing?
- Tumor or target sparing
Organs at Risk

Red 70 Gy
Orange 69.4 Gy
Yellow 50 Gy
Green 40 Gy
Blue 30 Gy
Light Blue 20 Gy
Lavendar 10 Gy

Cannon and Lee, IJROBP, 2008

Organs at Risk

• Retrospective, 2003-2009
• 90 post-operative patients
  – Oral cavity, opx, larynx
  – 56% chemo
• 17 local-regional recurrence
  – 11 were in-field
  – 6 failed at the margin
    • 3 periparotid, 2 dermal and 1 retrostyloid
  – No geographical misses

Chen, IJROBP, 2011

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Dose trade-offs

• Cannot compromise on critical normal structures (unless they are clearly involved)
  – Cord, Brainstem, Brain, Optic apparatus
• Routinely to reluctantly, give up sparing some structures that are within the CTV or PTV
  – Ipsilateral parotid, pharyngeal constrictors, submandibular gland
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Planning process When is it “good enough”?

- Difficult balance between target coverage and acceptable dose to the normal structures
  - Patient and MD risk taking
- Salt-n-Pepa
  - Push it
- Mick Jagger
  - You can’t always get what you want…but you get what you need.

Future Directions

- Auto-contouring
- Adaptive treatments
  - Mid-treatment, weekly or daily?
- Functional imaging

Conclusions

- Target delineation is challenging and time consuming
  - Attention to detail is crucial
  - Understanding lymphatic drainage and failure patterns is essential
- Collaboration with dosimetry and physics is mandatory
- Best treatment is prevention
**Additional References**

- Chao & Ozyigit, *IMRT for H&N Cancer*, Lippincott Williams & Wilkins, 2003

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**Questions?**