Evaluation of Inverse Optimization in Brachytherapy for Locally Advanced Cervix Cancer

Innovation/Impact:
We propose to use inverse optimization in HDR GYN brachytherapy planning, which could reduce dose to normal structures while maintaining the target coverage with additional benefit of reduced planning time.

Introduction: Brachytherapy is a vital component in treating locally advanced cervix cancer. Point-based 2D treatment planning is conventionally used. New CT/MRI-compatible applicators for HDR brachytherapy made 3D conformal planning possible. GEC-ESTRO endorsed the EMBRACE (intErmational study on MRI-guided BRachytherapy in locally Advanced CErval cancer) protocol which recommends standard-plan-based manual optimization over inverse optimization due to the concern of the uncertainty of high dose in the target and adjacent normal tissue. However, manual planning could be time consuming and may not result in the most ideal DVH parameters especially for the new Vienna applicator. The parametrial needles provide extra flexibility to the treatment but added complexity to the planning at the same time. This study evaluated inversely planning as an alternative in HDR GYN planning.

Methods: The study included eight cases using tandem and ring applicators (Nucletron®) with or without parametrial needles. Both manually and inversely optimized plans using Oncentra® Brachy were generated for each case following the guidelines from EMBRACE. The planning goal was to satisfy the coverage recommendation while keeping the dose to organs at risk (OAR) as low as possible. The target coverage would be sacrificed if the OAR dose exceeded the recommended criteria. Manual optimization involved adjusting the weight of dwell positions and shifting point A, whereas inverse optimization was via IPSA (Oncentra Brachy). Planning time and DVH parameters were compared including D90 and V100% for HR-CTV, D90 for IR-CTV, and D2cc for normal structures (bladder, rectum, sigmoid colon, and small bowel). Dose reported here is total EQD2 assuming 45Gy in 25 fractions from external beam followed by 28Gy in 4 fractions of HDR treatment. Prescription dose (PD) and PDx2 isodose volumes were recorded as well as the V100% and V200% for normal tissue (excluding all contoured OARs). Thus the high dose volumes will not be overlooked.

Results: On average, the inverse planning reduced the treatment planning time by 55%. Target coverage between inverse and manual plans differed by <2% for HR-CTV (D90 and V100) and IR-CTV (D90). Inverse planning reduced the D2cc for normal structures by 4.2%-5.7% and the V100% and V200% for normal tissue by 31% and 40%, respectively. The benefit of inverse planning is significant in cases with parametrial needles.

For 7 out of the 8 cases, small bowel was observed near the target and extra caution was paid during planning using either approach. Even though small bowel was not considered in traditional 2D planning or the EMBRACE protocol, a lower tolerance dose is expected based on the existing external beam data. For this study, we still set the dose limit of small bowel to D2cc < 75Gy the same as the rectum and sigmoid due to the lack of published DVH constraints.

Conclusion: In this study, inverse planning improved DVH parameters while decreasing planning time. Reported normal tissue dose should alleviate the concern of undetected high dose regions. Even though small bowel is not often considered in traditional planning, dose should be reported.