Dose blurring of three types of left-sided breast cancer plans due to the setup error: 3D-CRT, FIMRT, and VMAT

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Purpose

This study compared the dose blurring of three types of radiation therapy plans due to the setup error for the left-sided breast cancer; 3D conformal radiotherapy (3D-CRT), forward intensity-modulated radiotherapy (FIMRT), and volumetric modulated arc therapy (VMAT).

Methods and Materials

10 Patients

For each patients, there are three types of radiation therapy plans

1. 3D plan with two opposing open fields using enhanced dynamic wedges (15°~30°)
2. FIMRT plans with the same gantry angle with that of 3D plan (control points: 4~5 per beam)
3. VMAT plans with the similar gantry angle covering 190 degree

Radiation Treatment Planning System (RTPS): Eclipse V.13 (varian)

Prescription Dose: 5040 cGy (28 fractions; 180 cGy/fx)

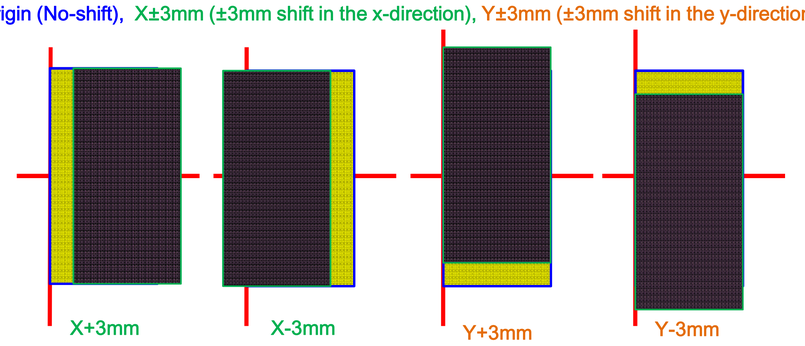
Target Volume (the only region with 5cm and more to the distance to skin and lung tissue)

➔ 533.0 ±219.6 cm^3 (from 239.5 cm^3 (Patient 06) to 916.7 cm^3 (Patient 04))

Generating the setup error

Five plans for each technique with iso-center shift in the beam's eye view (BEV)

Origin (No-shift), X±3mm (±3mm shift in the x-direction), Y±3mm (±3mm shift in the y-direction)



Evaluation Parameter

CI: conformity index

$CI = (TV_{PIV})^2 / (TV \times PIV)$

TV_{PIV}: Target Volume covered by Prescription Isodose Volume

TV: Target Volume, **PIV**: Prescription Isodose Volume

HI: homogeneity index

$HI = 100 \times (D_2 - D_{98}) / D_p$

$D_{2/98}$: minimum dose to 2%/98% of the target volume

Mean Dose: Lung_Lt (Ipsilateral lung), Lung_Rt (contralateral lung), heart, coronary artery (CA)

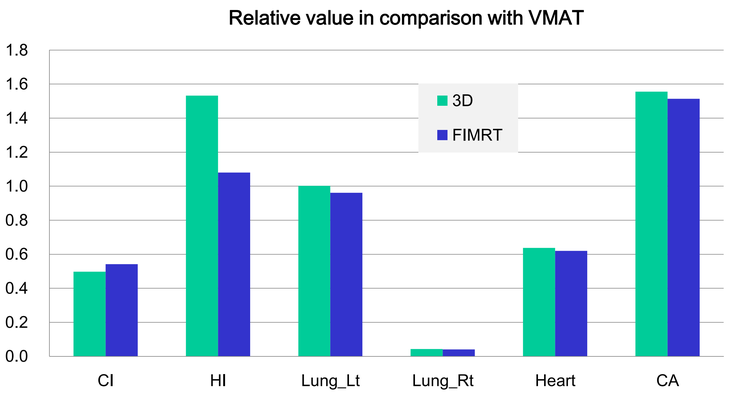
Results

MU Comparison

MU (medial direction)						MU (lateral direction)					
3D		FIMRT		VMAT		3D		FIMRT		VMAT	
average	stdev	average	stdev	average	stdev	average	stdev	average	stdev	average	stdev
114.40	3.60	109.20	4.34	224.40	24.75	108.20	4.71	105.80	5.47	207.80	27.17

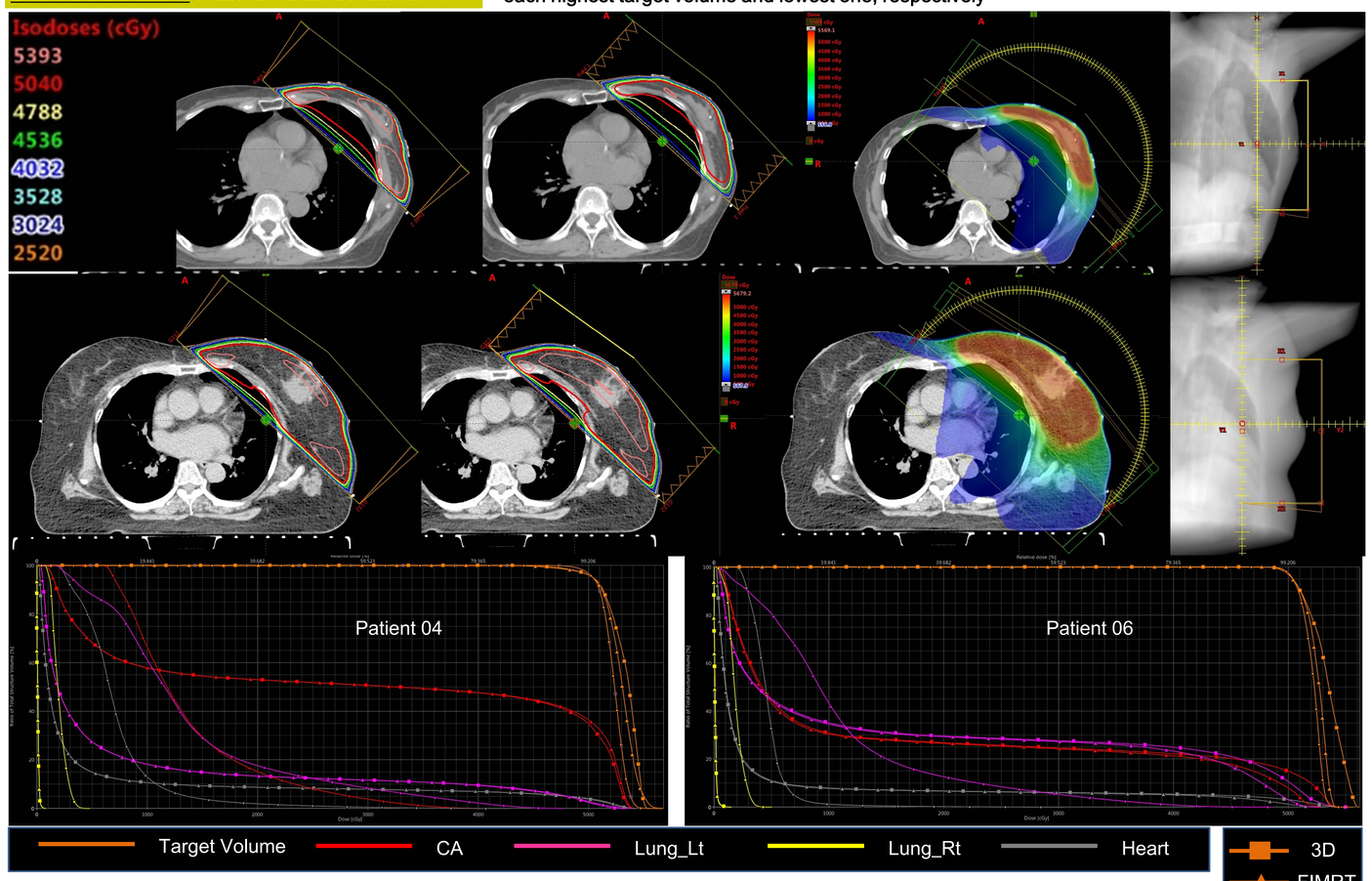
Plan Quality

VMAT is the best plan on the target coverage point

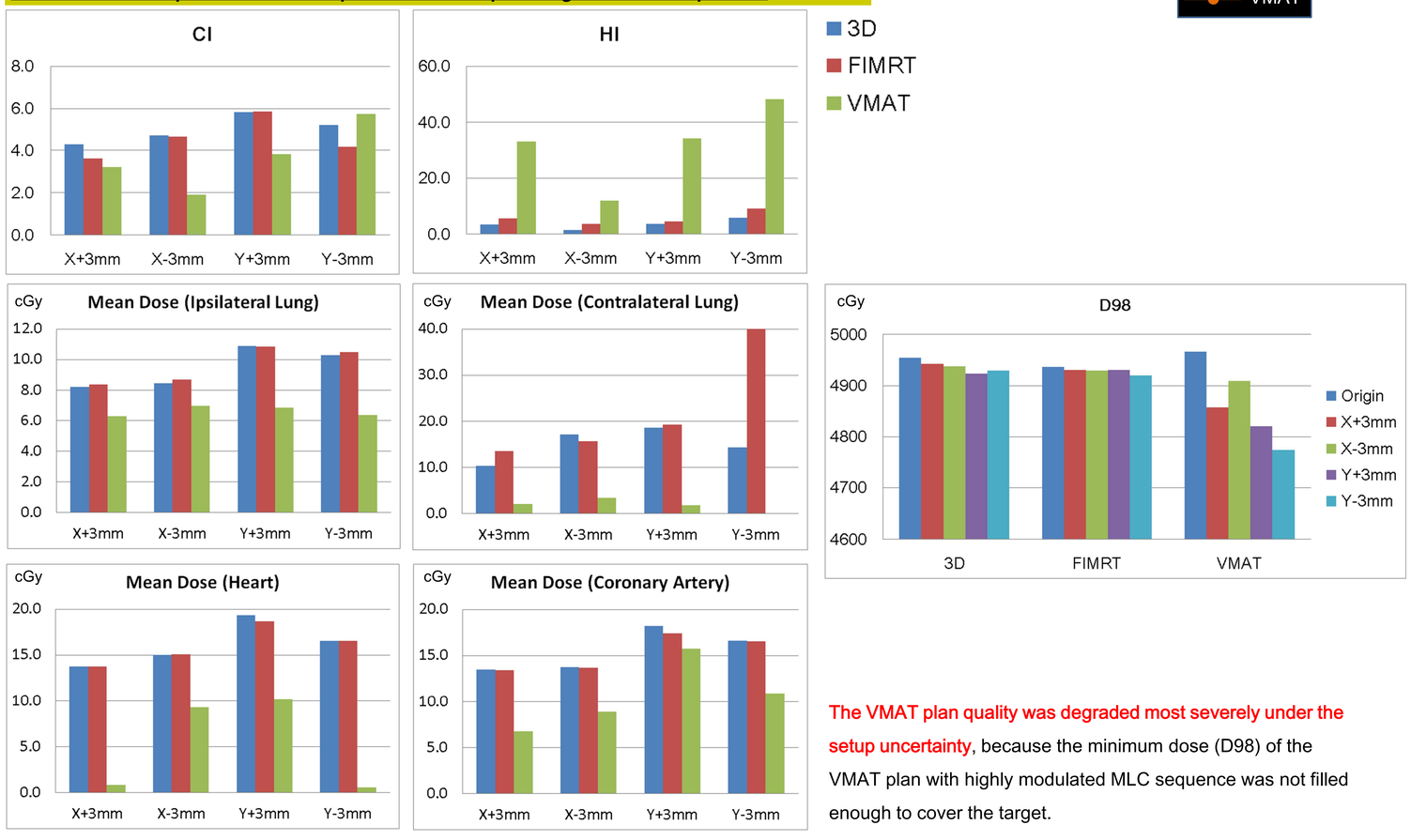


Dose Distribution: Patient 06 and Patient 04

each highest target volume and lowest one, respectively



Variation of the plan evaluation parameters depending on the setup error



The VMAT plan quality was degraded most severely under the setup uncertainty, because the minimum dose (D98) of the VMAT plan with highly modulated MLC sequence was not filled enough to cover the target.

Conclusion

For radiotherapy plans for the left-sided breast cancer, VMAT is the most useful technique for the target coverage and saving for the coronary artery if only the setup error can be minimized using CBCT and so on.

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