Radiochirurgia e Radioterapia stereotassica: non solo tecnica

CONVEGNO DEL GRUPPO REGIONALE PIEMONTE-LIGURIA-VALLE D'AOSTA

Associazione Italiana Radioterapia Oncologica

Nuovi constraints di dose

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● *Original Contribution*

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TOLERANCE OF NORMAL TISSUE TO THERAPEUTIC IRRADIATION

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- 1991
- Pre 3DCRT
- Volume effect (1/2-1/3-whole organ)

Table 1. Normal tissue tolerance to therapeutic irradiation

Organ	TD 5/5 Volume 1/3	TD 5/5 Volume 2/3	TD 5/5 Volume 3/3	TD 50/5 Volume 1/3	TD 50/5 Volume 2/3	TD 50/5 Volume 3/3	Selected endpoint
Kidney I	5000	3000*	2300	—	4000*	2800	Clinical nephritis
Kidney II							
Bladder	N/A	8000	6500	N/A	8500	8000	Symptomatic bladder contracture and volume loss
Bone:							
Femoral Head I and II	—	—	5200	—	—	6500	Necrosis
T-M joint mandible	6500	6000	6000	7700	7200	7200	Marked limitation of joint function
Rib cage	5000	—	—	6500	—	—	Pathologic fracture
Skin	10 cm² / —	30 cm² / —	100 cm² / 5000	10 cm² / —	30 cm² / —	100 cm² / 6500	Telangiectasia
	7000	6000	5500	—	—	7000	Necrosis Ulceration
Brain	6000	5000	4500	7500	6500	6000	Necrosis Infarction
Brain stem	6000	5300	5000	—	—	6500	Necrosis Infarction
Optic nerve I & II	No partial volume		5000	—	—	6500	Blindness
Chiasma	No partial volume		5000	No partial volume		6500	Blindness
Spinal cord	5 cm / 5000	10 cm / 5000	20 cm / 4700	5 cm / 7000	10 cm / 7000	20 cm / —	Myelitis necrosis
Cauda equina	No volume effect		6000	No volume effect		7500	Clinically apparent nerve damage
Brachial plexus	6200	6100	6000	7700	7600	7500	Clinically apparent nerve damage
Eye lens I and II	No partial volume		1000	—	—	1800	Cataract requiring intervention
Eye retina I and II	No partial volume		4500	—	—	6500	Blindness
Ear mid/external	3000	3000	3000*	4000	4000	4000*	Acute serous otitis
Ear mid/external	5500	5500	5500*	6500	6500	6500*	Chronic serous otitis
Parotid* I and II	—	3200*	3200*	— (TD 100/5 is 5000)	4600*	4600*	Xerostomia
Larynx	7900*	7000*	7000*	9000*	8000*	8000*	Cartilage necrosis
Larynx	—	4500	4500*	—	—	8000*	Laryngeal edema
Lung I	4500	3000	1750	6500	4000	2450	Pneumonitis
Lung II							
Heart	6000	4500	4000	7000	5500	5000	Pericarditis
Esophagus	6000	5800	5500	7200	7000	6800	Clinical stricture/ perforation
Stomach	6000	5500	5000	7000	6700	6500	Ulceration, perforation
Small intestine	5000		4000*	6000		5500	Obstruction perforation/fistula
Colon	5500		4500	6500		5500	Obstruction perforation/ ulceration/fistula
Rectum	Volume 100 cm³ No volume effect		6000	Volume 100 cm³ No volume effect		8000	Severe proctitis/ necrosis/fistula, stenosis
Liver	5000	3500	3000	5500	4500	4000	Liver failure

*<50% of volume doesn't make a significant change.

QUANTEC:

Organ	Volume segmented	Irradiation type (Partial organ unless otherwise stated)*	Endpoint	Dose (Gy), or dose/volume parameters*		Rate (%)	Notes on dose/volume parameters
Brain	Whole organ	3D-CRT	Symptomatic necrosis	Dmax	< 60	< 3	
	Whole organ	3D-CRT	Symptomatic necrosis	Dmax	72	5	Data at 72 and 90 Gy extrapolated from BED models.
	Whole organ	3D-CRT	Symptomatic necrosis	Dmax	90	10	
	Whole organ	SRS (single fraction)	Symptomatic necrosis	V12	< 5-10 cc	< 20	Rapid rise when V12 > 5-10 cc
Brain stem	Whole organ	Whole organ	Permanent cranial neuropathy or necrosis	Dmax	< 54	< 5	
	Whole organ	3D-CRT	Permanent cranial neuropathy or necrosis	D1-10cc****	≤ 59	< 5	
	Whole organ	3D-CRT	Permanent cranial neuropathy or necrosis	Dmax	< 64	< 5	Point dose << 1 cc
	Whole organ	SRS (single fraction)	Permanent cranial neuropathy or necrosis	Dmax	< 12.5	< 5	For patients with acoustic tumors
Optic nerve / chiasm	Whole organ	3D-CRT	Optic neuropathy	Dmax	< 55	< 3	
	Whole organ	3D-CRT	Optic neuropathy	Dmax	= 55-60	3-7	Given the small size, 3D CRT is often whole organ#
	Whole organ	3D-CRT	Optic neuropathy	Dmax	> 60	> 7-20	

But SBRT before

- protocols
- QUANTEC
- Report of AAPM Task Group 101

Dose tolerance guidelines were extremely rare

-> we began to accumulate sparsely published data

It grew to 500 dose tolerance limits and as of 2016 over 1000 published limits but

- Discordant
- Ever changing
- Lack quantitative estimates of corresponding incidence of complication

- NTCP for SBRT are considerably different from conventional RT due to extreme dose fractionation schemes

- Normal tissue dose limits for SBRT should not be directly extrapolated from conventional RT data

- Attention to fraction size, total dose, time intrafractions, OTT

Seminars in RADIATION ONCOLOGY
Volume 26, Number 2 April 2016

Dose Tolerance for Stereotactic Body Radiation Therapy

- NTCP for SBRT!

few published dose-response models to evaluate. The selection criteria for this issue of Seminars, therefore, are the complete opposite: each of these articles after the introduction presents new data and dose-response modeling from an institution, for a critical structure that previously did not have many published dose-response models for SBRT, or where an additional new model could supplement the information that had been sparse. We hope that both projects provide enduring value to the field.

Dose tolerance limit

Human dose tolerance to RT depends on many factors but must specify at least:

- Dose
- Fractionation
- Volume
- Endpoint
- Follow up
- Estimated risk of the endpoint occurring within the follow up time

Endpoint and length of follow up must be clearly stated
Emami 5 years -> convenient, both early and late toxicity but for SBRT…..

- No much available data yet
- Interest in timing of the onset of symptoms

DVH Risk Map:

Seminars in
RADIATION
ONCOLOGY

Introduction and Clinical Overview of the DVH Risk Map

Sucha O. Asbell, MD,[*] Jimm Grimm, PhD,[†] Jinyu Xue, PhD,[*]
Meng-Sang Chew, PhD,[‡] and Tamara A. LaCouture, MD[*]

- Simple graph

-> information relating a range of dose tolerance limits as a function of the number of fractions

-> help physicians make decisions

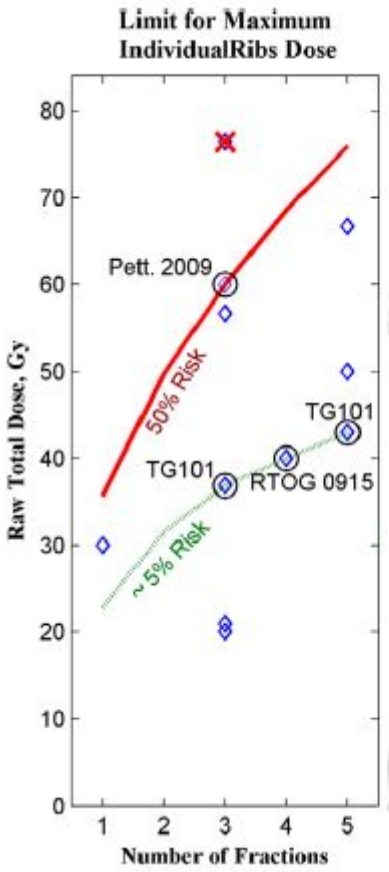
- Show the state of the literature for each critical structure

Low risk – high risk:

EMAMI: 5% and 50% risk levels

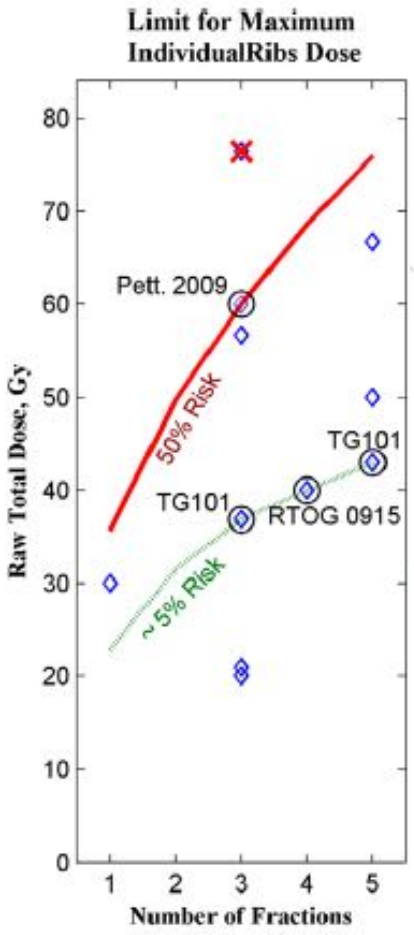
but some structures (spinal cord) required much lower complications rate than others structures as ribs.

compromise



QUANTEC: custom risk levels for each structure

- Includes a plot of all published dose tolerance limits in 1-5 fractions -> the highest commonly used limit is selected as the high risk limit
- Low risk limit



Number Of Fractions	Low-Risk Limit (~5%) Dmax Limit (Gy)	High-Risk Limit (~50%) Dmax Limit (Gy)
3 fx	36.9 Gy (ref 41), 4.5% Risk	60 Gy (ref 58), 49.9% Risk
4 fx	40.0 Gy (ref 39), 3.9% Risk	
5 fx	43.0 Gy (ref 41)	

The risk level of each of these limits can be determined from a dose response model, that is an equation that gives risk as a function of dose

✧ each published limit

X published complications for which there is insufficient data to know if it is an acceptable risk level

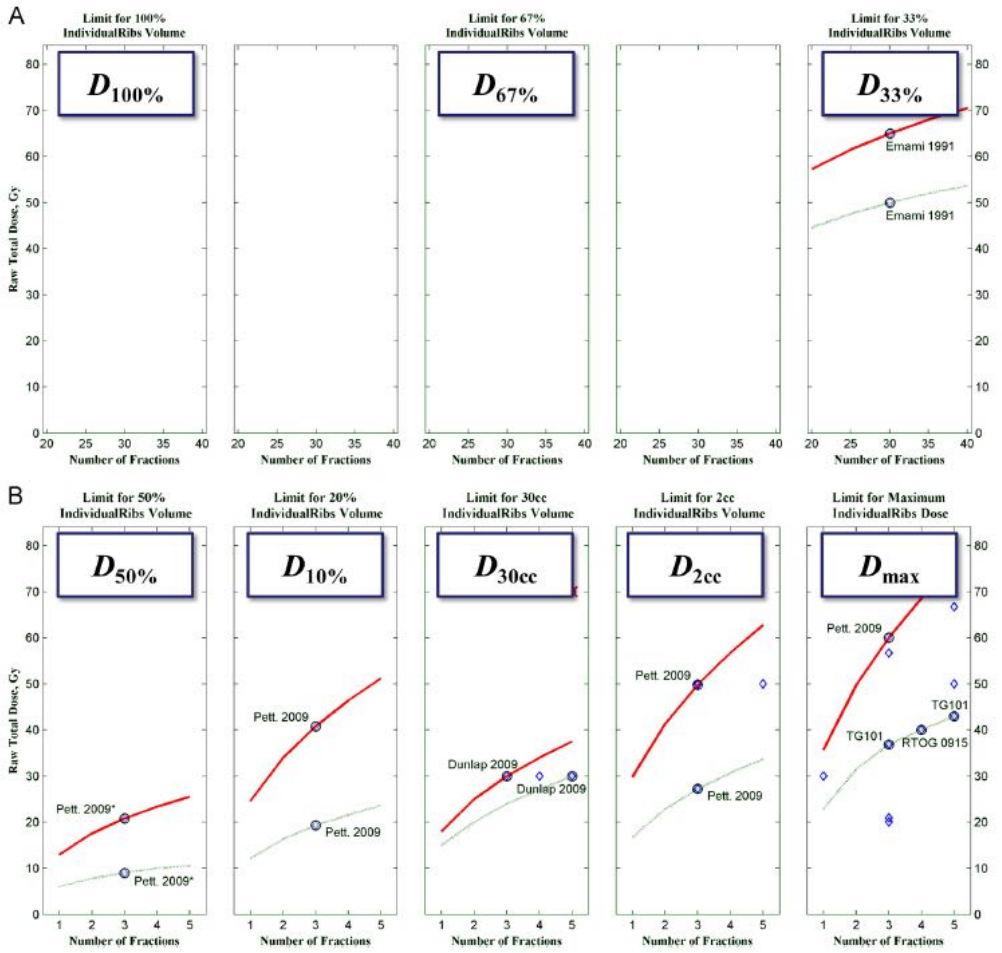
Volume effects:

1- Conventional fractionation

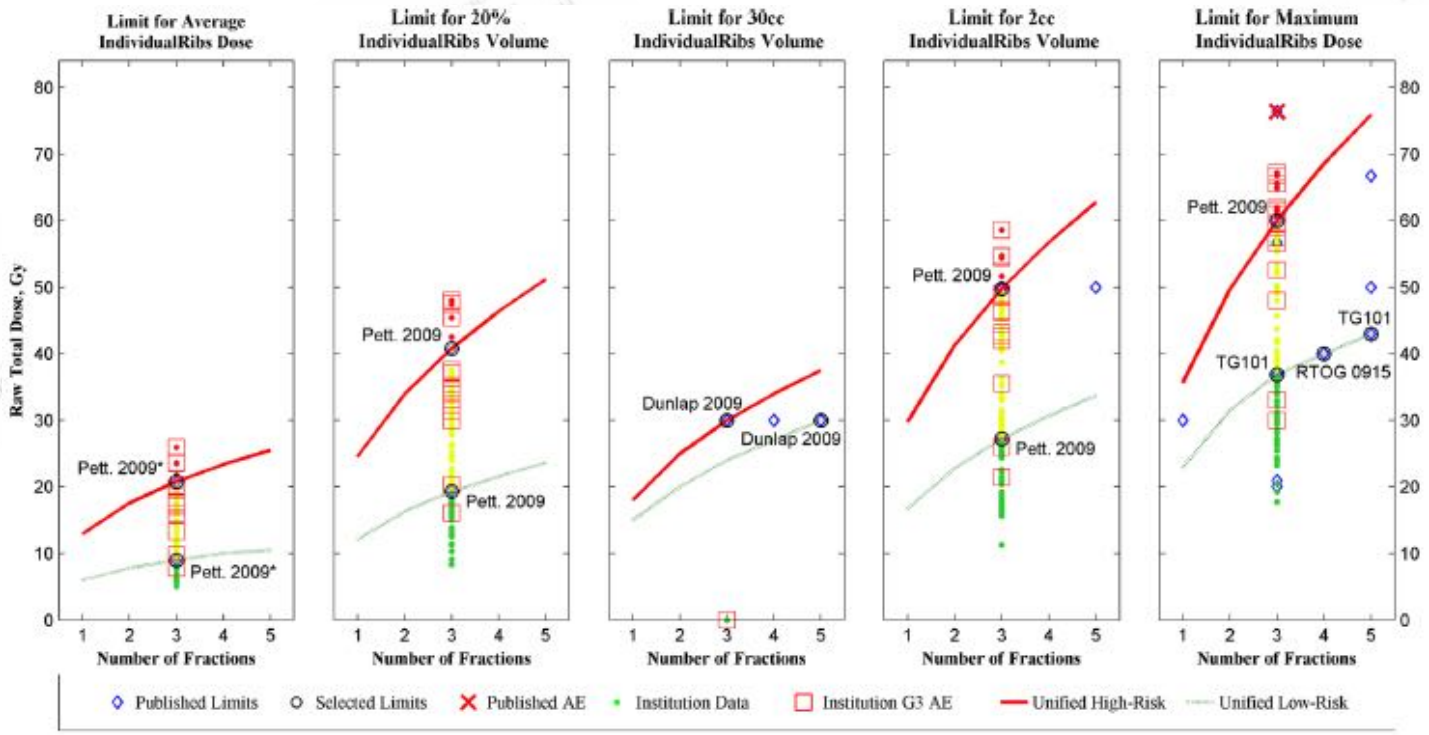
EMAMI: dose tolerance limits for large volumes

2- SBRT

Smaller volumes
Absolute volumes ->
Specific to each anatomical structure

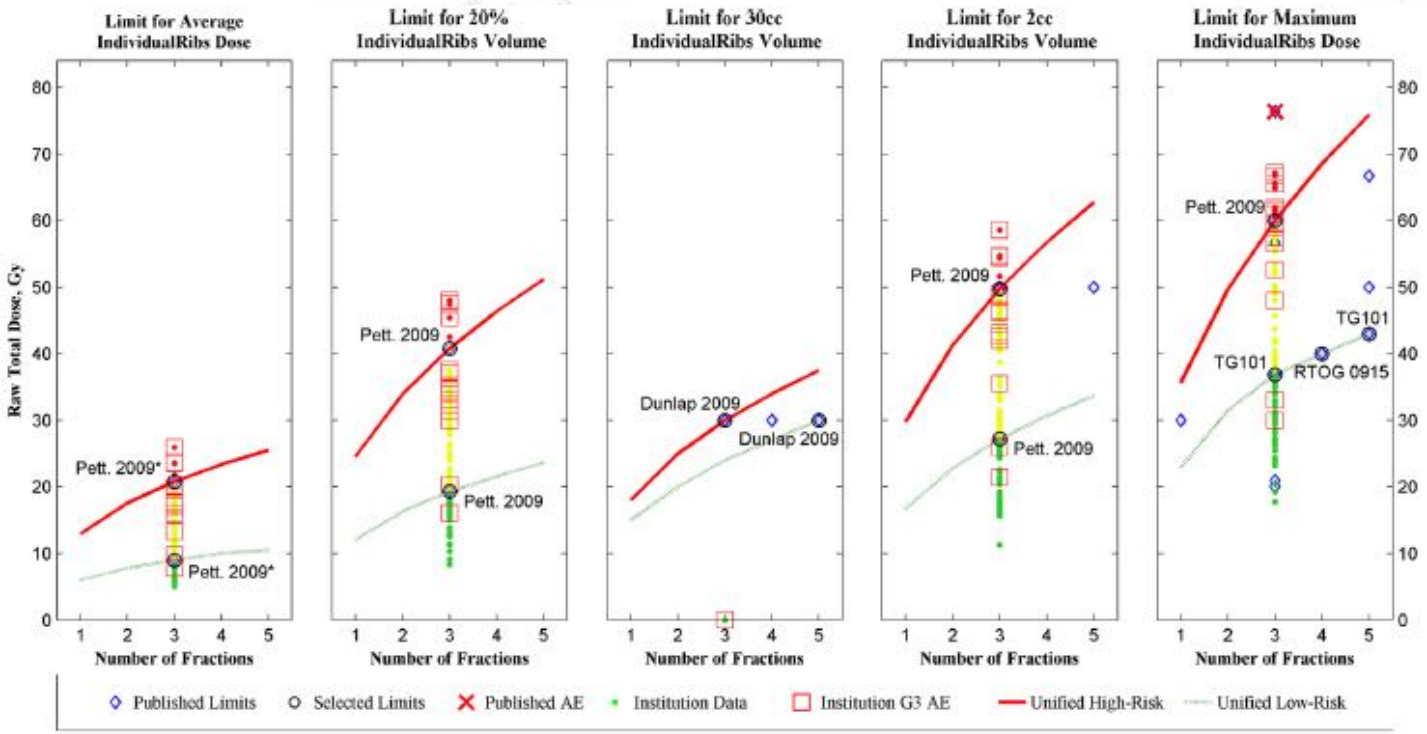


DVH Risk map for ribs:



Endpoint: RT induced rib fractures G1 up to G3-4

- dose volume points below low risk limits
- dose volume points above high risk limits
- dose volume points between low and high risk limits



	Low Risk Limits					High Risk Limits				
	Dmean Limit (Gy)	D20% Limit (Gy)	D30cc Limit (Gy)	D2cc Limit (Gy)	Dmax Limit (Gy)	Dmean Limit (Gy)	D20% Limit (Gy)	D30cc Limit (Gy)	D2cc Limit (Gy)	Dmax Limit (Gy)
1 fx	*6.0*	*12.1*	*15.0*	*16.7*	*22.9*	*12.9*	*24.6*	*18.0*	*29.8*	*35.7*
2 fx	*7.8, 5.0%*	*16.3, 5.0%*	*20.0*	*22.8, 5.0%*	*31.5, 5.0%*	*17.6, 50.0%*	*33.9, 50.0%*	*25.0*	*41.3, 50.0%*	*49.7, 50.0%*
3 fx	**9.0, 5.0%**	**19.3, 5.0%**	*24.0*	**27.2, 5.0%**	**36.9, 4.5%**	**20.8, 50.0%**	**40.8, 50.0%**	**30.0**	**49.8, 50.0%**	**60.0, 49.9%**
4 fx	*10.0, 5.1%*	*21.6, 5.0%*	*27.0*	*30.7, 5.0%*	**40.0, 3.9%**	*23.4, 50.0%*	*46.4, 50.0%*	*34.0*	*56.8, 50.0%*	*68.6, 50.0%*
5 fx	*10.5*	*23.6*	**30.0**	*33.7*	**43.0**	*25.5*	*51.2*	*37.5*	*62.8*	*76.0*

Next

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Normal Tissue Tolerance in Stereotactic Body Radiation Therapy

Edited by Jimm Grimm

Conclusions:

DVH risk map ->

- important information in relation to the choice of the fractionation and volume effect

- allow an immediate estimate of the risk


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FARMACI INNOVATIVI E RADIOTERAPIA IPOFRAZIONATA
quali effetti sui tessuti sani, come cambiano i vincoli di dose
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THANK YOU