Abstract

Radiotherapy is currently one of the most important treatment methods used in cancer treatment. Its aim is to deliver prescribed dose to the target volume while sparing healthy tissues. In order to reach this aim radiotherapy treatment should be applied in as precise manner as possible. Therefore patients setup uncertainties and their influence on the dose received during radiotherapy course was a subject of many research done through last decades. Studies at that time based on limited amount of information. Nowadays, technological progress in radiotherapy treatment allows to collect setup data during entire course of treatment. Analysis of such a big data are still lacking.

In presented work two sets of clinical data were analyzed. First group consisted of 100 patients treated in Maria Sklodowska-Curie Institute — Oncology Center in Warsaw (Poland), second group consisted of 835 patients treated in Erasmus MC University Medical Center Rotterdam (Netherlands). Both groups included data of setup errors for prostate cancer patients. The difference was in number of fractions received during entire treatment and methods used to detect setup errors (bony anatomy or gold markers).

The statistical analysis of the data collected for both populations showed that they were not normally distributed. Presence of inter-fraction time trends was investigated as one of possible reasons of non-normal distribution of setup errors. As in limited fraction treatment some trends can always be detected, the method to distinguish physiological trends (i.e. related to patient physiology and anatomy) from these which can be attributed to limited number of measurements was proposed.

The presented studies were done on two previously mentioned clinical datasets as well as on many different datasets with artificial setup errors mimicking the natural patients behavior — so called synthetic populations. Those synthetic populations were created in order to cover wide range of clinically relevant population parameters. Current methods of dealing with setup errors and incorporating this knowledge into the treatment planning and delivery process are mostly based on population parametrizations and concept of cumulative dose. In this work a parametrization taking into account time trends was investigated and compared with the conventional one, most often used in the clinical practice. It was shown that a wrong parametrization used to describe population of patients setup errors may lead to the underestimation of CTV-PTV margins. The investigated parametrization may be further used in margin-less planning.

In the presented work, apart from investigating alternative parametrization method, a possibility of estimating patient specific cumulative dose was examined. That methodology can be further used for individualization of margin-less planning algorithms.

One of the methods to deal with setup errors and uncertainties is to apply off-line and on-line verification protocols. Offline verification protocols require less workload. Still it is known from clinical practice that some patients will require an on-line verification. The mostly applied

No Action Level protocol efficiency is related to mean setup error estimation. A modification of this protocol was proposed in order to provide an easy method to distinguish patients who require more attention (i.e. more fractions with imaging). The modified protocol does not require additional workload in terms of average number of fractions with imaging. Instead of doing imaging in the same number of fractions for each patient, the fractions with imaging are not-equally spread within the population of patients.

Although off-line verification protocols may reduce the systematic errors, some residual errors will always be present. To ensure a proper irradiation of the target some margin is added to it during the treatment planning process. Currently the most applied margin recipes are based on conventional parametrization. That is why it does not take into account inter-fraction time trends. As existence of this trends was shown during population data analysis, the new recipe for margin calculation was provided. In limit of no time trends this new recipe simplifies to currently used one.

Keywords:

radiotherapy, setup errors, cumulative dose, verification protocols, CTV-PTV margins, time trends, Monte Carlo simulations