Anatomic and Dosimetric Correlation in the Treatment of Advanced Larynx Cancer - When is the Brachial Plexus at Risk?

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No Disclosures
Objectives

• Anatomical considerations
• Dosimetric issues in sparing the brachial plexus
• Our project - When is the brachial plexus at risk?
Brachial plexus - significance

• Innervation of Upper limb – sensory and motor (muscles) functions

• Injury = chronic pain and/or permanent weakness – a **painful, useless limb**
Brachial plexus anatomy

• Upper limit – C4/5 neural foraminae
• Lower limit – T1/2 neural foraminae
• Roots - C5 – T1 ventral rami
• Trunks – between anterior and middle scalene muscles to 1st rib
• Divisions and chords – distal to clavicle
Brachial plexus
Brachial plexus contouring – key = identify scalene muscles
“cheese burger”

Buns:
- anterior & mid scalene muscles

Meat:
- brachial plexus
Brachial plexus contouring – the “cheese burger”
Contouring tips

• Key = start with the great vessels of the neck and identify the anterior & middle scalene muscles

• Choose an axial slice where they clearly separate – forming the “cheese burger”

• This might be clear only on a few slices – and sometimes, only on one side

• Once identified, use this landmark to contour on other slices
Beams eye view (DRR) of brachial plexus and relationship to larynx
Brachial plexus tolerance doses at UW

• Keep dose as low as possible – ALARA

• Tolerance defined per treatment intent
  – high dose target (PTV 70) vs.
    - elective volumes (PTV 54)

• V60 < 5-10%

• Max point dose = 66-70 Gy
Dosimetric Considerations
Proximity to the targets
Dose level of each target
# Sparing

<table>
<thead>
<tr>
<th>Type of Treatment</th>
<th>Note</th>
<th>Dose(Gy)</th>
<th>No of FX</th>
<th>Start Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMRT to PTV 70</td>
<td>70</td>
<td>6996</td>
<td>33</td>
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### Objectives

<table>
<thead>
<tr>
<th>Structure Name</th>
<th>Dose/Volume constraint</th>
<th>Relative Importance</th>
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<tbody>
<tr>
<td>CTV</td>
<td>98% cover. Max &lt; 110%</td>
<td>1</td>
</tr>
<tr>
<td>PTV70</td>
<td>95% cover</td>
<td>1</td>
</tr>
<tr>
<td>PTV63</td>
<td>95% cover</td>
<td>2</td>
</tr>
<tr>
<td>PTV57</td>
<td>93-95% cover</td>
<td>3</td>
</tr>
<tr>
<td>Spinal cord + 5 mm</td>
<td>Max 45 GY</td>
<td>1</td>
</tr>
<tr>
<td>RT and left brachial plexus</td>
<td>Max 60GY</td>
<td>2</td>
</tr>
<tr>
<td>RT parotid gland</td>
<td>Mean 26GY</td>
<td>1</td>
</tr>
<tr>
<td>Left parotid gland</td>
<td>Mean 36-40GY</td>
<td>3</td>
</tr>
<tr>
<td>Mandible outside PTV70</td>
<td>Max 65Gy</td>
<td>3</td>
</tr>
<tr>
<td>Avoidance</td>
<td>Max 40Gy</td>
<td>2</td>
</tr>
<tr>
<td>Brain stem</td>
<td>Max 50 Gy</td>
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### Right Brachial plexus
Max dose < 60 Gy
Max dose < 64-67 Gy

### Left Brachial plexus

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<tr>
<td>PTV 70 (6996cGy- 212/#)</td>
<td>Cover with 95% iso, max &lt; 105%</td>
<td></td>
</tr>
<tr>
<td>PTV 63 (6270cGy-190/#)</td>
<td>Cover with 95% iso</td>
<td></td>
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<tr>
<td>Spinal canal + 5 mm</td>
<td>Max dose &lt; 45 - 48 Gy</td>
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<tr>
<td>Mandible (outside PTV 70)</td>
<td>Max dose &lt; 60-65 Gy</td>
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<td>Max dose &lt; 45 Gy</td>
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<td>Max dose &lt; 63 Gy</td>
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<td>Max dose &lt; 63 Gy</td>
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</tr>
<tr>
<td>Right parotid gland</td>
<td>Mean dose &lt; 24 Gy</td>
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<td>Left parotid gland</td>
<td>Mean dose &lt; 24 Gy</td>
<td></td>
</tr>
<tr>
<td>Right sub mandibular gland</td>
<td>Mean dose &lt; 26 -30 Gy</td>
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To spare the brachial plexus it may require adaptive planning.
CT from pt initial simulation
Re sim at fraction 18
CBCT last day of Treatment
## Patient treatment history

<table>
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<th>Original Plan</th>
<th>Modified based on rescan</th>
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<tr>
<td>IMRT H&amp;N 212 x 33</td>
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<tr>
<td>Right low neck SCF 200 x 25</td>
<td>Right low neck SCF 200 x 25</td>
</tr>
<tr>
<td>Right low neck bst 200 x 5</td>
<td>Right low neck bst 200 x 4</td>
</tr>
<tr>
<td>Right low neck final bst 200 x 3</td>
<td>Right low neck final bst 200 x 2</td>
</tr>
<tr>
<td>Left low neck SCF 200 x 25</td>
<td>Left low neck SCF 200 x 25</td>
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<tr>
<td>Left low neck bst 200 x 5</td>
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Changes in Isodose Distribution
Where have we come from?
Pt H&P

• T3, NO, M0 Larynx
• 11 Conventional fields
  ▪ Lats to 40 Gy
  ▪ Half beam SCF to 50 Gy
  ▪ Off Cords 10 Gy
  ▪ Rt & Lt Post Strip 10 Gy
  ▪ Cone Down 1 10 Gy
  ▪ Cone Down 2 10 Gy
Conventional Fields

- Posterior Strips Set-up on treatment machine
How does this distribution look?
Conventional Isodose distribution
What is the dose to the BP?
Conventional DVH

Dose Volume Histogram

Dose (cGy)

Norm. Volume

DVH Calculation
- Cumulative
- Differential

Dose Axis Display
- Normalized Dose
- Absolute Dose
- Auto-Compute Max
- Specify Max Dose

Volume Axis Display
- Normalized Volume
- Absolute Volume

Tabular DVH...

ROI Statistics

<table>
<thead>
<tr>
<th>Line Type</th>
<th>ROI</th>
<th>Trial</th>
<th>Min.</th>
<th>Max.</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>% Outside Grid</th>
<th>% &gt; Max</th>
<th>Generalized EUD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brachial plexus</td>
<td>Trial_1</td>
<td>132.4</td>
<td>5736.0</td>
<td>3600.2</td>
<td>1780.4</td>
<td></td>
<td>0.00 %</td>
<td>0.00 %</td>
<td>--</td>
</tr>
<tr>
<td>GTV glottic</td>
<td>Trial_1</td>
<td>7137.8</td>
<td>7255.5</td>
<td>7229.0</td>
<td>18.9</td>
<td></td>
<td>0.00 %</td>
<td>0.00 %</td>
<td>--</td>
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IMRT
What is one of the best rules of thumb I have learned in my career?
For IMRT treatment plans every mm of separation the isodose line should fall off about 5%
IMRT contours to help spare the BP
BP+
1 to 2 mm
BP 1 to 2 mm - PTV = Planning PTV
Trick to push BP
Trick to push BP
Trick to push BP
Trick to push BP
Primary and Nodal GTV DVHs
What did we learn for the retrospective analysis?
Retrospective analysis
Retrospective analysis
When is the brachial plexus at risk?
Background

• RT induced BP injury (RTBP) is a devastating and irreversible clinical problem that risks loss of upper limb function and/or chronic pain.

• Contouring of brachial plexus (BP) is a painstaking exercise that utilizes valuable time - a limited resource.

• Gap in knowledge to identify specific tumor situations that increase the risk of BP injury.
C = carotid artery  
J = Jugular vein  
“cheese burger”  
Scalene muscles  
Brachial plexus
Our hypothesis

• Based on the anatomical location, we hypothesized that BP would be at risk in tumors located posterior to the great vessels in the infra hyoid neck.
Patients

- Larynx cancer patients who underwent definitive radiation therapy from 2009-2012.

- Randomly selected 6 node negative (T3N0) and 6 node positive (T2-3N1-2c)

- All the N+ patients had involved lymph nodes in levels 3-4.
methods

• Using the RTOG atlas, BP was delineated on the axial CT scans of all the plans on Pinnacle planning system. Dose volume histograms were analyzed.

• We compared the V60 (volume of BP receiving $\geq 60$ Gy) between the plans.

• Among the N+ patients, we evaluated the dosimetric impact of the anatomical location of the nodal disease; - anterior to jugular vein (IJ) vs. posterior to IJ.
Two N0 and one N+ patients were treated using conventional RT (CRT). IMRT was used to treat 4 N0 and 5 N+ patients.

All received 70 Gy in 33-35 fractions to the gross tumor and elective nodal RT to levels 2-6.
results

- **Node negative cases**
  - In 5 out of the 6 N0 patients (2 CRT and 3 IMRT) V60 of brachial plexus was 0% (Figure 1).
  - One N0 patient planned with IMRT had a V60 of 2%.
Node negative case: T3N0 Glottic Cancer

Green: PTV 70, Yellow: Brachial plexus
PTV70 was treated to 70 Gy in 35 fractions with conc chemotherapy.

V60 of brachial plexus = 0%
Max dose of brachial plexus = 52 Gy
results

• **Node positive cases**
  In contrast to the N0 patients, the V60 ranged from 1% - 54% (1%, 2%, 6%, 8%, 29%, 54%) in the N+ patients.

• In patients with nodal disease located:
  - anterior to IJ, V60 = 1 - 8%
  - posterior to IJ, V60 = 29% and 54%
Node positive Glottic Cancer
node located anterior to great vessels

Green: PTV 70, Yellow: Brachial plexus
PTV70 was treated to 69.96 Gy in 33 fractions with conc chemotherapy.
V60 of brachial plexus = 4.78%.
Node positive Glottic Cancer
node located posterior to great vessels

Green: PTV 70, Yellow: Brachial plexus
PTV70 was treated to 69.96 Gy in 33 fractions with concurrent chemotherapy.
V60 of brachial plexus = 50.74%.
conclusions

• tumors located posterior to the great vessels in the infrahyoid neck are at risk for RTBP injury.

• The dose to the BP in advanced larynx cancers with N0 status or with nodal involvement anterior to great vessels is low and unlikely to exceed BP tolerance.

• Future clinical studies should focus on the “at risk” subset to understand the true incidence and risk of RTBP injury.
Brachial plexus – remember the “cheese burger”
Co-investigators

Jason Sun MD
Jay J. Liao MD

Thanks to the dosimetrist at UWMC
Tom, Tammy, Bill, & Patty