Evolving Rectal Sparing in Fiducial Based Image Guided Proton Therapy for Localized Prostate Cancer

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Purpose

In April 2015, hydrogel rectal spacer was introduced in our institution as an option to endorectal balloon (ERB) in the treatment of prostate cancer, and in July, our proton system was upgraded to pencil beam scanning in all treatment rooms. The purpose of this study is to report the impact on rectal sparing when comparing prostate cancer patients treated with an endorectal balloon using uniform scanning (US) proton therapy versus pencil beam scanning (PBS) proton therapy. Additionally, patients treated with a hydrogel rectal spacer (Gel) using PBS were compared with the previous modalities.

Methods

• 146 patients underwent proton therapy for localized prostate cancer.
• Gel placements were performed as an outpatient trans-perineal procedure under local numbing.
• All patients received 78 Gy$_{\text{RBE}}$ in 39 fractions to the PTV.
• For US(ERB) and PBS(ERB), PTV margins were 3mm posterior and 4mm elsewhere.
• For PBS(Gel), PTV margins were 5mm posterior and 6mm elsewhere.
• Dosimetric indices were compared between all three groups using ANOVA, Scheffe’s Test, Kruskal-Wallis tests, and Mann-Whitney U tests.

Results

• All Gel placements were performed successfully.
• All dosimetric data is shown in table 1.
• The average rectum DVH for each data group is shown in figure 1.
• Examples of the dose distribution for each of the data groups are shown in figure 2.
• PBS(Gel) reduced the mean rectal V70.2 Gy$_{\text{RBE}}$ by 83% when compared to PBS(ERB) (p<0.001) and by 87% when compared to US(ERB) (p<0.001).
• Target coverage, defined by PTV D99%, and bladder sparing (bladder V90%) were not significantly different between any of the groups.

Conclusions

PBS proton therapy improved rectal sparing when compared to uniform scanning in the treatment of prostate cancer patients with an endorectal balloon. However, the lowest rectal doses were achieved in patients treated with a combination of PBS proton therapy and a hydrogel rectal spacer, particularly in the higher dose range of 65-78 Gy$_{\text{RBE}}$.

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<table>
<thead>
<tr>
<th>Number of Patients</th>
<th>US(ERB)</th>
<th>PBS(ERB)</th>
<th>PBS(Gel)</th>
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<tbody>
<tr>
<td>Rectum V78 Gy$_{\text{RBE}}$</td>
<td>2.02%</td>
<td>0.95%</td>
<td>0.09%</td>
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<tr>
<td>Rectum V74 Gy$_{\text{RBE}}$</td>
<td>5.85%</td>
<td>3.98%</td>
<td>0.52%</td>
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<td>Rectum V70.2 Gy$_{\text{RBE}}$</td>
<td>7.75%</td>
<td>5.77%</td>
<td>1.00%</td>
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<tr>
<td>Rectum V65 Gy$_{\text{RBE}}$</td>
<td>10.10%</td>
<td>7.87%</td>
<td>0.94%</td>
</tr>
</tbody>
</table>

Table 1. Number of patients and average rectum DVH data for all data groups

Figure 1. Average rectum DVH for US(ERB) – green dashed, PBS(ERB) – blue dotted, and PBS(Gel) – brown solid. Orange line indicates V70.2 Gy$_{\text{RBE}}$ also highlighted in table 1

Figure 2. Typical dose distributions for each data group. A) US(ERB). B) PBS(ERB). C) PBS(Gel). Prostate – red, rectum- brown, Gel - blue