

Standardizing Dose Assessment for Patients with Multiple **Courses of Treatment: A Single Institution Experience**

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1. Introduction

The frequency of re-irradiation cases at our clinic is steadily increasing, due to successes of SBRT, SRS and systemic therapies. Repeating radiation treatment (RT) and treating disease in the proximity of previously irradiated tissues is a challenge. The treatment team needs clear information on potential overlap, planning limits and final cumulative doses.

We have developed a systemic approach to manage the planning of re-irradiation cases. The dose assessments are well documented and so are the potential sources of uncertainty in total dose estimation for

2. Intention:

Course 1

Left Inguinal

50Gy in 25Fx

- Ensure accurate EQD2 dose reporting in patient chart
- Raise awareness about the limitations and uncertainties inherent in volumetric EQD2 dose summation
- Reduce the number of planning attempts caused by violations of cumulative EQD2 dose limit. We implemented a pre-planning assessment to estimate total EQD2 doses and modify RT planning technique accordingly.
- Discourage requests for EQD2 sum plans for reporting purposes

3. Clinical context:

- Until March 2020, volumetric and point EQD2 dose conversions were done in an ad-hoc manner, at the discretion of a treating physician and a physicist on planning support duty.
- There were variations in approaches and expectations, including the amount of information recorded in the patient chart.
- While back-of-the-envelope estimates can be very helpful, we agreed that ACCURATE dose estimates are essential.

critical organs.

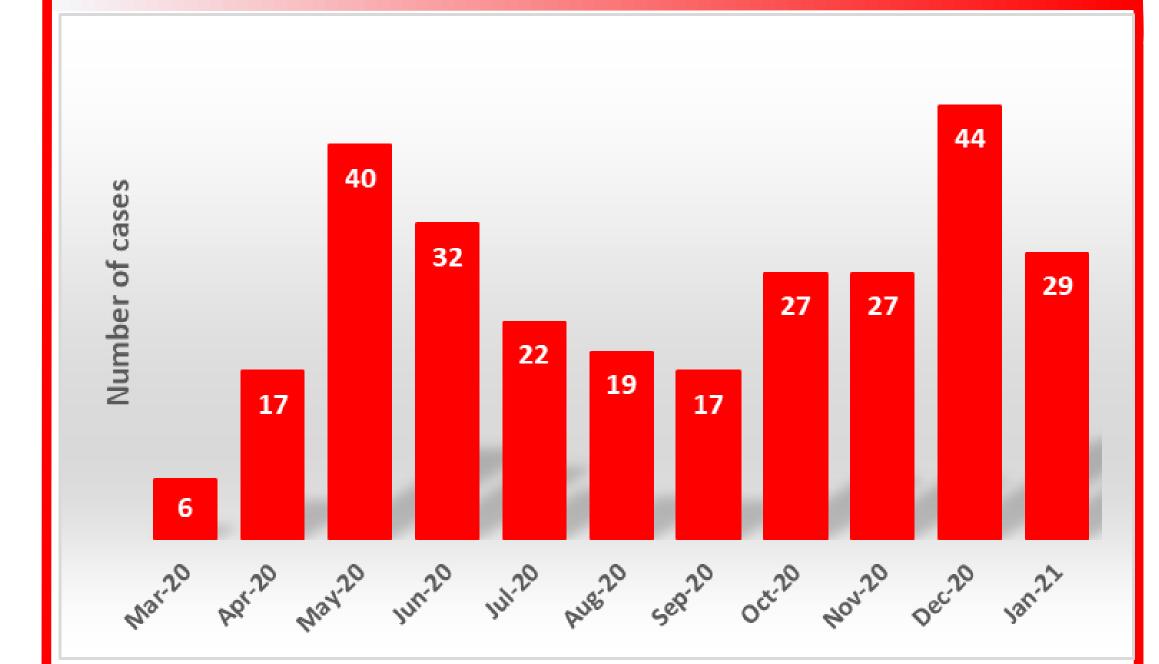
4. Our workflow

only and limit complex analyses to cases where EQD2 plan sum affects immediate clinical decision on how to treat.

16 months

It is essential to communicate sources of uncertainty involved in the dose summation, and document them clearly in the patient chart for future reference.

5. Re-Irradiation Assessment Workload



Since clinical implementation on March 5, 2020, the process has been heavily utilized by Radiation Oncologists. The assessment is requested with radiation treatment intent, which helps guide physicists and dosimetrists with plan design. The assessments are completed by 'Planning Support' physicist on duty.

Treatment Planning

• Review previous treatment courses • Review image registration(s) • Provide RT intent, dose, fractionation, OARs with their respective α/β ratios and EQD2 dose limits

• The default α/β ratio of 3 is commonly used for OARs • We don't have institutional standard treatment protocols for reirradiation cases.

Pre-Planning Dose Evaluation

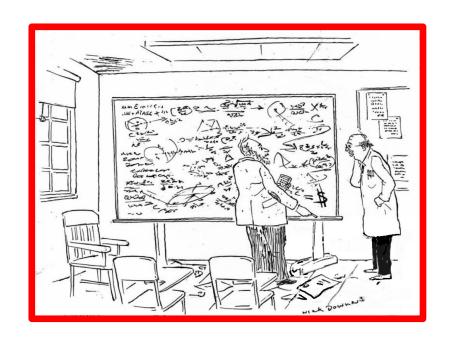


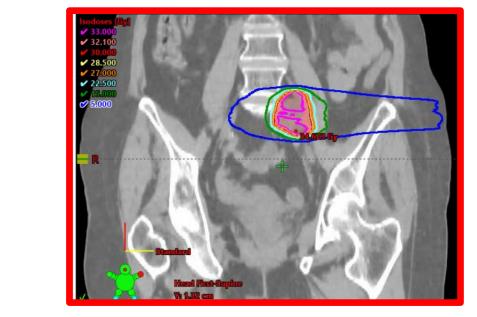
MedPhys

RadOnc

• Used for cases of recurrence or partial overlap with likelihood that OAR cumulative dose will violate dose constraints. • Convert dose distributions of existing plan(s) to EQD₂ dose distributions

• Recommend to the dosimetrist planning techniques and OAR limits that will comply with desired cumulative dose limits





Course 2

30Gy in 5Fx

Left Retroperitoneun

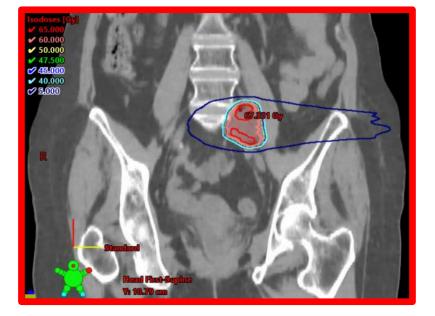
Post-Planning Dose Evaluation

• For the newly created plan, convert dose distribution to EQD₂ dose • Use one (or more) rigid image registrations to get most accurate volumetric dose parameters for OARs

• Create Sum Plan Report in EMR, including dose information only for OARs in regions of accurate image registration, and include comments on uncertainties

• Follow up with a phone call to treating physician





TAKE LEAVE I'M SORRY, WHAT OTHER OPTIONS ARE THERE

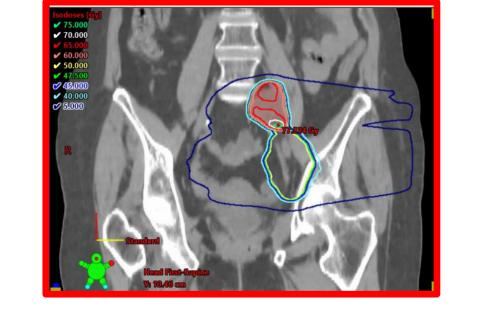
7. Future work

- Develop data-driven guidelines on dose limits
- Initiate an institution-wide effort to follow patients prospectively to measure long-term outcomes
- Develop treatment planning tools to incorporate bioequivalent EQD2 optimization tools

8. Acknowledgements

We acknowledge the work of Julia Albers, MSc, who developed Plan Evaluation Tool (Albers, J. Software Development for Prospective and Retrospective Analysis of Lung Stereotactic Body Radiation Therapy *Treatment Planning*, MSc thesis, 2018, McGill University) We also acknowledge fruitful discussions with Chuck Mayo, PhD (Paradis, K, Mayo, C et al. Advances in Radiation Oncology, 2019, 4, 559-565).

Final Decision to Treat • Make the final decision on whether to treat or modify treatment intent • Approve Sum Plan Report document in EMR





6. Automation: Plan Evaluation Tools in ESAPI

Plan evalutation tool			- • ×
Plan Information			
Patient ID:	Course:	Plan:	Pefreth

Plan evalutation tool					
Plan Information					
Patient ID:			Course:	Plan:	
OA SCRIPT	Load	Lastname Firstname OA SCRIPT	C1	FP1 LT LUNG	Refresh

METRIC	C1	C1+C2a	C1+C2b
Duodenum			
8 D0.1cc[Gy]	28.97 Gy	29.31 Gy	29.22 Gy
8 D0.1cc(LQ, α/β=2.5)[EQD2Gy]	53.42 Gy (LQ2)	53.64 Gy (LQ2)	53.59 Gy (LQ2
Esophagus			
8 D0.1cc[Gy]	11.84 Gy	18.59 Gy	16.59 Gy
OD.1cc(LQ, α/β=2.5)[EQD2Gy]	12.79 Gy (LQ2)	20.13 Gy (LQ2)	17.82 Gy (LQ2
Kidney_R	_		
V18Gy[%] [Changed]	40.00%	40.28%	40.22%
8 V18EQD2Gy(LQ, α/β=2.5)[%] [Changed]	 47.35% (LQ2) 	47.42% (LQ2)	47.40% (LQ2)
Kidney_L			
V18Gy[%] [Changed]	▼ 0.00%	0.00%	0.00%
V18EQD2Gy(LQ, α/β=2.5)[%] [Changed]	 0.00% (LQ2) 	0.00% (LQ2)	0.00% (LQ2)
Bowel_Small			
O D0.1cc[Gy]	- 28.87 Gy	28.89 Gy	28.87 Gy
OD.1cc(LQ, α/β=2.5)[EQD2Gy]	▼ 53.01 Gy (LQ2)	53.03 Gy (LQ2)	53.03 Gy (LQ2
SpinalCord			
O0.1cc[Gy]	▼ 19.11 Gy	23.32 Gy	21.82 Gy
OD.1cc(LQ, α/β=2.5)[EQD2Gy]	26.84 Gy (LQ2)	29.16 Gy (LQ2)	28.04 Gy (LQ2
Stomach			
O0.1cc[Gy]	✓ 24.58 Gy	24.75 Gy	24.68 Gy
8 D0.1cc(LQ, α/β=2.5)[EQD2Gy]	40.49 Gy (LQ2)	40.67 Gy (LQ2)	40.63 Gy (LQ2
Liver-GTV			
8 Mean[Gy]	▼ 12.94 Gy	18.12 Gy	16.82 Gy
8 Mean(LQ, α/β=2.5)[EQD2Gy] [Changed]	20.40 Gy (LQ2)	30.09 Gy (LQ2)	27.66 Gy (LQ2
Clinical NTCP Liver Metastatic	 0.00% (LQ2) 	2.02% (LQ2)	0.52% (LQ2)

RadOnc

	Structure ID	Enter Structure ID manually	Patient Structure	DVH Objective	Evaluator	Variation	Priority	Met	Achieved	Cost
Þ	Cord		SPINAL_CORD	Max[Gy]	<=18		1	Goal	15.37 Gy	0
	Esophagus		ESOPHAGUS	Max[Gy]	<=27		1	Goal	9.16 Gy	0
	Heart		HEART	Max[Gy]	<=30		1	Goal	14.62 Gy	0
	Brachial plexus R			Max[Gy]	<=24		1	Not evaluated	Structure not fou	-
	Brachial plexus L			Max[Gy]	<=24		1	Not evaluated	Structure not fou	
	Both lungs - GTV		LUNGS-ITV	V20Gy[%]	<=15		1	Goal	2.90 %	0
	Ribs		RIBS	Max[%]	<=110		1	Not met	112.85 Percent	8.12
	Skin		SKIN	V30Gy[cc]	<=10		1	Goal	0.00 cc	0
	Skin		SKIN	Max[Gy]	<=32		1	Goal	19.97 Gy	0
	Chest wall		CW	V30Gy[cc]	<=30	70	1	Variation	43.47 cc	181.44
	Body		BODY	V24Gy[cc]	>=1		Report	-	168.43 cc	-
	HIGH DOSE SPILL		Body-PTV+2cm	Max[Gy]	<=24		1	Not met	28.53 Gy	20.52
	EVAL_PTV_VOL			V0Gy[cc]	>=1		Report		Structure not fou	
	EVAL_PTV_R100			V48Gy[cc]	>=1		Report	-	Structure not fou	-
	EVAL_PTV1_VOL			V0Gy[cc]	>=1		Report	-	Structure not fou	-
	EVAL_PTV1_R100		BODY	V48Gy[cc]	>=1		Report	-	42.14 cc	-
	EVAL_PTV2_VOL			V0Gy[cc]	>=1		Report		Structure not fou	
	EVAL_PTV2_R100			V48Gy[cc]	>=1		Report	-1	Structure not fou	-
	EVAL_PTV3_VOL			V0Gy[cc]	>=1		Report	-	Structure not fou	-
	EVAL_PTV3_R100			V48Gy[cc]	>=1		Report	-	Structure not fou	-
•		1				1				_

Designed to facilitate the evaluation of RT plans and built as a standalone executable, this feature evaluates the protocol compliance.

Structure ID	Enter Structure ID	Patient	DVH	NTEC Plan Rating	Achieved	Toxicity Endpoint	
	manually	Structure	Objective		(EQD2)	[Rate]	
Spinal cord		SPINAL_CORD	Max[Gy]	=50	24.97 Gy	Myelopathy [0.20%]	
Spinal cord		SPINAL_CORD	Max[Gy]	=60	24.97 Gy	Myelopathy [6%]	
Spinal cord		SPINAL_CORD	Max[Gy]	=69	24.97 Gy	Myelopathy [50%]	
Cochlea			Mean[Gy]	<=45	Structure not fou	Sensory-neural h	
Parotid bilateral			Mean[Gy]	<=25	Structure not fou	Long-term salivar	
Parotid bilateral			Mean[Gy]	<=39	Structure not fou	Long-term salivar	
Parotid unilateral			Mean[Gy]	<=20	Structure not fou	Long-term salivar	
Pharyngeal const			Mean[Gy]	<=50	Structure not fou	Symptomatic dys	
Larynx			Max[Gy]	<66	Structure not fou	Vocal dysfunctio	
Larynx			Mean[Gy]	<50	Structure not fou	Aspiration [<30%]	
Larynx			Mean[Gy]	<44	Structure not fou	Edema [<20%]	
Larynx			V50Gy[%]	<27	Structure not fou	Edema [<20%]	
Lung		LUNG_L	V20Gy[%]	<=30	2.19 %	Symptomatic pne	
Lung		LUNG_L	Mean[Gy]	=7	0.02 Gy	Symptomatic pne	
Lung		LUNG_L	Mean[Gy]	=13	0.02 Gy	Symptomatic pne	
Lung		LUNG_L	Mean[Gy]	=20	0.02 Gy	Symptomatic pne	
Lung		LUNG_L	Mean[Gy]	=24	0.02 Gy	Symptomatic pne	
Lung		LUNG_L	Mean[Gy]	=27	0.02 Gy	Symptomatic pne	
Esophagus		ESOPHAGUS	Mean[Gy]	<34	0.01 Gy	Grade 3+ esopha	
Esophagus		ESOPHAGUS	V35Gy[%]	<50	0 %	Grade 2+ esopha	
Esophagus		ESOPHAGUS	V50Gy[%]	<40	0 %	Grade 2+ esopha	
Esophagus		ESOPHAGUS	V70Gy[%]	<20	0 %	Grade 2+ esopha	
Heart (Pericardium)		HEART	Mean[Gy]	<26	0.02 Gy	Pericarditis [<15%]	
Heart (Pericardium)		HEART	V30Gy[%]	<46	0%	Pericarditis [<15%]	
Unad		UCADT	1050-011	-10	0.%	Long town south	

The achieved dose criteria can be converted to EQD2 values and compared with QUANTEC constraints.

Finally, protocol compliance of multiple plans and plan sum will be displayed for easy assessment (*work in* progress)