Teaching Lecture: The integration of multimodal imaging in the radiation treatment process: pitfalls and challenges

SP-0005
The integration of multimodal imaging in the radiation treatment process: pitfalls and challenges

K. Haustermans[1], A. Debucquoy[1]
[1]*University Hospital Gasthuisberg, Radiation Oncology, Leuven, Belgium*

Radiation oncology is a rapidly evolving specialty. In analogy with the evolution from conventional radiotherapy over 3D conformal radiotherapy to intensity modulated radiotherapy and volumetric modulated arc therapy there has been a shift from the use of anatomical imaging (e.g. CT, MR) to functional imaging (e.g. DW-MRI, DCE-MRI) and biological imaging (e.g. 18F-FDG PET). In the current process of radiation treatment, the radiobiological response of tumor and normal tissue in patients is monitored non-invasively by a variety of imaging techniques. Integration of these imaging techniques into therapy selection strategies and radiation treatment can serve several purposes.
First, pre-treatment assessments can steer decisions on the radiation treatment as such or on the combination with other modalities.
Second, biology-based objective functions can be introduced into the radiation treatment planning process by co-registration of molecular imaging. Relevant radiobiological parameters that can be assessed include tumour burden, tumour hypoxia, tumour proliferation and tumour metabolism. This would allow us to generate customized heterogeneous dose distributions with escalated doses to tumour areas where radiotherapy resistance mechanisms are most prevalent. However, there are some hurdles to overcome including the discrepancy between resolution of imaging techniques and spatial scale at which radiosensitivity is determined and the treatment induced temporal and spatial changes in tumor morphology and biology.
Third, monitoring of temporal and spatial variations in these radiotherapy resistance mechanisms early during the course of treatment can discriminate responders from non-responders. With such information available shortly after the start of treatment, modifications can be implemented or the radiation treatment plan can be adapted based on the biological response pattern.
In this teaching lecture, some background on the different imaging techniques at our disposal for early response monitoring wil be given and examples of current applications and future prospectives for the further integration of imaging in the radiation treatment process will be shown.

Teaching Lecture: How to manage geometric uncertainties

SP-0006
How to manage geometric uncertainties

B. Sobotta[1]
[1]*Scientific RT GmbH, Department of Medical Physics, Reutlingen, Germany*

Uncertainties are still a major challenge in cancer treatment. The resulting deviations between planned dose and delivered dose need to be minimized.
The widely used PTV-approach contains several pitfalls. Firstly, it is based on a single patient-snapshot in time, whereas patient treatment is a dynamic process. Secondly, expanding the clinical target volume (CTV) to the planning target volume (PTV) always entails an increased dose in the organs at risk (OARs). Lastly, it is geared towards geometric uncertainties in conjunction with conventional radiotherapy and fails in hadron-based therapy.
For more than a decade, alternate approaches have been an active area of research. Thus, there is a multitude of methods to be found in literature. While their sheer number can be overwhelming, the vast majority fits in two distinct categories. On one hand, there are methods that strive to control the dose to each element in a volume of interest. On the other hand are algorithms, that control the outcome metric (e.g. max dose, equivalent uniform dose (EUD)). Even though they have considerably different prerequisites, strength and weaknesses, they share the common goal of target dose escalation and/or improved OAR sparing. This also and especially includes non-conventional modalities such as hadron-based therapy. Fortunately, with the increasing availability of imaging information, the wide-range deployment of next generation treatment planning via such methods is feasible.
This teaching lecture will elaborate the general differences between both schools of thought, as well as present their similarities. It turns out that, upon closer inspection, even a quantitative relation can be established. The lecture will also include an excursion into algorithm-internal uncertainty management. More specifically, it will cover effects that arise from finite sample sizes, e.g. due to a limited number of images available at the time of planning. The impact of treatment fractionation on uncertainty handling will also be touched upon. It is the ultimate goal of the lecture to build a mind map about different kinds of uncertainties, and how they may be tackled. This will be underpinned with an exemplaric overview of current literature.

Teaching Lecture: Use of imaging to predict toxicity and tumour control

SP-0007
Use of imaging to predict toxicity and tumour control

C. Brink[1,2]
[1]*University of Southern Denmark, Institute of Clinical Research, Odense, Denmark*
[2]*Odense University Hospital, Laboratory of Radiation Physics, Odense, Denmark*

Medical images of various modalities are important factors in establishing diagnosis and stage of the disease, and are used extensively before, during and after radiotherapy of cancer patients. However, from treatment planning is commenced until radiotherapy has ended, image information is except for the dose calculation usually considered only in a very strict geometrical sense: To define the target and delineate critical structures on planning images, and to realign the patient in 2, 3, 4 or 6 dimensions according to pretreatment imaging.
Imaging is currently also used in response evaluation after radiotherapy. Both tumor progression and normal tissue reactions such as radiological pneumonitis are routinely evaluated on CT images after radiotherapy for lung cancer. Even though a direct link between radiological observations and clinical symptoms is not always evident, any radiological finding contain information of the tissue response to radiation; a response which might be hard to detect clinically due to other co-morbidities, and which might contain information on potential emerging toxicity.