Mise au point : MRI-only radiotherapy, benefits and remaining challenges

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Résumé

Introduction:
The aim of current presentation is to provide an overview of the current status of MRI-only treatment planning and MRI-only radiotherapy in general. It is well known that MRI provides an optimal soft tissue differentiation and allows more accurate target volume delineation in modern radiotherapy. Current dose calculation algorithms require electron density though, thus MRI and CT data need to be registered, increasing uncertainty. A direct dose calculation on MRI images can reduce the uncertainty and simplifies the treatment planning process. Recently introduced radiotherapy specific MRI systems allow positioning the patient in the actual treatment position and image distortions are corrected at a 1 mm level.

Methods and materials:

The main focus of current presentation will be an overview of the different methods described in literature to calculate dose on MRI images, by conversion of MRI to pseudo CT. These conversion algorithms were originally introduced for attenuation correction calculations on PET/MRI systems, and later fine-tuned for treatment planning purposes. The simplest method consists of assigning so-called bulk densities. For each delineated organ a unique density is defined. The main disadvantages of this method are the need of delineation (sometimes semi-automatically) and the fact that inhomogeneities within organs are ignored. In spite of the high level of approximation, this method has proven to lead to an acceptable dosimetrical precision for a number of clinical indications, such as prostate cases. A second popular method is based on deformable image registration using reference images (atlas-based methods). Depending on the quality of the deformation algorithm, this method provides excellent results for the majority of treatment plans, and can be applied without any user interaction (no contouring required). On the other hand, when the patient geometry is very specific, deformations cannot always reconstruct the geometry correctly. A third method is based on a direct conversion of the MRI grey values and mostly demands dedicated MRI sequences, having T1 and T2 weighting removed, such as UTE or ZTE sequences. Some authors have also considered combining some of the methods described above.

Other aspects, important for MRI-only radiotherapy, such as MRI simulation, MRI compatible positioning tools, optimization of radiotherapy specific MRI antennas and the impact of image distortions will be discussed as well.

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Conclusion:
Listing all these challenges might seem discouraging to go towards MRI-only radiotherapy, but we probably do not have a choice of treatment precision needs to be further improved. Currently, when using the most advanced radiotherapy techniques, all having a sub-millimeter precision regarding positioning and tracking, the remaining uncertainty is in de definition of the GTV, which demands the most advanced imaging modalities.