

Tomoterapia: patologie pediatriche

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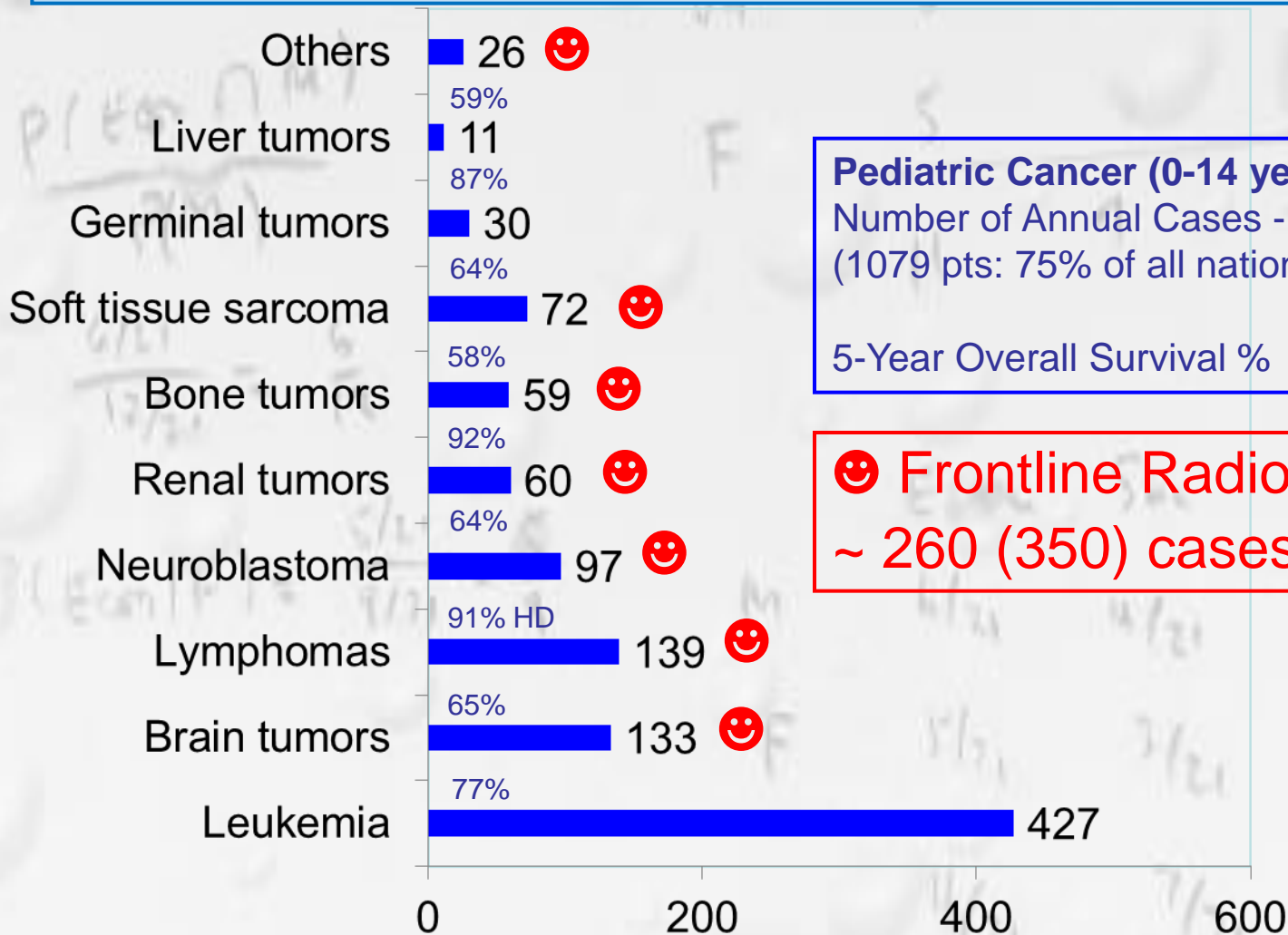
Learning Objectives

1. Describe the relevant clinical aspects of RT for common childhood malignancies.
2. Identify the general guidelines for administering Tomotherapy in children.
3. Consider the importance of normal tissue irradiation and treatment related effects.



Pediatric Cancer 1989-1998

Number of Annual Cases - AIEOP Registry



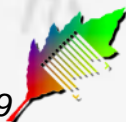
Pediatric Cancer (0-14 years)
 Number of Annual Cases - AIEOP Registry
 (1079 pts: 75% of all national childhood cancer)

5-Year Overall Survival %

😊 Frontline Radiotherapy
 ~ 260 (350) cases

Modified from:

Pession A. et al. AIEOP study, *E J Cancer* 44 (2008) 1282-1289



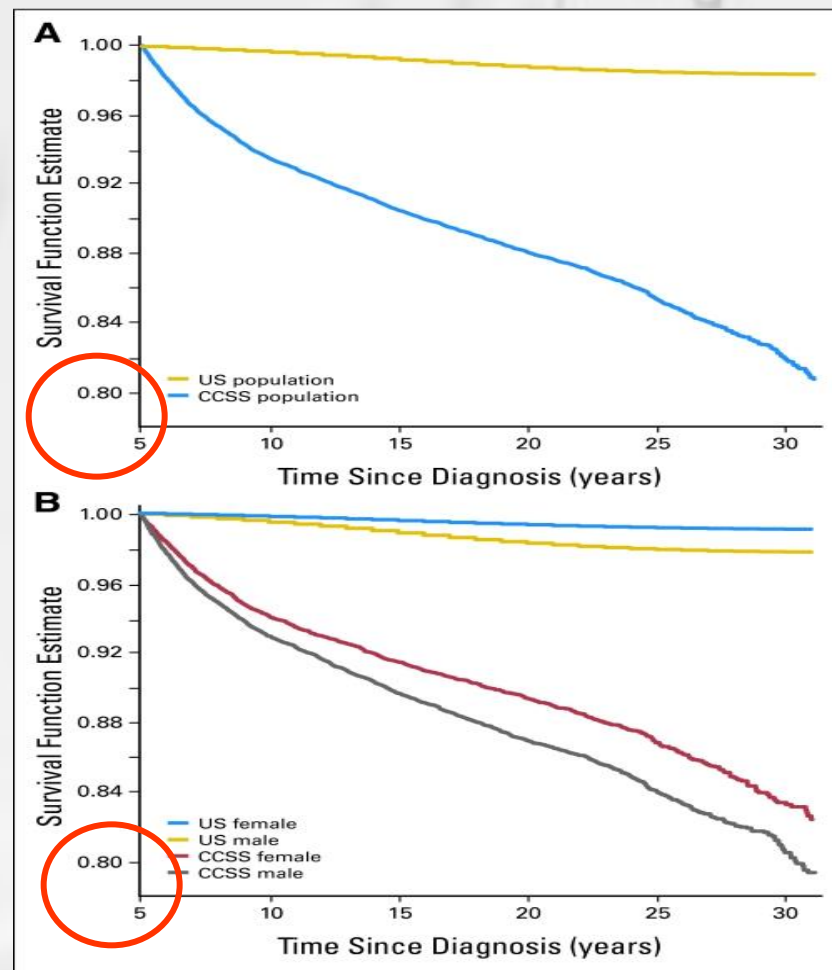
Late mortality experience in five-year survivors of childhood and adolescent cancer: the Childhood Cancer Survivor Study (20.483 pts; years 1979-2002)

Recurrent disease remains a major contributor.

A significant excesses in mortality risk is associated with treatment related complications.

- **Quality**

- **Quantity**



Pediatric Oncology

• Characteristics

- Variety of tumors/sites
- Prognoses documented
- Broad range of effects
- **Combined modality therapy**
- **Large treatment volumes**
- **Potential for long term survival**

• Trends considerations

- **Decrease indications for RT (Ped Onc)**
- **Increase indications for newRT (Rad Onc)**
- Young patients routinely treated
- Volumetric treatment
- Interest in late effects
- **Late effects of new technologies**



Target Definition



Target Volume Definition

Contouring

Nasal cavity

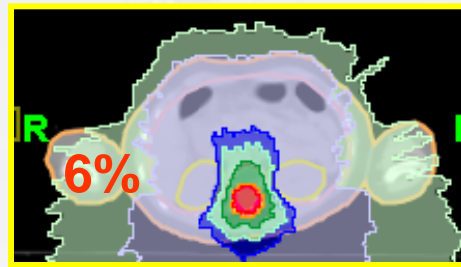
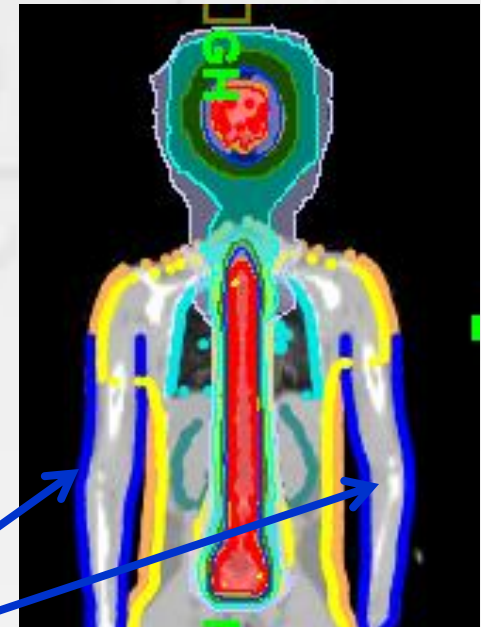
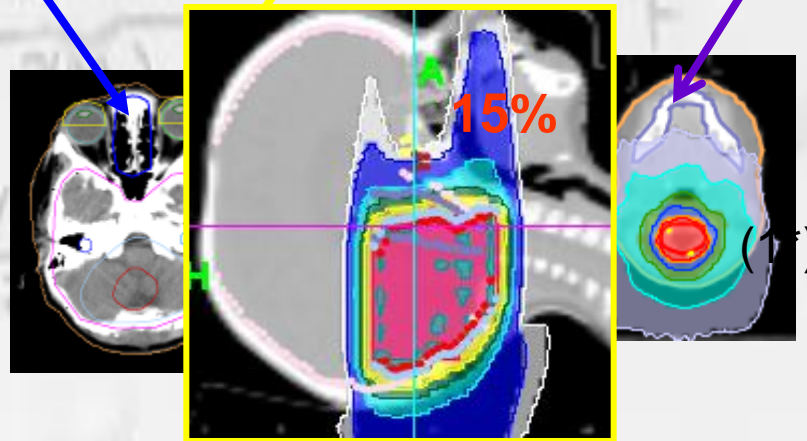
Eye, anterior part

Teeth

Arms

Breasts

- 32.4
- 30.78
- 22.68
- 16.2
- 9.72
- 6.48
- 3.24

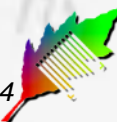
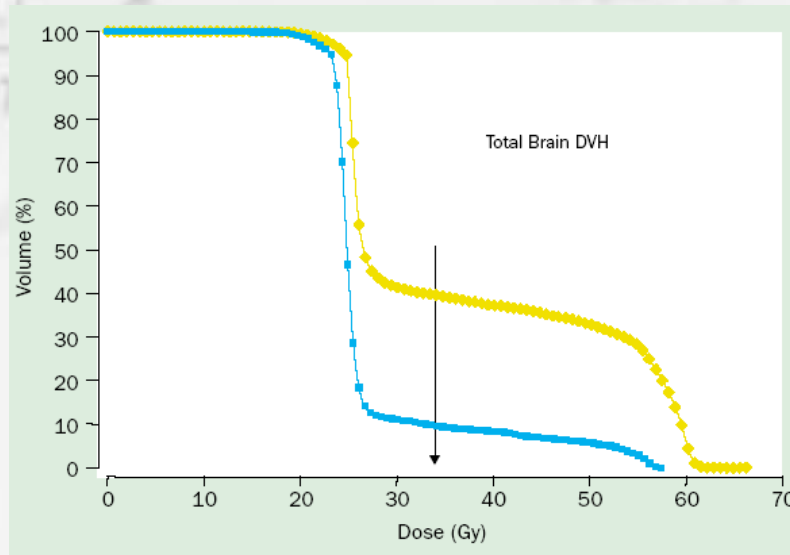
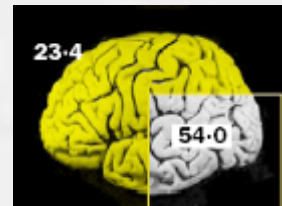
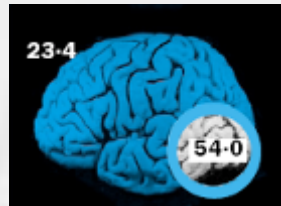
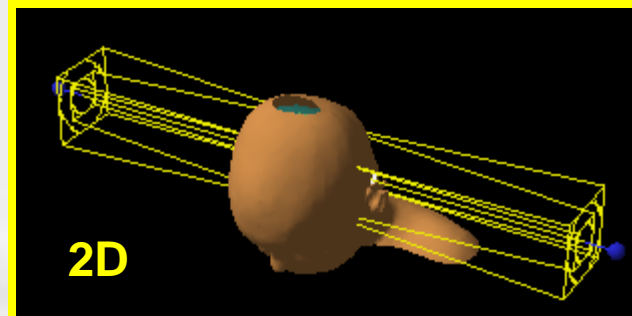
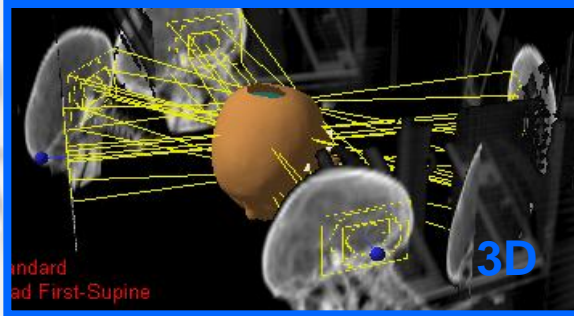


If you don't contour, it doesn't "count" (OAR)



Posterior fossa RT

% of supratentorial brain irradiated



$$P(Ecom|M) = \frac{P(Ecom \cap M)}{P(M)}$$

	Ecom	Sci	P.I Sci	
M	6	4	2	12
F	5	3	2	9
		7	3	21

Immobilization and IGRT

$$P(Ecom|F) = \frac{5/21}{9/21} = \frac{5}{9}$$

	Ecom	Sci	P.I Sci	
M	6/21	4/21	2/21	12/21
F	5/21	3/21	2/21	9/21
		7/21	3/21	21/21

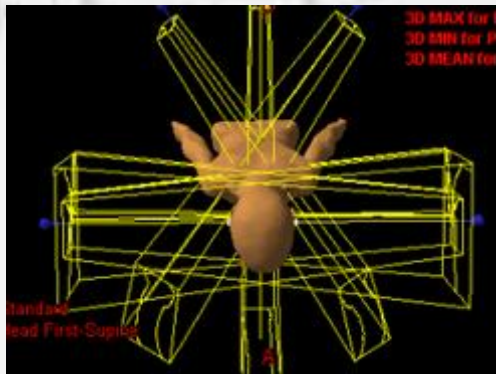


•IMRT - Tomo in Pediatric-Adolescent Patients

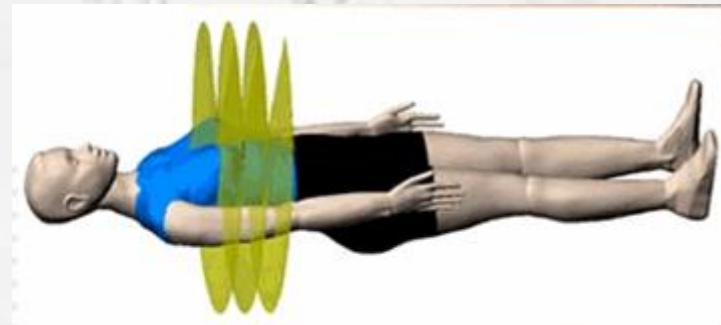
What do we change with Tomo?

•**The position of patient**

•**Supine position is well accepted by anesthesiologists**



Traditional → Prone

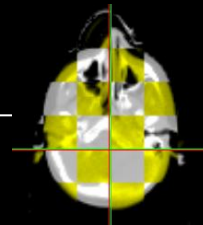
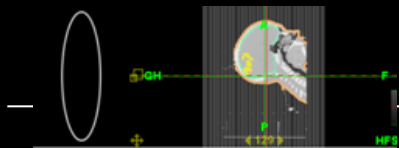


Tomo → Supine

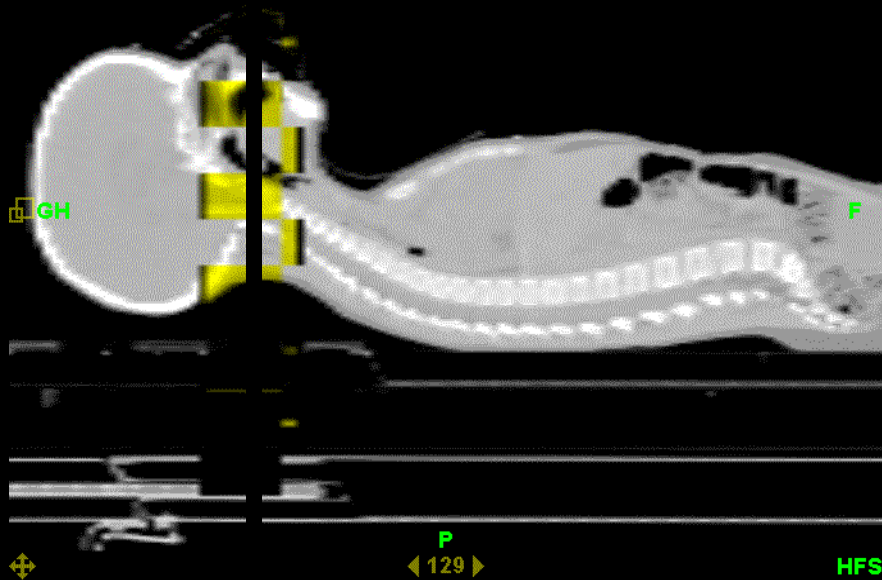


Image Guided Radiotherapy and Tomo

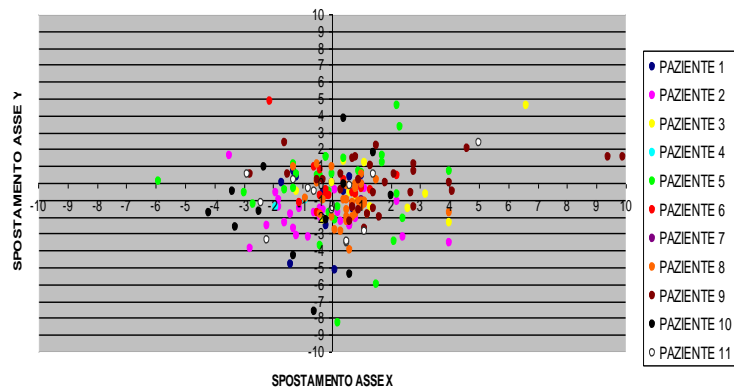
Brain: CT Guidance



A
MVCT



Mask and sedation



< 4 mm Motion and 2° Roll

MVCT imaging fused with planning CT



Patients selections for new technologies



Selections

Criteria for which we have chosen IMRT-Tomo:

- ✓ **The conformality of RT to the target is critical**
- ✓ **Target close to an OAR**
- ✓ **The tumor's shrinking after CT/RT**
- ✓ **Potential disadvantages, like “low-dose bath”**
- ✓ **Importance of the positional uncertainty of dose delivery IGRT**
- ✓ **Time for therapy (setup and anesthesia)**
- ✓ **The time required for planning RT**

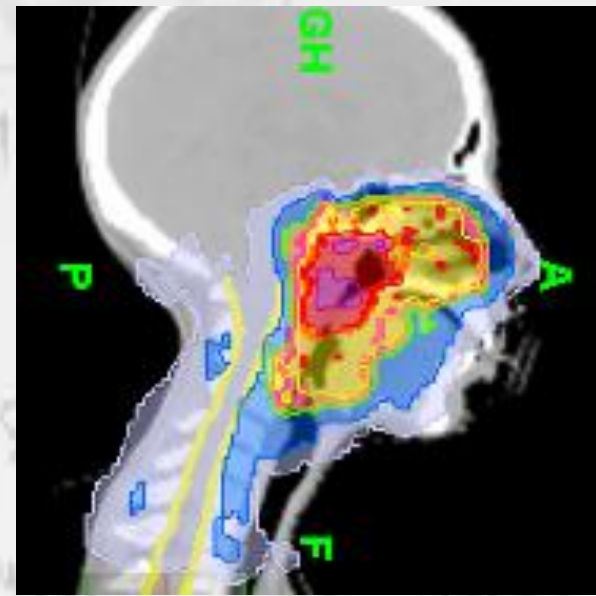
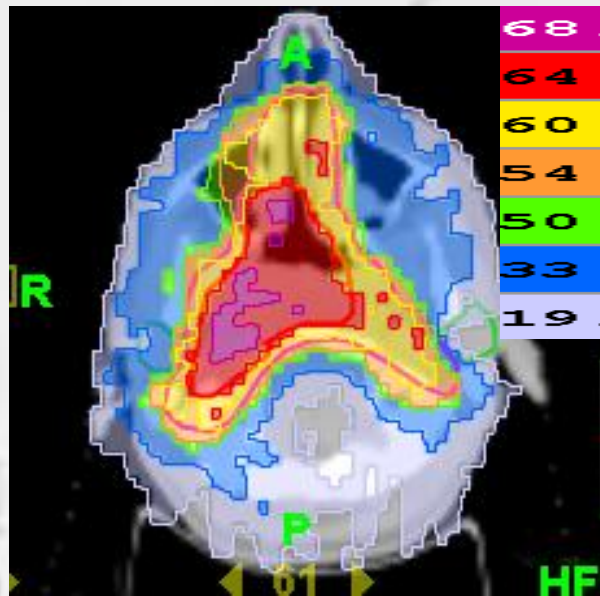
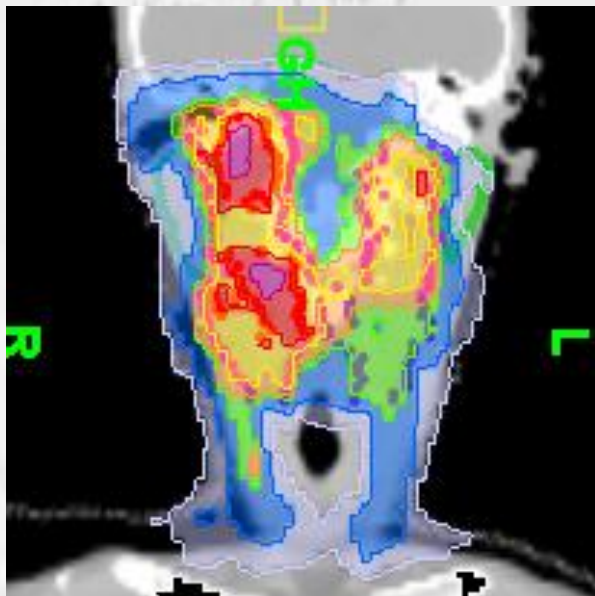


Dose Distribution



Nasopharynx cancer

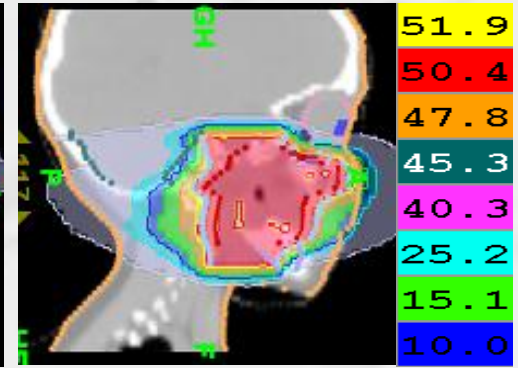
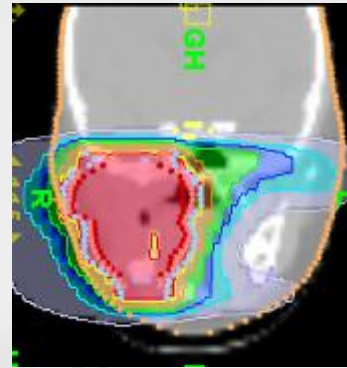
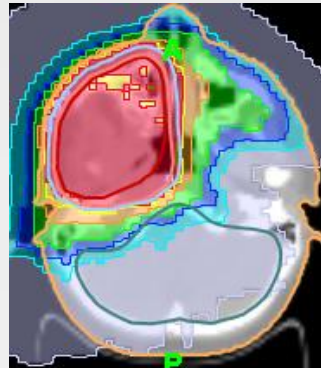
Female 14 y,
Nasopharynx carcinoma



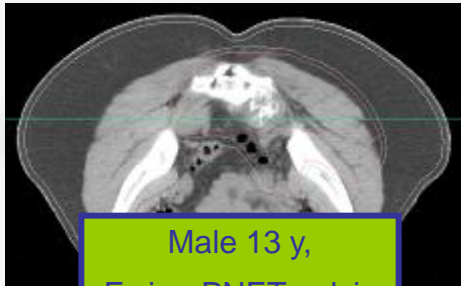
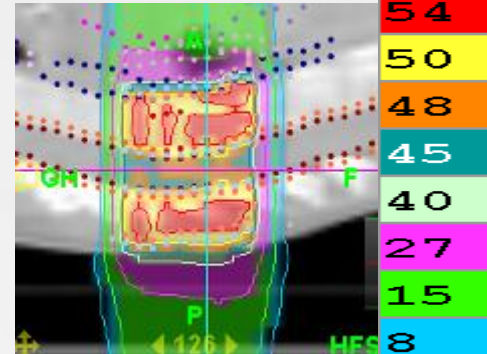
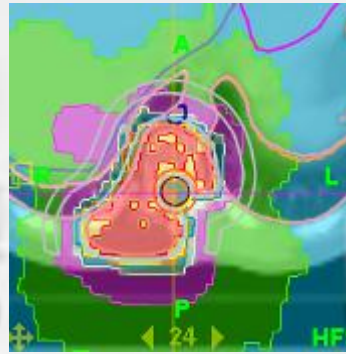
Soft tissue and bone sarcomas



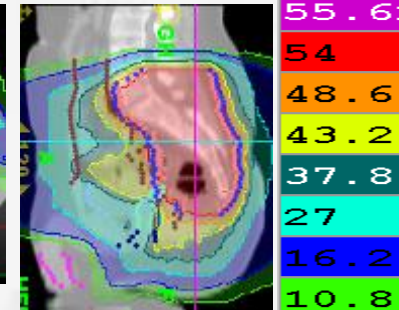
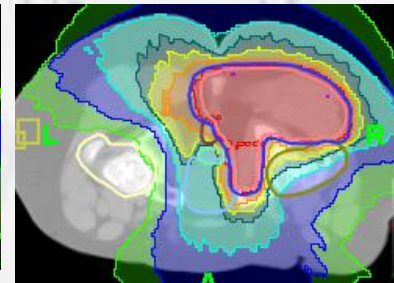
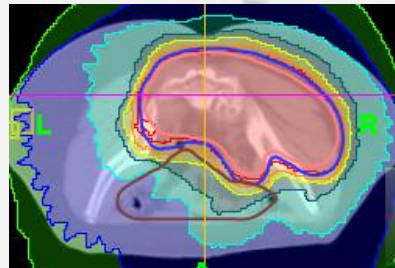
Female 3 y,
Parameningeal RMS



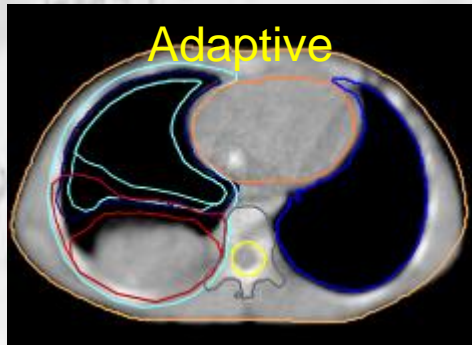
Female 8 y,
D9 Ewing sarcoma



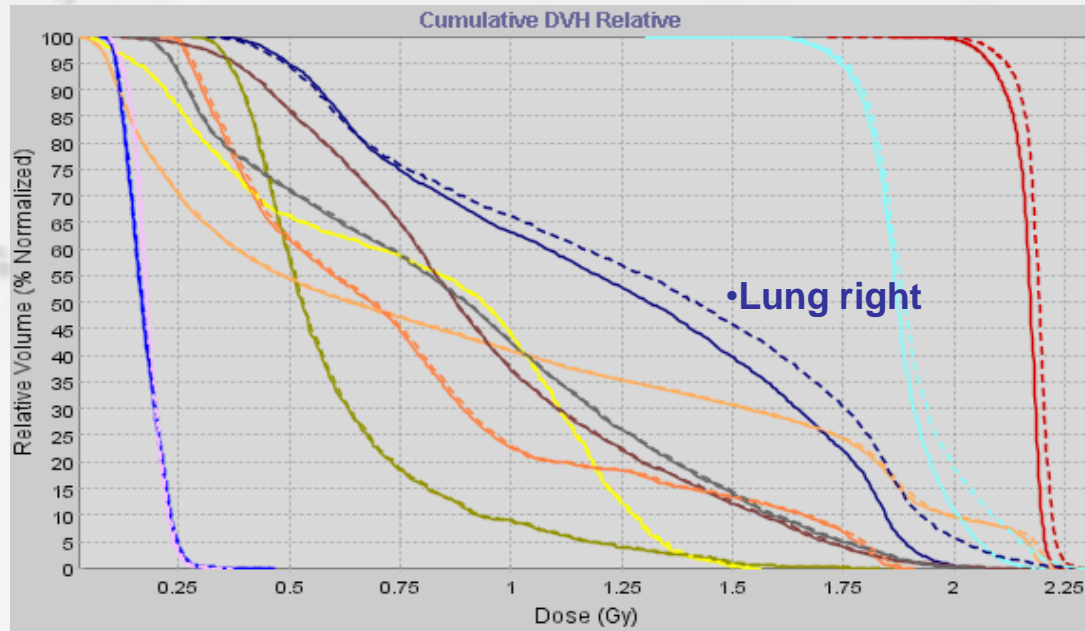
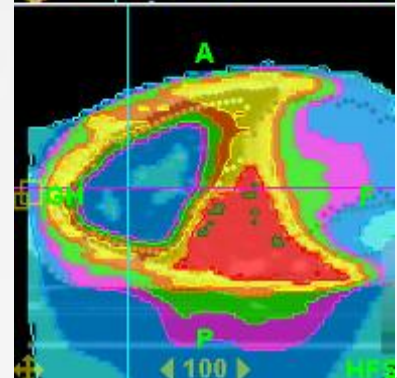
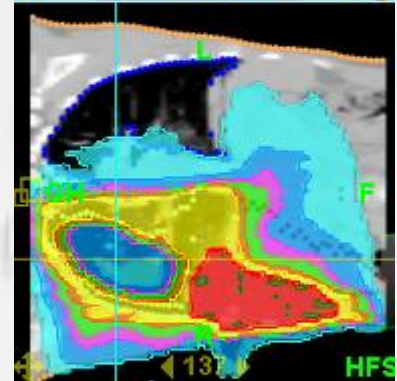
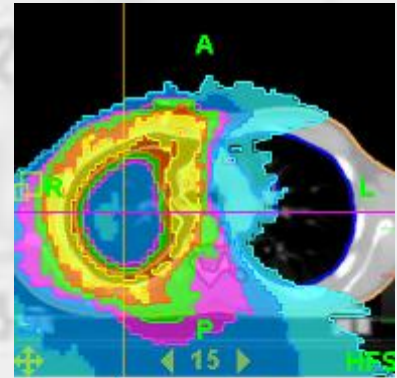
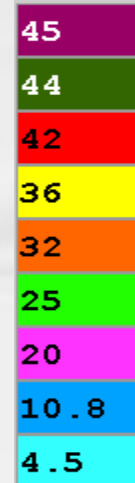
Male 13 y,
Ewing-PNET pelvis



Soft tissue and bone sarcomas



Male 10 y,
Pleural Ewing-PNET sarcoma



Lung right	<input checked="" type="checkbox"/>	■
GTV	<input checked="" type="checkbox"/>	■
PTV	<input checked="" type="checkbox"/>	■

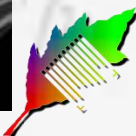
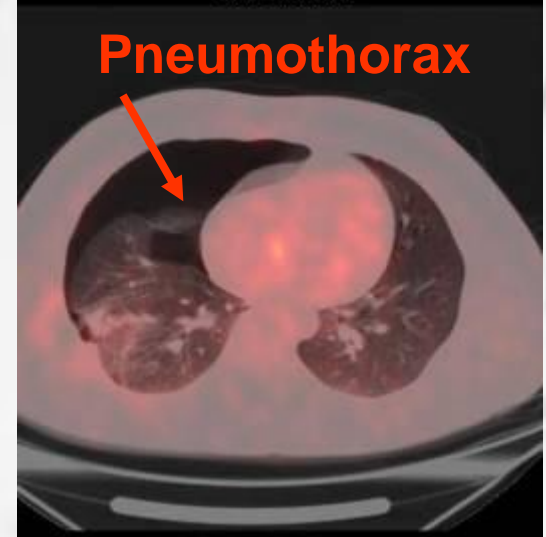
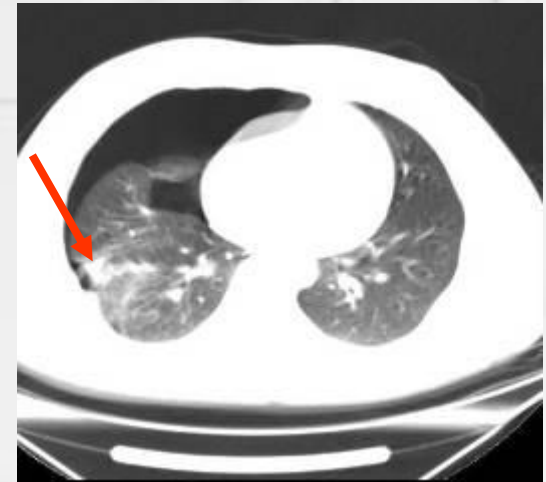
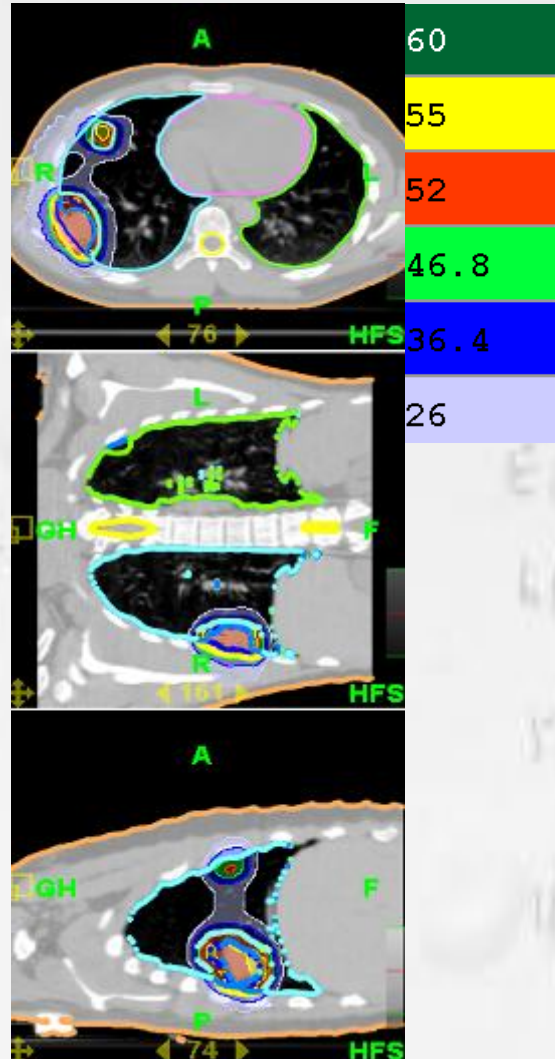
Sensitive Structure Settings

Name	Display	Color
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Couch	<input type="checkbox"/>	■
Lung left	<input checked="" type="checkbox"/>	■
Spinal cord	<input checked="" type="checkbox"/>	■
Liver	<input checked="" type="checkbox"/>	■
Kidney right	<input checked="" type="checkbox"/>	■
Kidney left	<input checked="" type="checkbox"/>	■
Heart1	<input checked="" type="checkbox"/>	■



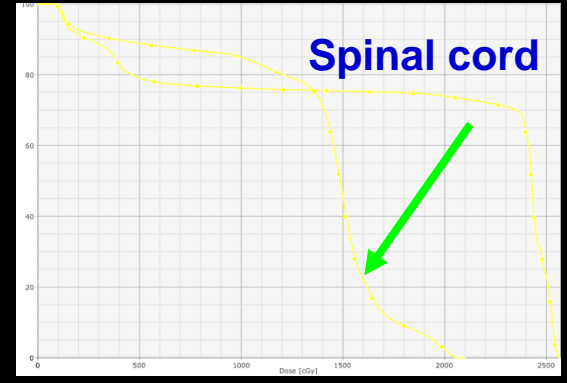
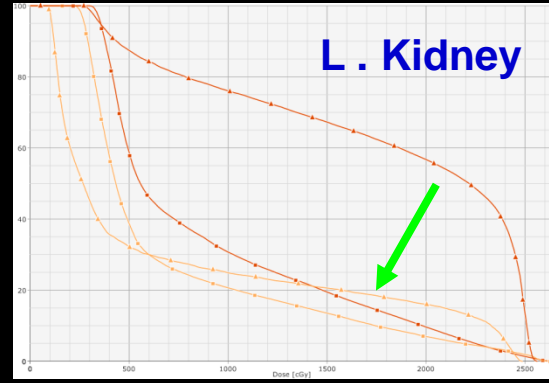
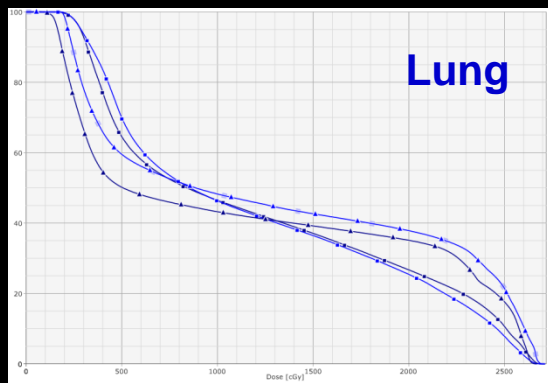
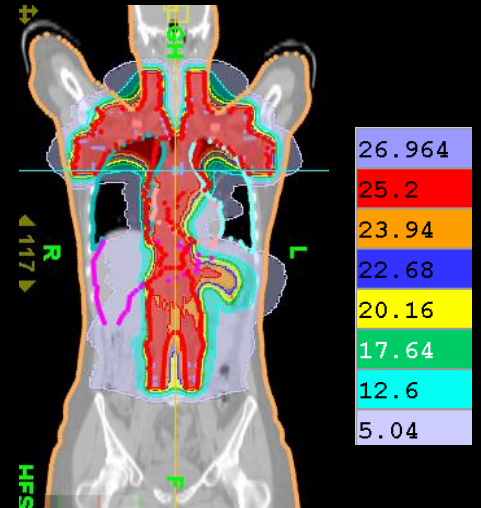
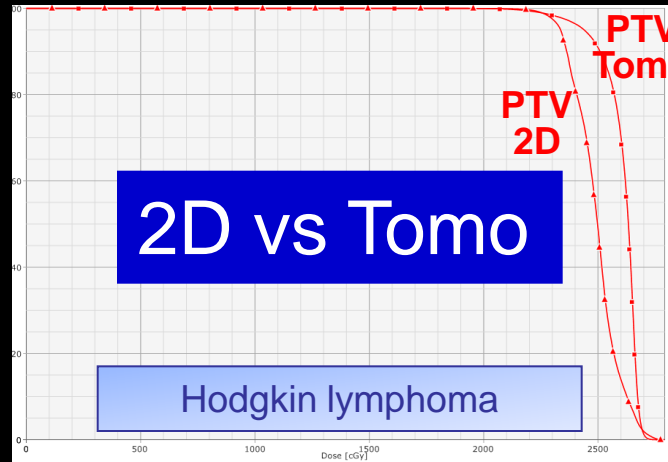
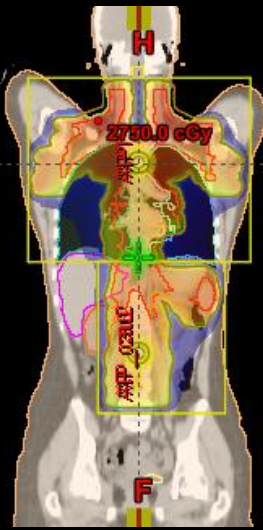
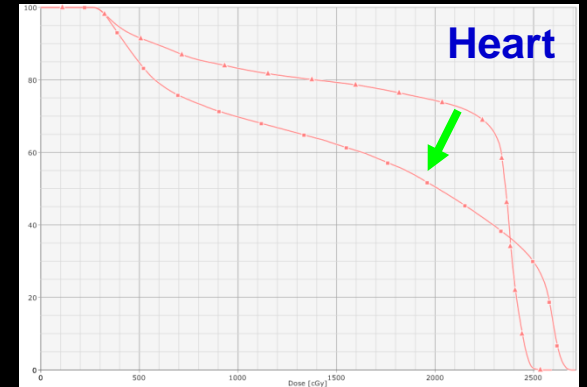
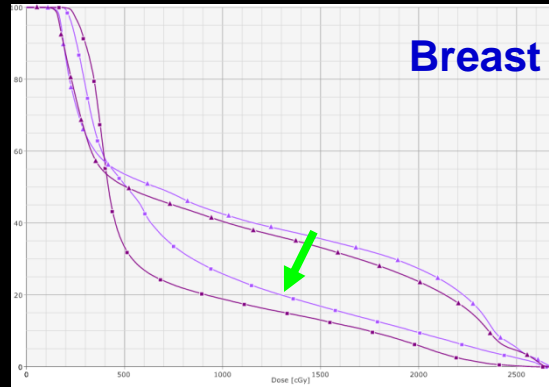
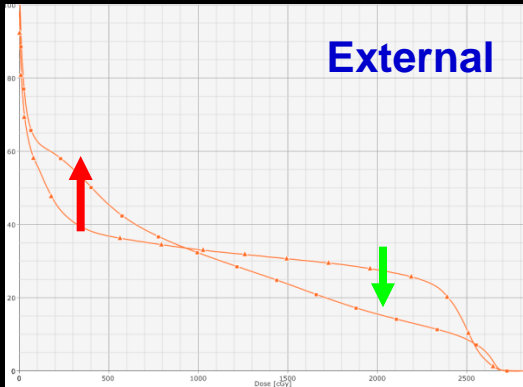
Soft tissue and bone sarcomas

Male 17 y,
Lung Metastasis – Synovial sarcoma



Hodgkin lymphoma

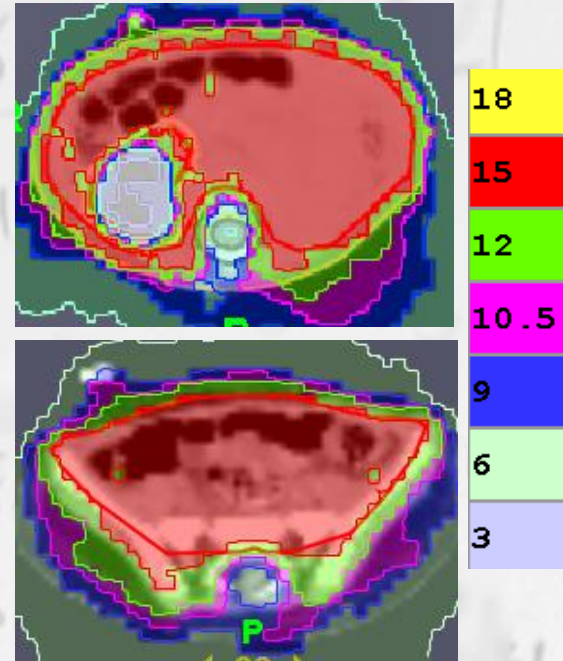
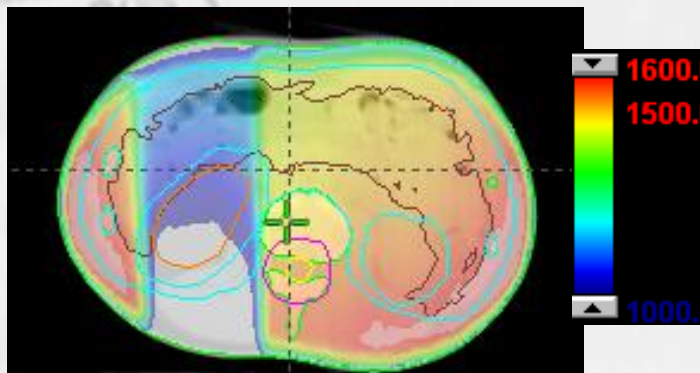




TOMO in Wilm's tumor

Whole abdominal irradiation

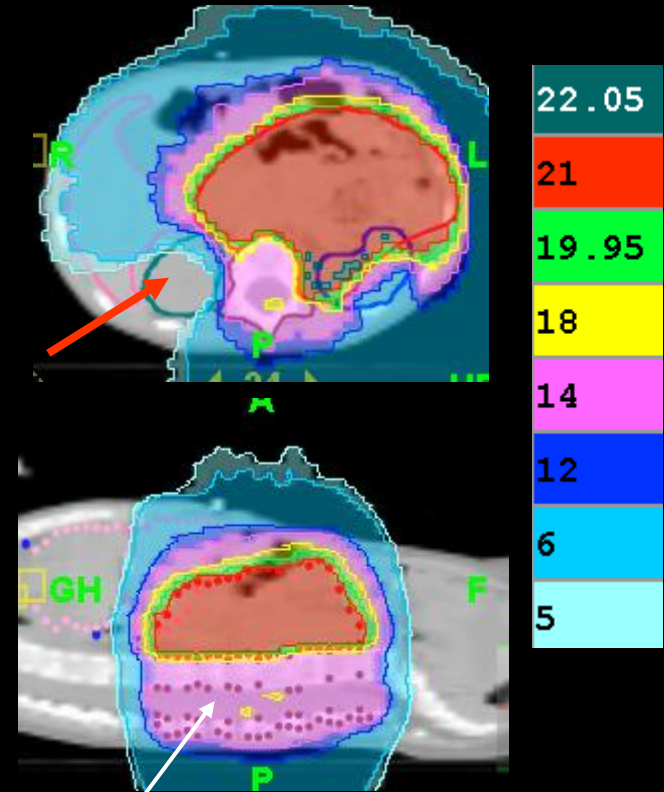
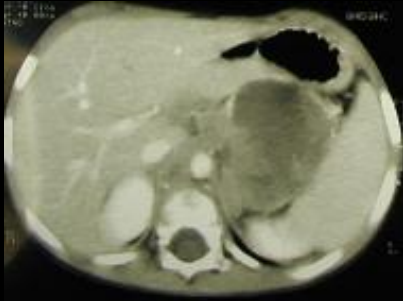
Male 2 y,
Wilm's tumor



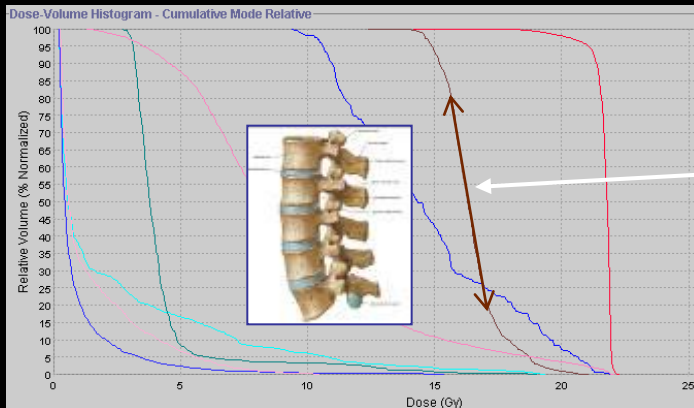
2AP fields	Tomo
Block to kidney	Kidney < 40%
	Spinal cord < 40%
	PTV homogeneity



Tomo in Neuroblastoma



**Male 2 y,
Left adrenal gland Neuroblastoma
(21 Gy/14 fr)**



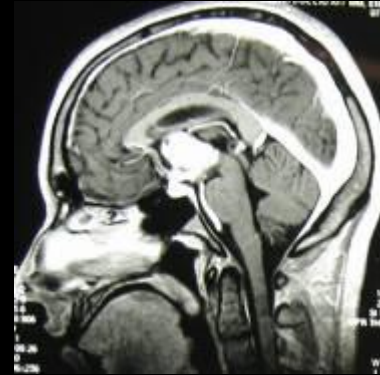
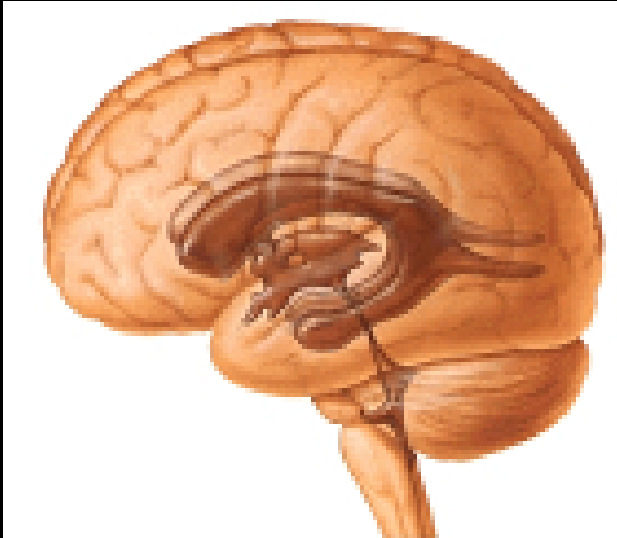
Homogeneous dose
to the vertebral body



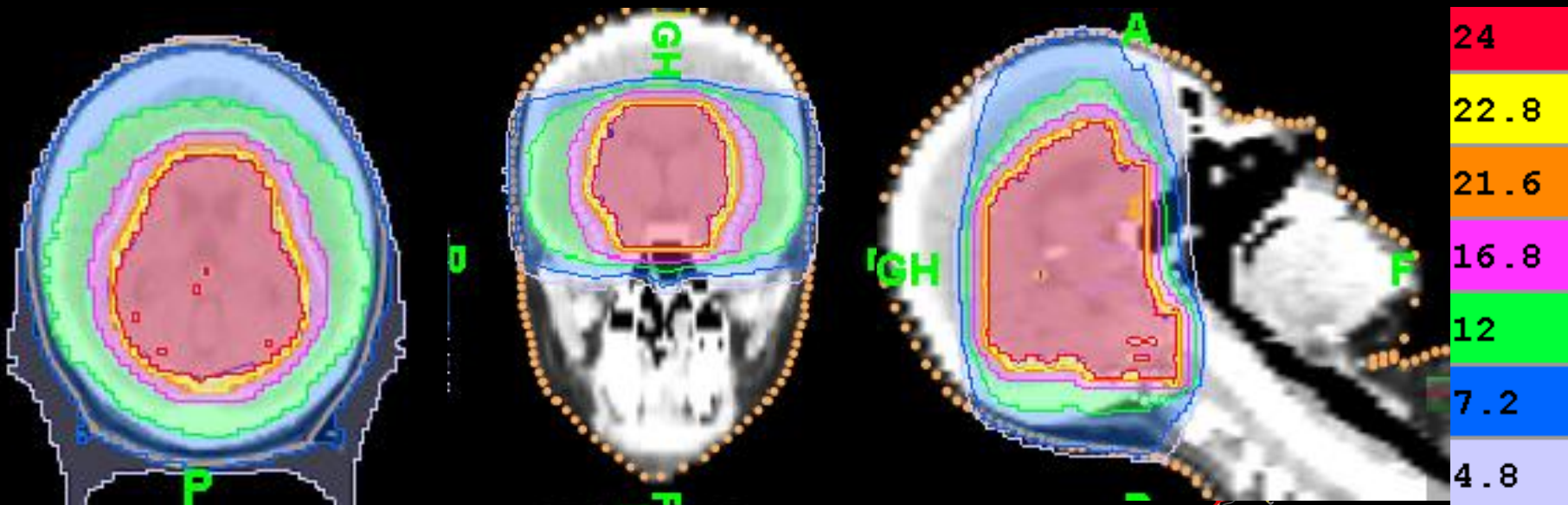
Brain tumors



TOMO in CNS tumors



Male 16 y,
SNC Germ cells tumor



Craniospinal Radiotherapy in Pediatric Patients

Conventional CSI

3DCRT CSI

IMRT CSI

TOMO CSI

Gy

25.03
23.40
22.23
18.72
11.70
7.02
4.68
2.34

Gy

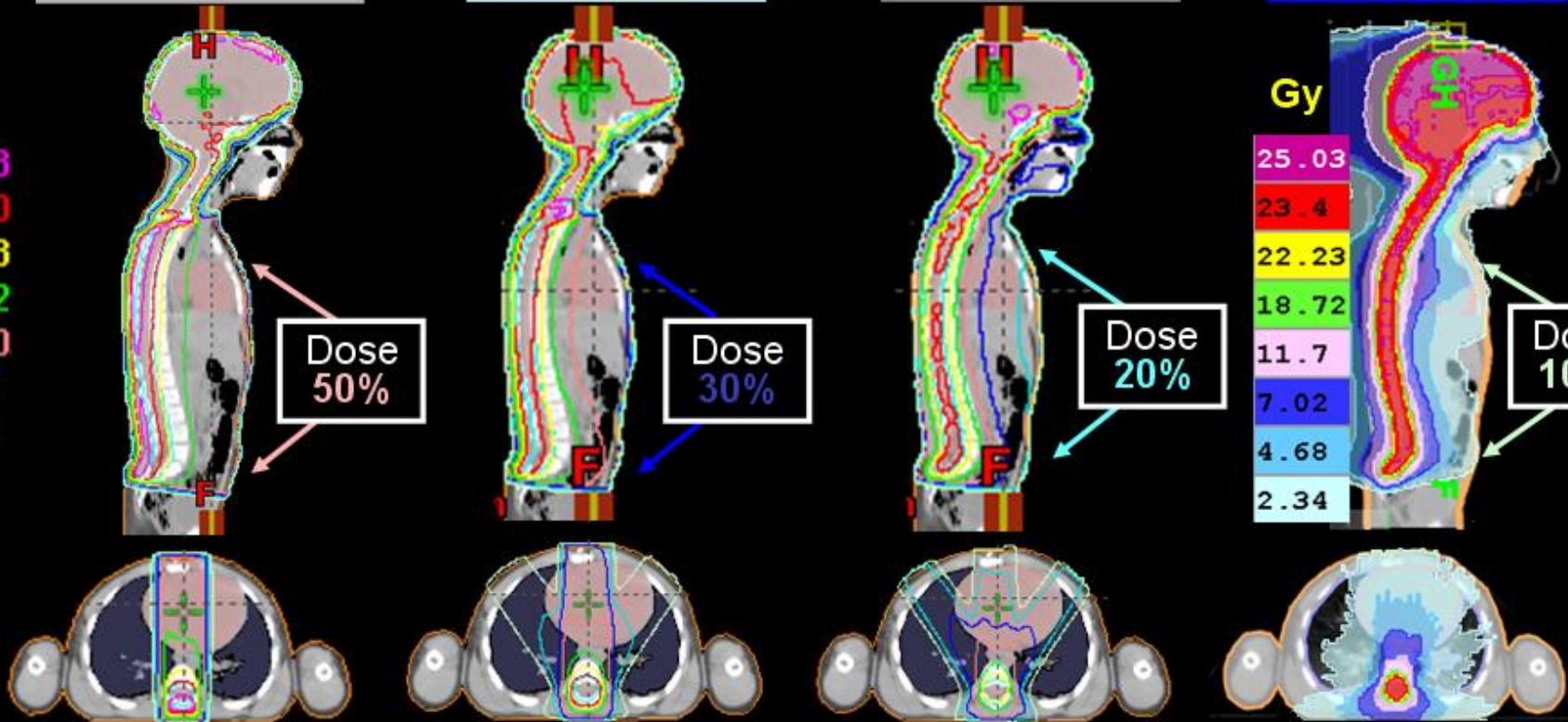
25.03
23.4
22.23
18.72
11.7
7.02
4.68
2.34

Dose
50%

Dose
30%

Dose
20%

Dose
10%



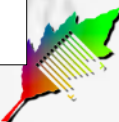
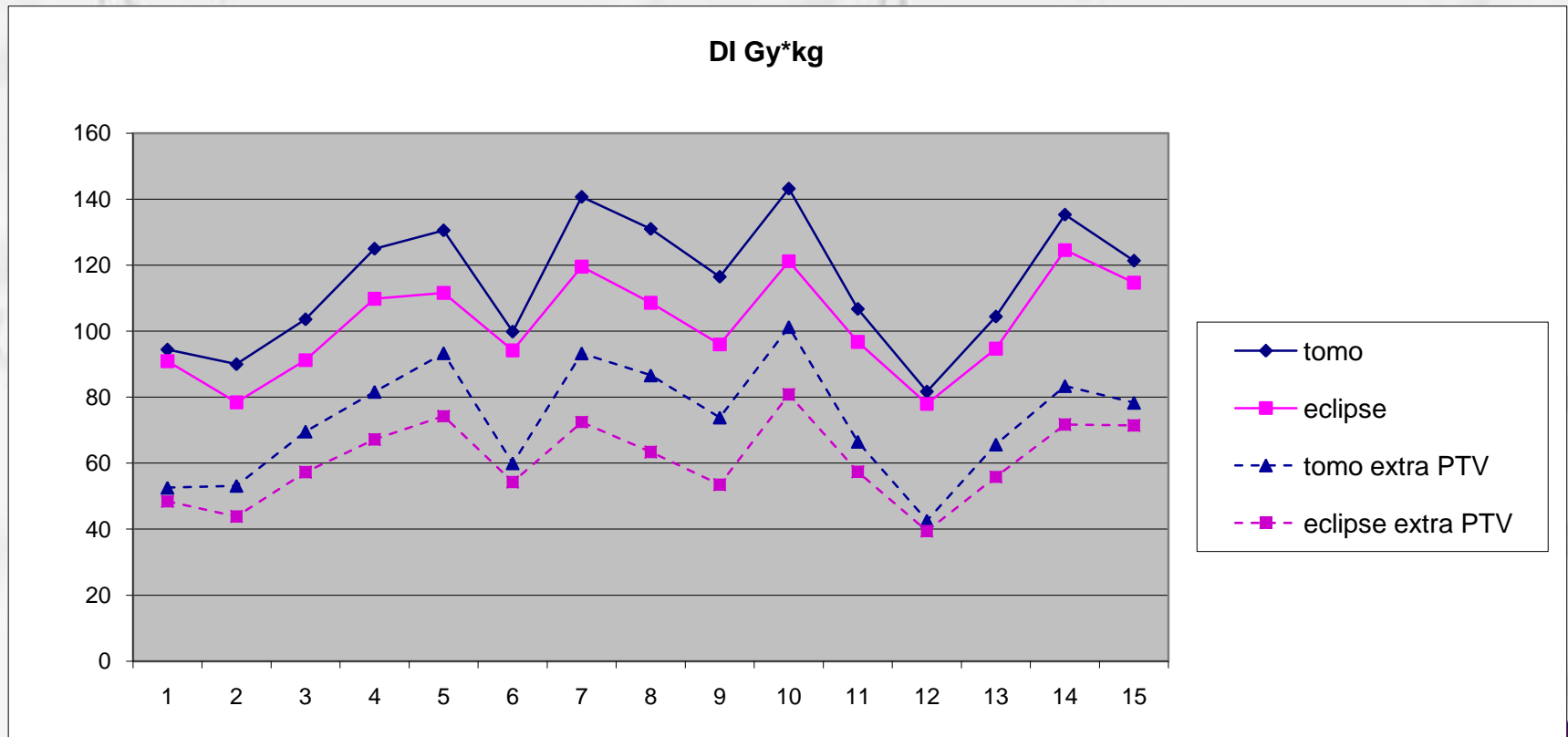
Integral dose



Does Tomo CSI plan increase or decrease Integral Dose?

$$ID = \rho V \check{D}$$

ρ mean density, V volume, \check{D} mean dose



Secondary cancer



Second cancers and new techniques

- ✓ With **IMRT and Tomo** the peripheral low-dose exposure at distant sites is greater than with conventional or 3DRT techniques.

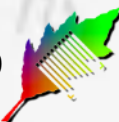
Klein EE, Med Pys 2006

- ✓ The added carcinogenicity of neutrons compared to photons: data indicates neutrons have significantly greater biologic potential for carcinogenesis. **High energy photon irradiation** (>18 MV X-rays) and **protons** increase the risk of neutron exposure.

Suit H., Radiat Res 2007
Hall EJ IJROBP 2006

“Ironic”

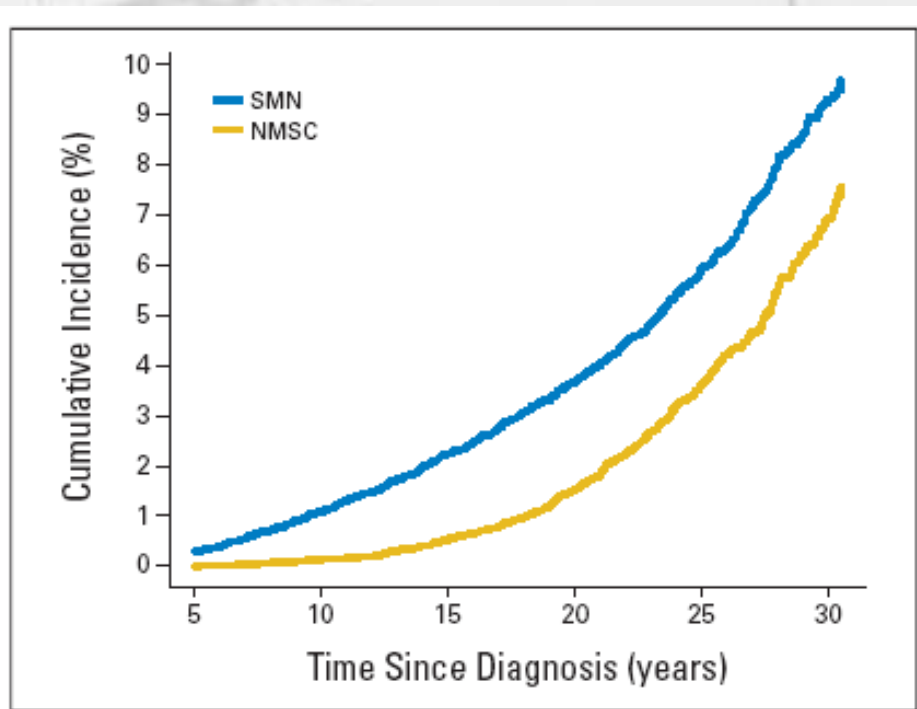
Kun LE, Pediatric Radiol 2009



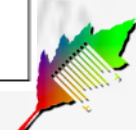
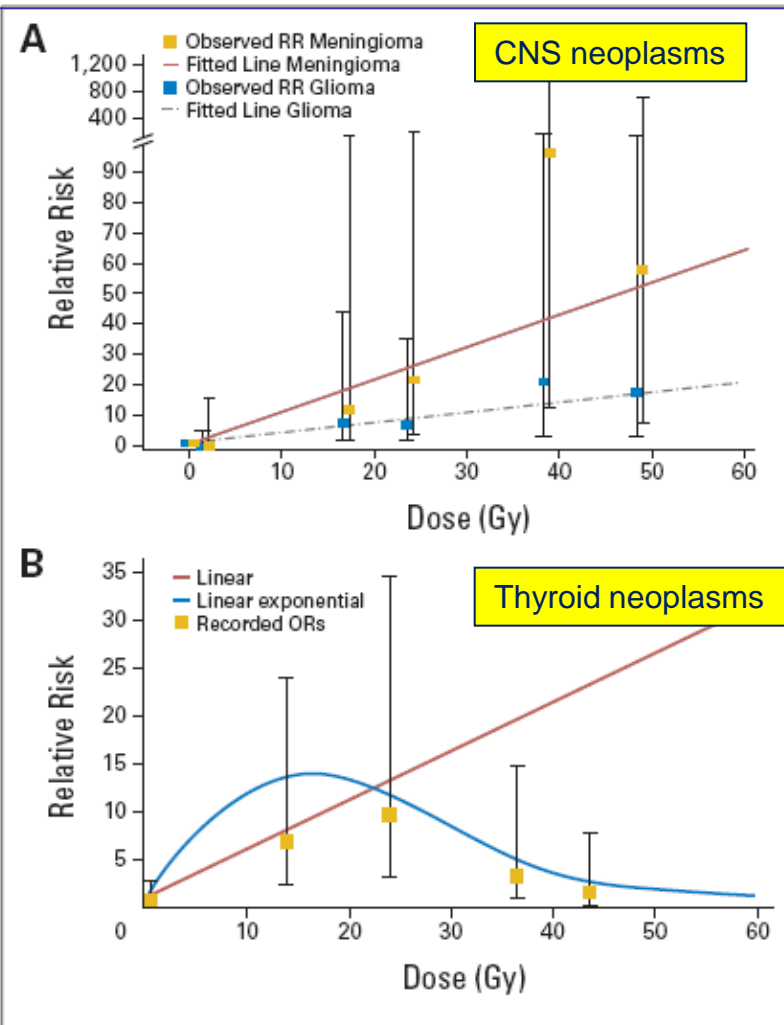
Second Neoplasms in Survivors of Childhood Cancer: Findings From the Childhood Cancer Survivor Study Cohort

Anna T. Meadows, Debra L. Friedman, Joseph P. Neglia, Ann C. Mertens, Sarah S. Donaldson, Marilyn Stovall, Sue Hammond, Yutaka Yasui, and Peter D. Inskip

Among 14,358 cohort members, treated between 1970-86, 730 reported **802 SMNs**



The 30-year cumulative incidence of SMNs was 9.3% and that of non-melanoma skin cancer was 6.9%.

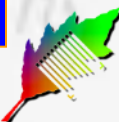


IMRT-Tomo in Pediatric-Adolescent Patients

Our experience: (04/2005° - 05/2006* to 09/2010)

	<i>Treatment*</i>	IMRT°	Tomo*	Sedation
Brain tumors	93	15	78	(5+23) 28
Sarcomas	33	8	25	(0+5) 5
Head and neck	8	3	5	
Neuroblastoma	11	8	3	(4+2) 6
Lymphoma	12	1	11	
Other	6	1	5	(0+1) 1
	0			
TOTAL	163 #	36	127	(9+30) 40

130 pts (35 IMRT, 95 Tomo; median age 12 years (range 1-21 y))



Tomo in Pediatric-Adolescent Patients

•The working time

Patients treated with TOMO until 09/2010

May 2005- Sept 2010

127 treatment

30 with sedation

Age range (mediana)	1-21 years(9)
Simulation time	1 hour
Contouring	3-10 hours
Planning	4-18 hours
Verification	0,5-1 hours
Room time	15- 30 minutes
Room time with sedation	20 - 60 minutes
Beam on	6 - 22 minutes
Re-planned (*3 for technical problems with Tomo)	6*



Conclusion

- RT treatment in a child is a **multi-step process**.
- **Decisions made** at the time of simulation, target and tissue delineation, planning, delivery and verification process **impact on the entire radiotherapy process**.
- IMRT/Tomo in comparison with 3DCRT, **can spare a significant amount of normal tissue**, when we consider higher doses.
- **Whole Body Integral Dose** is in favour of 3DCRT.
- **All organs are not equal** before the risk of a secondary radio-induced tumor (...brain, breast and thyroid).



Acknowledgments

Annalisa Drigo, PhD
Paola Chiovati, PhD

