Pilot Study on Normal Organ Dose Reduction Using Online Adaptive Radiotherapy for High-Dose-Rate Intracavitary-Interstitial Brachytherapy

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BACKGROUND & MOTIVATION

Recently, EBRT has been moving towards online adaptive radiotherapy (oART). The purpose of this project was to investigate oART in brachytherapy to determine if there were any significant opportunities to improve treatment, specifically reduction of normal tissue irradiation.

Our institutional current workflow for ^{192}Ir- based high-dose-rate (HDR) hybrid intracavitary-interstitial brachytherapy (IC/ISBT) is in Figure 1. The process is repeated for Fx3 and Fx4 the following week.

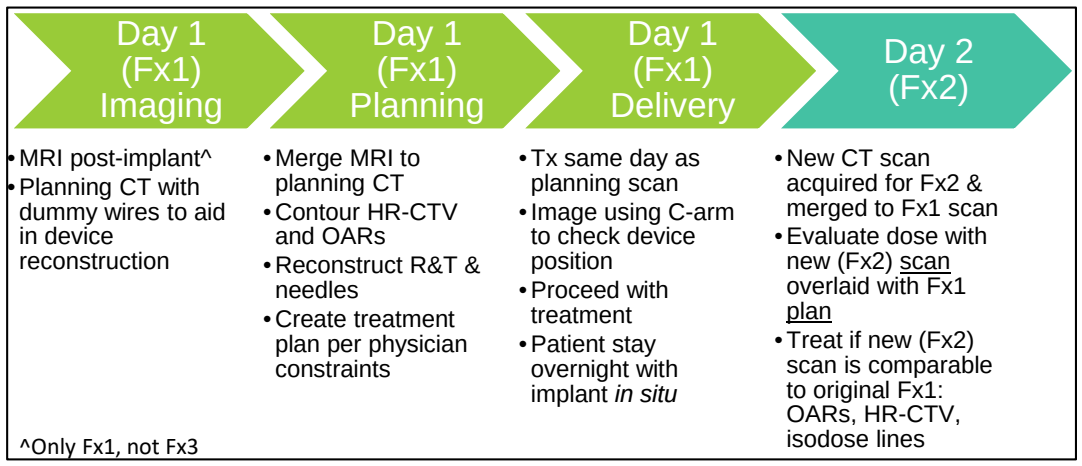

Figure 1. YNHH workflow for 2-day HDR IC/ISBT

MATERIALS & METHODS

Imaging CTs were gathered for a pilot cohort of n=5 patients previously treated with ring-and-tandem (R&T) IC/ISBT, each with 2 implants for a total of 10 pairs of Implant and Next Day plans. Organ at risk (OAR) contours were produced by a certified medical dosimetrist (CMD), verified by a second CMD, and approved by a resident radiation oncologist. Reconstructions were produced by a CMD, verified by a second CMD, and approved by a certified medical physicist. Two methods of dose evaluation were used. Contour-based (CB): Next Day contours were overlaid onto Implant Day CT based on image registration to R&T.

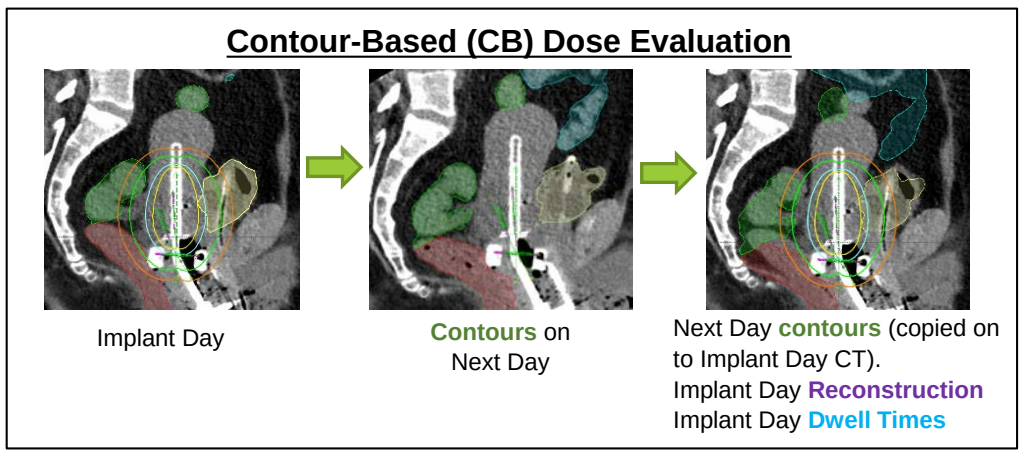

Figure 2. Contour-based (CB) dose evaluation workflow for 2-day HDR IC/ISBT

MATERIALS & METHODS (cont'd)

Applicator-based (AB): channels were reconstructed based on Next Day CT, with Implant Day dwell times and Next Day contours. Based upon the EMBRACE II guidelines, D_{2cc} for OARs bladder, bowel, rectum, and sigmoid was recorded and converted to EQD_2, with 7 Gy per fraction and α/β=3 Gy. Lastly, the time required for each task was recorded.

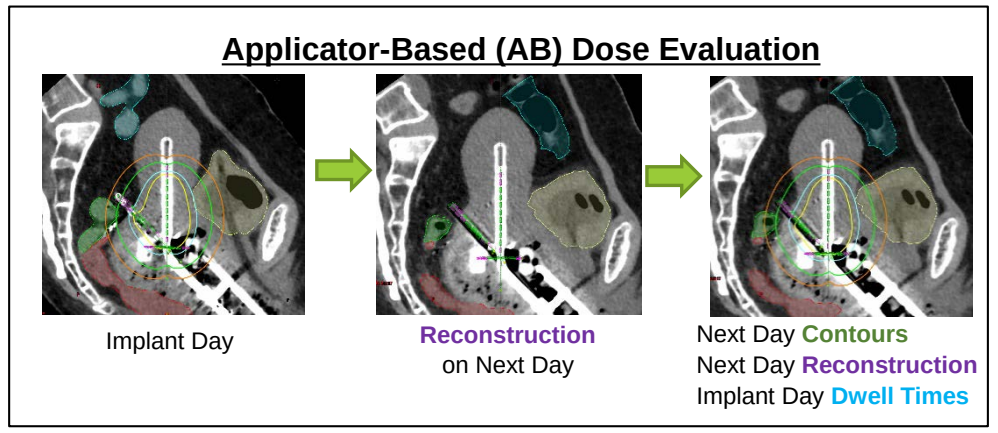

Figure 3. Applicator-based (AB) dose evaluation workflow for 2-day HDR IC/ISBT

RESULTS & CONCLUSIONS

In the cohort, the mean change in D_{2cc} ~1 Gy_3, see reference tables for support data. CB contouring took 7-10 min per OAR (~30 min total). AB reconstructing channels took 10-15 min, inserting dwell times and recalculating dose took 5 min (~15-25 min total). In AB, next day CT were always taken with stylets inserted, so they do not faithfully represent the bend as well as marker wires. In AB, needles which migrated produced significant changes which suggests that this may be the highest yield for oART in IC/ISBT.

TABLE I. Aggregated D_{2cc} values [Gy_3] for different organs: original values versus contour-based (CB) and applicator-based (AB) evaluation

		Fx1 [Gy3]	CB [Gy3]	% Difference b/w Fx1 & CB	Abs Difference b/w Fx1 & CB	AB [Gy3]	% Difference b/w Fx1 & AB	Abs Difference b/w Fx1 & AB	
Bladder	min	4.69	3.05	-35.06%	1.64	3.09	-34.06%	1.60	Bladder
	max	11.07	15.41	39.22%	4.34	15.16	36.97%	4.09	
	mean	8.75	9.46	8.18%	0.72	9.53	8.95%	0.78	
	st dev	1.87	3.78	101.95%	1.91	3.60	92.61%	1.73	
Rectum	min	1.41	1.40	-0.61%	0.01	1.36	-3.01%	0.04	Rectum
	max	5.64	5.14	-8.85%	0.50	9.63	70.79%	3.99	
	mean	2.89	3.24	12.11%	0.35	3.76	29.80%	0.86	
	st dev	1.38	1.34	-3.01%	0.04	2.42	75.40%	1.04	
Bowel	min	0.59	0.39	-34.74%	0.21	0.38	-35.70%	0.21	Bowel
	max	4.22	3.52	-16.64%	0.70	3.53	-16.34%	0.69	
	mean	1.59	1.81	13.76%	0.22	1.66	4.16%	0.07	
	st dev	1.25	1.12	-10.23%	0.13	1.03	-17.77%	0.22	
Sigmoid	min	2.93	3.08	5.16%	0.15	1.89	-35.61%	1.04	Sigmoid
	max	4.96	7.01	41.14%	2.04	6.85	38.06%	1.89	
	mean	4.05	4.90	21.00%	0.85	4.58	12.94%	0.52	
	st dev	0.69	1.34	95.74%	0.66	1.60	133.34%	0.91	

In our pilot study of n=10 implants (n=5 patients), there were discernible changes in organs and channel reconstructions between Implant CT and Next Day CT which suggests that oART may merit further investigation.

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