Quality Variation and Clinical Impact in Head and Neck IMRT

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# Tumor Control by IMRT vs non-IMRT in Patients with Oropharyngeal Carcinoma

<table>
<thead>
<tr>
<th>Patient Type</th>
<th>Patient No.</th>
<th>Median F/U</th>
<th>2yr LRC</th>
<th>2yr DFS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Def. Non-IMRT</td>
<td>153</td>
<td>3.5 yr (1.6-17.7)</td>
<td>68.3%</td>
<td>58.4%</td>
</tr>
<tr>
<td>Def. IMRT</td>
<td>31</td>
<td>3 yr (12-58)</td>
<td>87.5%</td>
<td>73.5%</td>
</tr>
<tr>
<td>Post-op Non-IMRT</td>
<td>142</td>
<td>3.9 yr (1.3-19.8)</td>
<td>75.7%</td>
<td>73.5%</td>
</tr>
<tr>
<td>Post-op IMRT</td>
<td>43</td>
<td>2.8 yr (9-60)</td>
<td>95.0%</td>
<td>94.3%</td>
</tr>
</tbody>
</table>

T2N1M0 SCC of Base of the Tongue
T2N1M0 SCC of Base of the Tongue

Consensus on Nodal Level Delineation
UCL, Erasmus, RTOG, EORTC, DAHANCA, GORTEC
PET/MRI/CT—GTV Boundary


<table>
<thead>
<tr>
<th>Pair</th>
<th>Mismatched Volume (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT To MR imaging</td>
<td>26 (6.2/23.8)</td>
</tr>
<tr>
<td>CT To FDG PET</td>
<td>48 (7.8/16.3)</td>
</tr>
<tr>
<td>CT To specimen</td>
<td>81 (10.2/12.6)</td>
</tr>
<tr>
<td>MR Imaging To CT</td>
<td>45 (9.3/20.8)</td>
</tr>
<tr>
<td>MR Imaging To FDG PET</td>
<td>67 (11.0/16.3)</td>
</tr>
<tr>
<td>MR Imaging To specimen</td>
<td>107 (13.4/12.6)</td>
</tr>
<tr>
<td>FDG PET To CT</td>
<td>17 (3.5/20.8)</td>
</tr>
<tr>
<td>FDG PET To MR imaging</td>
<td>15 (3.6/23.8)</td>
</tr>
<tr>
<td>FDG PET To specimen</td>
<td>46 (5.8/12.6)</td>
</tr>
<tr>
<td>Specimen To CT</td>
<td>10 (2.0/20.8)</td>
</tr>
<tr>
<td>Specimen To MR imaging</td>
<td>9 (2.2/23.8)</td>
</tr>
<tr>
<td>Specimen To FDG PET</td>
<td>13 (2.1/16.3)</td>
</tr>
</tbody>
</table>
Nodal CTV Delineation – Margin?
Microscopic Tumor Extension outside Nodal Capsule

- 97 ECE+ LNs from 49 patients
- Tumor extension through the LN capsule by:
  - Actual presence of tumor cells
  - Desmoplasia (associated stromal reaction)
  - Giant cell reaction to keratin
- Greatest linear distance perpendicular from external capsule border to furthest extent of tumor
  - Nearest tenth of millimeter with micrometer
  - Extrapolation when appropriate
- Largest axial diameter of LN

Results

- 96% ECE within 5 mm of capsule
- None beyond 10 mm
- Inverse correlation between ECE incidence and distance from capsule

Results

- No correlation between LN and extent of ECE
- Mean ECE
  - LN < 1 cm: 2.1 mm
  - LN > 1 cm: 2.2 mm
Nodal CTV Delineation

HN IMRT Challenges Ahead

- Significant growth of IMRT accompanied by increase in time-consuming contouring

- Significant variation in target determination and delineation
EVALUATION OF THE QUALITY OF CARE HAS become a critical issue in medical practice, and it is particularly important in the management of cancer patients where we are almost always dealing with life-threatening illness. The practice with a wide geographic distribution (Table 1). Dr. David F. Herring has been an important contributor since inception of the study. We have felt it extremely important to estab-

“I must hasten to add that for disease sites examined, many more variances appear, …..”

THE STUDY OF THE PATTERNS OF CANCER CARE IN RADIATION THERAPY

SIMON KRAMER, MD
Treatment portals for elective radiotherapy of the neck: an inventory in The Netherlands

Peter Nowak*, Erik van Dieren, John van Sörnse de Kost, Henry van der Est, Ben Heijmen, Peter Levendag

Department of Radiation Oncology, Dr. Daniel den Hoed Cancer Center/University Hospital Rotterdam–Dijkzigt,
Groene Hilledijk 301, 3075 EA, Rotterdam, The Netherlands

Radiotherapy and Oncology 43 (1997) 81–86
Four neuroradiologists
Four radiation oncologists

Contoured GTV on 20 laryngeal cancer CT images

One to one comparison of concordance
Degree of GTV Agreement

Range from 0% to 81.8%
Average 53.17 +/- 3.8%
Variations in CTV Target Delineation for Head and Neck IMRT

An International Survey

Theodore S. Hong,
Wolfgang A. Tomé,
Richard J. Chappell,
Paul M. Harari

University of Wisconsin
Department of Human Oncology

20 institutions

H&N IMRT Practice Heterogeneity

Courtesy of Dr. Harari
Local failure in RTOG-0022 protocol variations

- 4 of 53 patients with evaluable plans had major protocol variations due to underdose of PTV66.

- Local recurrence:
  - 2/4 (50%) patients with major PTV66 variation (underdose)
  - 3/49 (6%) patients without major PTV66 variations
  - P=0.04
Outcome: Local recurrence

Treatment plan of a patient with a major PTV66 underdose
Phase III Registration Trial
TROG 02.02 (HeadSTART)

Patients with Stage III or IV SCCHN
(stratified by stage, site, hemoglobin)

Randomization

• Cisplatin, RT

• Tirapazamine, cisplatin, RT

Courtesy of Dr. Lester Peters
Accrual - 861 patients from 89 sites in 16 countries (Sep 02 – Apr 05)
RT Volume Variation Adversely Impacts Tumor Control

Patients who had received at least 60Gy of RT to PTV2

Estimated percentage locoregional failure-free

Years following end of radiotherapy

2P < 0.0001
Advanced Knowledge-based Intelligent Tool
PHYSICS CONTRIBUTION

REDUCE IN VARIATION AND IMPROVE EFFICIENCY OF TARGET VOLUME DELINEATION BY A COMPUTER-ASSISTED SYSTEM USING A DEFORMABLE IMAGE REGISTRATION APPROACH

K. S. Clifford Chao, M.D.,* Shreerang Bhide, FRCR,† Hansen Chen, M.S.,‡ Joshua Asper, PAC,* Steven Bush, M.D.,§ Gregg Franklin, M.D., Ph.D.,§ Vivek Kavadi, M.D.,|| Vichaivood Liengswangwong, M.D.,¶ William Gordon, M.D.,# Adam Raben, M.D.,† Jon Strasser, M.D.,‡ Christopher Koprowski, M.D.,‡ Steven Frank, M.D.,* Gregory Chronowski, M.D.,* Anesa Ahamad, M.D.,* Robert Malyapa, M.D., Ph.D.,** Lifei Zhang, Ph.D.,†† and Lei Dong, Ph.D.‡‡

*Department of Radiation Oncology, the University of Texas M. D. Anderson Cancer Center, Houston, TX; †Department of Head & Neck Oncology, Royal Marsden Hospital, London, United Kingdom; ‡Department of Radiation Oncology, Christiana Care Health Services, Newark, DE; ¶IKOE Education and Training Unit, Houston, TX; #Department of Radiation Oncology, New Mexico Cancer
Knowledge-based Computer-assisted Target Delineation

Contouring from scratch  Computer-assisted Contouring
## IMRT Target Dose Specification

<table>
<thead>
<tr>
<th>Target Volume</th>
<th>Concurrent Chemotherapy</th>
<th>Butler</th>
<th>RTOG H-0022</th>
<th>Lee</th>
<th>Chao</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All Site 1</td>
<td>NO</td>
<td>NO</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>CTV1</td>
<td></td>
<td>60/2.4Gy 25fx</td>
<td>66/2.2Gy 30fx</td>
<td>70/2.12Gy 33fx</td>
<td>70/2Gy 35fx</td>
</tr>
<tr>
<td>CTV2</td>
<td></td>
<td>-</td>
<td>60/2Gy</td>
<td>59.4/1.8Gy</td>
<td>63/1.8Gy</td>
</tr>
<tr>
<td>CTV3</td>
<td></td>
<td>50/2Gy</td>
<td>54/1.8Gy</td>
<td>54/1.64Gy</td>
<td>56/1.6Gy</td>
</tr>
</tbody>
</table>
## Target Delineation and Dose Spec in 2010

### Definitive

<table>
<thead>
<tr>
<th></th>
<th>CTV1</th>
<th>CTV2</th>
<th>CTV3</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMRT 35 fx</td>
<td>70/2.0</td>
<td>63/1.8</td>
<td>56/1.6</td>
</tr>
<tr>
<td>IMRT 33 fx</td>
<td>70/2.1</td>
<td>60/1.8</td>
<td>54/1.6</td>
</tr>
<tr>
<td>2D 35 fx</td>
<td>70/2.0</td>
<td>60/2.0</td>
<td>50/2.0</td>
</tr>
</tbody>
</table>

### Post-op

<table>
<thead>
<tr>
<th></th>
<th>CTV1</th>
<th>CTV2</th>
<th>CTV3</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMRT 30 fx</td>
<td>63/2.1</td>
<td>60/2.0</td>
<td>54/1.8</td>
</tr>
<tr>
<td>2D 30 fx</td>
<td>66/2.0</td>
<td>60/2.0</td>
<td>50/2.0</td>
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T2N1M0 SCC of Base of the Tongue
Summary

• Do no harm with evidence-based guidance

• Image-pathological study to refine GTV-CTV

• Bridging knowledge gap