Non-coplanar Arc Based Treatment Improves Pancreatic SBRT Organ at Risk Exposure

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Abstract

Background: Pancreatic stereotactic body radiation therapy (SBRT) has emerged as a promising improvement to the radiation component of trimodality therapy for pancreatic adenocarcinoma. Recent data have shown dramatic clinical outcome improvements for patients treated with dose escalated SBRT. However, the sensitivity and proximity of organs-at-risk (OARs) such as the duodenum, stomach, and small bowel pose a considerable challenge to the escalation of prescription dose necessary to facilitate adequate local control when used definitively, or to facilitate R0 resection when used neoadjuvantly. In our study, we identified patients treated on our institutional pancreatic SBRT protocol to 33Gy/5x, and sought to determine if replanning each case with non-coplanar arcs would yield dosimetric improvement with respect to organ at risk exposure. Methods and Materials: 10 patients treated under pancreatic SBRT institutional protocol were identified. Each was treated with respiratory gating, triggered kV imaging, axial-arc VMAT plans (2-3 arcs) on a Varian Edge linac, with 10MV FFF beam. Plans were optimized in Eclipse TPS. Each patient’s treatment was re-planned with the addition of two non-coplanar arcs, at 10° and 350° couch kicks. To isolate the impact of the non-coplanar beam arrangements on plan quality, the plans were optimized congruently with the clinical plans and utilized identical dose constraints. If PTV coverage of reoptimized plan was less than its clinical counterpart, the replan was normalized to identical PTV coverage percentage. Dosimetric quantities compared were: D[0.1cc] to duodenum, small bowel, and stomach; D[5.0cc] to duodenum, small bowel, and stomach; PTV prescription dose coverage. Each re-plan was exported to Mobius 3D QA system which validated delivery of the plan with respect to gantry/patient/table clearance. One-sided paired Wilcoxon signed rank test was used to determine if the distributions of plan quality metrics were improved with non-coplanar planning. If PTV coverage of reoptimized plan was less than its clinical counterpart, the replan was normalized to identical PTV coverage percentage. Dosimetric quantities compared were: D[0.1cc] to duodenum, small bowel, and stomach; D[5.0cc] to duodenum, small bowel, and stomach; PTV prescription dose coverage. Each re-plan was exported to Mobius 3D QA system which validated delivery of the plan with respect to gantry/patient/table clearance. One-sided paired Wilcoxon signed rank test was used to determine if the distributions of plan quality metrics were improved with non-coplanar planning. Results: All non-coplanar arc replans met previously utilized clinical constraints, including spinal and renal limits. Mobius 3D verified each plan as deliverable with respect to patient/gantry/table clearance. The addition of non-coplanar arcs improved plan quality for nearly every single metric evaluated in the re-planned case at no dosimetric expense. Median duodenum, stomach, and small bowel D0.1cc reductions were 295.45cGy, 186.8cGy, and 159.95cGy (p = 0.00256). Median duodenum, stomach, and small bowel D5cc reductions were 74.75cGy, 154.6cGy, and 128.4cGy (p = 0.0465, 0.00621, 0.00256). PTV coverage was equivalent or improved in each of the non-coplanar arc plans (p <0.05). Dmax distribution differed only slightly between plan types (median difference = 4%, p = 0.06944). Conclusion: The incorporation of non-coplanar arcs is a simple and effective method to reduce OAR dose
exposure in pancreatic SBRT planning. Such techniques will become increasingly important as efforts to further dose escalate pancreatic SBRT treatments become more commonplace. Additional couch angles do however pose additional considerations with respect to collision verification, treatment time associated with room entry, and image guidance; the impact of each must be considered by the treatment team. These may soon become of less concern with continued advancement in delivery of orchestrated couch and gantry dynamic movements for non-coplanar beams without room entry.