Clinical implementation of the MRLinac in Odense, Denmark

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BACKGROUND AND OBJECTIVE

At Odense University Hospital, the MRLinac (MRL), Unity, Elekta, was installed during 2018. The MRL provide the means of soft-tissue image contrast at the time of treatment to visualize the target and the surrounding normal tissue for MR guided radiotherapy (RT). The MRL adapts the treatment based on the daily anatomical changes. This may lead to smaller margins and increased use of hypo-fractionation. The potential is to adapt the treatment not only based on anatomical changes but also biological response, e.g. Diffusion-Weighted Imaging (DWI).

METHODS

The implementation is based on a multidisciplinary team of clinicians, physicists, and RTTs. [1] Everyone had experience in conventional RT in a department, where both CT and MR are used for RT planning. All patients treated at the MRL are treated within clinical protocols focusing on treatment outcome and side effects. CT and an MR scans are acquired for pre-treatment planning. Contouring is based on the MR scan, while the electron density information is linked from the CT to the MR scan using deformable image registration. In addition to the standard target and organ at risk (OAR) volumes used for the treatment optimization, a set of MRL specific volumes are auto-generated:

- DelineationVolume: the volume, where OAR re-delineation is required on the MR scan to include the anatomical changes for the online plan adaptation.
- ActionVolume: the volume, which determines if second adaptation is required.
- TrackingVolume: the volume that the CTV should stay within during irradiation.

A reference treatment plan is optimised in the treatment planning system, Monaco, based on the planning MR scan. This plan is independently checked and verified, using the ArcCheck phantom. The reference-treatment plan is never used; it only serves as a starting point for the optimisation of the online-created adaptive treatment plans.

The Online workflow is used after the patient is set-up in the MRL including the MR-coil positioning. A 3D MR is acquired, which is automatically fused to the planning MR scan. Based on the daily anatomy of the patient, the target structures from the initial pre-treatment planning scan may be shifted and rotated or possibly re-delineated while the OAR structure may require daily adjustment within the DelineationVolume. Based on the adapted contours, a

new plan and dose distribution is optimised, and this new treatment plan is checked independently prior to delivery. While the delineation and re-planning are being performed, a DWI sequence is acquired in the background for research purposes. Prior to treatment, a fast 3D MR validation scan is acquired to evaluate whether the patient's anatomy has changed during re-delineation and re-planning. If part of the target is outside the ActionVolume, the treatment beams are repositioned, and a fast re-calculation of the delivered dose is performed. Finally, during patient irradiation, a 2D MR scan is run in cine mode to validate the target position within the TrackingVolume. At the very last part of the treatment delivery, an additional fast 3D MR scan is acquired for evaluation purposes. The total treatment time from the patient is entering the room to leaving the treatment room is in the range of 21-60 min.

RESULTS AND DISCUSSION

Treatments on the MRL at OUH were initially in the pelvic region. However, currently, patients with abdominal cancers are also treated at the Unity system. Until 1st of July 2020 129 patients have been treated on the Unity system – most of the treatments are based on either a hypofractionation or SBRT scheme. Figure 1 shows the different sites treated and related fractionations; only prostate cancer patients are treated with 20 fractions.

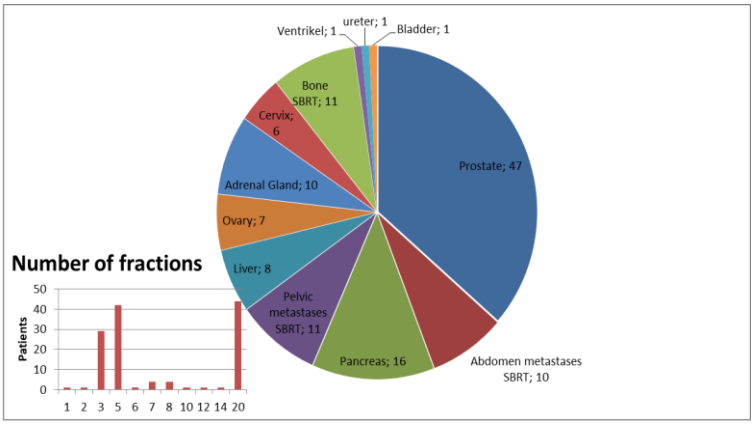

Figure1 Distribution of the number of patients treated so far based on the target position and the fractionations used.

CONCLUSIONS

Implementing the MRL in a clinical setting requires education of a multidisciplinary team. The MRL institutions are accumulating clinical data in a joint registration protocol, which may form the basis for selecting future patients for MRL treatment based on the possible gains relative to standard linac treatment. The MRL gives the RT community a new opportunity to "see what is being treated, while treating". This can be used to evaluate, not only what is treated on the MRL, but the knowledge can feed into margins and patterns of known anatomical movements during RT. The DWI research could provide biological response information, such that the treatments can be adapted based on the likely tumor and toxicity outcome of the individual patient.

REFERENCES

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