From Anisotropic Analitical Algorithm to Acuros XB: Clinical implications in VMAT planning for lung, head&neck and prostate treatments

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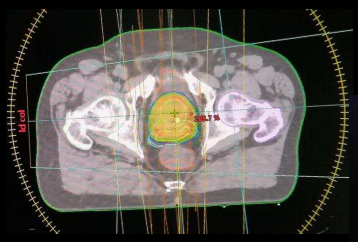
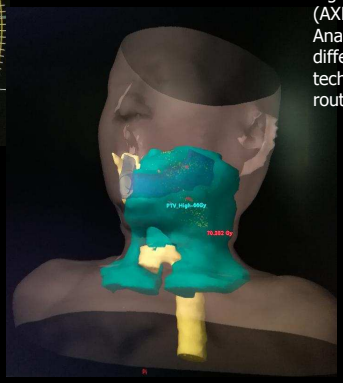
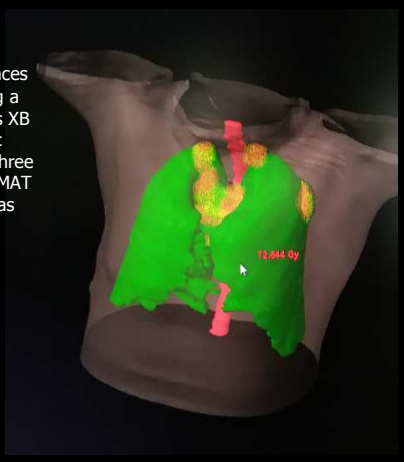




PURPOSE:

To determine the dose differences and clinical implications of using a high accuracy algorithm, Acuros XB (AXB) instead of the Anisotropic Analitical Algorithm (AAA), for three different treatment sites with VMAT technique, in order to use AXB as routine algorithm.



METHODS:

Representative samples of patients have been choosen (15 for prostate and head &neck sites ans 17 for lung cases). All of them had been optimized and calculated with AAA . These plans were recalculated with AXB and dose differences were evaluated in several representative dose-volume points (those that could lead to clinical consequences both for the PTV and for the OAR involved). All data were statistically treated in order to obtain correct and applicable conclusions to all patients.

For PTV, clinical consequences in terms of coverage and homogeniety were derived.

For OAR, taking into account that classic dose tolerances have been stated based on AAA or even simpler algorithms, we focused on those dose-volume points in which AXB algorithm offers statistically significant lower calculated doses than AAA.

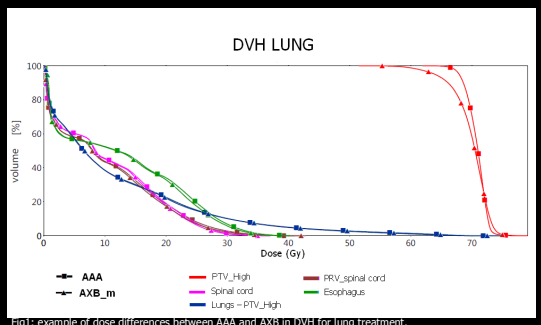


Fig1: example of dose differences between AAA and AXB in DVH for lung treatment.

Analysis of DVH points:

Coverage for PTV: D_{max} , $D_{2\%}$,$D_{5\%}$, D_{mean}, $D_{95\%}$, $V_{95\%}$

Organs at Risk (OAR): D_{max} , D_{mean}, $V_{30\%}$, $V_{40\%}$, $V_{60\%}$, depending on OAR type (see tables below)

RESULTS:

PTV: For lung and head & neck patients, due to the high heterogeneity involved, it is observed a worse coverage and homogeneity in plans recalculated with AXB. Consequently, if AXB is used in routine clinical practice, a more demanding optimization is needed to meet objectives, leading to better local control of the disease. For prostate sites, no clinically relevant differences have been obtained concerning to PTV.

OAR: In those DVH points where statistically significant dose differences have been found, an additional restriction (AR) for the OAR tolerance criteria is proposed : AR= Mean(%)+3σ_M

LUNG

P_{AAA}-P_{AXB}	PTV					
	$V_{95\%}$	$D_{95\%}$	D_{mean}	$D_{5\%}$	$D_{2\%}$	D_{max}
Mean[%]	4.31	2.15	0.56	-0.42	-0.63	-1.91
σ_M	0.74	0.33	0.19	0.21	0.23	0.26
p-value	<0.001	<0.001	0.008	0.064	0.013	<0.001

	Lungs-PTV			Spinal cord	PRV_spinal cord+1cm	Esophagus	
	D_{mean}	V_{20}	V_{30}	D_{max}	D_{max}	D_{mean}	V_{55}
Mean[%]	0.530	-0.040	0.041	1.08	1.37	2.14	0.55
σ_M	0.17	0.11	0.04	0.19	0.28	0.16	0.17
p-value	0.021	0.716	0.274	<0.001	<0.001	<0.001	0.002
A.R.	1.0	0.0	0.0	1.6	2.2	2.6	1.1

HEAD&NECK

P_{AAA}-P_{AXB}	PTV					
	$V_{95\%}$	$D_{95\%}$	D_{mean}	$D_{5\%}$	$D_{2\%}$	D_{max}
Mean[%]	3.03	2.52	1.63	1.00	0.84	-0.32
σ_M	0.40	0.30	0.06	0.11	0.12	0.35
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	0.367

	Spinal cord	PRV_spinal cord+0.5cm	PRV_spinal cord+1cm	Parotid glands		Mandible	Brain stem	Thyroid gland	
	D_{max}	D_{max}	D_{max}	D_{mean}	D_{max}	D_{max}	D_{max}	D_{mean}	D_{max}
Mean[%]	1.68	2.58	2.39	2.42	1.77	2.11	2.25	2.78	1.78
σ_M	0.17	0.24	0.19	0.14	0.35	0.24	0.39	0.36	0.37
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003
AR.[%]	2.2	3.3	2.9	2.8	2.8	2.8	3.4	3.8	2.9

PROSTATE

P_{AAA}-P_{AXB}	PTV					
	$V_{95\%}$	$D_{95\%}$	D_{mean}	$D_{5\%}$	$D_{2\%}$	D_{max}
Mean[%]	0.61	0.78	0.72	0.31	0.10	-0.95
σ_M	0.22	0.07	0.04	0.07	0.07	0.16
p-value	0.016	<0.001	<0.001	<0.001	0.167	<0.001

	Rectum					Femoral heads
	D_{mean}	V_{60}	V_{50}	V_{40}	D_{max}	D_{max}
Mean[%]	2.02	1.88	0.70	0.39	0.34	2.14
σ_M	0.09	0.29	0.11	0.06	0.16	0.16
p-value	<0.001	<0.001	<0.001	<0.001	0.049	<0.001
AR.[%]	2.3	2.7	1.0	0.6	0.8	2.6

	Bladder					Penile bulb	
	D_{mean}	V_{50}	V_{40}	V_{30}	D_{max}	D_{mean}	D_{max}
Mean[%]	2.18	0.84	0.53	0.26	-0.27	2.05	1.74
σ_M	0.21	0.14	0.12	0.05	0.17	0.46	0.43
p-value	<0.001	0.001	0.002	0.000	0.125	<0.001	0.001
AR.[%]	2.8	1.2	0.9	0.4	n/a	3.4	3.0

Tables 1,2,3: For the three evaluated sites, mean of dose differences (Mean[%]), standar error of the mean (σ_M), p-value and the calculated additional restriction (A.R.) are shown

p<0.05: the null hypothesis is not accepted. We apply an additional restriction to the OAR tolerance criteria.

p >0,2: the null hypothesis is accepted: there are no significant difference doses between AXB and AAA

0.05<p<0.2: it is not safe to accept the null hypothesis. We apply an additional restriction to the OAR tolerance criteria

CONCLUSIONS:

For most of the points studied, the results obtained with AXB differ from those obtained with AAA. Since AXB has been proven to be more accurate, we propose to use it in clinical practice.

Nevertheless, we strongly recommend being cautious about OAR tolerances, setting an additional restriction to the tolerance criteria when required, at least until these have been reviewed and an international consensus is adopted taking into account the new algorithms.

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