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ORIGINAL ARTICLE

NTCP reduction for advanced head and neck cancer patients using proton therapy for complete or sequential boost treatment versus photon therapy

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Abstract

Purpose. To determine by treatment plan comparison differences in toxicity risk reduction for patients with head and neck squamous cell carcinoma (HNSCC) from proton therapy either used for complete treatment or sequential boost treatment only.

Materials and methods. For 45 HNSCC patients, intensity-modulated photon (IMXT) and proton (IMPT) treatment plans were created including a dose escalation via simultaneous integrated boost with a one-step adaptation strategy after 25 fractions for sequential boost treatment. Dose accumulation was performed for pure IMXT treatment, pure IMPT treatment and for a mixed modality treatment with IMXT for the elective target followed by a sequential boost with IMPT. Treatment plan evaluation was based on modern normal tissue complication probability (NTCP) models for mucositis, xerostomia, aspiration, dysphagia, larynx edema and trismus. Individual NTCP differences between IMXT and IMPT ($\Delta\text{NTCP}_{\text{IMXT-IMPT}}$) as well as between IMXT and the mixed modality treatment ($\Delta\text{NTCP}_{\text{IMXT-Mix}}$) were calculated.

Results. Target coverage was similar in all three scenarios. NTCP values could be reduced in all patients using IMPT treatment. However, $\Delta\text{NTCP}_{\text{IMXT-Mix}}$ values were a factor 2–10 smaller than $\Delta\text{NTCP}_{\text{IMXT-IMPT}}$. Assuming a threshold of $\geq 10\%$ NTCP reduction in xerostomia or dysphagia risk as criterion for patient assignment to IMPT, less than 15% of the patients would be selected for a proton boost, while about 50% would be assigned to pure IMPT treatment. For mucositis and trismus, $\Delta\text{NTCP} \geq 10\%$ occurred in six and four patients, respectively, with pure IMPT treatment, while no such difference was identified with the proton boost.

Conclusions. The use of IMPT generally reduces the expected toxicity risk while maintaining good tumor coverage in the examined HNSCC patients. A mixed modality treatment using IMPT solely for a sequential boost reduces the risk by 10% only in rare cases. In contrast, pure IMPT treatment may be reasonable for about half of the examined patient cohort considering the toxicities xerostomia and dysphagia, if a feasible strategy for patient anatomy changes is implemented.