Streamlining Reirradiation Evaluation: An ESAPI-Based Script for Rapid Cumulative Dose Assessment and Consultation Reporting

Veng Jean Heng[1]; Lucas Vitzthum[1]; Lianli Liu[1]; Cynthia Chuang[1]; Murat Surucu[1]; Yu Gao[1]*
[1]Department of Radiation Oncology, Stanford University, Palo Alto, CA, USA · *yugao97@stanford.edu

2026 JULY 19–22 VANCOUVER, BC
JOINT AAPM | COMP MEETING

INTRODUCTION

Reirradiation cases are becoming an increasingly common occurrence in the clinic. Safe planning requires an estimate of cumulative equieffective dose to nearby organs at risk (OARs) while accounting for tissue recovery since the time of the prior radiation.

Paradis et al. [1] described a structured physics consult in which prior doses are converted to EQD2, accumulated, and compared with OAR constraints.

Matrosic et al. [2] identified calculation and visualization of three-dimensional equieffective dose as the highest-priority software need for re-irradiation.

Objective: Develop and validate **ReRT-ESAPI**, an open-source ESAPI plugin that implements this workflow within Eclipse.

METHODS

ReRT-ESAPI was developed as an ESAPI plugin script to perform the dose accumulation process described by Paradis et al. [1]. From a selected plan sum, the script matches structures to configured OAR aliases, calculates their time-based tissue recovery factors [1], and converts each relevant plan doses to EQD2 using OAR-specific α/β.
The script handles dose accumulation through 2 methods:
Rigid registration-based method (Preferred). For every plan's dose grid, relying on their rigid registration, ReRT-ESAPI identifies which structure from the user-selected structure set each voxel belongs to. Based on this structure mask, each component of the plan sum is converted to EQD2 while applying the relevant OAR-specific α/β and tissue recovery factors. These dose objects are saved on Eclipse and can be visualized individually. A final plan sum object is then created to accumulate these converted equieffective doses.
Conservative near-max dose method. When rigid registration is not suitable, ReRT sums each plan's $D_{0.1cc}$ as a conservative estimate of the OAR's near-maximum dose. This accumulation can be restricted to a limited region surrounding a target of interest, to avoid accumulating maximum doses from faraway anatomy.
Automatic report. ReRT evaluates configured constraints, then generates a .docx physics consult report (see Fig. 4) ready for physicist review and patient-chart upload. The report documents all parameters used to perform the conversion and presents the evaluated dose metrics for each OAR against a set of predefined constraints. The constraints published by the UMichigan group [1] are used by default. The report body is defined in a template html file, which institutions can customize.

Steps to perform a reirradiation special medical physics consult using ReRT-ESAPI:
1. Create rigid registrations in Eclipse of all prior plan image sets onto the current or relevant image set. Create an Eclipse plan sum of all prior and current plans on the relevant image set.
2. Launch ReRT-ESAPI and confirm each course's prescription, delivered fractions, and treatment dates. Although they are automatically fetched through ESAPI, they can be incorrect when imported from outside records.
3. Select the relevant OARs for which to evaluate the accumulated dose and their α/β values. The structure-specific time-based discount factors are automatically calculated based on the elapsed time since the treatment approval date.
4. Choose the dose accumulation method: either the registration-based method if rigid registration is appropriate or the conservative near-max dose method otherwise.
5. Review the generated consult report and compare achieved accumulated doses against pre-defined constraints.

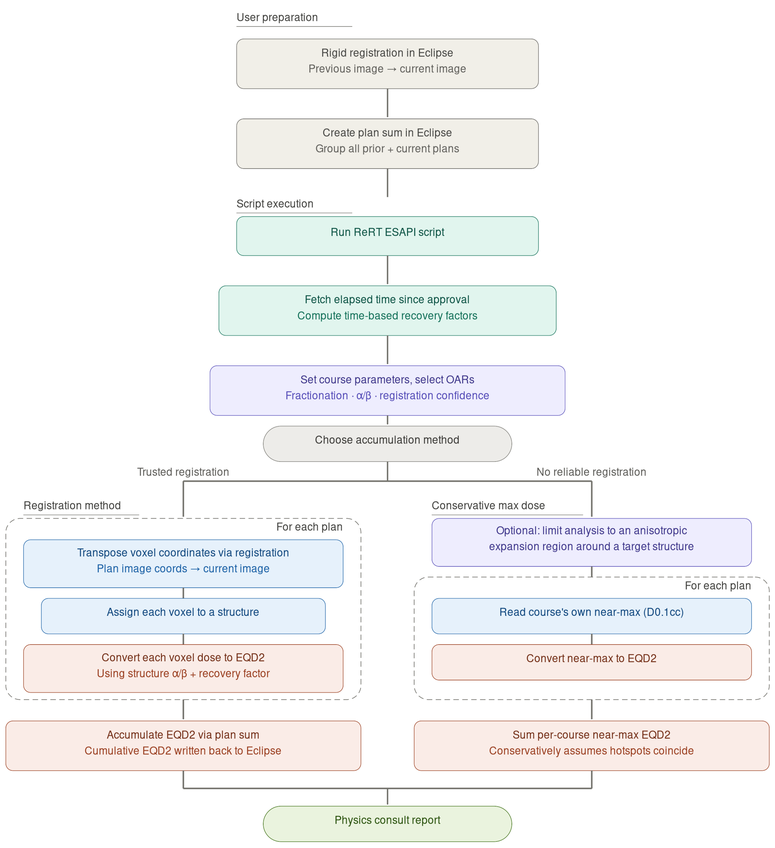


Figure 1. Flowchart describing how ReRT-ESAPI handles the dose accumulation of reirradiation cases. Prior to running the script, the user must manually perform the rigid registration of all prior plan image sets onto the current image set and create an Eclipse plan sum.

SCRIPT GUI

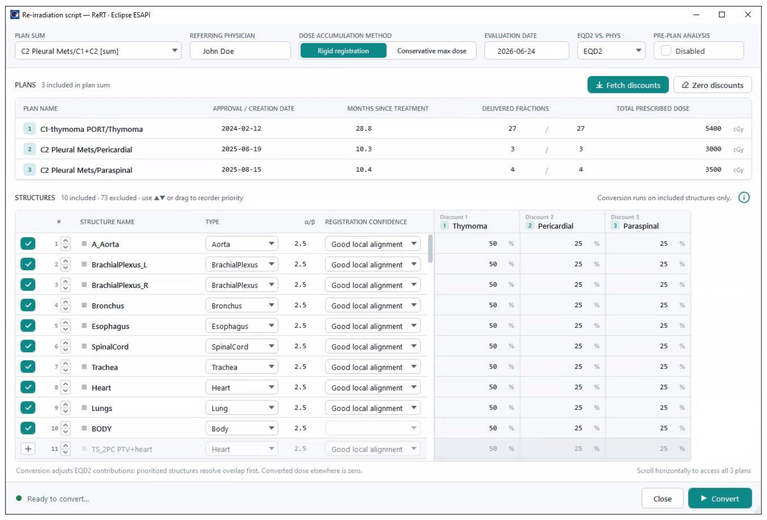


Figure 2. Registration-based method: doses are accumulated voxel-by-voxel using Eclipse's rigid registration. The converted EQD2 plan sum can be visualized natively in Eclipse.

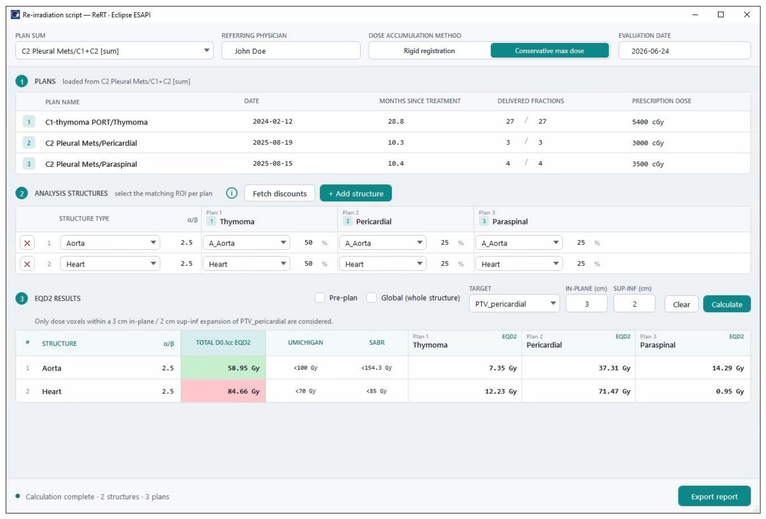
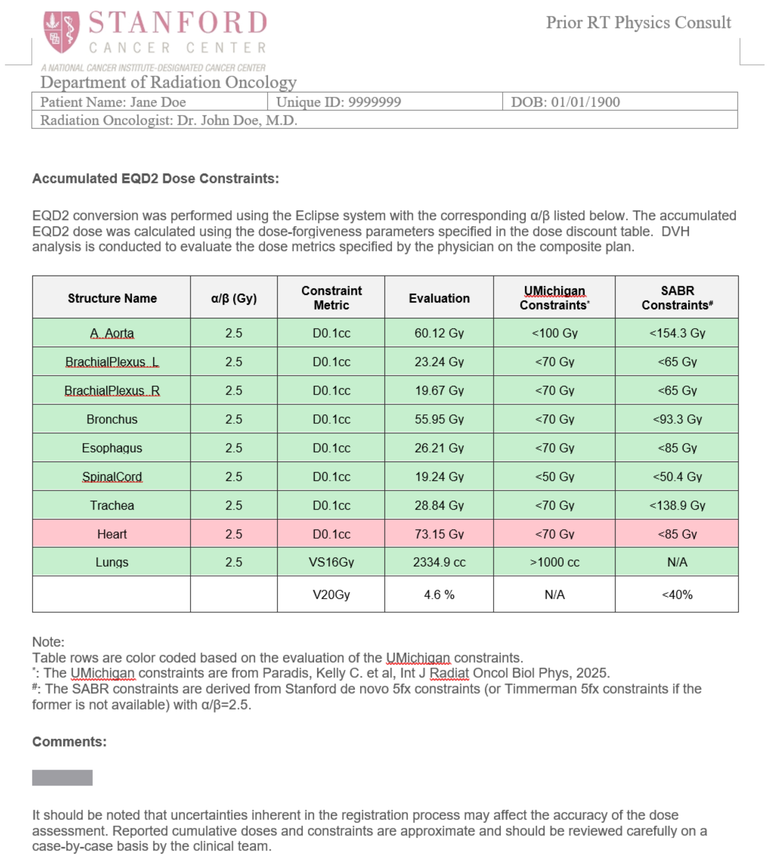


Figure 3. Conservative method: sum the per-plan $D_{0.1cc}$ values without dose mapping between image sets.



STANFORD CANCER CENTER
A NATIONAL CANCER INSTITUTE-DESIGNATED CANCER CENTER

Prior RT Physics Consult

Department of Radiation Oncology

Patient Name: Jane Doe	Unique ID: 9999999	DOB: 01/01/1900
Radiation Oncologist: Dr. John Doe, M.D.		

Accumulated EQD2 Dose Constraints:

EQD2 conversion was performed using the Eclipse system with the corresponding α/β listed below. The accumulated EQD2 dose was calculated using the dose-forgiveness parameters specified in the dose discount table. DVH analysis is conducted to evaluate the dose metrics specified by the physician on the composite plan.

Structure Name	α/β (Gy)	Constraint Metric	Evaluation	UMichigan Constraints*	SABR Constraints#
A_Aorta	2.5	D0.1cc	60.12 Gy	<100 Gy	<154.3 Gy
BrachialPlexus_L	2.5	D0.1cc	23.24 Gy	<70 Gy	<65 Gy
BrachialPlexus_R	2.5	D0.1cc	19.67 Gy	<70 Gy	<65 Gy
Bronchus	2.5	D0.1cc	55.95 Gy	<70 Gy	<93.3 Gy
Esophagus	2.5	D0.1cc	26.21 Gy	<70 Gy	<85 Gy
SpinalCord	2.5	D0.1cc	19.24 Gy	<50 Gy	<50.4 Gy
Trachea	2.5	D0.1cc	28.84 Gy	<70 Gy	<138.9 Gy
Heart	2.5	D0.1cc	73.15 Gy	<70 Gy	<85 Gy
Lungs	2.5	VS16Gy	2334.9 cc	>1000 cc	N/A
		V20Gy	4.6 %	N/A	<40%

Note:
Table rows are color coded based on the evaluation of the UMichigan constraints.
*: The UMichigan constraints are from Paradis, Kelly C. et al, Int J Radiat Oncol Biol Phys, 2025.
#: The SABR constraints are derived from Stanford de novo 5fx constraints (or Timmerman 5fx constraints if the former is not available) with α/β=2.5.

Comments:

It should be noted that uncertainties inherent in the registration process may affect the accuracy of the dose assessment. Reported cumulative doses and constraints are approximate and should be reviewed carefully on a case-by-case basis by the clinical team.

Figure 4. Consult report records assumptions, accumulated metrics, and constraint results for physicist review. This report can be customized by each institution through a template html file.

VALIDATION

To validate the registration-based dose accumulation and EQD2 conversion pipeline, ReRT-ESAPI was compared with MIM Maestro in 12 re-irradiation cases using 81 paired metrics across 17 OAR types. For each case, ReRT-ESAPI was run within Eclipse. The default structure-specific tissue recovery factors were applied based on the time elapsed since the treatment approval of each plan. α/β was varied between 2-3 for validation purpose. All relevant metrics were extracted from the automatically generated report. The doses and structure sets were then exported to MIM, where an equivalent built-in EQD2 dose accumulation workflow was performed. As applying a structure-specific scaling factor is not possible on MIM, different global scaling factors were applied to generate multiple copies of the accumulated dose as needed. The relevant metrics were then manually read on MIM and plotted against ReRT-ESAPI in Fig. 5 and 6.
Lin's Concordance Correlation Coefficient (CCC) exceeded 0.998 for every metric class, suggesting excellent agreement between both methodology. ReRT-ESAPI estimated D0.1cc were found to be lower than MIM by a mean of 0.35 Gy. This trend is consistent with literature reported differences of structure dose metrics evaluated by Eclipse vs. MIM.

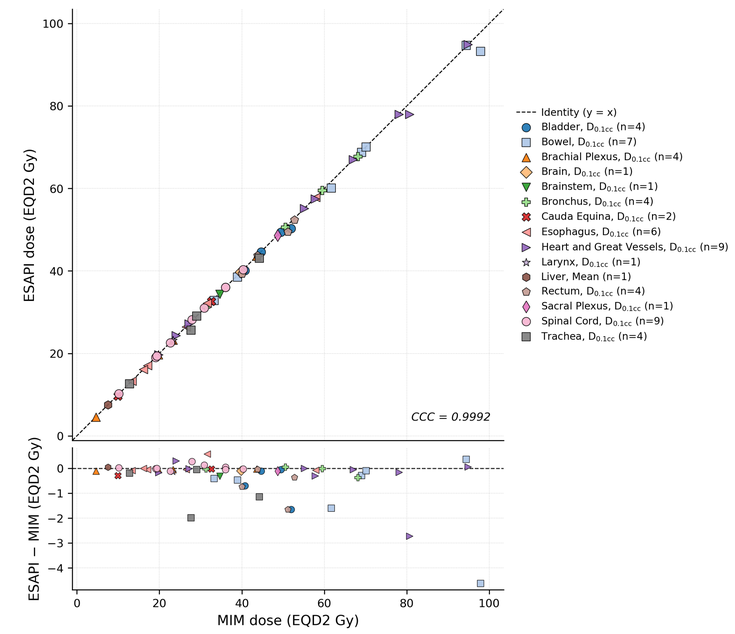


Figure 5. Accumulated OAR dose: ReRT vs MIM. Residuals are ReRT − MIM; CCC = 0.9992.

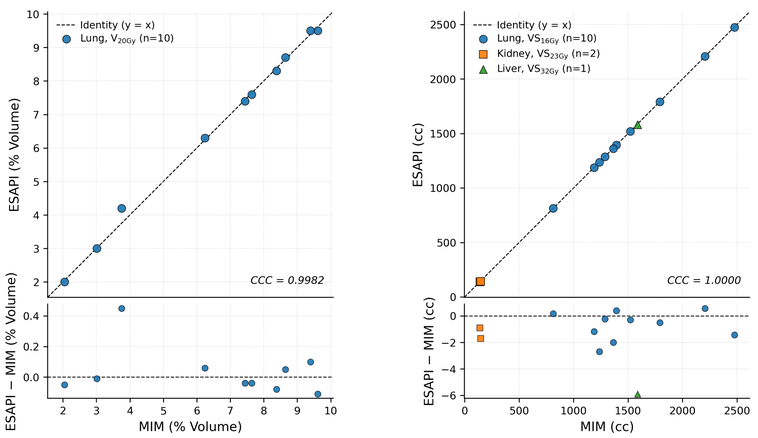


Figure 6. Volumetric agreement: lung $V_{20\,Gy}$ (left) and absolute volume spared (right).

CONCLUSION

- ReRT-ESAPI brings EQD2 accumulation, OAR-specific recovery, constraint checks, and consult reporting into Eclipse.
- If rigid registration is not reliable, ReRT-ESAPI also handles a conservative near-maximum dose sum approach.
- Implementation was validated against MIM, but we recommend each clinic to perform their own validation prior to usage.

KEY REFERENCES

1. Paradis KC et al. Adv Radiat Oncol. 2019;4:559–565.
2. Matrosic CK et al. Int J Radiat Oncol Biol Phys. 2025;122:181–185.

CONTACT & GITHUB
Yu Gao · yugao97@stanford.edu
github.com/vengjean/rert-esapi
Open source under the MIT license