MRI-guided Radiotherapy

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Its excellent soft tissue contrast makes MRI extremely well suited for oncology, both to define the geometry of the tumour process and characterize its functional information. A major challenge is to translate MRI towards on-line and real-time guidance in radiotherapy.

In recent years, using cone beam CT-linac radiotherapy systems, great success has been realized in the minimal invasive treatment of prostate tumours, stereotactic ablative body radiotherapy of lung tumours and stereotactic treatment of tumours of the brain. For these tumours, there is good visualization of the tumour itself or there is a good visualization of tumour related fiducial markers. Ther e is a clear trend towards better targeting with less normal tissue involvement and thus less toxicity, less surgery and less fractionation. However, for most other tumour locations the limited visualization using cone beam CT and the lack of dynamic information hinders this development. On-line and real-time MRI guidance may offer the possibility to implemented this stereotactic revolution for all remaining tumour locations like radiotherapy of tumours of the rectum, oesophagus, pancreas, kidney, individual lymph nodes, etc. This may provide a breakthrough in the application of radiotherapy and redefine the relation radiotherapy and surgery.

Essential is the availability of high quality MRI (e.g.1.5T Philips Ingenia) during the actual treatment process. The design of the experimental UMCUtrecht/Elekta MRI-Linac combination has been described in Lagendijk et al. [2008] and Raaymakers et al. (2009). The MRI accelerator facilitates continuous patient anatomy updates regarding translations, rotations and deformations of targets and organs at risk. Accounting for this, demands high speed, online intensity-modulated radiotherapy re-optimization. The MRI must supply real-time information about the actual position of the tumour and organs at risk. Dedicated sequences and correction protocols are being developed to guarantee extreme fast and geometrically correct imaging. Essential is that the complete anatomy can be followed in real-time. 4D MRI using multi-band, radial under sampling and Caipirinha techniques are being investigated. Demonstrations of gated as well as tracked delivery on the basis of feed-back from pencil-beam navigators have been performed.

MRI therapy guidance will start a paradigm shift in radiotherapy: the core becomes MR imaging and guidance not fractionation and/or radiobiology. As a consequence, radiotherapy becomes more an interventional radiology process. Close collaboration is needed between the radiation oncologist, radiologist, pathologist, medical physicist, MRI physicist and surgeon. Such a multidisciplinary team will guided the care of those oncology patients with local disease.

Lagendijk JJW et al. Radiother Oncol. 2008; 86(1), 25-9
Raaymakers BW et al. Phys Med Biol. 2009; 54(12), N229-37