Inter-fraction motion in SBRT with VMAT and on-line correction: systematic and random setup errors from analysis of 125 image registrations for toracic and abdominal oligometastases.

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BACKGROUND

- ✓ Stereotactic body radiotherapy (SBRT) involves the delivery of high biological equivalent doses in a small number of fractions (typically 1–5).

- ✓ Accurate treatment delivery is therefore essential, as small changes in patient position can confer significant dosimetric impact on adjacent structures and on target coverage.

MATERIALS AND METHODS

Retrospective analysis of
125 PLANNING CT - CBCT IMAGE REGISTRATIONS

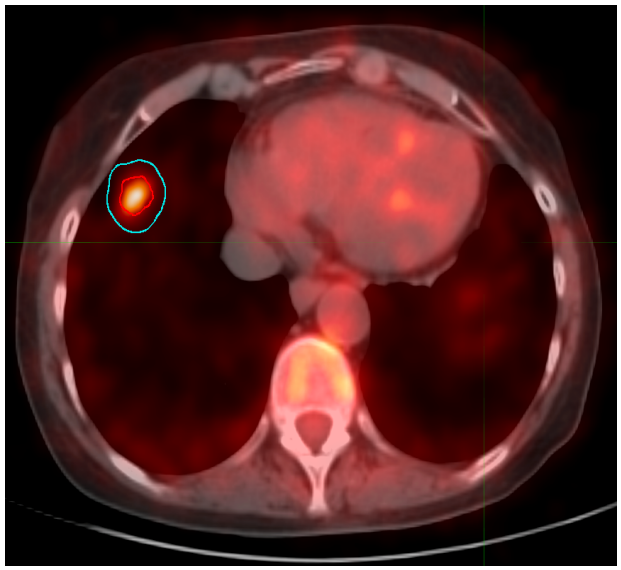
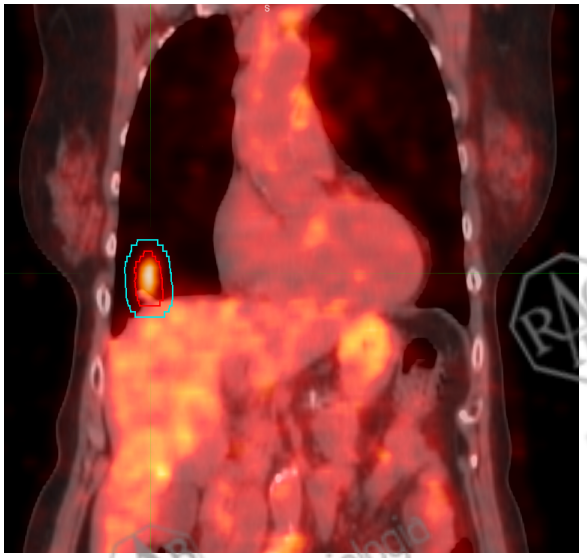
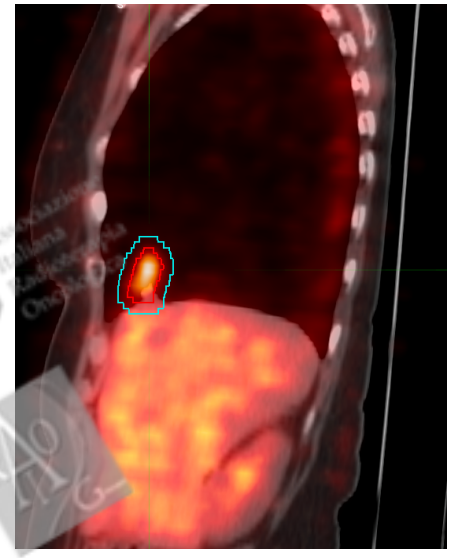
22 oligometastatic pts
treated
with VMAT SBRT
from May 2015
to January 2016
at San Donato
Hospital (Arezzo)

THORAX

3 bone, 8 lung, 1 lymph nodes metastases
(Primary:
6 lung, 5 breast, 1 prostate)

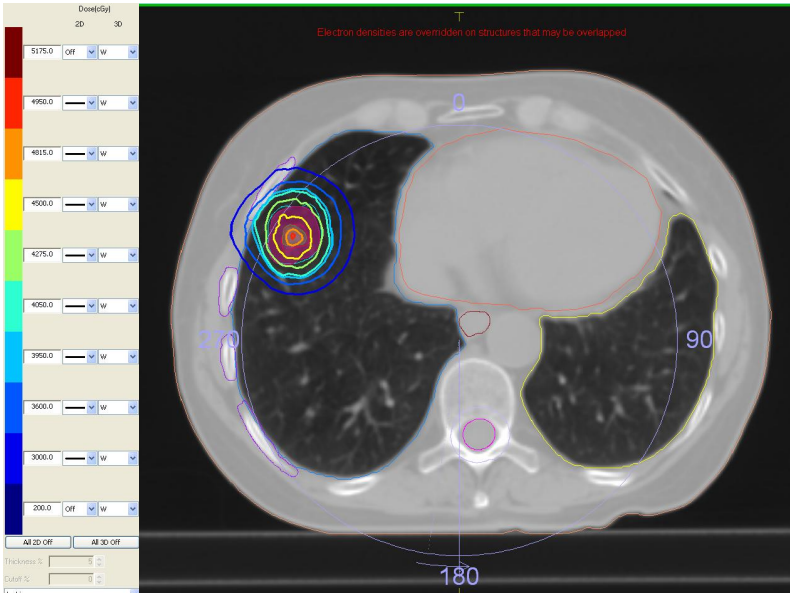
ABDOMEN

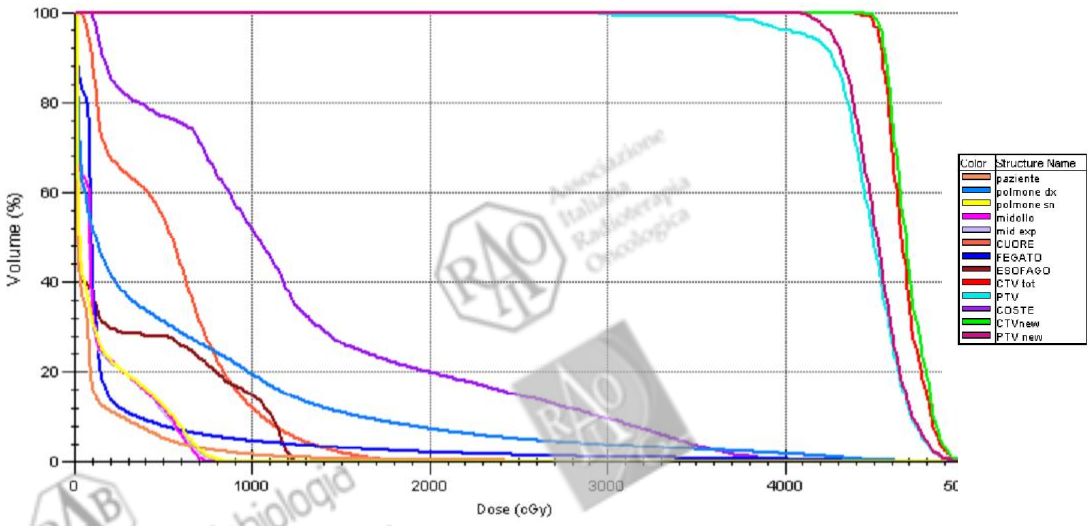
5 bone, 5 lymph nodes metastases
(Primary: 9 prostate, 1 rectum)

- ✓ Patients underwent 4D-CT simulation, with fusion of diagnostic CT/PET, for delineation of tumour and OAR.

- ✓ The target volume was expanded by 3-mm isotropic margin to create the planning target volume (PTV).



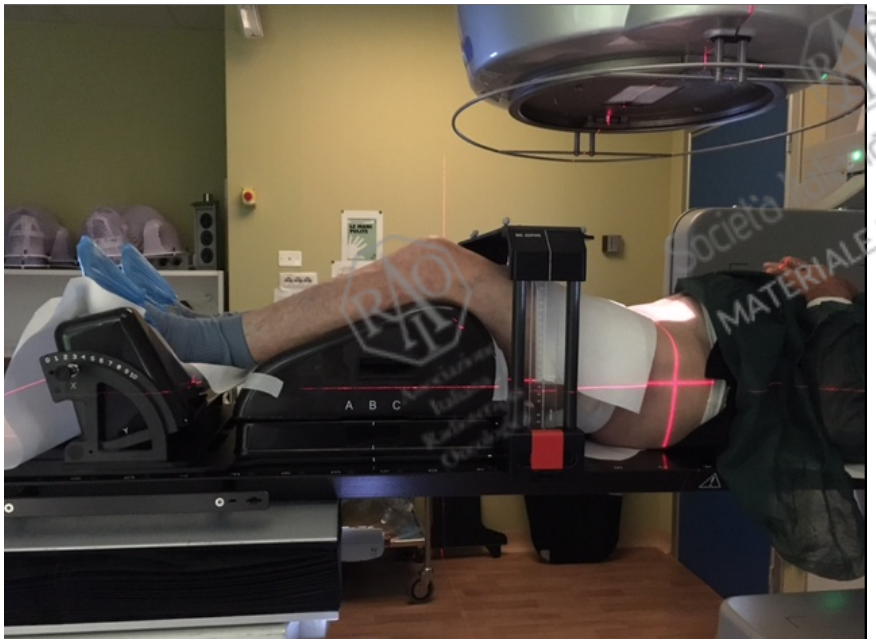


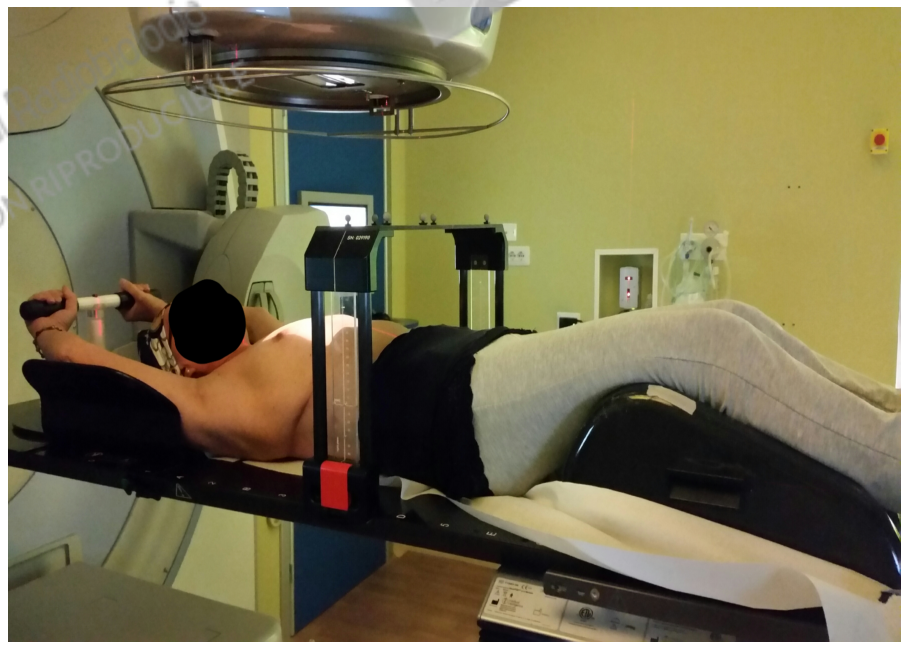
- ✓ All patients were treated with volumetric-modulated arc therapy (VMAT) using two co-planar arcs to achieve the goal of at least 95% of the PTV volume covered by at least 95% of the prescribed dose while limiting dose to normal structures.

- ✓ Prescribed doses included 30 – 48 Gy delivered in 3 to 5 fractions.

MATERIALS AND METHODS

All patients were treated in a supine position,
and method of immobilisation varied according to anatomic site.

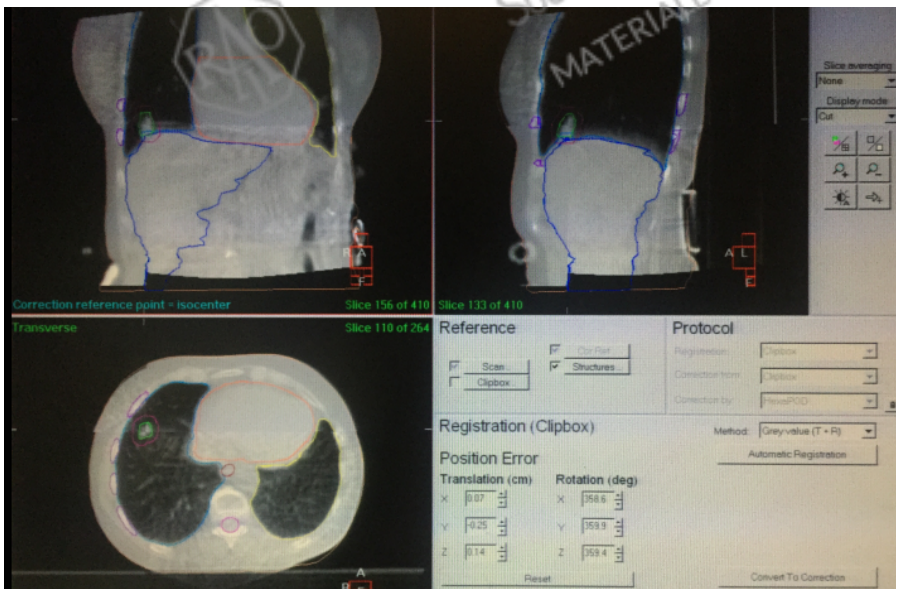


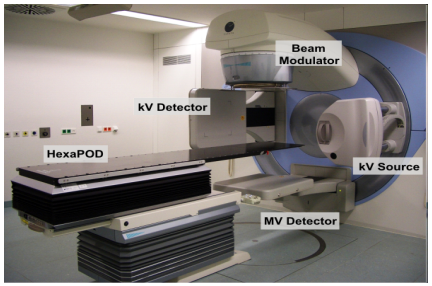


IGRT

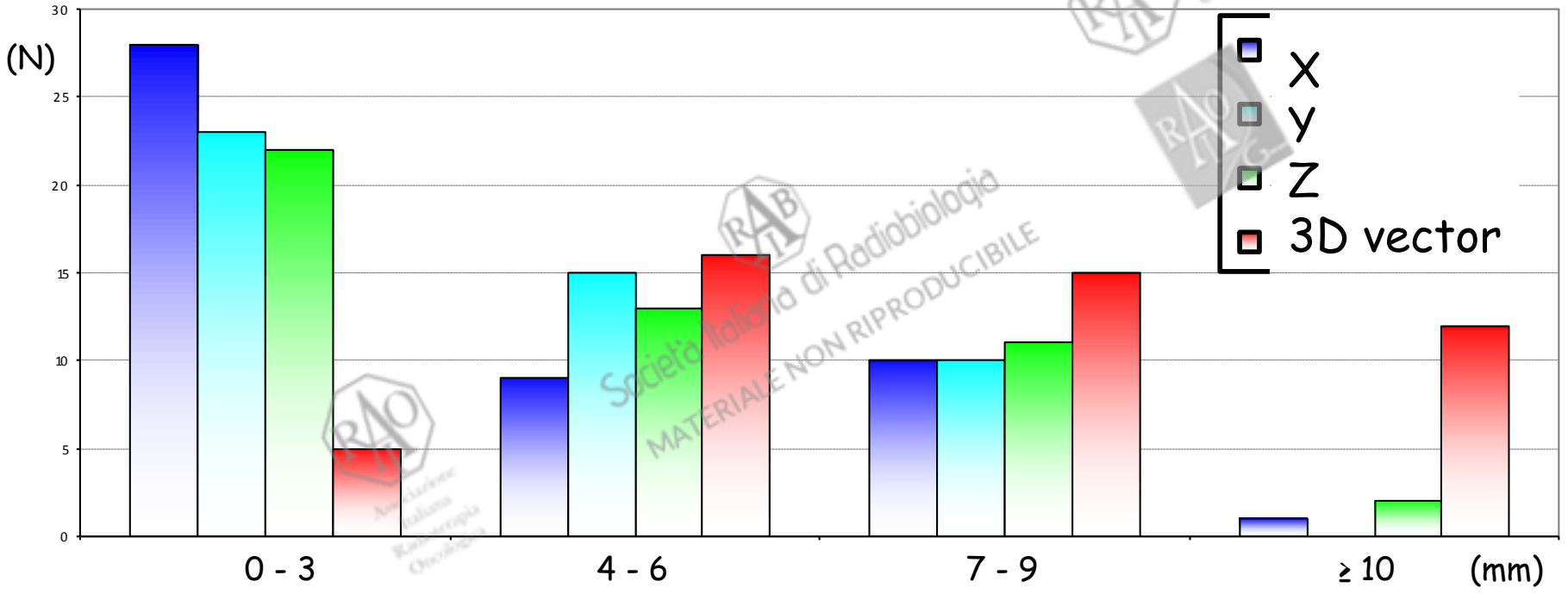
- ✓ Before VMAT, planning CT images were matched online with the daily CBCT images using by alignment clip-box.

- ✓ Positional error was calculated by the XVI software in x, y and z translational planes, and x, y and z rotational axes and then corrected using the robotic couch, applying 2 mm and 2° action levels.



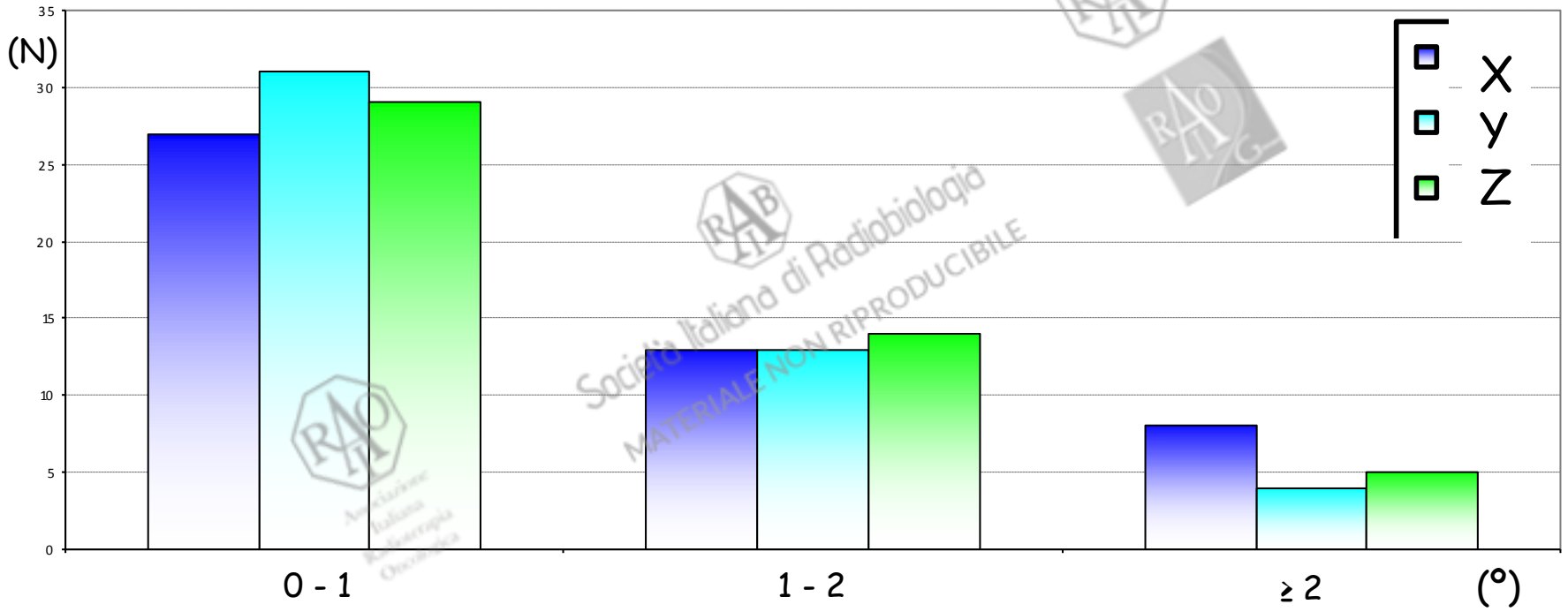


THORAX: translational error



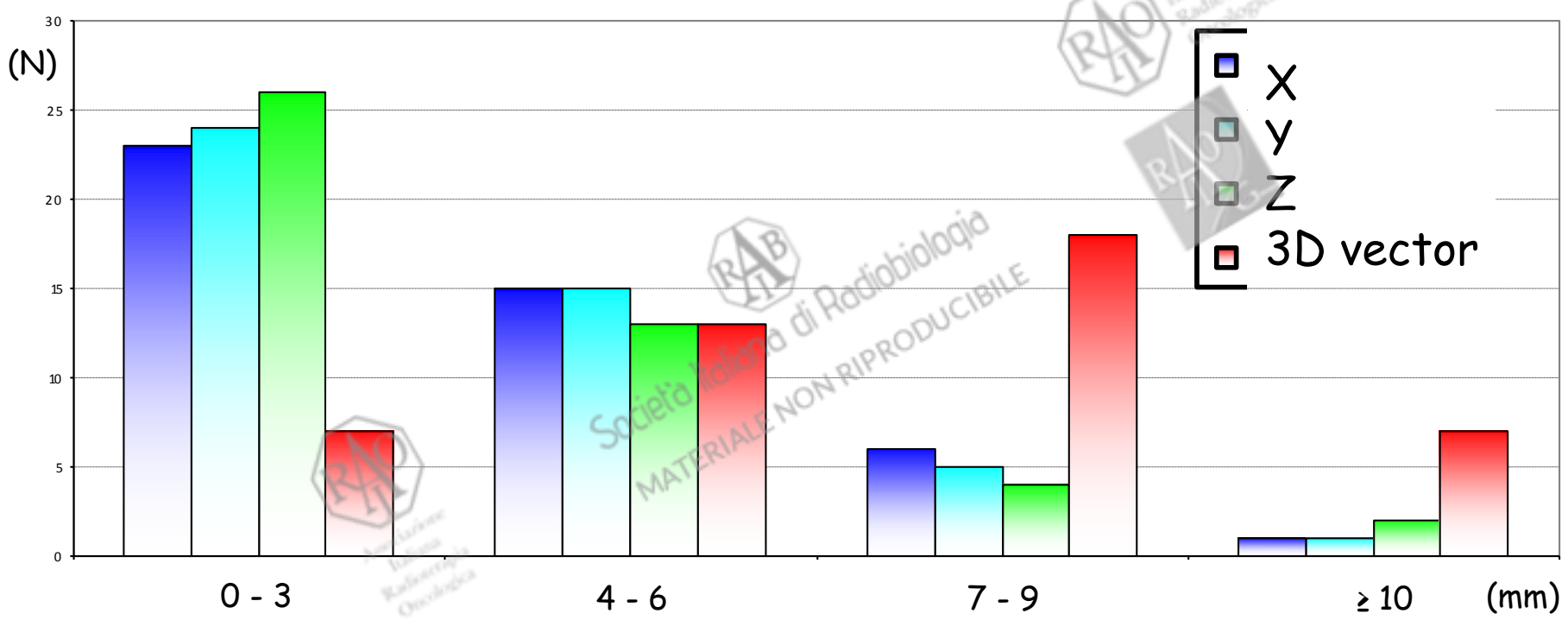
	X	y	Z	3D vector
(mm) ±SD	0 ±4.8	0 ±4.4	-0.8 ±5.2	7.2 ± 4.1

THORAX: rotational error



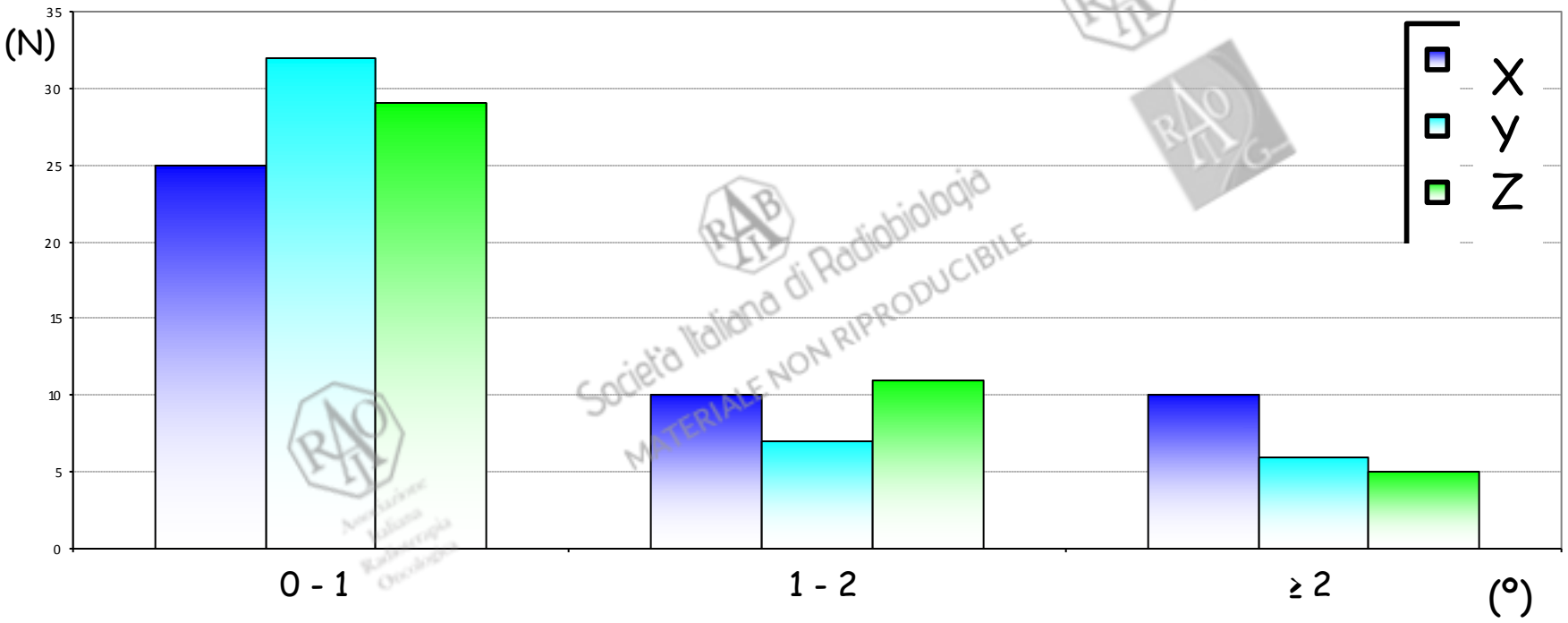
	X	Y	Z
° ±SD	-0.3 ±1.4	0.2 ±1.4	0.1 ±1.1

ABDOMEN: translational error



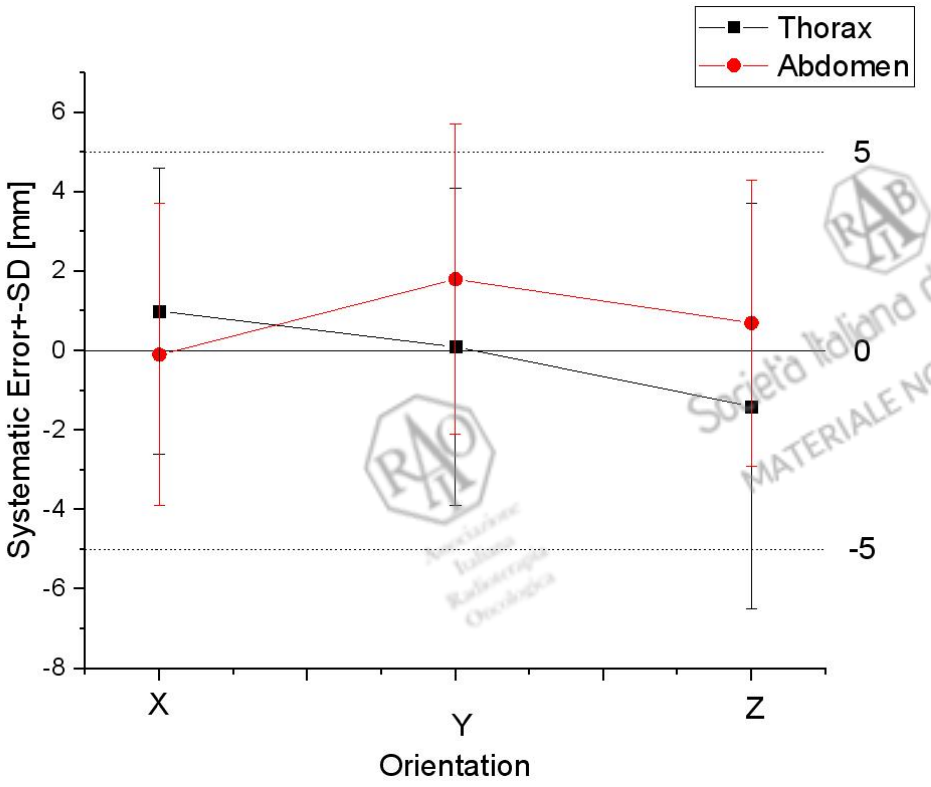
	X	Y	Z	3D vector
(mm) ±SD	0.2 ±0.5	1.8 ±5.9	1 1	7.3 ±5

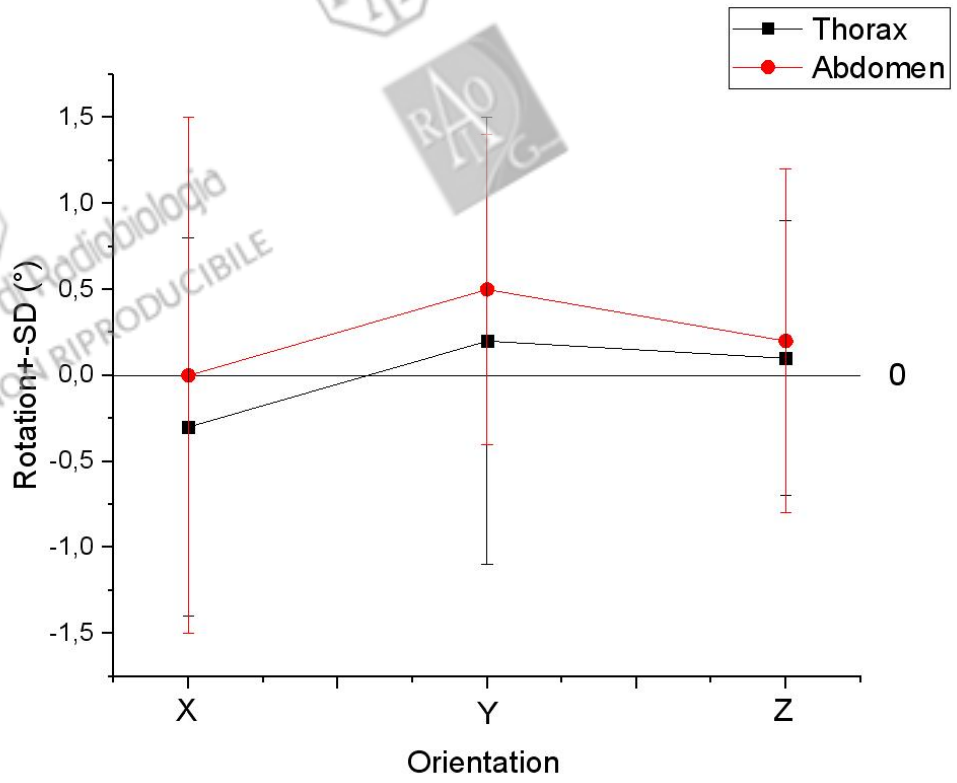
ABDOMEN: rotational error



	X	Y	Z
° ±SD	0.1 ±1.7	0.4 ±1.5	0.2 ±1.3

SYSTEMATIC ERROR

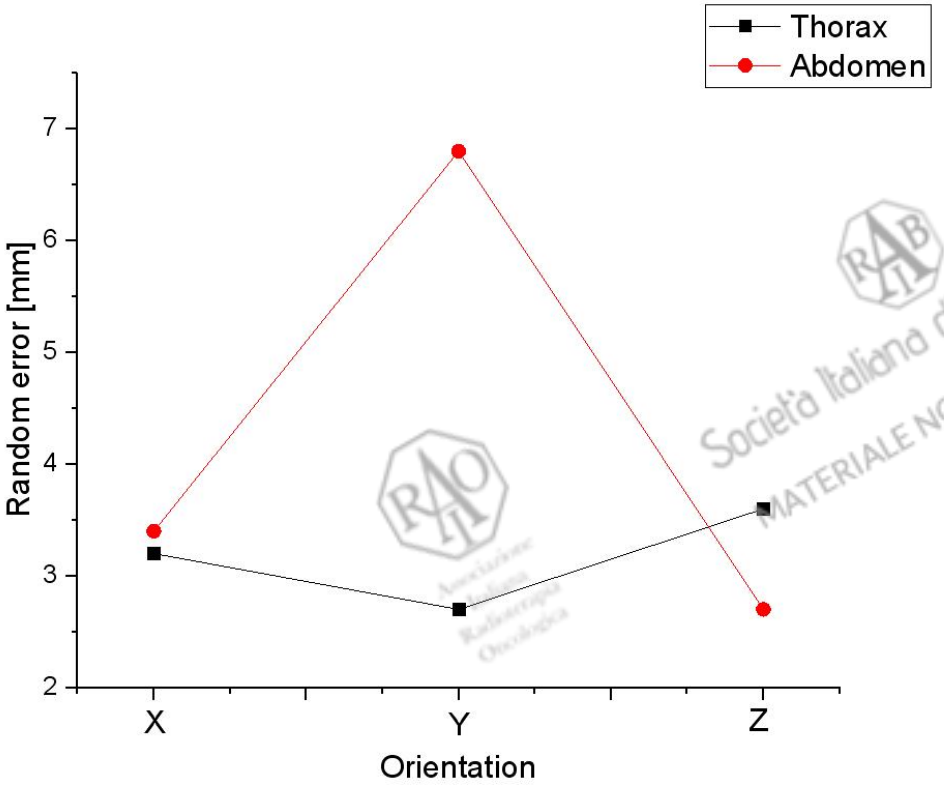


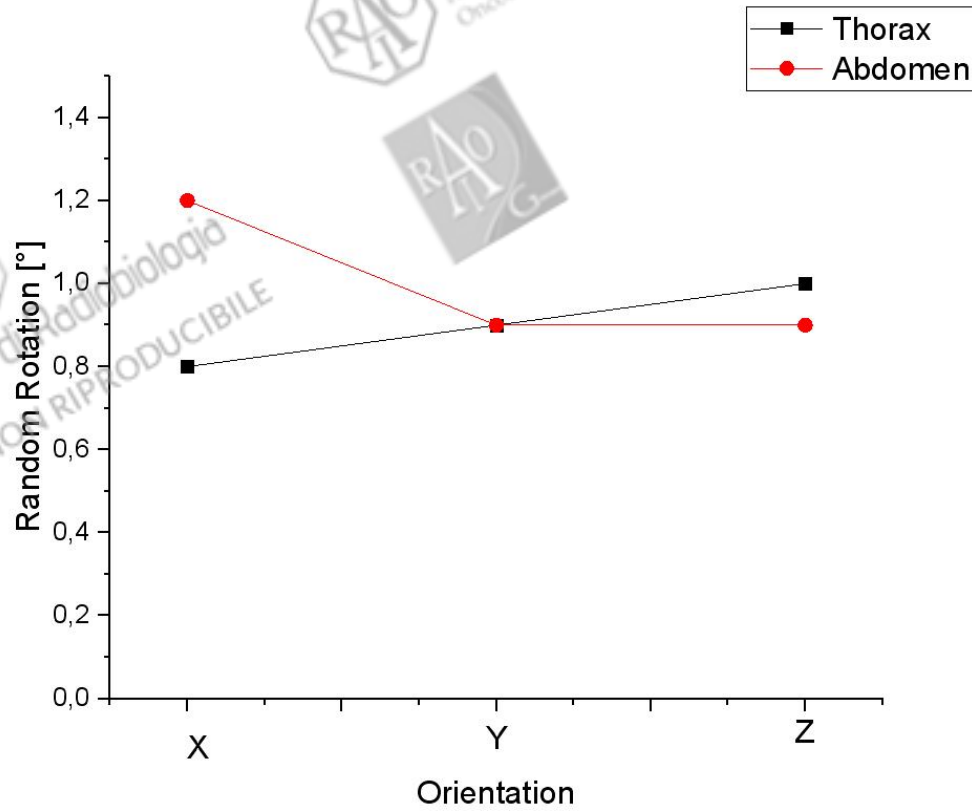


SYSTEMATIC ERROR (M) = the average of all individual means.

Van Herk M, Sem Rad Oncol 2004

RANDOM ERROR





RANDOM ERROR (δ) = the root mean squares of the SD of all patients.

Van Herk M, Sem Rad Oncol 2004

What if without IGRT?

Then he got an idea!
An awful idea!
THE GRINCH
GOT A WONDERFUL,
AWFUL IDEA!

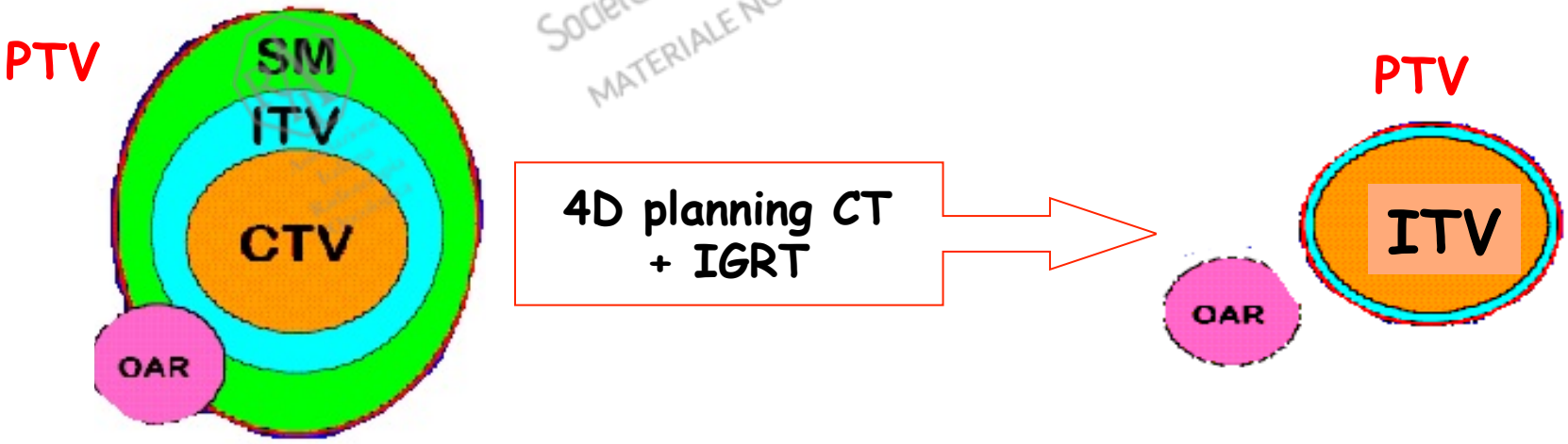
Dr Seuss, 1957

CTV to PTV MARGIN without IGRT

FORMULA	THORAX (mm)			ABDOMEN (mm)		
	X	Y	Z	X	Y	Z
ICRU 62 **Σ + 0.7 σ**	5.8	5.8	7.5	6.2	8.6	5.5
Stroom's **2 Σ + 0.7 σ**	9.6	9.7	12.5	10	12.6	9.1
Van Herk's **2.5 Σ + 0.7 σ**	11.2	11.6	15	11.9	14.5	10.9

...so IGRT MATTERS!!!

With IGRT,
the CTV to PTV margin can be 0 mm?



RESIDUAL SOURCES OF ERROR

- ✓ Resolution of imaging
- ✓ Accuracy of image fusion
- ✓ Accuracy of target delineation
- ✓ Accuracy of mechanical isocentre (<2 mm radius at our Institution)
- ✓ Intrafraction error
- ✓ Accuracy of radiation/treatment isocentre (0.5 mm at our Institution).
- ✓ Resolution of couch positioning (0.5 mm and 0.5°).

CONCLUSIONS

- ✓ IGRT improves the accuracy of VMAT SBRT, reducing set-up uncertainty.

- ✓ With 4D planning CT and image-guidance with CBCT, the current applied planning margins for abdominal and thoracic oligometastases at our Institution appear safe.

Thanks for your attention!