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Organ motion in proton therapy: clinical mitigation techniques of the interplay effect

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Pencil beam scanning (PBS) is the most common delivery techniquein proton therapy nowadays because of its high potential to reach gooddose homogeneity to the target and organs at risk (OAR) sparing. It ispossible to modulate each beam in terms of position, intensity andenergy to reach the best plan quality. In case of static lesions, thequality of the dose distribution can be more easily ensured as long asposition and range uncertainty are taken into account. For movingtargets the intra-fraction anatomy changes can have a great impact onthe dose distribution [1]. This is true for any type of external beamradiotherapy because the anatomy being treated is not the same as theone used during the planning [2–3].

In PBS proton therapy treatments the active delivery system addsanother source of uncertainty to the final dose distribution: the activedelivery and the movement of the target can lead to an interplay effect[4-5]. This effect is more evident when the delivery time structure is onthe same scale as the organ motion. The interplay effect is more severefor pencil beam scanning treatments because of the high gradient dosedistributions achievable with ions respect with modulated photonradiotherapy and the resulting dose distortion can be clinically unacceptable.

There are different methods to reduce the interplay effect [5]. These methods can be distinguished into twoclasses: motion mitigation techniques (like abdominal compression and breathhold) and dose distortion mitigation (like beam gating, rescanning, beam tracking, spot size variations) techniques.

A combination of these methods can be used to mitigate the interplayeffect [17]. Both of these classes bring with them some negativeeffects. For example, motion mitigation techniques can be uncomfortablefor the patient and it must be verified if the patient cancomply with these procedures before starting the treatment workflow.Dose distortion mitigation techniques have an impact on the treatmentduration and this could conflict with the scheduling of the treatments(especially in a multi-gantry facility) or with the patient compliance.Typically, the formers are the first used in a proton therapy facility tomitigate the interplay effect because the commissioning time and thedefinition of the procedures are faster and easier to implement.

In clinical practice the best combination of these techniques has to be used in order to ensure the most robust treatment possible. In this presentation clinical examples like liver, lung, mediastinal and heart tumours will be presented to show practical applications of these methodologies.

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