Comparison Between Different Dosimetric Tools Applications in Radiotherapy

Medicine

Keywords: Radiotherapy, dosimetry, XiO treatment planning system, MATLAB, dose distribution, beam modeling.

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Abstract

The purpose of this study is to compare some different dosimetric tools applications of professional software such as XiO with other non professional methods. XiO treatment planning system (TPS) provided by ELEKTA is one of the most important professional software used in radiotherapy. TPS plays an important role in the treatment of patients in radiotherapy. TPS system provides a way to design treatment plans, which aim optimal distribution of the prescribed dose to the target volume (tumour bed) and save as much as possible normal tissue or organs at risk (OAR) structure surrounding the tumour. We used MATLAB as a scientific and research environment to demonstrate the possibilities that this software gives in radiotherapy, especially in quality assurance (QA). MATLAB is a high-level language and interactive environment for numerical computation, visualization, and programming. Using MATLAB, we can analyze data, develop algorithms, and create models and applications such CERR (Computational Environment for Radiotherapy Research) and DREES (Dose Response Explorer System). These modules are customized for modelling and exploring dose response in radiation oncology. Various analytical and graphical features are embedded to facilitate navigation and analysis of complex radiobiological interactions and their relationships with treatment outcomes.

1. Introduction

Dosimetry, as a branch of applied physics, aims to define and accurately calculate the radiation doses in cells and its biologic effect (Palmans, 2002). Dosimetric applications are extensive and their use should be carried out in by experts of this field. Dosimetric methods used by physicians to treat patients and acceptance of the dosimetric values, gives us a high chance of cure tumor diseases. In this paper we set out the main procedures of verification and quality assurance of radiation beam from XiO - TPS (Elekta, 2013) and Matlab by taking into account data from dosimetric procedures determined for transport of energy to water in accordance with AAPM/RTOG (AAPM, 1999) protocols and International Code of Practice on Dosimetry in Radiotherapy (IAEA, 2000) of IAEA (International Atomic Energy Agency). Referring to the International Standards Organization, ISO 9000, with quality assurance will understand all systematic actions necessary to provide us full security to a product or process meets specified requirements for quality. Quality assurance control is essential for safety and effective treatment of the patient in whole process of treatment with radiation. TPS is an important component because it covers a range of applications. Incorrect operation of TPS leads to wrong treatment of the patient. So the goal of QA for TPS is to develop a process that ensures that every patient will get optimal treatment that is planned with no errors during use and the implementation of TPS in clinical case (Barret et al., 2009). Is important to say that no software and applications can be perfect and give us the idea that TPS is subject of electronic and mechanical defects. For this reason, various comparative methods are used to calculate the accuracy of the doses used in treatment plans. Lack of quality assurance procedures cause serious accidents. Treatment plan system is an indispensable tool and its control should be developed in centres where radiotherapy treatment is provided

2. The process of clinical radiotherapy treatment

The process of clinical radiotherapy treatment is complex and includes one or several steps such as: patient diagnosis and decision to treat with radiation, patient positioning and immobilization, images from computerized tomography, magnetic resonance (ICRUM, 2000). The difference between the thicknesses of slices various from 1 mm to 10 mm and depends on the protocol followed and by the anatomical scanned area. Based on these images, oncologists can assess the size, scope and location of the tumor. The next step is to prepare a treatment planning using computer system software which in our case is XiO. This TPS imports data from CT imaging to the system. Based on these images radiation oncologists and physicists, can assess the size, scope, location of the tumor, can select anatomical structures and outline target volumes. Is very important be determined the Gross Tumor Volume (GTV), Clinical Target Volume (CTV), and Planning Target Volume (PTV = CTV + 1 cm) based on graphical representation of the volumes of interest. Contouring usually is a “homemade” process but for regular structures, this can be performed automatically. According to this information, we can predict the radiation fields and modifying the radiation beam so we have a better view of the tumor and the organs at risk. Then, we describe and calculate the doses and treatment time. Distribution of dose is estimated by analysis histogram of dose - volume, or seeing the target volume to be covered by optimal isodoses and organs at risk to be limited to tolerable and acceptable radiation dose. After evaluation and approval by the team printed treatment plan of patient is archived. As part of the preliminary treatment is preparation of plastic mask fixation, blocks to protect organs at risk, or bolus to compensate for patient for changes in the surface dose, etc.

3. Comparison between TPS with XiO and Matlab

The data importing procedure in XiO treatment plan is described in many studies as well in the manufacturer's manuals. Our XiO supports a range of treatment modalities, including 2D, 3D, MLC-based IMRT, solid compensator-based IMRT and brachytherapy. In addition, dynamic conformal arc therapy is supported. XiO offers more advanced dose calculation algorithms, including Clarkson, FFT Convolution, MultiGrid Superposition, Fast Superposition and Electron Monte Carlo. We can choose the algorithm that is most appropriate for each plan. With XiO TPS, we can create a virtual patient and can present the beam's eye view (BEV) that are projecting to the patient and digitally reconstructed Radiography (DoR), which is reconstructed radiograms (digitally reconstructed radiography DRR),(see Figure 1). This DRR tool computes a "virtual radiograph" from the planning CT data. The DRR looks like a plain X-ray but has the advantage of displaying the target volumes and normal tissues contoured from the CT scan data. This is very important for treatment verification and quality assurance. The DRR can have the radiation portal shape superimposed upon it. The DRR is used to verify that treatment delivery is being done as planned. Images of the patient can be transferred to TPS via DICOM RT format. This format was adopted in 1993 by the American College of Radiology (ACR) and National Electrical

Figure 1 - Virtual patient and beam's eye view (BEV) that are projecting to the patient and digitally reconstructed Radiography

Manufacturers Association (NEMA). Then comes the formation of three dimensional structures outlining external structures (surface of the patient), target volumes and risk organs as is shown in Figure 2. After receiving the anatomical data and PTV which will be treated we flocks of ionizing radiation in the XiO treatment plan. Radiation beams have the features which are set by the physicists in the treatment plan.

Figure 2 – Three dimensional structures outlining external structures (surface of the patient), target volumes and risk organs taken from XiO

By setting the optimal parameters as required daily or total dose beam, number of fields, angles of radiation field size, etc., we take a picture of isodose curves which give us a clear idea about the radiation and the dose distribution in the area which will be addressed and for the quantity of the dose distributed to the OAR surrounding the tumor (Knoos et al., 2006), Figure 3.

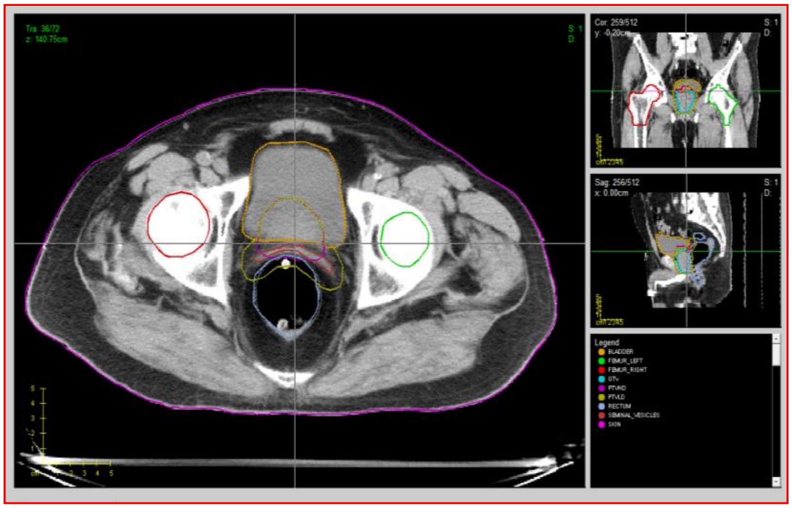

Figure 3- The picture of isodose curves related to the radiation and the dose distribution for each structure taken from CERR

While in Matlab we can perform this procedure with the CERR module (Deasy et al., 2003), (Hyka, 2013). With CERR, we can import different format of data: DICOM, RTOG, Gamma Knife ect. In our example we choose the same image, DICOM format.

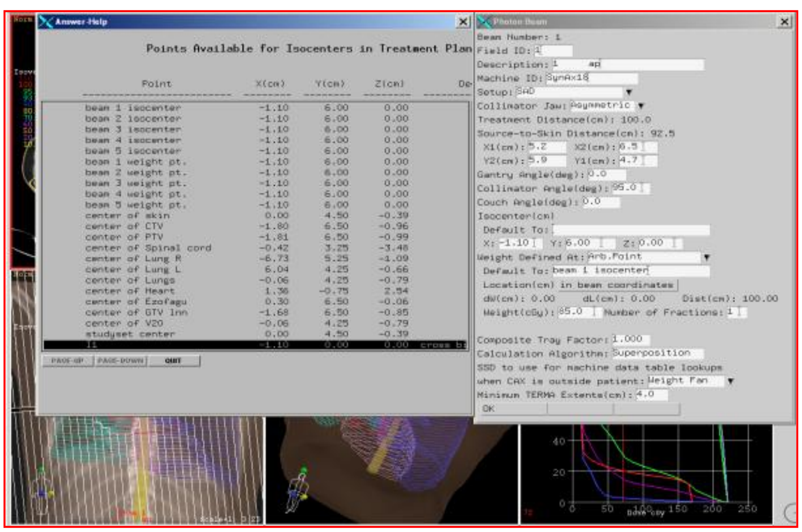

Figure 4- TPS preliminary data set to design and modeling the radiation beam of patient with XiO

Several dosimetric end points have been defined in ICRU Reports (International Commission on Radiation Units & Measurements). Very important is to defined prescription or reporting point along with detailed information regarding total dose, fractional dose and total elapsed treatment days allows for proper comparison of outcome results. Dose specification is based on: minimum target dose from a distribution or a dose volume histogram (DVH), maximum target dose from a distribution or a DVH, mean target dose. With CERR we can calculate the volume and dose for each structure, maximum dose, and minimum dose. In TPS should be included a preliminary data set to design and modelling the radiation beam of patient (Figure 4). The first aspect of the TPS configuration is to create a database that contains a description of the treatment apparatus; model of a device such as linac. Each TPS requires the introduction of a specific set of parameters to create geometric and mechanical descriptions of the treatment accelerator.

4. Results and Discussion

Implementation of a protocol for QA of TPS is one of the levels of safety and quality assurance in radiotherapy. The whole process of QA in terms of radiotherapy dosimetry, treatment plans or conditions of the equipment is the responsibility of physicist. QA enables patient protection against the occurrence of injuries. The system provides the calculation of the dose distribution within the standards and the possible spread of radiation dose conformal. This paper present two different method for TPS and QA, preparation of protocols and treatment in radiotherapy. Quality assurance procedures and treatments provide by CMS XiO are performed based on the idea of the simulation of the patient treatment process. CERR module combined with the MATLAB environment provide different benefits such us, the ability to import treatment plans from a wide variety of commercial and academic treatment planning systems, a treatment plan data architecture which is self describing, compact, easily manipulable, and extendable, the ability to manipulate treatment plans within a powerful data analysis and programming environment, for example for dose-volume-outcomes analyses, visual plan review tools axial, sagittal, and coronal viewers (Hyka, 2013). Non commercial using of Matlab package is the main difference with XiO. The procedures of TPS, QA importing and exporting of data, are relatively easy to perform with Matlab.

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