Personalized adapted treatment planning based on effective radiosensitivity derived from repeated FDG PET scans

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Purpose

The identification of predictive factors for tumour response assessment at an early stage of radiotherapy is fundamental for cancer treatment adaptation and individualization. For advanced head and neck (H&N) cancer patients, where treatment failure is often caused by poor loco-regional control, an early adaptation of the treatment is crucial.

This study aimed at mapping the most radioresistant sub-regions of the tumour and applying a dose escalation strategy to the patients identified as non-responders to treatment.

Materials & Methods

Twenty eight patients with an advanced stage of H&N cancer were imaged with [18F]-fluorodeoxy-G-glucose positron emission and computed tomography (FDG PET-CT) before the start of radiotherapy and after delivering 18-20 Gy of the prescribed 70 Gy dose to the primary gross tumour volume, GTVprim.

A previously developed method for the assessment of the responsiveness of tumours to radiotherapy developed for lung cancer (1) was applied to the present H&N cancer patients to identify non-responders to treatment. Volumetric maps within GTVprim of an operational parameter, effective radiosensitivity $\alpha_{eff}$ (accounting for the dose delivered until the second PET scan and variations in the FDG uptake) were calculated. As a proof of concept, the feasibility of applying dose escalation of 84 Gy to the more radioresistant tumour sub-regions ($\alpha_{eff,i} < 0$) was explored for two patients using both photon and proton beams.

Results

The stratification of patients in responders/non-responders to treatment based on the previously proposed method was feasible for H&N cancer patients.

Figure 1 shows the $\alpha_{eff}$ map for a selected slice of the GTVprim of a non-responder patient (panel 1, upper row). The sub-region in the tumour showing resistance to treatment is confined making it suitable for boosting strategies (blue area, panel 1, upper row). Original, photon and proton adapted plans are shown in the Figure (panels 2-4, upper row).

Dose volume histograms (DVHs) of the PTVs with prescribed dose of 70 Gy and 51.8 Gy in the original treatment plan and DVHs of the boost volume are shown together with DVHs of the organs at risk (OARs) for the treatment plans under analysis (lower row).

A similar coverage in the region of the PTVs outside the boost areas as prescribed in the original plan is feasible and OAR constraints are fulfilled.

Conclusions

Confined tumour sub-regions with increased radioresistance to treatment can be identified and exploited for early treatment adaptation in non-responder H&N cancer patients.