APPROPRIATE BEAM ENERGY FOR RADIOTHERAPY OF EARLY LARYNGEAL CARCINOMA

CONSIDERATIONS AND PRACTICES FOR IMPROVEMENT OF RADIOTREATMENT CONDITION

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Abstract In our department, 17 patients with stage I histologically confirmed squamous cell carcinoma of the vocal cord were treated with $^{60}$Co $\gamma$-rays, 25 with 10MV x-rays, and 52 with 4MV x-rays. The 5-year recurrence-free survival rates were 88%, 60% and 91%, respectively. The results might indicate that $^{60}$Co $\gamma$-rays and 4MV x-rays are suitable for treating for early laryngeal carcinoma, and high photon energy beams such as 10MV x-rays are not.

Key words: Radiation therapy, Photon beam energy, Laryngeal carcinoma
Running title: Appropriate beam energy for radiotherapy

INTRODUCTION

Patients with early stage laryngeal carcinomas are preferentially selected for radiotherapy$^{1-9}$, because the voice is preserved in more than 80% of patients treated with radiotherapy, and primary surgical therapy has not shown results superior to those obtained by primary radiotherapy with surgery held in reserve$^{10-12}$.

By the way, when an air cavity exists in an irradiated tissue, ionization build-up and build-down effects can occur near the surface layers of the cavity, with a corresponding decrease in the absorbed dose in these areas$^{13}$. The higher the energy of the photons, the larger the effects. This is an important consideration in radiotherapy for laryngeal carcinoma, as the larynx has a rather large air cavity inside. This is a retrospective study to survey the effect of different energy beams on the treatment outcomes in patients with laryngeal carcinoma.

MATERIALS AND METHODS

In our department, the history of radiotherapy for laryngeal carcinoma can be divided into three periods in accordance with the energy of the treatment beam. From 1958 through 1970, $^{60}$Co $\gamma$-rays were employed. After abandonment of the $^{60}$Co teletherapy unit because of aging, 10MV x-rays were employed from 1971 through 1984. Since 1985, when a 4MV linear accelerator was installed, 4MV x-rays were employed.

Ninety-seven patients with stage I (T1N0M0) histologically confirmed squamous cell carcinoma of the vocal cord were treated with these photon beams: 17 with $^{60}$Co $\gamma$-rays ($^{60}$Co-group), 25 with 10MV x-rays (10MV-group), and 52 with 4MV x-rays (4MV-group). The characteristics of the patients are shown in Table 1. All patients were staged according to the UICC TNM clinical classification system$^{14}$. Radiation was administered through two lateral opposing fields. A daily dose of 1.8 or 2.0 Gy at the midplane was delivered in the $^{60}$Co-group and 10MV-group, and 2.0 Gy in the 4MV group in 5 fractions per week. Hemi- or
total laryngectomies were performed for recurrences. The actuarial survival and recurrence-free survival rates in the three groups were calculated by the Kaplan-Meier method with statistical significance assessed by the log-rank test.

Table 1. Characteristics of Patients and Treatment Conditions

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>60Co-group</th>
<th>10MV-group</th>
<th>4MV-group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>17</td>
<td>25</td>
<td>52</td>
</tr>
<tr>
<td>Mean age</td>
<td>61.4</td>
<td>65.9</td>
<td>64.5</td>
</tr>
<tr>
<td>Male:Female</td>
<td>17:0</td>
<td>25:0</td>
<td>48:4</td>
</tr>
<tr>
<td>T1a:T1b</td>
<td>12:5</td>
<td>16:9</td>
<td>37:15</td>
</tr>
<tr>
<td>Treatment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field size (cm)</td>
<td>4x5 to 6x8</td>
<td>5x5 to 6x8</td>
<td>5x5 to 6x8</td>
</tr>
<tr>
<td>Filter (number)</td>
<td>open field</td>
<td>open field (6)</td>
<td>open field (21)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>wedge filter (19)</td>
<td>wedge filter (9)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3DCF* (22)</td>
<td></td>
</tr>
<tr>
<td>Mean dose (Gy)</td>
<td>63</td>
<td>66</td>
<td>65</td>
</tr>
<tr>
<td>(range)</td>
<td>(50-70)</td>
<td>(50-80)</td>
<td>(60-66)</td>
</tr>
</tbody>
</table>

* 3DCF: Three-dimensional compensating filter

RESULTS

The 5-year actuarial survival rates were 94%, 92% and 98% in the 60Co-, 10MV- and 4MV-groups, respectively. No statistically significant difference between these values was found. The 5-year recurrence-free survival rates were 88%, 60% and 91% in the 60Co-, 10MV- and 4MV-groups, respectively (Figure 1). Statistically significant differences were observed between the 10MV-group and 60Co-groups (p=0.05), and also between the 10MV-group and 4MV-group (p=0.05).

All recurrences were observed at the primary sites. In the 10MV-group, 10 patients had recurrence. Radiation doses of 54Gy, 60Gy, and 66Gy for 2, 4, and 4 patients, respectively were delivered. No major complication related to radiotherapy, such as a laryngeal necrosis, was observed.

DISCUSSION

The actuarial survival rates for the 60Co-, 10MV- and 4MV-groups are comparable to those previously reported (Table 2). The 5-year recurrence-free survival rates in the 60Co-group (88%) and 4MV-groups (91%) are also acceptable. However, 60% for the 10MV-group seems definitely inferior to the usual results after treatment with 60Co γ-rays and 4 MV x-rays.

In the 1970s, Spring et al. and Salmo et al. reported lower recurrence rates after 180-190kV x-rays treatment for laryngeal carcinoma than after 60Co treatment16,17. This finding has been
attributed to ionization build-up and build-down effects with a decrease in the absorbed dose at the interior surface layers of the larynx. Koskinen et al. reported that an air cavity of $2 \times 2 \times 2$ cm$^3$ and a field of $4 \times 4$ cm$^2$ provided a dose at the surfaces of the air cavity which was 6% lower than that assumed in ordinary dose planning for 60Co $\gamma$-rays in two lateral opposing fields radiation. Recently, Klein et al. reported that the same condition, namely an air cavity of $2 \times 2 \times 2$ cm$^3$ and a field of $4 \times 4$ cm$^2$, produced 10% decrement of dose at the surfaces of the air cavity for 4MV x-rays. Thus, it is highly probable that 10MV x-rays will produce a more significant decrease in the absorbed dose.

In Japan, 60Co $\gamma$-rays, 4MV, 6MV, and 10MV x-rays are widely used for external radiation therapy. Our department has no experience using 6MV x-rays for the treatment of the malignancies. However, Rudoltz et al. reported 86% in 5-year local control rate in T1 squamous cell carcinoma of the glottis treated with 6MV x-rays.

**CONCLUSION**

The results of the present clinical study might indicate that 60Co $\gamma$-rays and 4MV x-rays are suitable for treatment of early laryngeal carcinoma, and 10 MV x-rays are not.

Part of this study has been reported at the 48th meeting of the Japan Radiological Society.

### REFERENCES

16. Spring, E., Rissanen, P.M.: The effect of the treated


要旨：当科では、早期喉頭扁平上皮癌(T1N0M0)でコバルトγ線による放射線治療を受けた患者は17名。10MVX線によるもの25名、4MVX線によるもの52名であり、局所制御率は各々88％、60％、91％であった。早期喉頭癌の放射線治療には、コバルトγ線や4MVX線のようなエネルギーの比較的低い放射線が適しており、10MVX線のような高いエネルギーの放射線は不適當であることが示された。