CONFORMITY INDEX FOR BRAIN CANCER PATIENTS

Sonja Petkovska¹, Cveta Tolevska¹, Slavica Kraleva¹, Elena Petreska²

¹ University Clinic for Radiotherapy and Oncology, Vodnjanska 17, Skopje, R. Macedonia, pet.sonja@gmail.com, skraleva@gmail.com
² City University of New York, Menheeten, New York, USA, elena_petreska@yahoo.com

Abstract – The purpose of this study is to present the level of conformity achieved by using 3D conformal radiotherapy for brain cancer patients. Conformity index is a helpful quantitative tool for assessing (evaluating) the quality of a treatment plan.

Treatment plans made for ninety patients with brain tumor are worked on this paper. The patients are in supine position and immobilized with thermoplastic masks for the head. Computed tomography data sets with 5 mm scan thickness are used to create a 3D image. All structures of interest are contoured. In order to obtain an optimal dose distribution, treatment fields are fit around target volume with set-up margins of 7mm in each direction.

The conformity index values are between 1.21 and 2.04. Value of 1.8 is exceeded in eighteen cases; nine of them are bigger than 1.9 and only three of them are above 2. The target volume for each of these extreme CI values is ideal covered (between 95% and 105% of the prescribed dose). The most acceptable conformity index value in this paper belongs to the plan with the lowest minimal dose (84.7%).

It can be concluded that conformity index is necessary but not sufficient factor for assessing radiation treatment plan conformity. To be able to estimate the acceptability of some treatment plan in daily practice, additional information as minimal, maximal and mean dose into target volume, as well as health tissues coverage must be taken into account.

Keywords – treatment planning, brain cancer, 3D conformal radiotherapy, conformity index

1. INTRODUCTION

Three-dimensional conformal radiation therapy (3DCRT) is a high-precision type of radiotherapy, regarding volumes definition (target and organs at risks), patient immobilization, and treatment delivery. The use of multileaf collimator (MLC) gives a possibility of shaping the isodose surfaces around volume of interest (i.e., the planning target volume) in all three dimensions. This enables to approach the first principle in radiotherapy: increase the dose in the tumor as much as possible and minimize the irradiated normal tissue volumes at the same time. Quantification of the three dimensional dose distribution is represented in the form of dose–volume histograms (DVH). By using DVH, it became possible to define the maximal, minimal, mean, and modal dose values delivered to each volume of interest. It also allows comparison of DVHs for the same structures into two (or more) different plans for the same patient. We can easily choose between several options ensuring the same tumor coverage and the same protection of some critical organs in favor of the option that most effectively protects the other organ at risk. But, all healthy tissues cannot be taken into account, because of the difficulties of delineation and absence of sufficient data concerning the tolerance of these tissues to the absolute dose received, or the magnitude of the volume irradiated [1].

In spite of the facts above, it is not easy to determine the level of conformity. Analysis of each parameter relevant for the treatment (e.g. clinical, radiologic, radiobiologic geometric, dosimetric) is very complex and time-consuming. An additional tool that integrates all these data and quantitatively assess the quality of a treatment option is the conformity index.

The conformity index was first proposed in 1993 by the Radiation Therapy Oncology Group (RTOG) and described in Report 62 of the International Commission on Radiation Units and Measurements (ICRU). It is presented as a relation between the volume of the reference dose (Vₚ) and the target volume(TV).

\[
\text{Conformity index}_{\text{RTOG}} = \frac{V_{\text{RI}}}{TV}
\]

According to the RTOG guidelines, ranges of conformity index values have been defined to determine the quality of conformation. If the conformity index is situated between 1 and 2, the treatment is considered to comply with the treatment...
plan; an index between 2 and 2.5, or 0.9 and 1, is considered to be a minor violation, and when the index value is less than 0.9 or exceeds 2.5, the protocol violation is considered to be major, but may nevertheless be considered to be acceptable [2].

CI=1 is an ideal, theoretical value but even if it is a real one, it doesn’t mean that high level of conformity is achieved. Volume of reference dose could be shifted out of target volume with perfect mathematical corresponding. Obviously to be able to assess conformity in daily practice, additional parameters as minimal isodose surrounded target volume, or maximal dose and mean dose into target volume, must be determined.

In this paper we will evaluate dose distribution, conformity index and its relation to minimal dose.

2. MATERIALS AND METHODS

Ninety brain cancer patients (Glioblastomas-50, Astrocytomas-20, oligodendrogliomas-20), selected consecutively from our clinical database in the period of one year 2007, treated on the same linear accelerator, have been evaluated retrospectively. Prescribed dose for all patients is 60Gy in 30 fractions, 1 fraction per day, 5 days weekly.

Treatment plans were created according to the three-dimensional conformal radiotherapy [3D-CRT] on computed tomography (CT) data sets of above brain tumor patients. The CT scan should start at the top of the cranial vertex and down to the neck to encompass the entire cranial contents and the head. CT scan thickness is 0.5 cm through the whole scanning region. The patients are in supine position, immobilized with thermoplastic head&neck mask. CT isocenter is marked on the mask.

The gross tumor volume (GTV), situated in the parietal or frontal lobe and outlined on all CT slices in which the structure exist, has a margin of 1cm to define clinical target volume (CTV). Planning target volume (PTV) is 1cm around the CTV. The brain stem and both lenses are delineated as organs at risk (OAR). Because of the anatomical barriers or OAR that are not infiltrated, in some cases PTV is corrected.

The aim of the planning is to cover the PTV with at least 95% of the prescribed dose. Treatment plans are made with 3 fields, left, right and vertex (couch rtn 90°, gantry angle depended on the tumor and eyes position is between 20° and 70°). The planning fields are fit around the PTV with setup margine of 7mm. The MLC is always adjusted to the planning field. Enhanced dynamic wedges are also available. If the CT isocenter was changed during the planning, it is marked on the mask additionally (before irradiation treatment starts) using movable lasers mounted on CT couch.

3. RESULTS

Dose distribution

ICRU protocol requires a minimal dose of 95% (which is also reference dose in this paper) and a maximal dose of 107% of prescribed dose into target volume (PTV in this paper). Most of the PTVs (more than 50%) are close to the eyes or body surface, so a minimal dose of 95% into PTV is very difficult to achieve. The lowest value of the minimal dose is 84.7%, but the mean dose is not less than 99.2% in all cases (Table 1).

<table>
<thead>
<tr>
<th></th>
<th>D_{\text{min}} (%)</th>
<th>D_{\text{max}} (%)</th>
<th>D_{\text{mean}} (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>from</td>
<td>84.7</td>
<td>103.4</td>
<td>99.2</td>
</tr>
<tr>
<td>to</td>
<td>96.5</td>
<td>108.7</td>
<td>102.1</td>
</tr>
<tr>
<td>mean</td>
<td>92.9</td>
<td>105.6</td>
<td>100.6</td>
</tr>
</tbody>
</table>

The minimal doses of the invested patients are presented below (Fig. 1). In 10% of them the minimal dose is less than 90%.

As it is shown below (Fig 3) there are 11 cases where the maximal dose exceeds 107%, but is less than 109% and situated always in PTV.

Conformity index

According to the RTOG guidelines, a conformity index value less than 1 means that not whole PTV is covered by reference dose. Values above 2 point that even coverage of PTV is acceptable; health tissue included into the reference dose volume is not negligible.

In the results presented below (Fig. 3), it can be seen that there is not any conformity index value less than...
1, which means that the reference dose volume ($V_{95}$) is always bigger than the target volume (PTV). Conformity index values are between 1.21 and 2.04, $CI_{\text{mean}}$ is 1.68. Most of the values (eighty patient plans or 90%) are situated in the region between 1.4 and 1.9. Value 1.8 is exceeded in eighteen cases; nine of them are bigger than 1.9 and only three of them are above 2.

**Fig. 3 – Conformity Index (%)**

In order to find some relation between CI and dose distribution, we present (Fig 4) how the conformity index depends on the corresponding minimal dose.

**Fig. 4 – CI-Minimal dose corresponding**

As it is shown on this figure the conformity index is not proportional to the minimal dose.

**Table 3. CI values and its corresponded doses**

<table>
<thead>
<tr>
<th>CI</th>
<th>$D_{\text{min}}$ (%)</th>
<th>$D_{\text{max}}$ (%)</th>
<th>$D_{\text{mean}}$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.21</td>
<td>84.7</td>
<td>105.3</td>
<td>99.6</td>
</tr>
<tr>
<td>1.26</td>
<td>89.0</td>
<td>108.7</td>
<td>100.2</td>
</tr>
<tr>
<td>1.45</td>
<td>95</td>
<td>105.9</td>
<td>102.1</td>
</tr>
<tr>
<td>1.55</td>
<td>89.7</td>
<td>105.3</td>
<td>99.2</td>
</tr>
<tr>
<td>1.56</td>
<td>95.5</td>
<td>103.3</td>
<td>99.9</td>
</tr>
<tr>
<td>1.68</td>
<td>96.0</td>
<td>104.3</td>
<td>100.8</td>
</tr>
<tr>
<td>1.68</td>
<td>91.8</td>
<td>108.7</td>
<td>99.4</td>
</tr>
<tr>
<td>1.98</td>
<td>95</td>
<td>105</td>
<td>100.9</td>
</tr>
<tr>
<td>2.01</td>
<td>95.2</td>
<td>105</td>
<td>100.0</td>
</tr>
<tr>
<td>2.04</td>
<td>93.5</td>
<td>105.2</td>
<td>100.2</td>
</tr>
<tr>
<td>2.04</td>
<td>94</td>
<td>105.7</td>
<td>99.8</td>
</tr>
</tbody>
</table>

Some of the conformity index values and its corresponding doses are shown in Table 3. As it is shown above, the best conformity index value (1.21) belongs to the treatment plan with a lowest value of the minimal dose (84.7%). CI=2.01 corresponds to $D_{\text{min}}=95.2$% and $D_{\text{max}}=105.0$%.

Even if we select a subgroup with perfect PTV coverage, $95%<D_{\text{PTV}}<106%$, CI varies between 1.46 and 2.01, 1.67 in average, and there is also no dose dependency.

**4. CONCLUSION**

From the results we can note that: CI for brain cancer patients worked on this paper is in the frame of RTOG recommendations; it is above 1.46 even in the case of the best PTV coverage; and it does not correspond to the minimal dose. The intention of the pretreatment planning should be lower CI than presented value, but decreasing of CI (e.g. $V_{95%}$) leads to underdosage of the target volume.

It can be concluded that conformity index is necessary tool for evaluation of treatment plan adequacy, but it is not sufficient factor for assessing radiation treatment plan optimality. To be able to estimate the acceptability of some treatment plan in daily practice, additional information as minimal, maximal and mean dose into target volume, as well as health tissues coverage must be taken into account. Together with other evaluation tools (DVH, visual isodose inspection e.t.c.) it should be used for determining the level of conformity.

In the future we should try to improve the treatment planning modalities, to be able to decrease the volume of the reference dose ($V_{95%}$), and at the same time achieve a target volume (PTV) included into the reference dose volume.

**5. REFERENCES**


