IMRT AND BRACHYTHERAPY FOR HEAD AND NECK CANCER PATIENTS

Jurgita Laurikaitienė, D. Adlienė, K. Jakštas, I. Cibulskaitė, G. Adlys, A. Andrejaitis

Kaunas, 2011-10-13/15
Introduction

Technological innovations with modern planning and treatment techniques have transformed the way of HNC treatment. Technical improvements in radiation therapy (RT) process exclude three important components of radiation planning and delivery:

1. Volumetric imaging for planning;
2. Volumetric treatment delivery techniques;
3. Improvements in verification of treatment delivery.

Fig. 1. HNC patient BEV image.

IMRT technique

More precise delivery of radiation has enabled a greater sparing of normal tissue. Given the close proximity of critical organs such as the spinal cord, brain stem, temporal lobes, and salivary glands, has the risk of exposing the patient to acute and/or delayed and sometimes severe complications and is recommended in the treatment of HNC using intensity-modulated radiotherapy (IMRT).

Fig. 2. HNC patient’s IMRT technique scheme.

IMRT technique

- Immobilization.
- Imaging and target volume outline.
- Defining the dose-limiting structures, dose constraints, and prescribed dose to the GTV or microscopic tumor sites.
- Plan verification and quality assurance (QA).

Fig. 3. Examples of the (a) IMRT and (b) 3D conformal plans. Primary and elective nodal PTVs, parotid glands and the spinal cord are shown. For the IMRT plan the patient has an extended neck and the conventional plan is for a patient with a straight neck.

Pros and Cons of IMRT

Advantages of IMRT:
- Dose conformity
- Ability to treat complex shaped (concave or convex) structures
- Sparing of critical normal structures
- Differential dose intensity delivery with altered fractionation

Disadvantages of IMRT:
- Prolonged treatment-planning process
- Longer treatment delivery time
- Dose inhomogenity within target
- Increased volume of normal tissue exposure

Table 1. Mean and median treatment times per session according to the different treatment parameters.

<table>
<thead>
<tr>
<th>Treatment parameters</th>
<th>n</th>
<th>Mean time (min)</th>
<th>Median (min)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>324</td>
<td>11.6</td>
<td>10.0</td>
<td>5.9</td>
</tr>
<tr>
<td>Type of energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrons</td>
<td>24</td>
<td>5.4</td>
<td>5.5</td>
<td>1.7</td>
</tr>
<tr>
<td>Photons</td>
<td>300</td>
<td>12.1</td>
<td>11.0</td>
<td>5.8</td>
</tr>
<tr>
<td>Treatment technique</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IMRT</td>
<td>59</td>
<td>15.1</td>
<td>12.0</td>
<td>6.8</td>
</tr>
<tr>
<td>IMRT 5–7 fields</td>
<td>51</td>
<td>13.6</td>
<td>12.0</td>
<td>5.4</td>
</tr>
<tr>
<td>IMRT 9–14 fields</td>
<td>8</td>
<td>25.5</td>
<td>25.5</td>
<td>4.7</td>
</tr>
<tr>
<td>IMRT, no EPID</td>
<td>26</td>
<td>12.2</td>
<td>10.5</td>
<td>5.9</td>
</tr>
<tr>
<td>IMRT, EPID</td>
<td>37</td>
<td>13.7</td>
<td>14.0</td>
<td>6.7</td>
</tr>
<tr>
<td>No IMRT</td>
<td>265</td>
<td>10.9</td>
<td>10.0</td>
<td>5.4</td>
</tr>
<tr>
<td>No IMRT, no EPID</td>
<td>179</td>
<td>8.8</td>
<td>8.0</td>
<td>3.8</td>
</tr>
<tr>
<td>No IMRT, with EPID</td>
<td>86</td>
<td>15.1</td>
<td>14.0</td>
<td>5.7</td>
</tr>
<tr>
<td>EPID</td>
<td>119</td>
<td>15.7</td>
<td>14.0</td>
<td>6.1</td>
</tr>
<tr>
<td>EPID, no IMRT</td>
<td>86</td>
<td>15.1</td>
<td>14.0</td>
<td>5.7</td>
</tr>
<tr>
<td>EPID, IMRT</td>
<td>33</td>
<td>17.3</td>
<td>14.0</td>
<td>6.7</td>
</tr>
<tr>
<td>No EPID</td>
<td>205</td>
<td>9.3</td>
<td>8.0</td>
<td>4.3</td>
</tr>
<tr>
<td>No EPID, no IMRT</td>
<td>179</td>
<td>8.8</td>
<td>8.0</td>
<td>3.8</td>
</tr>
<tr>
<td>No EPID, IMRT</td>
<td>26</td>
<td>12.2</td>
<td>10.5</td>
<td>5.9</td>
</tr>
<tr>
<td>Fraction number</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Starter</td>
<td>17</td>
<td>19.5</td>
<td>19.0</td>
<td>6.9</td>
</tr>
<tr>
<td>Non-starter</td>
<td>307</td>
<td>11.2</td>
<td>10.0</td>
<td>5.5</td>
</tr>
<tr>
<td>Performance status</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good performance</td>
<td>300</td>
<td>11.4</td>
<td>10.0</td>
<td>5.8</td>
</tr>
<tr>
<td>Bad performance</td>
<td>24</td>
<td>15.0</td>
<td>14.0</td>
<td>6.1</td>
</tr>
</tbody>
</table>

1. E. Van de Werf et al./Radiotherapy and Oncology 93 (2009) 137–140
IMRT or/and Brachytherapy for HNC

The application of RT or intraoperative (IORT) with external beams is significantly limited by cost, logistic issues, and technical problems. Due to this reason the high dose rate (HDR) afterloading brachytherapy today can be promising method, being cost effective, logistically sound, and suitable for a wide range of different anatomic sites.

1. Localized tumors (e.g., organ confined prostate carcinoma).
2. Palliative indications (to improve efficacy and reduce the overall treatment time and morbidity).
3. Tumors recurrent after EBRT where the dose of radiation should be as anatomically circumscribed as possible to minimize dose to previously irradiated normal tissues.
4. Postoperative treatment of the tumor bed where the region at highest risk for recurrence is within the range that can be encompassed by brachytherapy.

Fig. 4. Typical set of applicators, accessories, catheters and sleeves used for HDR treatments.
The Use of Brachytherapy for HNC in Compare with External Beam Alone...

1. The use of brachytherapy in the treatment of HNC causes practitioners hesitation, owing to the proximity to vital structures including the carotid arteries, the jugular veins, other major blood vessels and in some cases the brain.
2. Ability of radioactive implants to deliver a higher concentrated radiation dose more precisely to tissues, which contributes to improved local control, provided that the tissue is clinically delimitable and accessible.
3. At the same time, the surrounding healthy tissues are spared from irradiation.

**Fig. 5.** AP and LR X-ray image with localization markers

1. A. Zuchora Rep Pract Oncol Radiother, 2006; 11(1): 9-12
Technical and Physical Issues of Different RT Verification Techniques
RT Verification Techniques: **IMRT**

**Fig. 6.** Phantoms for (a) Film tests: configuration and orientation of the beams and films for the (i) commissioning tests and individual fields (dotted arrow) and (ii) combined fields (all arrows) and (b) Ion chamber tests: the CIRS 002HN Head and Neck phantom.

**Fig. 7.** Two-dimensional diode array (MapCheck)

RT Verification Techniques: *Brachytherapy*

**Fig. 9.** LiF:Mg,Cu,P pin-worm TLDs (MCP-Np TLD). TLD are re-usable, but are sensitive to handling and they lose sensitivity with repeated use.

**Fig. 10.** Experimental set up for dose measurements.

Portal Dosimetry

1. Pre-treatment IMRT verification by EPID is a fast and accurate method.
2. This method requires detailed knowledge of the detector characteristics and the development of algorithms for geometric correction and dose reconstruction for segmented and dynamic IMRT.
3. The permanent availability of EPIDs on LINAC makes them however, attractive tools as a part of QA programme for pre-treatment and in vivo dose verification.
4. Are re-usable method, as ionization chambers and semiconductor dosimeters.
Films Dosimetry

**Advantages:**
1. High spatial resolution
2. 2D information
3. Repeat reading
4. Wide availability and flexibility
5. Linearity of dose at least in short range
6. Radiographics films are cost effective

**Disadvantages:**
1. Radiographic films: chemical processing, energy dependance
2. Radiochromic films: sensitivity variation, costs
3. Difficult absolute dosimetry
4. Are not re-usable.
5. Film reading: non-online information.
Gel Dosimetry Systems

**Advantages**
1. Due to large proportion of water, polymer gels are nearly water equivalent and no energy corrections are required for electron and photon beams used in radiotherapy.
2. Are well suited for use in high dose gradient regions (e.g. stereotactic radiosurgery)
3. There is a semi-linear relationship between the NMR relaxation rate and the absorbed dose at the point in the gel dosimetry.

**Disadvantages:**
1. Method usually needs access to an MRI machine.
2. A major limitation is the continual post-irradiation diffusion of ions, resulting in a blurred dose distribution.
3. Post-irradiation effects can led to image distortion.
4. Gels are not re-usable.
5. Possible post-irradiation effects:
   - Continual polymerization
   - Gelation and strengthening of the gel matrix.
Conclusions

1. Experience over several decades treating HNC using RT has demonstrated that a high tumor dose is required to achieve local tumor control, but it is important issue to pay attention to the critical and healthy tissues.

2. BRT can be used as an alternative a highly effective technique for the HNC treatment over fractionated external beam, because it is difficult to spare normal tissues (salivary glands, the mandible, and mastication muscles which sustain undesirable late effects) using fractionated external beam radiation therapy only.

3. The main task and challenge using IMRT or BRT techniques for HNC treatment is pre-treatment QA (verification), using most appropriate dosimetry techniques and methods.
Thank You for Your Attention!