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EASTERN TIME [GMT-4]

Impact of 5D Accumulated Dose on Toxicity Predictions Compared to 3D Planned Dose for Non-Small Cell Lung Cancer Treated with IMRT and PSPT

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Background

- In 4DCT-based treatment planning of non-small cell lung cancer (NSCLC), patient anatomy is usually represented by a 3DCT **(3D planned dose)**. Taking breathing motion into consideration, dose summed from 4DCT phase images is currently the gold-standard representation of planned dose **(4D planned dose)**.
- However, to consider **inter-fractional anatomy change**, weekly 4DCTs taken throughout the treatment course can be utilized to calculate accumulated dose where 4D summed dose of each week is accumulated onto the planning 4DCT **(5D accumulated dose)**.
- To our knowledge, there is a lack of systematic comparison **between 3D/4D planned dose and 5D accumulated** due to the complicated procedure**.**

Questions to answer

- What is the difference in clinical metrics between accumulated and planned dose?
- How much does this difference manifest in toxicity development?

Methods and Materials

- To date, **4DCT images of 12 locally advanced NSCLC** treated on a prospective trial with intensity-modulated radiation therapy (IMRT) or passive scattering proton therapy (PSPT) have been imported into RayStation 8.99 (RaySearch Laboratories, Stockholm, Sweden).
- **Hybrid intensity-based deformable image registration** (DIR) with both lungs as controlling ROI was performed intra/inter-4DCT to guide dose summation/accumulation for 4D planned dose and 5D accumulated dose (Figure 1).
- For each modality, 3D/4D planned dose and 5D accumulated dose were compared via
  - **clinical metrics** including mean lung dose and lung V20Gy (Table 1),
  - **overlap of isodose intervals** with 5Gy increments in the normal lung (Figure 2 and Figure 3),
  - post-treatment **fibrotic change** in these isodose intervals.

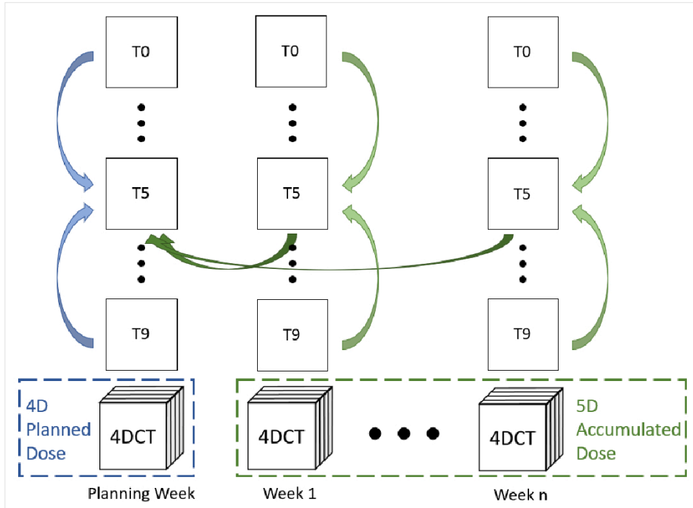

Figure 1. Processes to calculate 4D planned dose and 5D accumulated dose. Colored arrows represent DIRs with direction (pointing from target image to reference image). 4D planned dose was obtained from doses mapped with intra-4DCT DIRs (blue). 5D accumulated dose was obtained from doses mapped with intra-4DCT DIRs (lighter green) and then with doses accumulated with inter-4DCT DIRs (darker green).

Results

		Normal Lung					
		MLD [Gy]			V20 [%]		
		3D	4D	5D	3D	4D	5D
PSPT	1	11.0	10.8	11.2	18.0	17.9	18.7
	2	15.3	14.8	15.4	27.8	27.2	29.0
	3	6.9	6.9	6.6	12.2	12.2	11.8
	4	16.0	15.9	15.3	27.8	27.5	26.6
	5	23.4	24.0	23.1	43.9	45.3	43.6
	6	12.9	13.0	10.6	21.7	21.8	17.9
	avg	**14.3**	**14.2**	**13.7**	**25.2**	**25.3**	**24.6**
	σ	**5.6**	**5.8**	**5.7**	**10.9**	**11.4**	**11.2**
	p	**0.80**	**0.18**	**0.28**	**0.80**	**0.41**	**0.41**
IMRT	1	20.5	20.9	21.4	23.7	24.0	24.3
	2	15.7	15.8	15.6	22.3	22.6	22.2
	3	21.4	21.3	22.6	32.7	32.6	34.3
	4	20.5	20.9	21.4	29.6	30.2	31.1
	5	21.5	21.4	21.7	32.9	32.9	33.2
	6	21.5	19.2	19.6	30.2	30.2	30.9
	avg	**20.2**	**19.9**	**20.4**	**28.5**	**28.8**	**29.3**
	σ	**2.3**	**2.1**	**2.5**	**4.5**	**4.4**	**4.9**
	p	**0.50**	**0.67**	**0.06**	**0.10**	**0.03**	**0.10**

Table 1. Mean lung dose (MLD) and percent lung volume receiving ≥20Gy (V20) are shown for 3D/4D planned dose and 5D accumulated dose for patients treated with IMRT or PSPT, along with the mean value (avg) and standard deviation (σ). P value of paired Student's t-test was also shown for 3Dvs4D, 3Dvs5D, and 4Dvs5D, respectively from left to right.

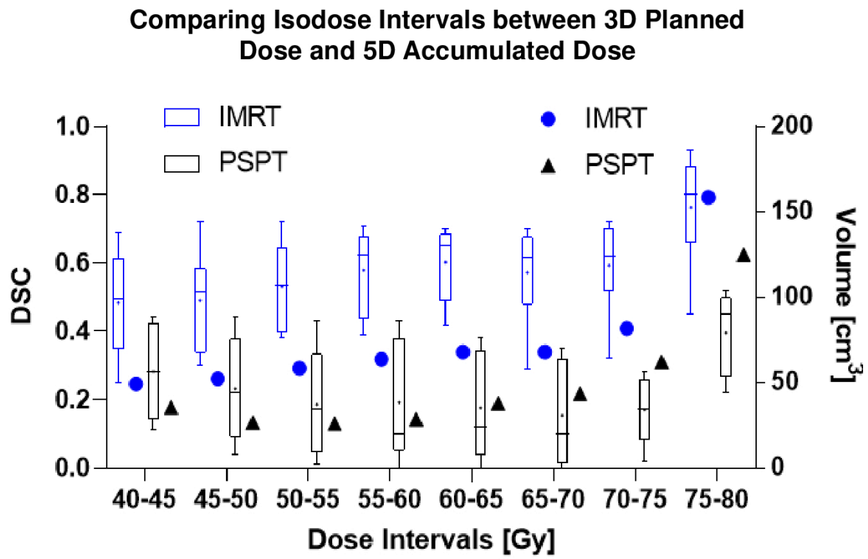

Figure 3. Boxplots of dice similarity coefficient (DSC) as a measurement of overlap between isodose intervals of 3D Planned Dose and 5D Accumulated Dose for IMRT and PSPT, along with the mean volume of isodose intervals under the 3D planned dose (dots and triangles). Mean DSC of all isodose intervals was 0.58 (IMRT) and 0.21 (PSPT). 1 PSPT case was excluded for lower prescription dose.

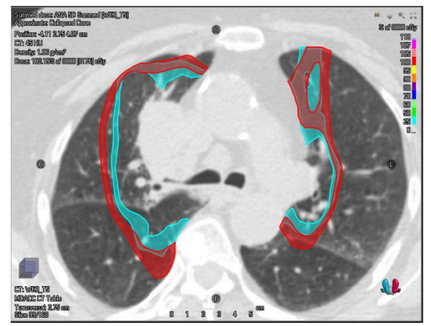

Figure 2. A sample view of isodose intervals enclosing voxels that received 70-75Gy under 3D planned dose (red) and under 5D accumulated dose (cyan).

- Representing toxicity developed within isodose intervals with Hounsfield Unit (HU) change from planning- to post-treatment- CTs, when comparing 3D planned and 5D accumulated doses, differences of up to 10% and 26% in HU change were seen for IMRT and PSPT cases, respectively.

Conclusions

Although differences in clinical metrics were clinically insignificant between 3D planned dose and 5D accumulated dose, substantial differences in %HU change within isodose intervals between the two dose representations indicate the **potential impact of dose accumulation on toxicity correlations for NSCLC.**

Acknowledgement

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