Comparison of deep learning with three other methods to generate pseudo-CT for MRI-only radiotherapy

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PO-1006 Patient-specific stopping power calibration for proton therapy based on proton radiographic images

Abstract withdrawn

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Purpose or Objective

Deep learning methods (DLM) have recently been developed to generate pseudo-CT (pCT) from MRI for radiotherapy dose calculation. The main advantage of these methods is the speed of pCT generation. The objective of this study was to compare a DLM to a patch-based method (PBM), an atlas-based method (ABM) and a bulk density method (BDM) for prostate MRI-only radiotherapy.

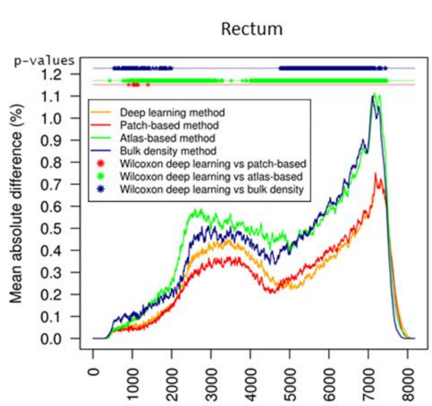
Material and Methods

Thirty-nine patients received VMAT for prostate cancer (78 Gy in 39 fractions). T2-weighted MR images were acquired in addition to the planning CT images. pCT were generated from MRI by four methods: a DLM, a PBM, an ABM and a BDM (water-air-bone density assignment). The DLM was a generative adversarial network (GAN) using a perceptual loss. The PBM was performed with feature extraction and approximate nearest neighbour search. DLM and PBM were trained with a cohort of 25 patients. The four methods were compared in a validation cohort of 14 patients. Imaging endpoints were mean absolute error (MAE) and mean error (ME) of Hounsfield units (HU) from voxel-wise comparisons between pCT and reference CT. Dose uncertainties of the methods were defined as the absolute mean differences between DVH parameters for the organs at risk and PTV calculated from the reference CT and from the pCTs for each method. 3D gamma index analyses (local, 1%/1mm) were also performed. The Wilcoxon test was used to compare the uncertainty of the DLM to those of the three other methods.

Results

In the whole pelvis, the DLM showed significantly lower MAE (mean value of 37 HU) compared to the PBM (41 HU), ABM (43 HU and) and BDM (99 HU). The ME obtained from the PBM (-1 HU) was lower compared to those of the DLM (-9 HU), ABM (-8 HU) and BDM (-18 HU). The table shows the dose uncertainty of each pCT generation method for each volume-of-interest. The figure shows the dose uncertainty of each method along the whole DVH for the rectum. Significant differences are displayed with the use of the symbol *. DVH differences were significantly lower when using the DLM and the PBM, than the ABM and BDM. All the mean gamma values were significantly lower with the DLM or the PBM, compared to the ABM and BDM.

Volumes of interest		Prostate CTV	Prostate PTV	Rectum		Bladder	
Dosimetric endpoints		$D_{99\%}$ (cGy)	$V_{95\%}$ (%)	V_{70Gy} (%)	D_{max} (cGy)	V_{50Gy} (%)	D_{max} (cGy)
CT_{ref} values		7150	96.4	5.9	7298	20.1	7770
Absolute difference between the dose calculated on the reference CT and the pseudo-CT	Deep learning method	52	0.7	0.5	52	0.2	26
	Patch-based method	51	0.7	0.5	52	0.2	25
	Atlas-based method	79	1.3	0.8	81	0.5	61
	Bulk density method	79	1.3	0.8	80	0.5	67



Conclusion

In order to generate pCT from MRI for dose calculation, the four assessed methods provide clinically acceptable uncertainties (<1%). The DLM and PBM provide however the lowest imaging and dosimetric uncertainties. The DLM appears particularly attractive due to its accuracy and the very fast calculation time (<1 min).