Dosimetric Analysis of Radiotherapy for Rectal Cancer

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INTRODUCTION

Despite the fact that radiotherapy is of vital importance for cancer treatment, adverse effects induced by radiotherapy and the potential growth of secondary tumors grow an imperative need for the implementation of newer radiotherapeutic techniques with lower toxicity at organs at risk (OAR).

The aim of this study is the dosimetric comparison of two techniques, 3D conformal with wedge (MW) and 3D conformal with Field in a Field (FIF) for phase I of preoperative radiotherapy for patients with locally advanced rectal cancer (Figure 1), in order to assess and compare the advantages and disadvantages of each technique, the effect and the potential benefit for the patient.

METHODS AND MATERIALS

This randomized prospective study included 27 cases of localized rectal cancer. A dosimetric comparison was conducted using the Eclipse V8.23 VARian treatment planning system, of Medical Physics Department of AntiCancer Hospital “THEAGENEIO”. Through a CT simulation contouring of anatomical structures was performed, on which the radiotherapy technique 3-field BOX (Fig. 2, 3) (3-field BOX with wedges and 3-field BOX with Field in a Field (FIF) (manual IMRT treatment planning)) was applied. The radiation dose for rectal cancer treatment was 45 Gy in 25 fractions of 1.8 Gy and the dose constraint to the bladder must be V45 less than 15% and V40 less than 40%. The comparison factor used was the mean dose received by the bladder, while the 95% of the Planning Target Volume (PTV) met the required dose. The energy of the X-ray beams used was 18 MV and the gantry angles were 90°, 270°, and 180° (or 0° for prone position). The monitor units (MU) and the treatment time were also compared. The treatment time is calculated as the ratio of MU to dose rate 400MU/min.

Statistical analysis of the data was performed with the software IBM SPSS Statistics Version 23. Statistical significance between our parameters was assessed with the paired t-test with a p value level of significance of p < 0.05.

RESULTS

The maximum, the minimum and the mean dose to the bladder for both techniques is shown in the Table 1. It is clear that the mean dose for the organ at risk is significantly lower using the 3D Conformal with field in a field (FIF) technique, while the dose delivered to the PTV remains the same for both techniques, as shown in the following Plan Tumor Volume (PTV, V95%) at Figure 3. Furthermore, the monitor units (MU) in 3D Conformal with FIF is significantly lower and shorter treatment time (Table 2).

Table 1: Comparison between two radiotherapy techniques for bladder’s dose

<table>
<thead>
<tr>
<th>BLADDER’S DOSE (Gy)</th>
<th>3D FIELD WITH FIF</th>
<th>3D FIELD WITH WEDGES</th>
</tr>
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<tbody>
<tr>
<td>MIN</td>
<td>11.7 ± 0.46</td>
<td>10.3 ± 0.31</td>
</tr>
<tr>
<td>MAX</td>
<td>38.7 ± 0.96</td>
<td>40.9 ± 0.68</td>
</tr>
<tr>
<td>MEAN</td>
<td>17.37 ± 0.36</td>
<td>18.54 ± 0.37</td>
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</tbody>
</table>

Table 2: Comparison between two radiotherapy techniques for MU and treatment time

<table>
<thead>
<tr>
<th>LINEAR ACCELERATOR</th>
<th>3D FIELD WITH FIF</th>
<th>3D FIELD WITH WEDGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIN (MU Monitor Units)</td>
<td>233.07 ± 11.41</td>
<td>397.26 ± 23.14</td>
</tr>
<tr>
<td>TREATMENT TIME (400MU/min)</td>
<td>0.582 ± 0.029</td>
<td>0.993 ± 0.058</td>
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CONCLUSIONS

In all cases, in both techniques the dose-constraints to the bladder V45=35% and V40=40% were easily achieved. Furthermore, it is evident that the best choice for phase I of preoperative radiotherapy for patients with locally advanced rectal cancer having the lowest dose to the bladder is 3-Field Box with Field in a Field (FIF) compared to 3-Field Box with wedges (MW). As with FIF technique treatment fields are significantly more conformal to the PTV due to the collimator angle. Also, it is proved that the treatment time is significantly lower using the FIF technique, which results in the better machine’s function and improving patient’s comfort.

REFERENCES

- Radiation Physics for Medical Physicists, E.B. Podgorsak, Springer, Montreal, Canada, May 1, 2003
- A phase II evaluation of preoperative chemoradiotherapy utilizing intensity modulated radiation therapy (IMRT) in combination with capecitabine and oxaliplatin for patients with locally advanced rectal cancer, RTOG 0812, Radiation Therapy Oncology Group (RTOG) of the American College of Radiology (ACR), 2016

Figure 1: Planning for rectal cancer

Figure 2: 3 Field BOX

Figure 3: Treatment planning comparison and Dose Volume Histogram for rectal cancer