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Feasibility of utilizing Spot-Scanning Proton Arc (SPArc) therapy for whole Lung Irradiation

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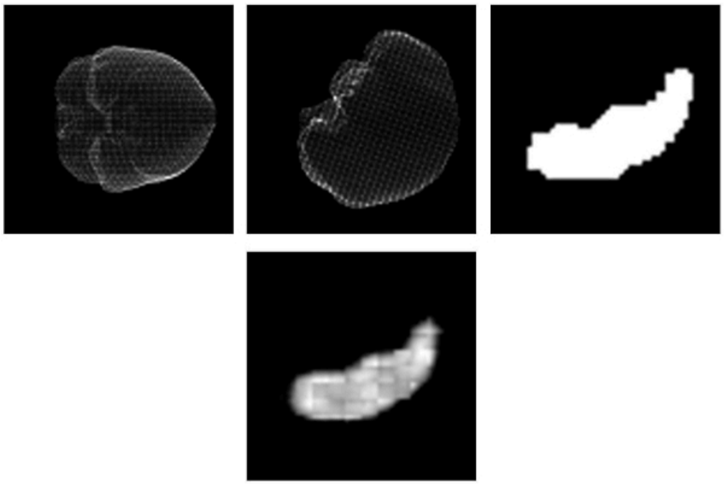
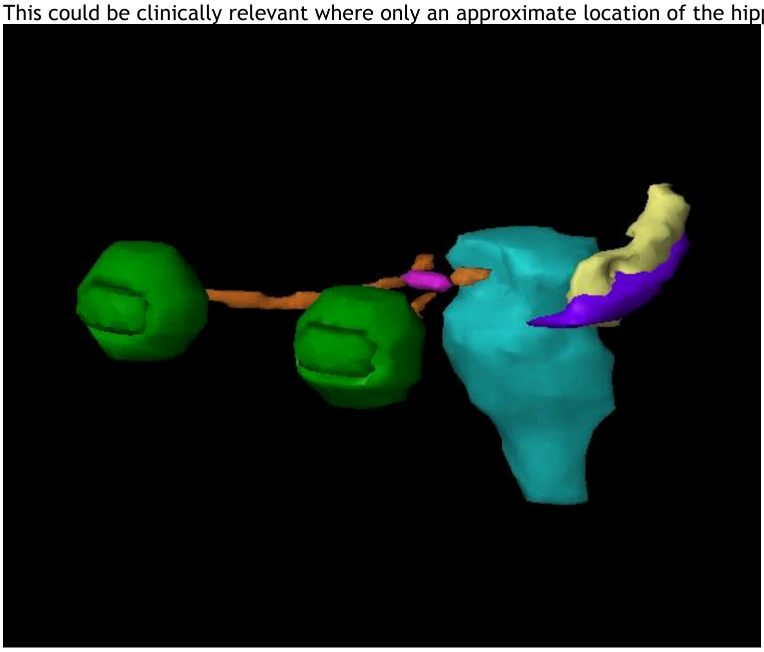


Results
Five brain patients unknown to the neural network were used for evaluation. The predictions of the left hippocampus were imported to the Eclipse treatment planning system (figure 2). The dice coefficients between the humanly delineated hippocampus (purple) and the machine delineated hippocampus (yellow) were found to be in the range from 0.15 to 0.41. This could be clinically relevant where only an approximate location of the hippocampus is needed.



Conclusion
It is found that a simple neural network based on the TensorFlow software package is able to predict the position and shape of the hippocampus fairly well based only on the brain contour from a CT-scan. This find is useful in itself because a MR-scan can be omitted, but also promising for future developments of more sophisticated neural networks for automatic delineation.

PO-1651 Feasibility of utilizing Spot-Scanning Proton Arc (SPArc) therapy for whole Lung Irradiation

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Purpose or Objective
We reported the first feasibility study of utilizing spot-scanning arc therapy (SPArc) whole lung irradiation for a pediatric patient to reduce cardiac toxicity.

Materials and Methods

A 13 year-old patient with metastatic Ewing sarcoma treated with Volumetric Modulated Arc Therapy (VMAT) in our institution was selected (Figure 1A). The clinical VMAT plan used three 360-deg arcs with 6 MV based on the Elekta HD. Intensity Modulated Proton Therapy (IMPT) plan was generated using 2 iso and 4 treatment fields (Figure 1B) based on the single field optimization approach in a clinical treatment planning system (TPS) (RayStation version 6). SPArc plan was generated in the same TPS through in-house scripting using a full 360-deg arc trajectory with 2.5-deg frequency via a single isocenter (Figure 1C). The Proton beam model was based on a synchrocyclotron system with 70-227 MeV energy. Both IMPT and SPArc plans applied the same robust optimization parameters (±5mm setup and ±3.5% range uncertainties). The prescription was 1500cGy in 10 fractions. VMAT, IMPT, and SPArc plans were normalized to at least 98% of the ITV receiving the prescribed dose. Heart dose-volume histograms (DVHs) and integral body dose were evaluated among the VMAT, IMPT, and SPArc plans. VMAT, IMPT, and SPArc plans' delivery efficiency were simulated based on the machine delivery sequence models. The VMAT delivery time was acquired from the LINAC machine logfile.

Results

The SPArc plan significantly spared the dose delivered to the healthy tissue, compared to the IMPT and VMAT plan, while providing similar coverage to the clinical target volumes (Table 1): the mean dose to the heart was 541 cGy in SPArc, compared with 856 cGy in the IMPT, and 956 cGy in the VMAT, respectively. The integral body dose was 137 Gy·L in VMAT,147Gy·L in IMPT, and 98 Gy·L in SPArc (Figure 1). The LINAC logfile showed that VMAT took 317s to deliver all three arcs. Based on a fixed gantry machine-specific delivery sequence simulation, it costed the IMPT plan 246s and SPArc plan 411s to irradiate all the spots and energy layers. Considering the additional parameters, such as the gantry mechanical motion and iso-center shift, the two-iso IMPT plan would require additional 5 mins for couch shift and imaging validation which makes the total treatment time around 563s. In contrast, SPArc does not require any iso shift. The simulation result from the DynamicARC® delivery showed the total treatment delivery 423s which is only 12s extra was used in the control point connection from the gantry mechanical limitations. (Table 1). Thus, SPArc was able to reduce more than 25% of the total treatment delivery time compared to IMPT.

Table 1. Dose statistic and delivery time comparison

Comparison index		VMAT	IMPT	SPArc
ITV	Max dose (cGy)	1594	1615	1599
	Mean dose (cGy)	1600	1529	1530
	D98 (cGy)	1494	1500	1500
PTV	Max dose (cGy)	1594	1615	1599
	Mean dose (cGy)	1600	1525	1520
	D98 (cGy)	1402	1402	1406
Heart	Max dose (cGy)	1541	1599	1595
	Mean dose (cGy)	956	856	541
	D98 (cGy)	589	7	45
Body integral dose (Gy·L)		137	147	98
Irradiation times†(s)		N/A	246	411
Total delivery time ‡(s)		317	563	423

† The irradiation time for proton beam therapy includes the delivery of all the spot and energy layer at a fixed beam angle. It includes spot drill time, spot scanning time, energy layer switching time, and burst to switch time.

‡ Total delivery time includes the irradiation time, the iso shift workflow, imaging verification time, as well as the gantry rotation time

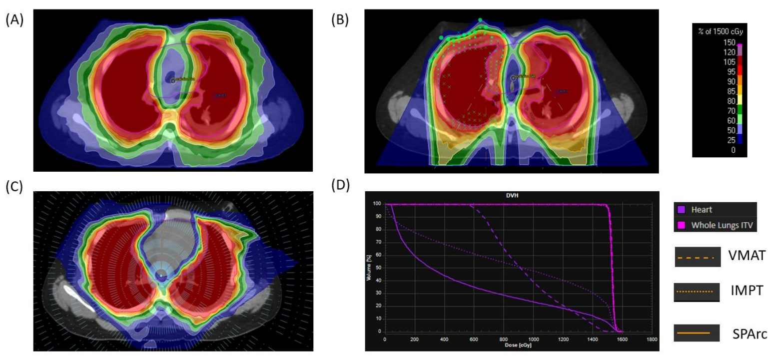

Figure 1. (A) VMAT **(B)** IMPT **(C)** SPArc **(D)** DVH comparison.

Conclusion

Our SPArc technique showed a significant dosimetric benefit in cardiac and integral dose sparing compared to VMAT and IMPT in the whole lung irradiation. Additionally, SPArc could simplify the clinical workflow with a single iso and improve the treatment delivery efficiency through the arc trajectory compared to the IMPT.