A Dosimetric Validation of MRI-based Synthetic CT for SBRT of Liver Cancer

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Aim Statement

MRI significantly improves the accuracy of target delineation for many disease sites due to its superior soft tissue contrast over CT. However, MRI data do not contain Hounsfield unit (HU) information that is necessary for dose calculation. This work aims to dosimetrically validate a deep-learning-based abdominal synthetic CT (sCT) generation method for MRI only liver stereotactic radiotherapy (SBRT) treatment planning.

Background

MRI has been widely used in combination with CT in radiation therapy because MRI improves the accuracy and reliability of target delineation due to its superior soft tissue contrast over CT. The MRI-only treatment process is currently an active field of research since it could eliminate systematic MR-CT co-registration errors, reduce medical cost, avoid diagnostic radiation exposure, and simplify clinical workflow. One major task in any MR-only treatment workflow is the generation of sCT images. These images can then serve as CT surrogates that can be used for dose calculation and digital reconstructed radiograph generation. Recently, we proposed a novel deep learning-based algorithm based on a 3D cycle-GAN to generate MRI-based sCT. This work aimed to apply this method to generate abdominal sCT for MRI-based liver SBRT.

Materials and Methods

A cohort of 21 liver cancer patients with co-registered CT/MR pairs was used to evaluate the method for abdominal sCT generation. All the patients were prescribed with a total dose of 45 Gy. The treatment plans were first created on the CT images and then transferred to the sCT images for dose calculation. Clinically-relevant dose volume histogram (DVH) metrics were extracted from the sCT and CT-based plans.

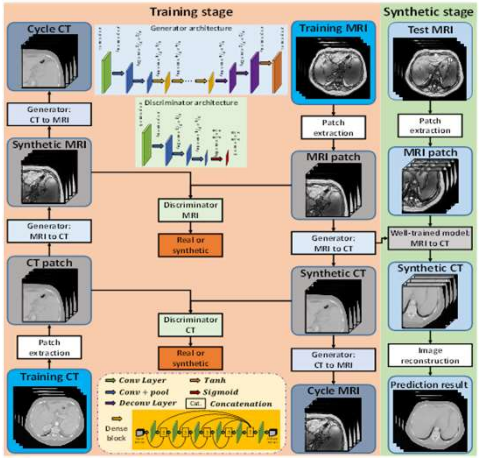

Figure 1. Schematic flowchart of the proposed algorithm

Results

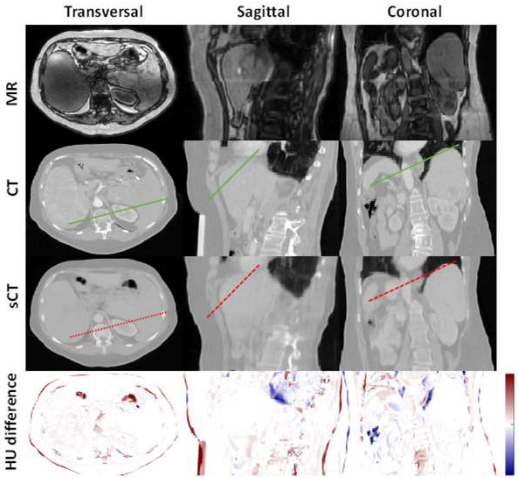

Figure 2. Imaging comparison and HU profiles

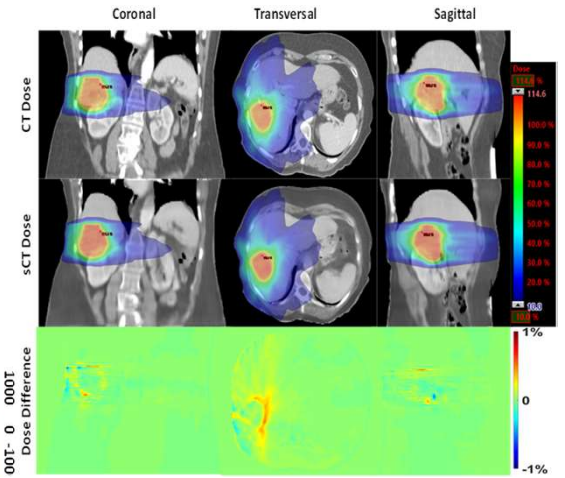

Figure 3. CT-, sCT-based dose distribution and relative dose differences

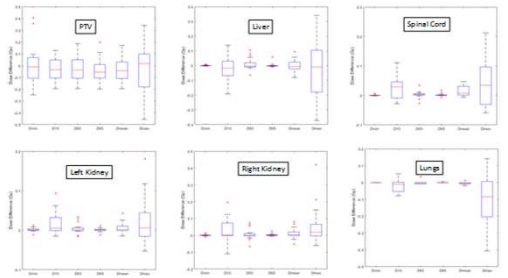

Figure 4. Box plot of absolute difference between sCT and CT for Dmin, D10, D50, Dmean and Dmax for the PTV and OARs.

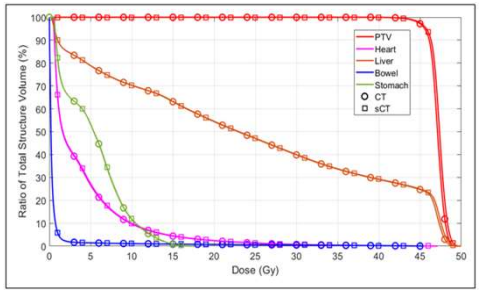

Figure 5. The DVHs of PTV, heart, liver, bowel and stomach of an exemplary patient.

Conclusion

This study has demonstrated the capability of our learning-based method for reliably generating sCT images and providing HU numbers for dose calculation with comparable accuracy to the real CT images. These results warrant further development of an MRI-only workflow for liver SBRT.

Acknowledgements

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Reference

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