Cureus

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Abstract

Evaluation of Stereotactic Body Radiation Therapy Pancreas Patient Plans Delivered Using Magnetic Resonance-Guided Radiotherapy

Joshua Kim [1] , Kate Aldridge [1] , Dongsu Du [2] , Anthony Doemer [1] , Carri Glide-Hurst [1] , Ning Wen [1] , Indrin J. Chetty [1] , Jadranka Dragovic [1] , Benjamin Movsas [1]

1. Radiation Oncology, Henry Ford Health System, Detroit, USA 2. Radiation Oncology, Henry Ford Health Systems

Corresponding author: Joshua Kim, jkim8@hfhs.org

Categories: Medical Physics, Quality Improvement, Radiation Oncology
Keywords: mr-linac, pancreas, sbrt, stereotactic body radiotherapy, mri guided radiotherapy, pancreatic cancer

How to cite this abstract
Kim J, Aldridge K, Du D, et al. (March 21, 2019) Evaluation of Stereotactic Body Radiation Therapy Pancreas Patient Plans Delivered Using Magnetic Resonance-Guided Radiotherapy . Cureus 11(3): a413

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Objectives: To evaluate the plan quality of a set of stereotactic body radiation therapy (SBRT) pancreatic cancer treatments using a combined magnetic resonance imaging and linear accelerator system (MR-linac). Methods: Since commissioning the system, six SBRT pancreatic cancer patients were treated on an MR-linac using a breath-hold approach. Five patients were treated to a prescription dose of 30 or 35 Gy in 5 fractions, while one was treated using a simultaneous integrated boost approach with 21 Gy planned to the planning target volume (PTV) and 27 Gy planned to the gross tumor volume (GTV). The MR-linac comprises a 0.345 T magnet and an S band, standing wave linac capable of delivering a 6 MV flattening filter free (FFF) beam. The beam is shaped using a double-stacked MLC with physical leaf width of 0.83cm. MLC banks are shifted to provide an effective leaf thickness of 0.415cm. An integrated treatment planning system (TPS) that utilizes a fast Monte Carlo dose prediction algorithm for plan optimization and dose calculation was used for plan generation. Patients were simulated on a wide bore (85cm bore) CT scanner and on the MR-linac. During CT-simulation, free-breathing, end-exhale and end-inhale breath hold, and 10-phase 4DCT images were acquired. Similarly, during MR-simulation in the MR-linac, freebreathing, end-inhale, and end-exhale scans were acquired. After simulation, the physician assessed patient compliance during breath hold scans and image quality and determined which breath hold to use for dose calculation. The system uses a step-and-shoot approach for intensity modulated radiation therapy (IMRT). The GTV was contoured on the selected breath hold image and expanded 5mm isotropically to generate the PTV. Dose was normalized so that 95% of the PTV would receive the prescription dose, and conformity index (CI) and R50 (ratio of 50% prescription isodose volume to the PTV) were evaluated. Organ-at-risk (OAR) constraints given by AAPM TG101 were used during optimization. Patient specific quality assurance (PSQA) was performed by mapping generated plans onto a phantom consisting of a stack of solid water and comparing to measurements acquired using a micro-ion chamber and radiochromic film. Results: The end-exhale phase was selected for all patients for treatment planning and delivery since it represented the most reproducible respiratory state. An average of 10 fields (range: 9-12) spaced 15-30 degrees apart were used. Depending on the volume (32.2 + 23.5cc) and location of surrounding OARs, the number of segments needed to generate an acceptable plan ranged from 24 to 49 (average: 36) to deliver an average of 2019.1 MU (range: 1254.4-2876.2 MU). Average CI for the patient set was 1.08 + 0.08, and R50 values were 4.02 + 0.91. All OAR constraints were met according to

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Published 03/21/2019

AAPM TG-101 report criteria. Extra attention was given to avoid small bowel and duodenum. For PSQA, ion chamber measurements averaged -0.4 + 1.1% difference from the value calculated in the TPS. For radiochromic film,
absolute gamma analysis results using 3%/1mm (global dose difference/distance-to-agreement, 10% dose threshold) criteria were 96.8 + 1.8%. Conclusion(s): Six pancreatic cancer patients were effectively treated using an SBRT regimen on an MR-guided linac. TPS generated plans met constraints given in TG101 and other plan quality metrics comparable to those treated with SBRT on other linacs. PSQA measurement results were within 1% of calculations.