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STEREOTACTIC BODY RADIATION THERAPY
Implementazione, Sostenibilità, Avanzamento Tecnologico e Risultati a Confronto

Image-guided SBRT of the prostate, 42 Gy in 7 fractions, for localized disease: dosimetric report of a phase-II study

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Introduction

We present our experience of the institutional prostate SBRT phase-II study, which has involved 40 patients, with a focus on treatment planning dosimetry and compliance with the study protocol.

Materials and Methods

Since 2012, 40 patients at low/intermediate risk for localized prostate cancer have been planned for SBRT. Fraction size is 6 Gy for 7 fractions scheduled to be delivered twice a week for a total dose of 42 Gy. For planning the GTV includes prostate with the 1/3 proximal seminal vesicles without margin; a margin of 3 mm in all directions around the GTV is used to define the PTV, as the SBRT protocol is based on 3 IGRT intra-prostatic fiducial markers with daily online checks by CBCT.
Treatment is delivered with a VMAT technique, with 2 arcs using 6MV photons from a Varian 2300 iX linac. Planning was performed with Eclipse 10.0 TPS with the AAA algorithm by 3 different planners. Dose prescription is the average dose to PTV with the request V95%≥ 95%.

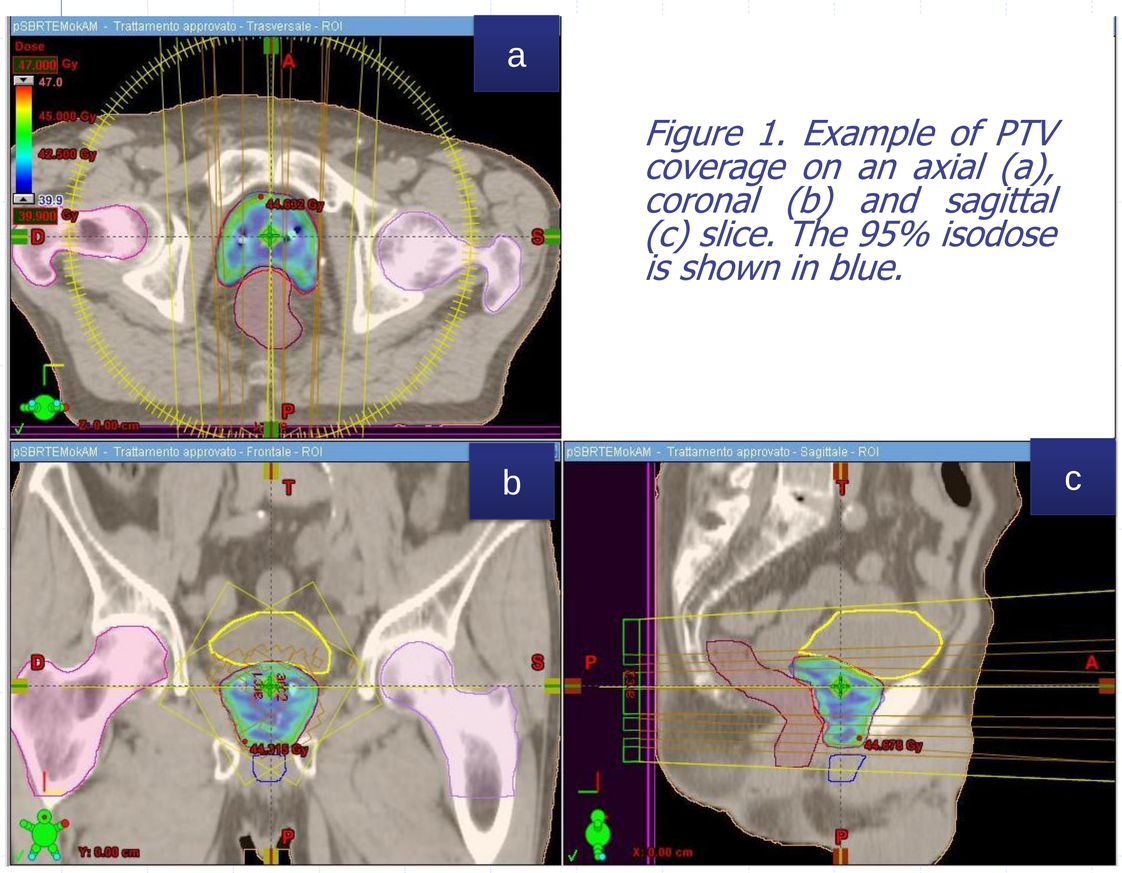
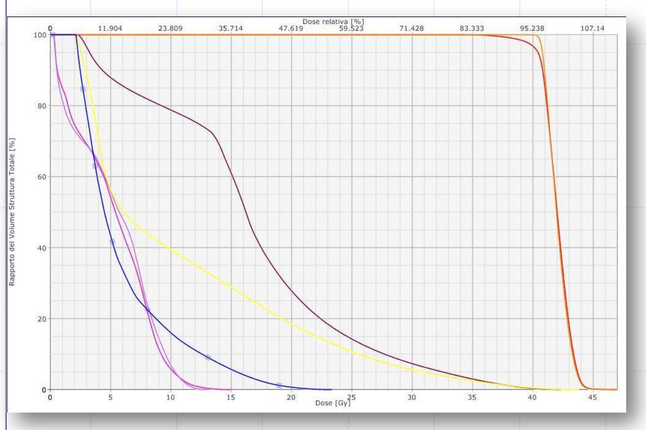


Figure 1. Example of PTV coverage on an axial (a), coronal (b) and sagittal (c) slice. The 95% isodose is shown in blue.

The DVH constraints for OAR's have been derived from literature and local experience. Constraints for acute urinary toxicity have been recently introduced too after the paper of Cozzarini et al [1].
In addition, the plan quality have been evaluated by van't Riet [2] dose conformation Number (CN) and by the intermediate dose spillage (Spill50%), defined as the ratio of the volume of 50% isodose to the volume of the PTV .
Dosimetric analysis focused on PTV coverage and OAR's sparing based on key DVH parameters corresponding to protocol constraints.



VMAT PLAN EVALUATION:
hypofractionated radiotherapy for prostate cancer
Prostate + Seminal Vescicles = 6 Gy x 7 fx= 42 Gy
Dose prescription: average dose to PTV

Patient: _____ Date: _____

b

ROI	Objective	Result	Comments
PTV Vol (cc)=_____	D_{median} (%)		
	$V_{95\%}$ > 95%		
	$V_{105\%}$ < 5%		
	$D_{98\%}$ > 94%		
	$D_{2\%}$ < 108%		
Rectum	V_{32} < 35%		
	V_{32} < 10%		
	V_{37} < 5%		
	$D_{1\%}$ < 40Gy		
	D_{mean} < 18Gy		
Overlap rectum-PTV	90%< D_{mean} < 95%		
Bladder	V_{21} < 40%		Acute Urinary Toxicity:
	V_{33} < 30%		V_{30} < 56 cc:_____
	V_{38}< 13%		V_{43} < 5cc: _____
	$D_{1\%}$ < 40 Gy		At least V40 < 10%:_____
	D_{mean} < 14 Gy		
Rt Femoral Head	D_{mean} < 10 Gy		
	$D_{1\%}$ < 18 Gy		
Lt Femoral Head	D_{mean} < 10 Gy		
	$D_{1\%}$ < 18 Gy		
Penile Bulb	D_{mean} < 10 Gy		
CN95%	> 0.90		$[V_{95\%}{}^{PTV}(cc)]^2 / [V_{95\%}{}^{Body}(cc) \cdot V^{PTV}(cc)]$
SPILL50%	$V50^{Body}(cc) / V^{PTV}(cc)$		PTV(cc) / tolerance range: 50.0 <4.0 <5.0; 70.0 <3.5 <4.8; 95.0 <3.3 <4.4; 126.0 <3.1 <4.0; 163.0 <2.6 <3.7

Medical physicist _____ Radiation Oncologist _____

Figure 2. a) Example of cumulative DVH for PTV and OAR's; b) Worksheet for plan evaluation and quality control.

Results

Main dosimetric results of the first 40 clinical plans are presented in the following table together with their compliance to the protocol. The PTV is covered by the 95% isodose for all patients, and only the constraint for the PTV near-minimum dose $D_{98\%}$ is not met in 2 cases. As for the OARs, most dosimetric parameters are well within the protocol constraints, with the notable exception of the maximal doses of rectum and bladder ($D_{1\%}$, equal to 95% and 100% of the prescription dose, respectively) for which the constraints are exceeded in about 20% of cases. The mean value of the CN is 0.90 with a coefficient of variation (CV) of 5.5%. The mean value of total MU's corresponds to a delivery of 3.3 min at a doserate of 600 MU/min.

Structure	DVH parameters statistics	mean	CV	Constraint	N. of pts with minor deviations
PTV Vol=115.6 cc (CV=26.9%)	D_{median}	100.0%	0.8%	--	
	$V_{95\%}$	97.4%	1.2%	≥ 95%	0
	$D_{98\%}$	94.7%	1.3%	≥ 93%	2
	$D_{2\%}$	104.9%	1.4%	≤ 108%	0
Rectum Vol=57.8 cc (CV=28.0%)	$D_{1\%}$	37.9 Gy	18.1%	≤ 40 Gy	9
	V_{37Gy}	3.2%	47.5%	≤ 5%	3
	V_{32Gy}	7.7%	31.3%	≤ 10%	2
	V_{20Gy}	30.6%	11.2%	≤ 35%	0
Bladder Vol=139.7 cc (CV=52.2%)	$D_{1\%}$	40.7 Gy	3.8%	≤ 42 Gy	7
	V_{38Gy}	5.4%	122%	≤ 13%	3
	V_{33Gy}	8.2%	52.2%	≤ 30%	2
	V_{21Gy}	22.4%	40.5%	≤ 40%	0
Rt Femoral Head	D_{mean}	6.6 Gy	28.4%	≤ 10 Gy	3
	$D_{1\%}$	13.5 Gy	25.9%	≤ 20 Gy	0
Lt Femoral Head	D_{mean}	6.5 Gy	30.7%	≤ 10 Gy	1
	$D_{1\%}$	13.6 Gy	24.2%	≤ 20 Gy	0
Penile Bulb	D_{mean}	10.2 Gy	53.3%	≤ 20 Gy	2
$CN_{95\%}$		0.90	5.5%	≥ 0.80	0
MU		1956	14.9%	--	

Table. Dosimetric results and number of patients with minor deviations in the 40 patient sample.

Finally, a significant correlation between van't Riet $CN_{95\%}$ and the number of MUs was observed (r=0,61; p<0,001) as shown in Figure 3. This means that for most of the plans the degree of conformality increases ($CN_{95\%}$ going to 1) at the expense of total MU's.

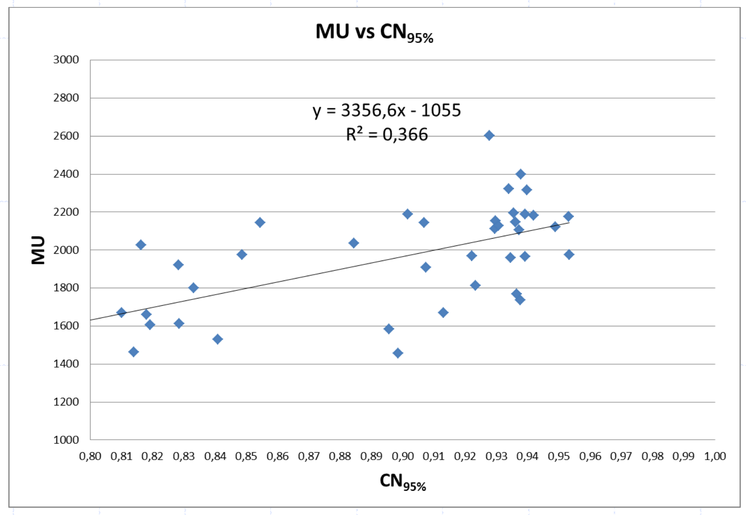


Figure 3. Total MU's as a function of Van't Riet CN.

Conclusions

Analysis has shown a good compliance with most of the protocol constraints for PTV and OAR's, except for the maximal doses $D_{1\%}$ of rectum and bladder when these organs are significantly included in the PTV. As for the measure of plan quality, the average value of van't Riet CN is well above the 0.80 threshold, while its small CV% suggests a consistent application of the planning protocol among the different planners involved in the study.

References

1. V. Carillo, C. Cozzarini, T. Rancati *et al.* Relationships between bladder dose–volume/surface histograms and acute urinary toxicity after radiotherapy for prostate cancer. *Int J Radiat Oncol Biol Phys,* April 2014 , Vol 111 (1) :100–105.
2. Van't Riet A., Mak A.C.A. *et al.* A conformation number to quantify the degree of conformality in brachytherapy and external beam irradiation: application to the prostate. *Int J Radiat Oncol Biol Phys,* 1997; 37 (3): 731-736.