Impact of Image Registration Surrogates on the PTV Geometry for Bladder Radiotherapy

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Abstract
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Purpose: Lipiodol is a radiopaque marker that has been used as the image registration surrogate for partial bladder radiotherapy to generate patient-specific PTV (PS-PTV) in order to facilitate dose reduction to normal tissue. However, injecting Lipiodol to demarcate the target volume is an invasive procedure. Center of Bladder (COB) and Bladder Wall Surface encompassed by the CTV (BWS) are proposed to be the alternative non-invasive surrogates. This study examines the impact of using these three surrogates for image registration on the resultant geometry of PS-PTV.

Materials and Methods: Twenty bladder cancer patients who had Lipiodol injection prior to planning CT were included. Lipiodol, CTV and Bladder were delineated on the planning CT. In addition, CTVs were delineated on five CBCTs from each patient. CBCTs were registered to planning CT using three different surrogates: Lipiodol, COB and BWS. Occupancy volume was generated by combining all five CTVs after each registration method, and a 3mm expansion was then applied to create the Lipiodol-PTV, COB-PTV and BWS-PTV. Using the Lipiodol-PTV as the reference, discrepancies between the PTVs were quantified using volumes, Dice Similarity Coefficient (DSC) and Distance between Surfaces.

Results: A total of 60 volumes were generated for analysis. BWS-PTV has a more comparable volume and shape to Lipiodol-PTV (Mean Ratio and DSC: 1.01 and 0.87) than COB-PTV (Mean Ratio and DSC: 1.11 and 0.79). There were five COB-PTVs (25%) and 10 BWS-PTV (50%) in which the volumes were smaller than Lipiodol-PTV. Mean Distance between Surfaces (mm) were 1.2, 1.2 and 1.3 for BWS-PTV and 1.6, 1.6 and 1.7 for COB-PTV in the left-right, anterior-posterior and superior-inferior direction, respectively. Mean percentage frequency of Distance between Surfaces >3mm and >5mm was significantly lower for BWS-PTV than COB-PTV (>3mm: 41% versus 58% and >5mm: 21% versus 39%, p<0.03).

Conclusions: Larger variation both in volume and shape from the Lipiodol-PTV was observed when COB was used for image registration. BWS is the preferred non-invasive surrogate for partial bladder radiotherapy. Further investigation on the interobserver variability of these image registration surrogates is needed to identify the optimal method.