Dosimetric verification of rectal wall sparing effect in intensity-modulated radiation therapy for prostate cancer patients with and without the use of a rectal balloon

Radiation Therapy Oncology Group guides radiation treatment scheme and dose-volume criteria based on clinical experiences. Intensity-modulated radiation therapy (IMRT) for localized prostate cancer has been applied to focus on increasing radiation treatment effects and sparing organs at risk, especially for the rectum (1,2). However, it is obscure to decide whether the suggested dose criteria and volume definition contain air cavity and its dosimetric effect.

Thus, we evaluated rectal wall sparing effect in 2 groups: patients with a rectal balloon (P_{air}) and patients without the immobilizer (P_{not}). IMRT plans were made using the same plan parameters (Table 1) and constraints on the planning target volume (PTV) and normal structures for both patient groups. Dose distributions calculated by the analytical anisotropic algorithm (AAA) algorithm were compared with those of pencil beam convolution (PBC) algorithm.

Table 1. IMRT plan parameters for prostate cancer patients with and without a rectal balloon.

<table>
<thead>
<tr>
<th>Plan parameters / Patients</th>
<th>Rectal Balloon</th>
<th>Radiation Beams</th>
<th>IMRT Constraints (Organs at risk)</th>
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<tbody>
<tr>
<td>6 prostate cancer patients (with a rectal balloon:3, without a rectal balloon: 3)</td>
<td>70 cc air injection (inflated balloon 4.5 cm in diameter and 5 cm in length)</td>
<td>10 MV photons 5 static fields (0, 50, 100, 260, and 310°)</td>
<td>V_{65} &lt; 15 &lt;br&gt; V_{60} &lt; 25 &lt;br&gt; V_{55} &lt; 65 &lt;br&gt; V_{50} &lt; 50</td>
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Figure 1. Comparison of calculated dose distributions by the AAA and PBC algorithms for a patient with the use of a rectal balloon in IMRT.

![Isodose](image)

(a) Acrylic insert to simulated the rectum filled with air  (b) Pass ratio in gamma analysis

Figure 2. Verification of rectal wall doses using rolled-up EBT2 films
The developed insert was useful to measure rectal wall doses by wrapping the outer and inner surface of the rectal wall with the 2 rolled-up EBT2 films [Fig. 2(a)]. Rectal wall doses are also verified using glass rod detectors placed in another insert simulating the rectum filled with air. Delivered doses to the rolled-up films were consistent with calculation values using the AAA algorithm within maximum 5% dose discrepancy. More than 93% pass ratio was obtained in each patient case for verification of rectal wall doses.

The AAA algorithm accurately estimated the perturbed doses by the air cavities in the rectum. Dose distribution calculated by the AAA algorithm described increase rectal volume received relatively low dose (30% value of the maximum dose) due to the contribution of the electrons generated in the air. Boundary of the target volume which was overlapped with the anterior rectal wall showed lower delivered doses than that of PBC algorithm [Fig. 3(a)].

The rectal balloon contributed to reduce the rectal wall volumes received high doses ranging from 97% to 103% of the prescribed dose. However, fraction of the rectal volume where the 70% or adjacent doses to the prescribed dose were delivered was increased [Fig. 3(b)].

References: