

Dosimetric impact in IMRT-SW dose optimization with the gEUD-based objective using the TPS Eclipse: An Investigation approach for the Organ at Risk

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Introduction:

The PO (Photon Optimization) algorithm uses biological optimization constraints, based on the concept of the Generalized Equivalent Uniform Dose (gEUD) whose the concept has been described by Niemierko..

The objective of this study is to evaluate the choice of the "a" parameter, which is the determining factor of the radiosensitivity of an organ.

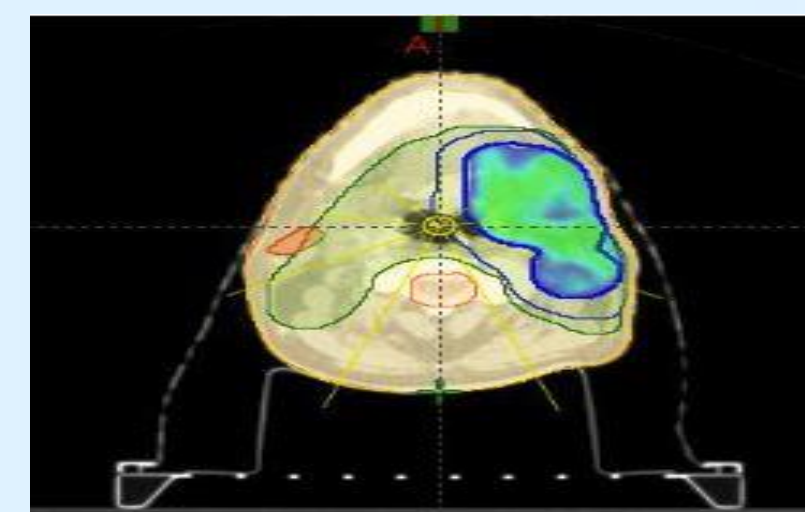
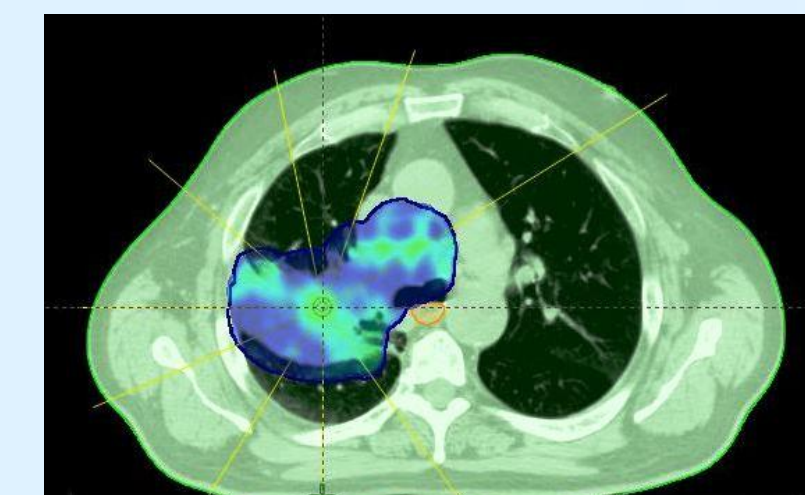
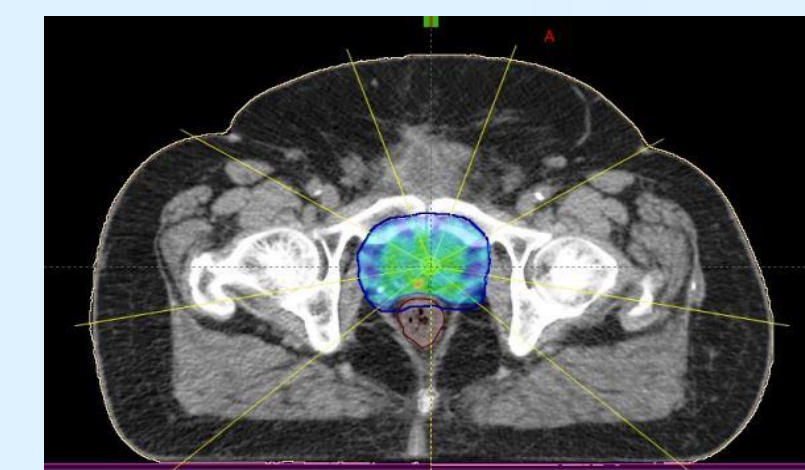
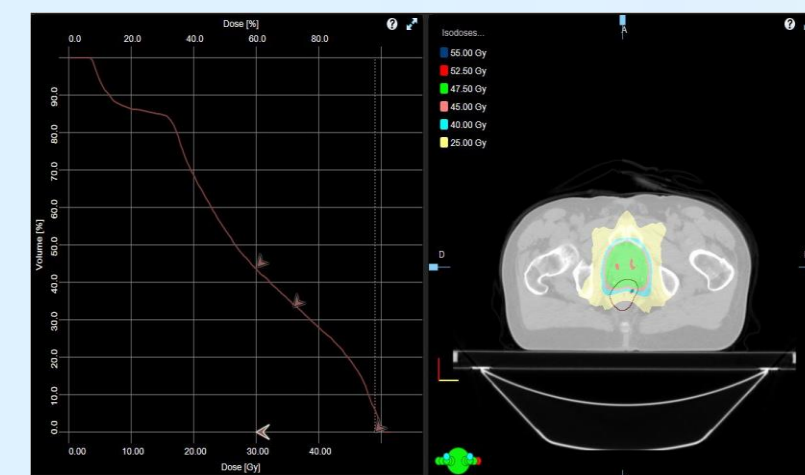
Materiels and Methodes:

- Study on Benchmark / Mock simulating various geometries of patients are proposed by the report of the AAPM -TG244-TG166 and TG119 and others clinical case[Prostate(bed);10 Prostate cases for the PTV50 of Pelvic Lymph Nodes),10Nasopharynx]
- Creation of two plans: a "standard" plan with only physical dose / volume objectives (DV) and a "gEUD" plan with added superior gEUD for organs at risk (CORD + 5mm, Parotids, Heart and Rectum).
- TPS Eclipse, v13.7 (Varian Medical Systems, Algorithm PO v13.7, 25mm grid, NTO Automatic, Heterogeneity of applied tissues, Number of iteration = 200.
- The Niemierko Formula used in the Algorithm:

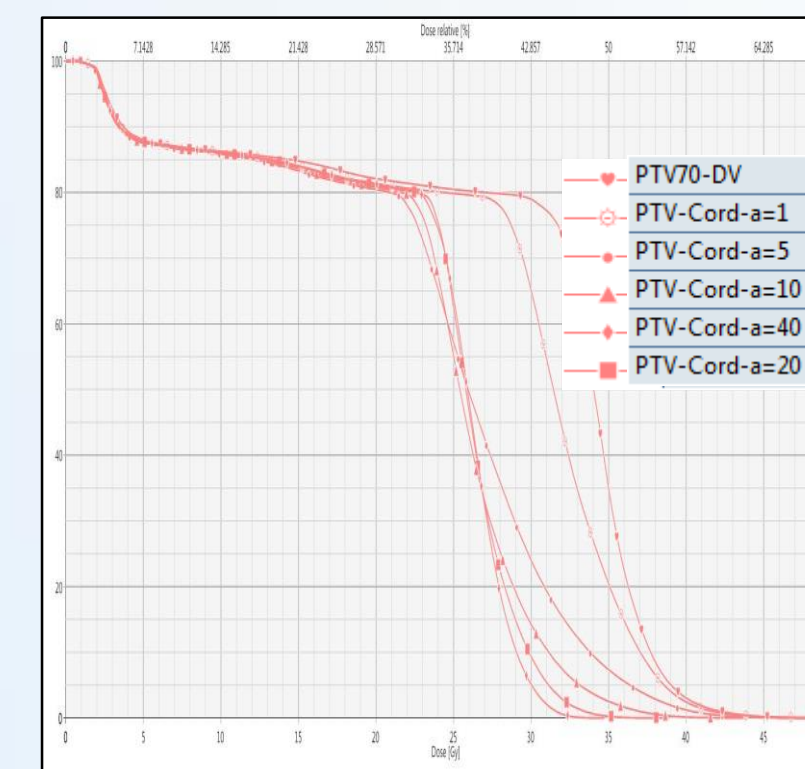
$$gEUD = \left(\sum_i v_i D_i^a \right)^{1/a}$$

- For the different localizations and for the different organs at risk, several planes were generated by changing the value of $a \in \{0.1, 1, 2, 5, 8, 10, 15, 20, 40\}$.

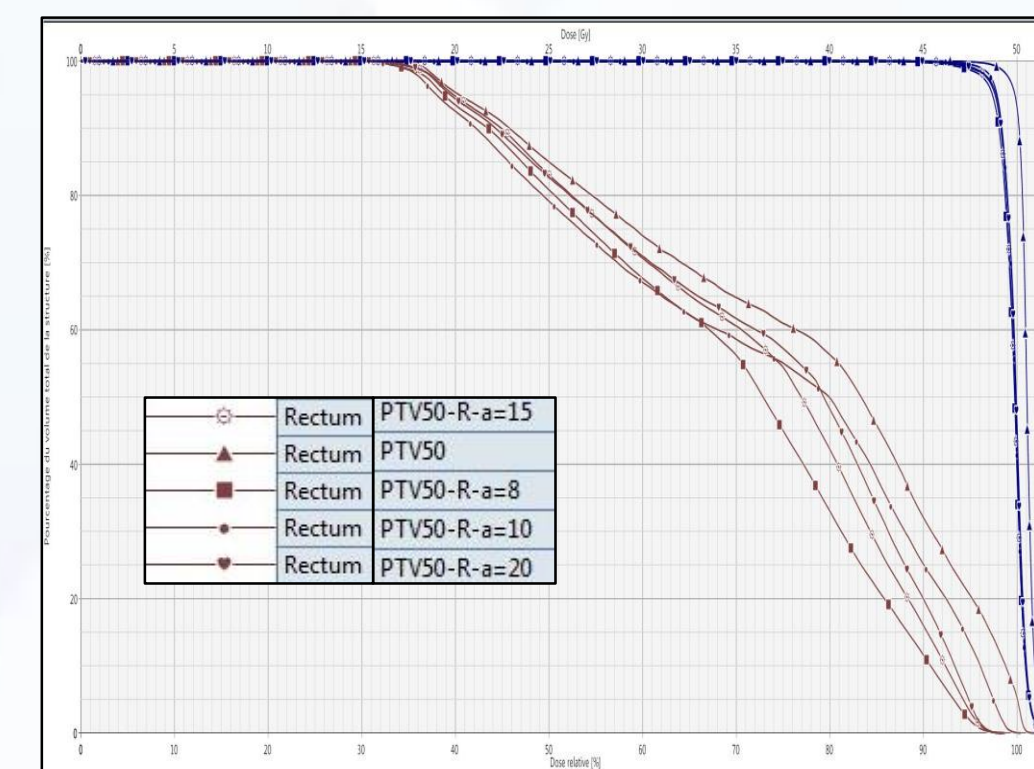
A DVH comparison of the two plans, and reporting the maximum dose at the risk organ studied and/or some criteria of $V_{xx}\% = yy\%$ ($V_{60}\%$, $V_{90}\%$)



Results:



Exemple of the DVH SpinalCord_05mm



DVH variation for the Rectum and PTV50

Localization	OAR	Goals	Parameter-gEUD	Dose(Gy)-Plan gEUD
HN TG244	Cord+5mm	D _{Max} < 50 Gy	a=	48.99
			a=1	48.75
			a=5	47.84
			a=10	43.9
			a=20	38.6
HN TG116	Parotides	V ₂₀ < 50%	a=	50.3 %
			a=1	47.7 %
			a=2	44.48 %
			a=5	44.7 %
			a=20	50 %
Prostate PTV	Rectum	V ₄₀ < 50%	a=	45.2%
			a=1	48.2%
			a=5	45 %
			a=10	46.5 %
			a=20	48.3%
Prostate Logo	Rectum	D _{Max} < 66 Gy	a=	65.36
			a=1	64.10
			a=8	62.24
			a=10	62.56
			a=20	61.9
Lung TG244	Heart	V ₃₀ < 2%	a=	V ₃₀ < 2% - V ₂₀ =16.73 Gy
			a=0.1	V ₃₀ < 2% - V ₂₀ =16.708 Gy
			a=1	V ₃₀ < 2% - V ₂₀ =16.7 Gy
			a=3	V ₃₀ < 2% - V ₂₀ =10.2 Gy
			a=5	V ₃₀ < 2% - V ₂₀ =14.9 Gy
a=20	48.3			

-*:Standard Plan (DV) without gEUD objectifs

- For the OAR CORD + 5mm(Cord), the value of $a = 20$, the maximum dose obtained is less than 40 Gy, an increase of this value $a > 20$ slightly modifies slightly the final DVH.
- For the parotid glands, changing the values of $a \in \{0.1, 1, 2, 5, \}$, the average dose is less than 25 Gy. For $a=1$, we found that the mean dose of the parotid is 22 Gy.
- For the 10 cases of Prostate High Risks,(first treatment course, PTV50=800±40cc),the value of $a = 8$, makes a better protection for the rectum, such as we found that for this organ $V_{90}\%(50Gy)=15\%$ and $V_{60}\%(50Gy)=35\%$ of the total rectal volume.
- In the five lungs cases, a better protection of the Heart for $a = 3$.
- In this study, for all the tested plans, we found that the optimization model based on the gEUD, whose factor "a" is the influential one, led to a better protection of the organs at risk, even beyond the QUANTEC requirements.
- A significant correlation of coverage of target volumes compared to that of the "standard" plan with a slight increase in the average dose. The dose sculpting for differents targets is still achievable when using the biological optimisation(for the OAR).

Conclusion:

In this work, we demonstrate that the use of the gEUD model, can be an excellent choice of optimization at least for the organs at risks wich mentioned (Cord PRV, Parotids, Rectum and the Heart.). Other tests are very necessary to complete and to evaluate the influence of this biological model optimization on target volumes.

References:

1. TG-166: « The use and QA of biologically related models for treatment planning: Short report of the TG-166 of the therapy physics committee of the AAPM » Med. Phys. 39 (3), pg. 1386-1409, March 2012.
2. The Eclipse User Manuel,Varian Medical Systems,Paolo Alto,CA.