Doses to the Lens of the Eye in Radiotherapy Imaging

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Abstract

The role of imaging in radiotherapy is rapidly growing, and in some treatment schemes relatively high-dose imaging procedures are repeated before every fraction. For patients with good prognosis and for the most radiation-sensitive organs the dose in radiotherapy imaging may be an issue. In the case of pre-treatment megavoltage imaging with the lens of the eyes within the field of view, the probability of radiation-induced cataract might be significant. In such cases the dose should be accounted for during radiotherapy treatment planning.

Keywords: patient dose, cone beam computed tomography, portal imaging, image-guided radiotherapy

Introduction

The doses in diagnostic radiology are subject to certain regulations, e.g. the Polish law [1] sets reference dose levels that should not be exceeded. It is known that the doses absorbed during diagnostic procedures (e.g. computed tomography) can exceed the levels known to increase the probability of cancer induction [2, 3].

Computed tomography and other imaging modalities are also used for radiotherapy planning and for radiotherapy verification. With the advent of electronic portal imaging devices (EPIDs) and, more recently, cone-beam computed tomography (CBCT), the role of imaging in radiotherapy has grown rapidly, especially for patients with problematic setups [4] or patients treated for prostate carcinoma with fiducial markers implanted [5]. In some situations megavoltage imaging contributes up to 20% of the dose at some locations outside the target volume [6]. Obviously, the use of kV imaging (x-ray CBCT) results in a substantial reduction of the doses compared to high energy MV imaging (EPIDs) [7, 8].

In this paper the dose to the lens of the eye in radiotherapy imaging is discussed.

Discussion

It is believed that the absorbed dose of 500 cGy may cause cataract in 5% of patients within 5 years of irradiation [9]. Some values of the dose absorbed by the lens for various imaging modalities used in radiotherapy verification are presented in Table 1. In all cases the tumour is located within the brain and lens of the eye are in the field-of-view. The dose values for CT, x-ray CBCT and megavoltage CBCT have been taken from the literature. The dose quoted for EPID has been calculated with treatment planning system and represents an extreme situation in which a ion chamber-based imaging system is used for the pre-treatment verification with two orthogonal 10 cm × 10 cm fields. The dose would be significantly lower for a modern flat panel detector which requires less dose to form an image of reasonable quality. In most cases it should be possible to avoid direct irradiation of the lens when using EPID (e.g. using MLC shaped fields).

It should be stressed that these are the values for a single examination. The total dose can be much higher if the procedure is repeated before each fraction (e.g. 20 times). In case of megavoltage imaging this leads to doses
Conclusions

In case of the pre-treatment megavoltage imaging with the lens within the field of view the dose to the lens may be significant. In such a case the dose should probably be accounted for during radiotherapy treatment planning and suitable protocols suggested.

References

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Table 1. Doses absorbed by the lens of the eye in a single examination

<table>
<thead>
<tr>
<th>Modality</th>
<th>Dose [cGy]</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>CT</td>
<td>2.5 [3]</td>
<td>strongly depends on scanner type and selected protocol</td>
</tr>
<tr>
<td>x-ray CBCT</td>
<td>0.06 – 2.5 [10]</td>
<td>Elekta Synergy, dose depends on image quality</td>
</tr>
<tr>
<td>EPID</td>
<td>25 a)</td>
<td>pre-treatment verification, two orthogonal 10 cm × 10 cm fields</td>
</tr>
</tbody>
</table>

a) simulated for Rando phantom, Varian Eclipse TPS, Varian Clinac 2300 C/D, 6 MeV photons, 10MU per image

which definitely cannot be neglected as they give a significant probability of complications.