

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 critical organs.

2. Intention:

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

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

4. Our workflow

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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 re-irradiation cases.

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Pre-Planning Dose Evaluation

- 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

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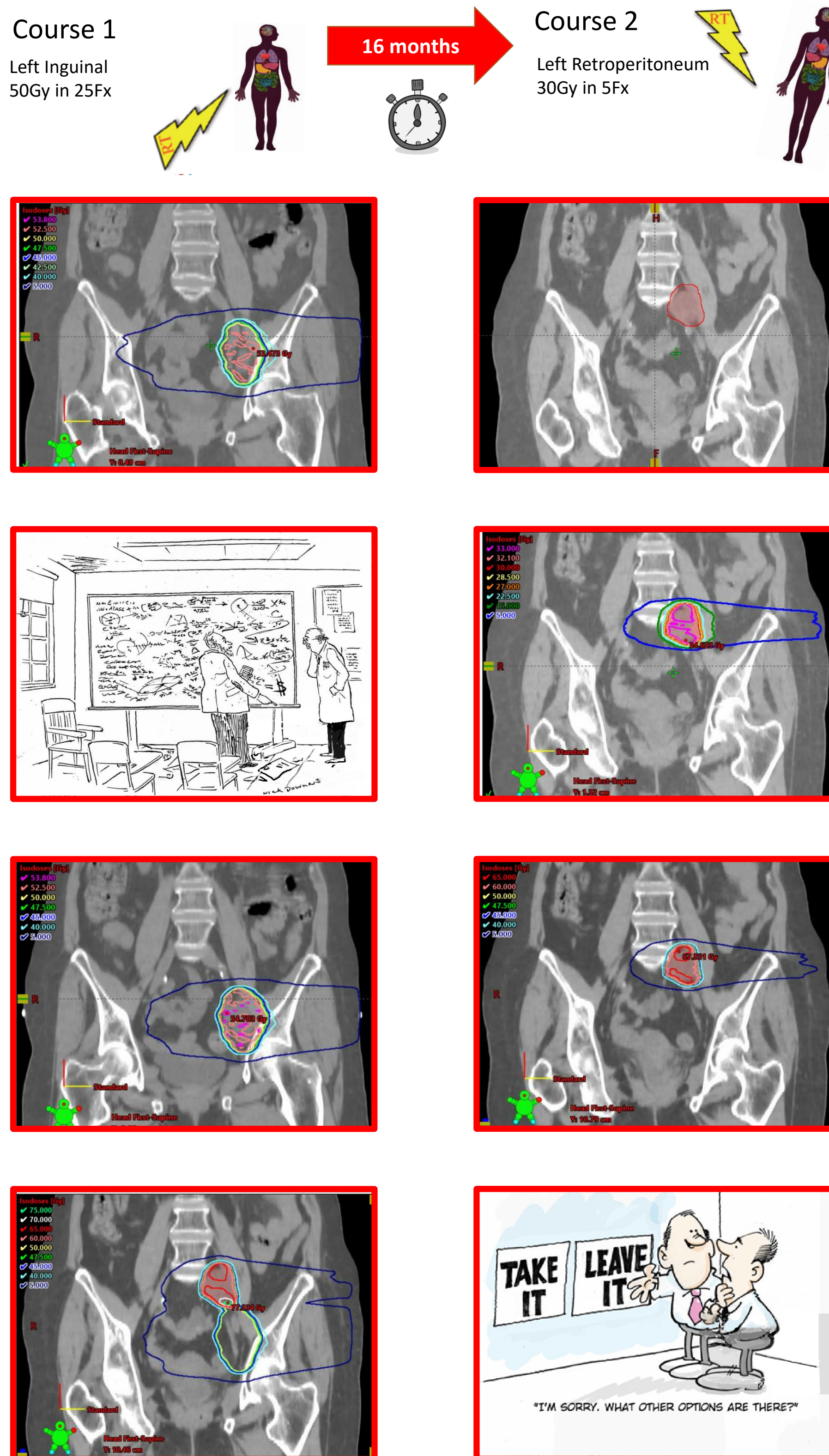
Post-Planning Dose Evaluation

- 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

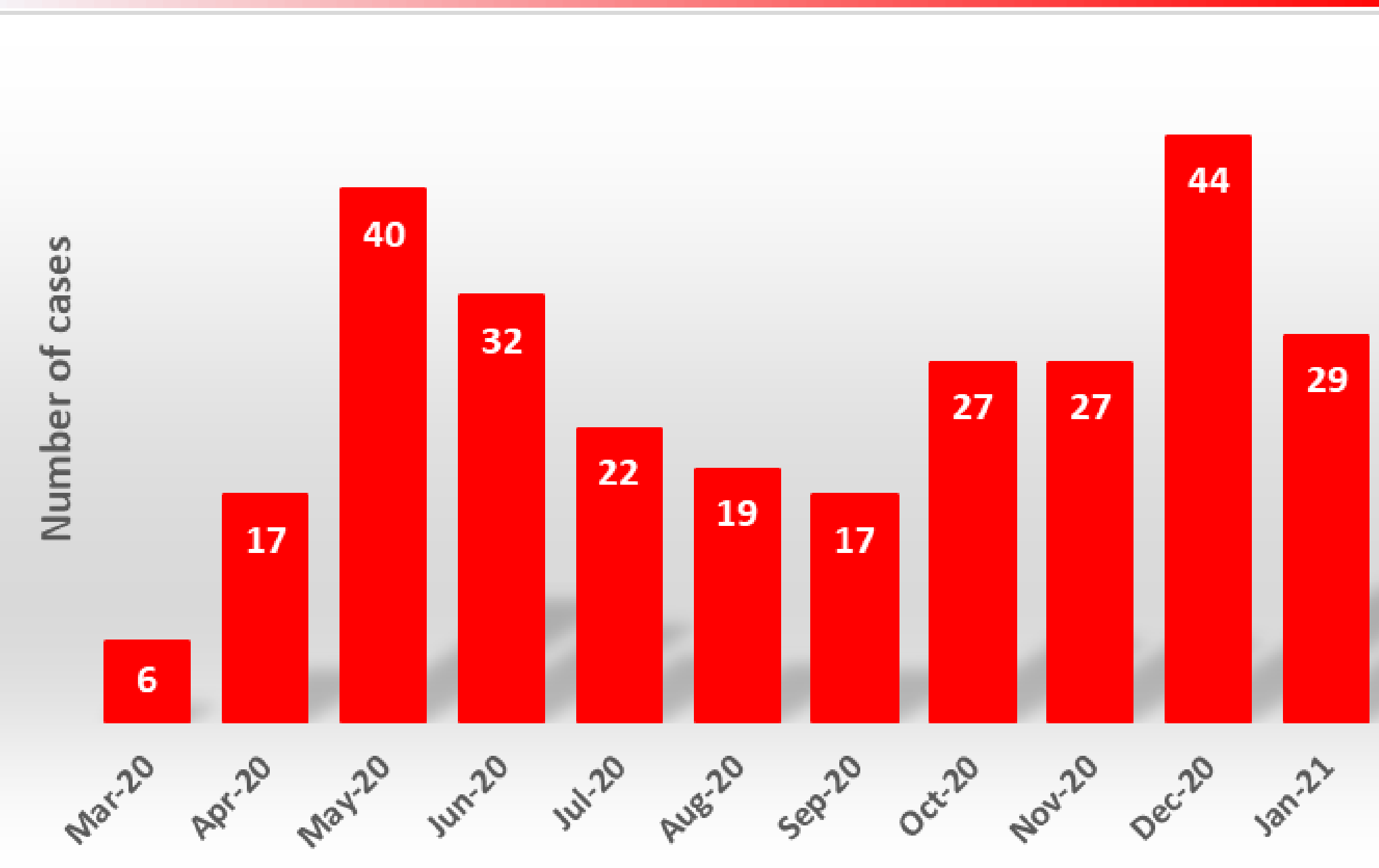
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Final Decision to Treat

- Make the final decision on whether to treat or modify treatment intent
- Approve Sum Plan Report document in EMR



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.

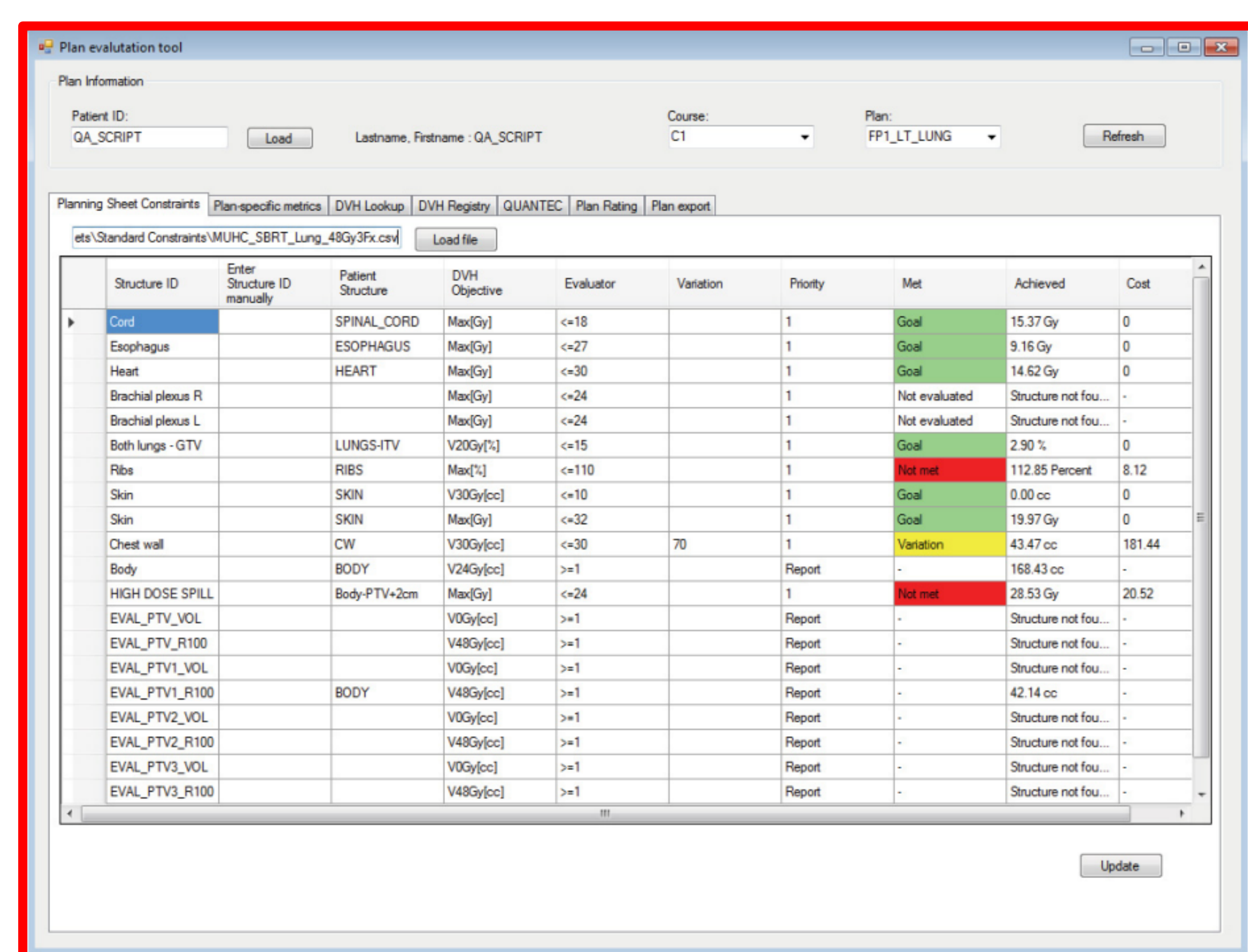
7. Future work

- 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

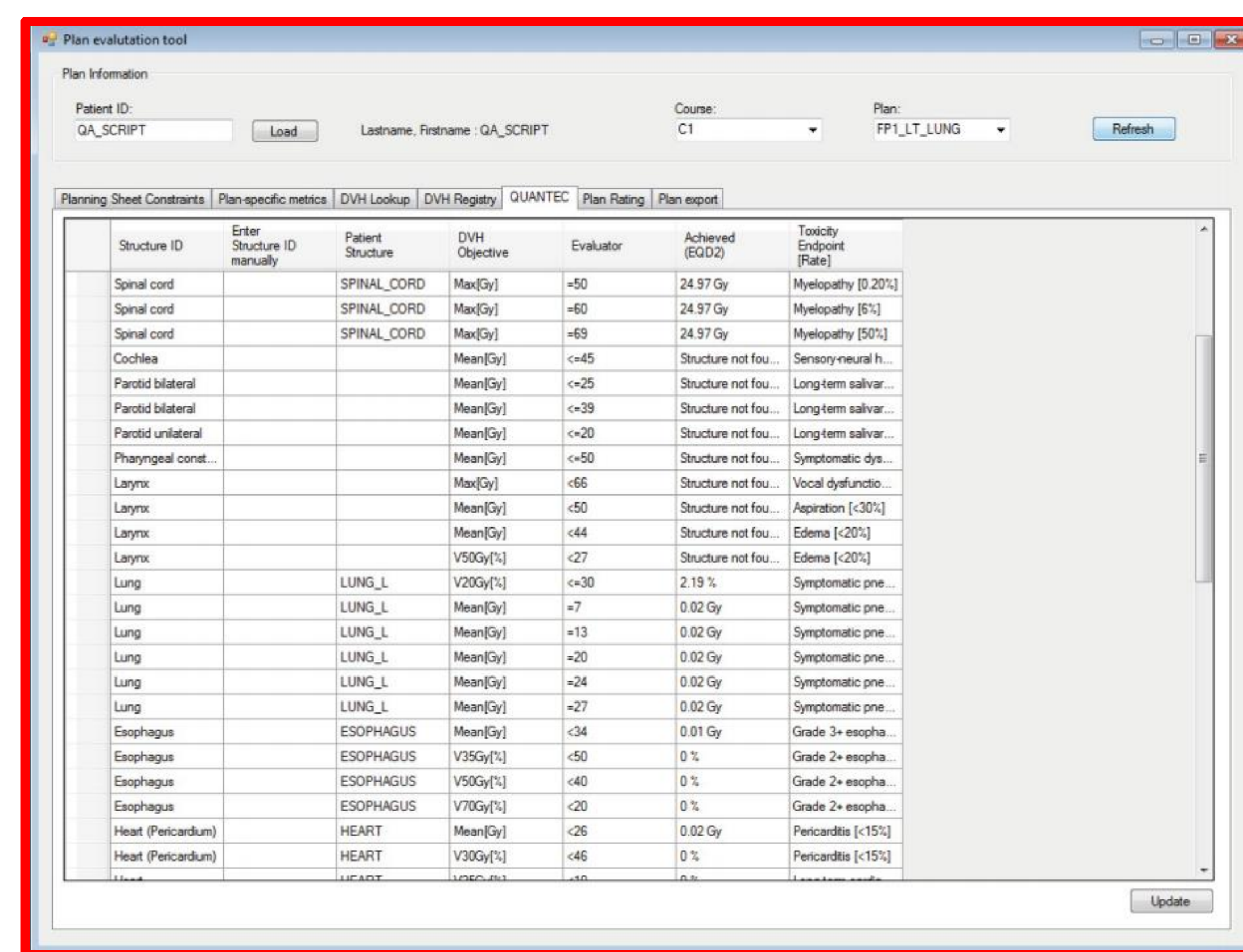
8. Acknowledgements

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).

6. Automation: Plan Evaluation Tools in ESAPI



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



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

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

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