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A Proton Arc Therapy Technique for Upright Position Treatment Systems

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Objectives

Proton arc (or quasi-arc) therapy has the potential to further reduce dose to normal tissues and the treatment time, so that proton SBRT can be applied in a safe and efficient manner to more treatment sites. Upright position treatment systems (a chair and horizontal fixed beam line) offer an easier approach to arc therapy by rotating the patient instead of the heavy weight gantry. We explore a quasi-arc technique by using the existing PBS delivery technology but rotating the patient during energy layer switching.

Methods

Each treatment arc contains multiple energy layers with the energy decreasing monotonically from high to low, just like a regular PBS treatment field. However, during each layer switching the patient rotates at a small angle. As a result, the proton arc consists of multiple static subfields each with only one energy layer aiming at the target from a slightly different direction. Several arcs may be needed for covering the target volume dosimetrically. A water equivalent thickness-based algorithm is implemented to generate the beam angle-energy distributions and spot placements. A commercial PBS treatment planning system is then used to optimize the beam spot weights according to the clinical requirement for the treatment. An experimental upright position treatment system has been tested to be able to rotate a patient at 12 degrees per second.

Results

The technique has been applied to a pancreas case originally treated in a gantry room with four fields at the angles of 140°, 160°, 180°, and 200°, with 67 total energy layers. The new technique used two quasi-arcs each with 34 subfields, with the arc angles spanning uniformly from 140° to 200° and back, respectively. Compared to the original treatment, the quasi-arc plan has improved both target volume coverage and organ dose reduction, and could have reduced treatment time as well.

Conclusions

In summary, we explored a proton arc irradiation strategy for upright position treatment systems. The method could potentially improve dose distribution and treatment efficiency.

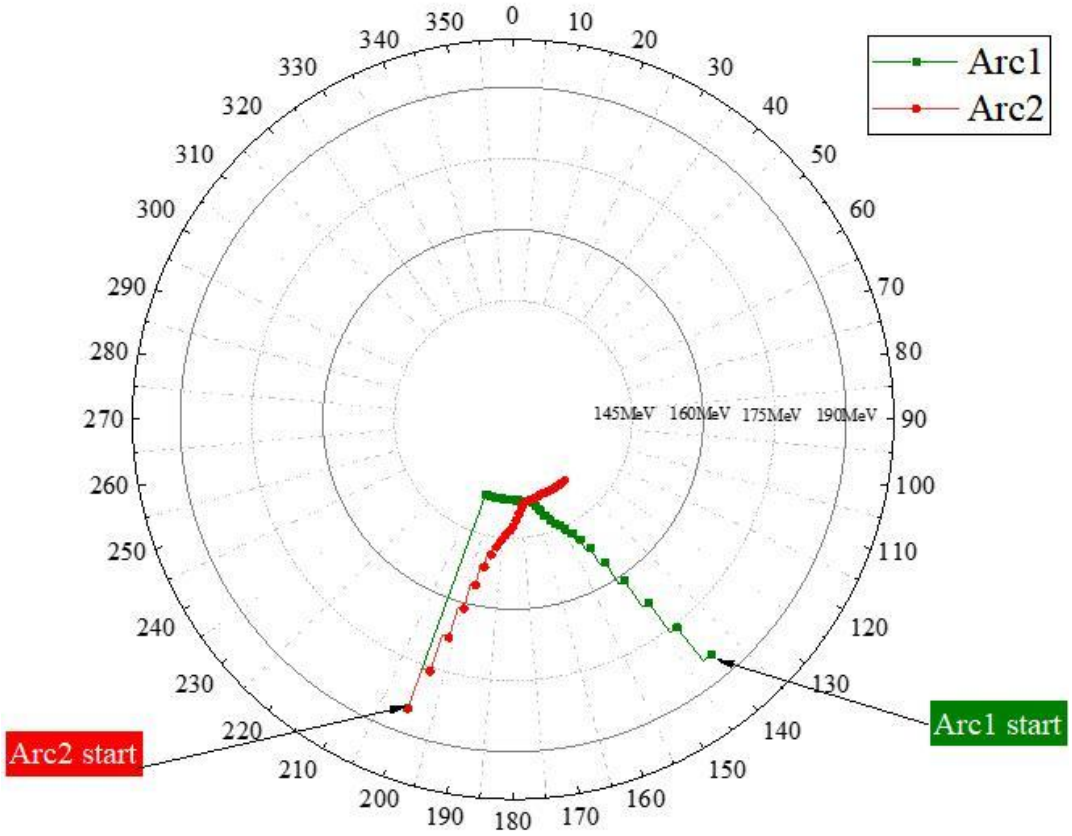

Fig.1 The relative beam angle-energy distribution of proton arc plan for the pancreas case example.

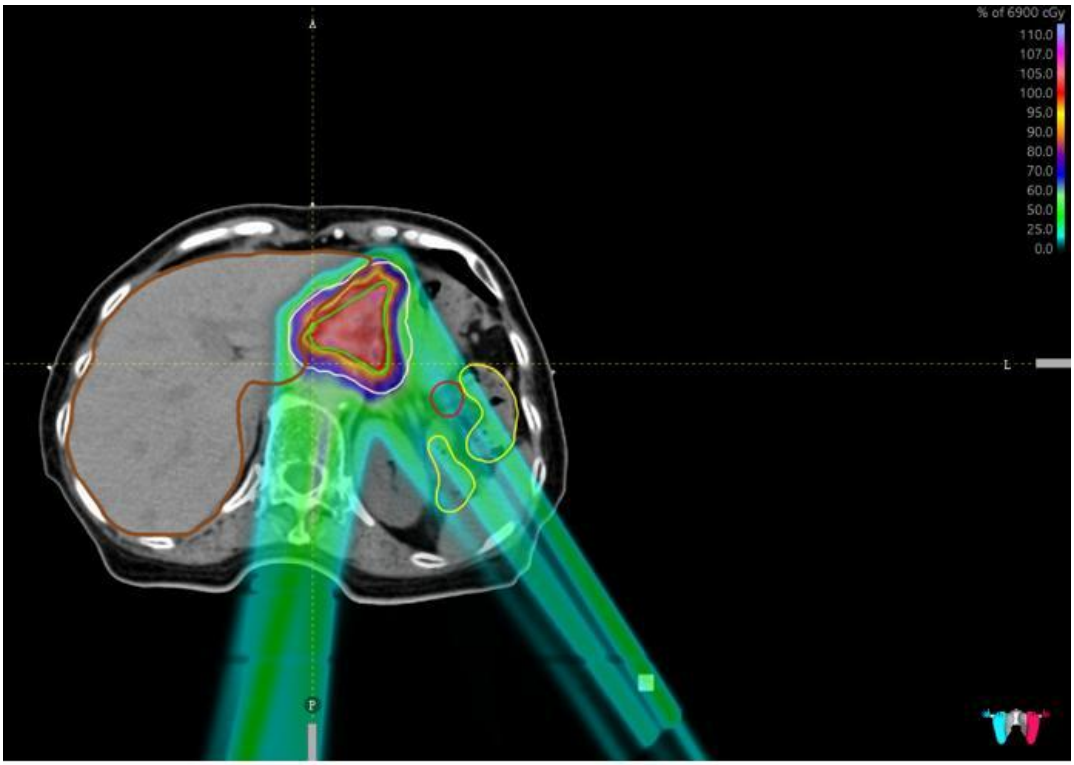

Fig.2 The dose distribution of proton arc plan for the pancreas case example.

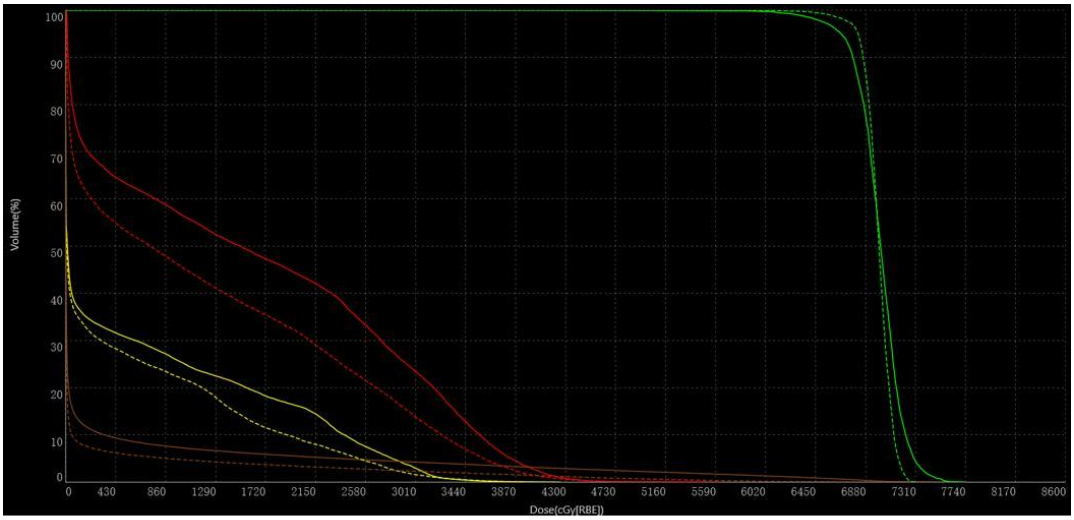

Fig.3 The dose volume histogram comparison between multiple static fields plan (solid line) and the quasi-arc technique (dot line). Green for pancreatic cancer target volume, red for small bowel, yellow for colon, brown for liver.