Conference Paper

Enhancement of Radiotherapy Planning Quality for Patients with Implantable Electronic Devices

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Abstract

Nowadays radiological physicists increasingly face with the problem of artifact-corrupted planning computed tomography images. Such artifacts caused by a metal case of cardiac devices. The purpose of the research was to apply the artifacts reduction method in order to provide qualitative irradiation planning as well as accurately calculate the dose in the devices. The results obtained in this work are essential for radiological physicists to avoid cardiac devices being damaged during radiotherapy.

Keywords: Artifacts reduction, radiation therapy, implantable device

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Received: 17 January 2018
Accepted: 25 March 2018
Published: 17 April 2018

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the PhysBioSymp17 Conference Committee.

1. Introduction

Published data report many cases of implantable cardiac devices failures in cancer patients during radiation therapy [1-5]. The devices monitor and maintain a heart rhythm, while damage can be fatal to a patient. The leads carry the electrical impulse from the cardiac device to heart and relay information about the heart's natural activity back to the device. The leads are generally considered to be insensitive to radiation [6].

In the radiotherapy planning, the analysis of the doses received by the areas of interest is commonly carried out using a cumulative dose-volume histogram (DVH). The ideal cumulative DVH for the planning target volume should be similar to the Heaviside step function, whereas 100% of organs at risk (or implantable cardiac devices) volume should receive a dose of 0 Gy. Conversely, in medical practice, radiological physicists deal with a real dose-volume histogram shown in Figure 1, where curve 1 corresponds to the cardiac device and curve 2 demonstrates the dose-volume dependence for the target volume.

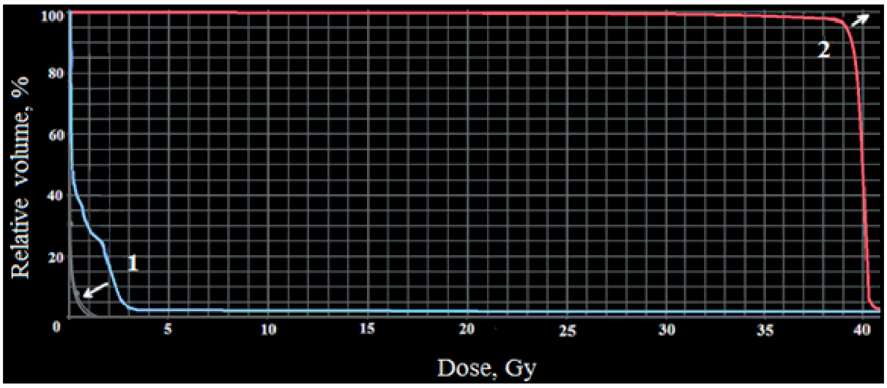

Figure 1: The dose-volume histogram constructed for cardiac device (1) and planning target volume (2) was obtained in VARIAN Planning System Eclipse 11.0.

However, getting close to the ideal type of the histogram does not guarantee the qualitative radiation plan as well as the precise dose calculation for cardiac devices, since planning computed tomography images have artifacts that seriously degrade the image quality. Artifacts are generally caused by the fact that a case of the cardiac devices consists of the metal such as titanium.

2. Materials and Methods

Considering the problem, Metal Deletion Technique was proposed to improve quality of the planning computed tomography images for patients with implantable electronic devices. This method is an iterative technique that was developed by F. Edward Boas and Dominik Fleischmann (The Department of Radiology, Stanford University Medical Center, USA) [7]. Metal Deletion Technique was never used for cancer patients with an implantable cardiac device in Masaryk Memorial Cancer Institute. Figure 2 demonstrates a simplified flowchart of the artifacts reduction method.

All treatment plans were designed in VARIAN Planning System Eclipse 11.0 for 6 cancer patients undergoing radiotherapy in Masaryk Memorial Cancer Institute. At first, radiotherapy planning was carried out based on initial artifacts-corrupted computed tomography images. Then, the plans were created for the same images processed by the artifacts reduction method. As a result, cardiac device doses before and after application of Metal Deletion Technique were compared.

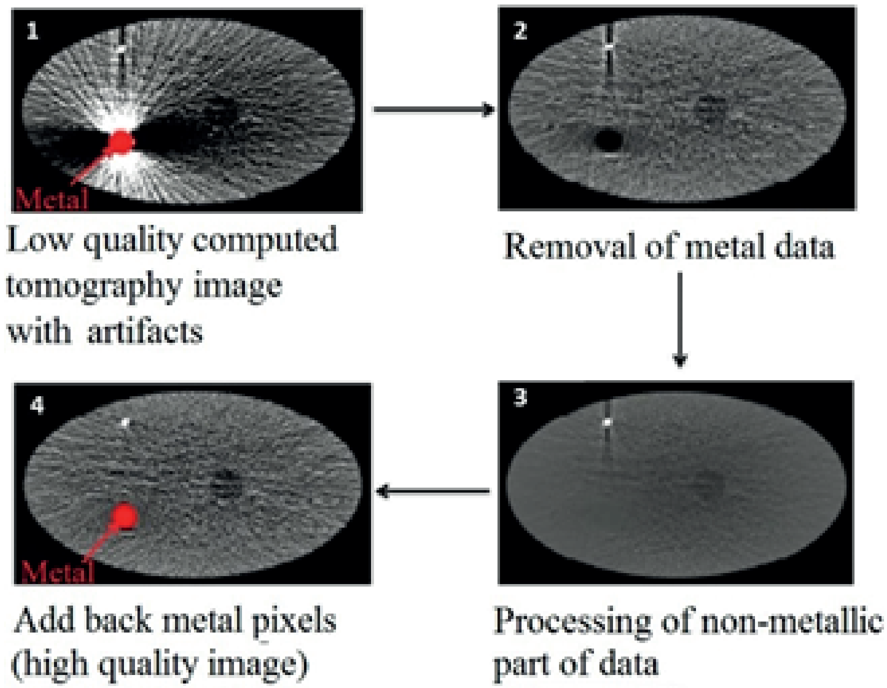

Figure 2: Metal Deletion Technique [7].

3. Results and Discussion

The cardiac device doses as a percentage of prescribed doses for all cancer patients are shown in Figure 3. The black bars correspond to the electronic device doses for the plans made based on computed tomography images with artifacts, whereas the white ones estimate doses in implantable devices after application of artifacts reduction method.

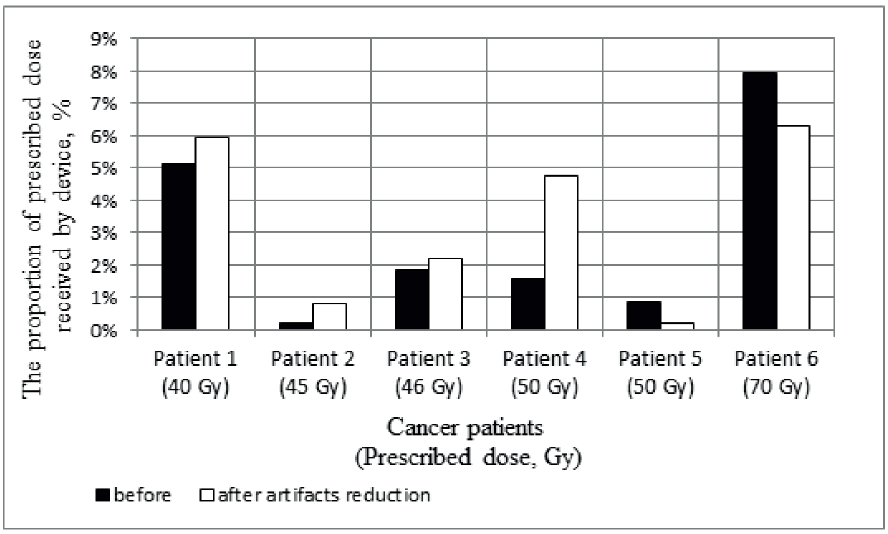

Figure 3: Comparison of doses in cardiac devices before and after artifacts reduction.

DOI 10.18502/ken.v3i2.1811

It can be observed that in all cases the doses received by implantable devices differ. Therefore, the design of a qualitative irradiation plan does not seem possible without artifacts reduction. For instance, the error in determining the cardiac device dose for Patient 6 reaches 1.63% and taking into account the high dose of 70 Gy in planning target volume, this inaccuracy can lead to electronic device failures.

Figure 4 clearly shows what becomes with the computed tomography image of Patient 6 after application of Metal Deletion Technique. Obviously, the quality of the image has become much better and cardiac device corresponds to real form.

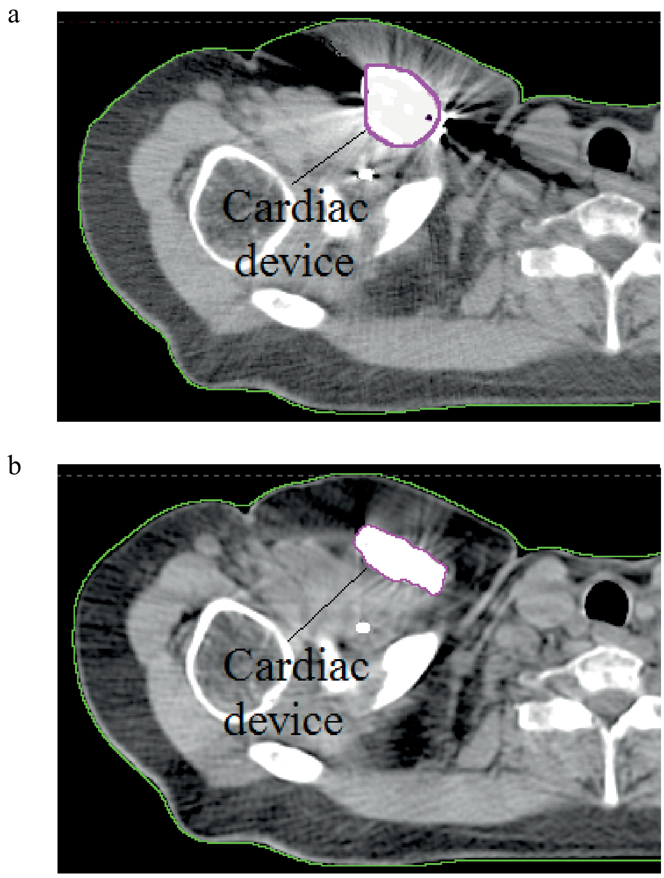

Figure 4: The implantable cardiac device with metal artifacts (a) and after artifacts reduction (b).

4. Conclusion

The results show that the influence of the artifacts reduction technique on treatment planning should be essential for radiological physicists dealing with cancer patients that have cardiac implantable devices. This approach reduces the likelihood of electronic device errors due to the correct estimation.

Acknowledgments

This work was supported by MH CZ - DRO (MMCI, 00209805).

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