PROTON THERAPY FOR PEDIATRIC CANCERS: RATIONALE, EVIDENCE & CLINICAL EXPERIENCE

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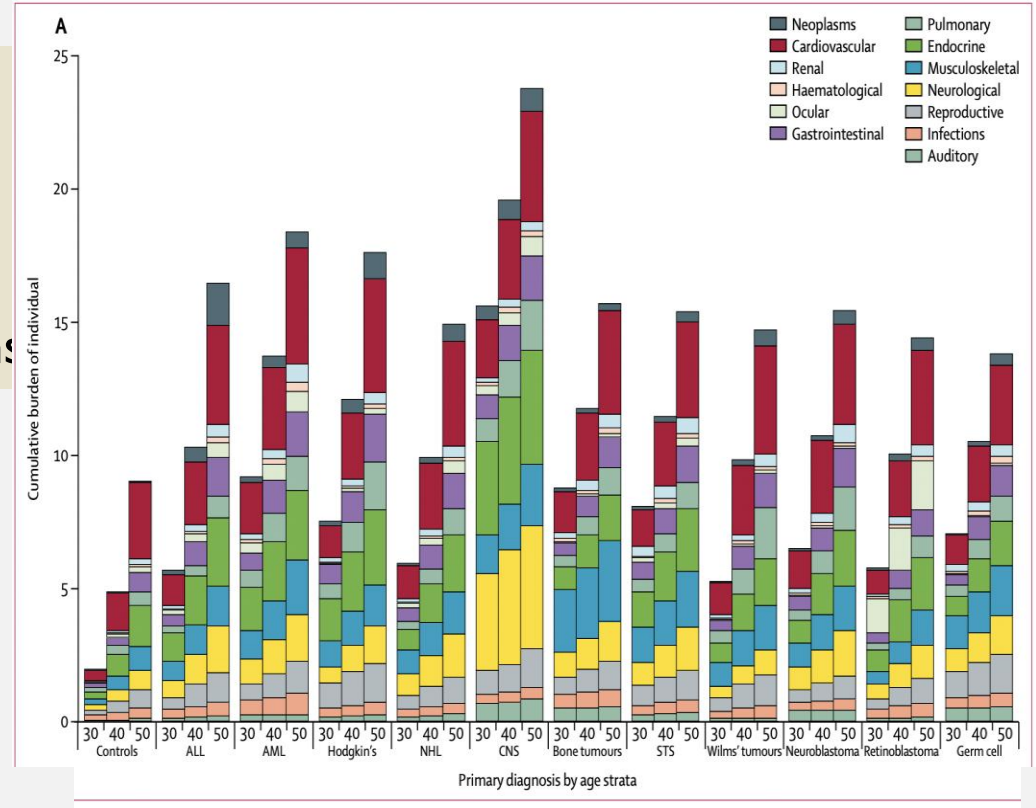
UNDERLYING PHILOSOPHY IN PEDIATRIC ONCOLOGY

-MITIGATE LATE EFFECTS

Avoiding treatments- wherever it's safe

Treatment de-intensification- wherever feasible

Highly conformal radiation therapy techniques with crisper margins



Bhakta N, et al Lancet 2017

RADIATION OMISSION/DE-ESCALATION

HISTORIC DATA-EPENDYMOMAS

Age < 3 years

↓

Chemotherapy

5YR EFS: 24% ± 5%
5YR OS: 43% ± 5%

Neuro Oncol 2014 16:457-65
Study Dates 1992-1997

Age > 3 years

↓

Radiation Therapy

5YR EFS: 57% ± 6%
5YR OS: 71% ± 6%

Pediatr Blood Cancer 2012 59:1183-9
Study Dates 1995-1999

ACNS-0121 study

	<3 yrs	>3 yrs	P value
5 yr EFS	62.9%	70.5%	NS
5 yr OS	87.4%	85.8%	NS

Immediate postoperative radiation nullified the effect of age

Age Eligibility criteria for RT - 12 months

DOSE ESCALATION

Local Failure Pattern Among Patients with Group III Disease

Patient subsets	IRS-III	IRS-IV	D9803
All patients	19%	13%	19%
Embryonal RMS	19%		20%
Alveolar RMS (and undifferentiated sarcoma for IRS-III)	17%		17%
Parameningeal	19%	16%	19%
Extremity	17%	7%	15%
Bladder/prostate	14%	19%	14%
N0	16%		19%
N1	32%		17%
≤ 5 cm	16%		10%*
> 5 cm	21%		25%*

*p=0.0004

Dose to primary tumor: ARST 1431

Clinical Group	no CR at Week 9**	CR at Week 9**	post DPE with negative margin	post DPE with microscopic margin	post DPE, gross residual disease
I, FOXO1 +	36	36	N/A	N/A	N/A
II	36	36	N/A	N/A	N/A
III, ≤5cm*	50.4	36	36	41.4	50.4
III, >5cm*	59.4	36	36	41.4	59.4

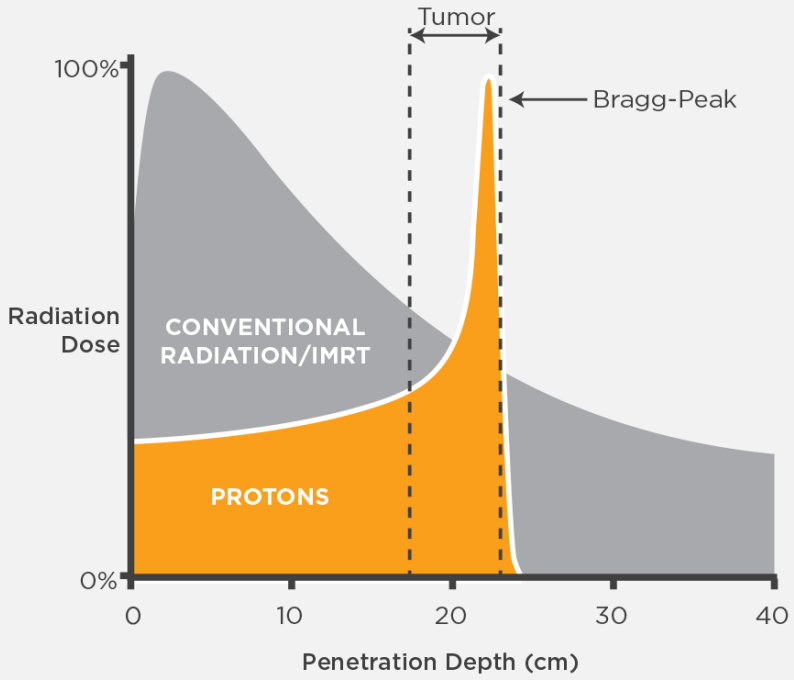
*Based on size at diagnosis
**CR defined as 1) Radiological CR by both PET and CT/MRI or 2) biopsy that shows no residual tumor.

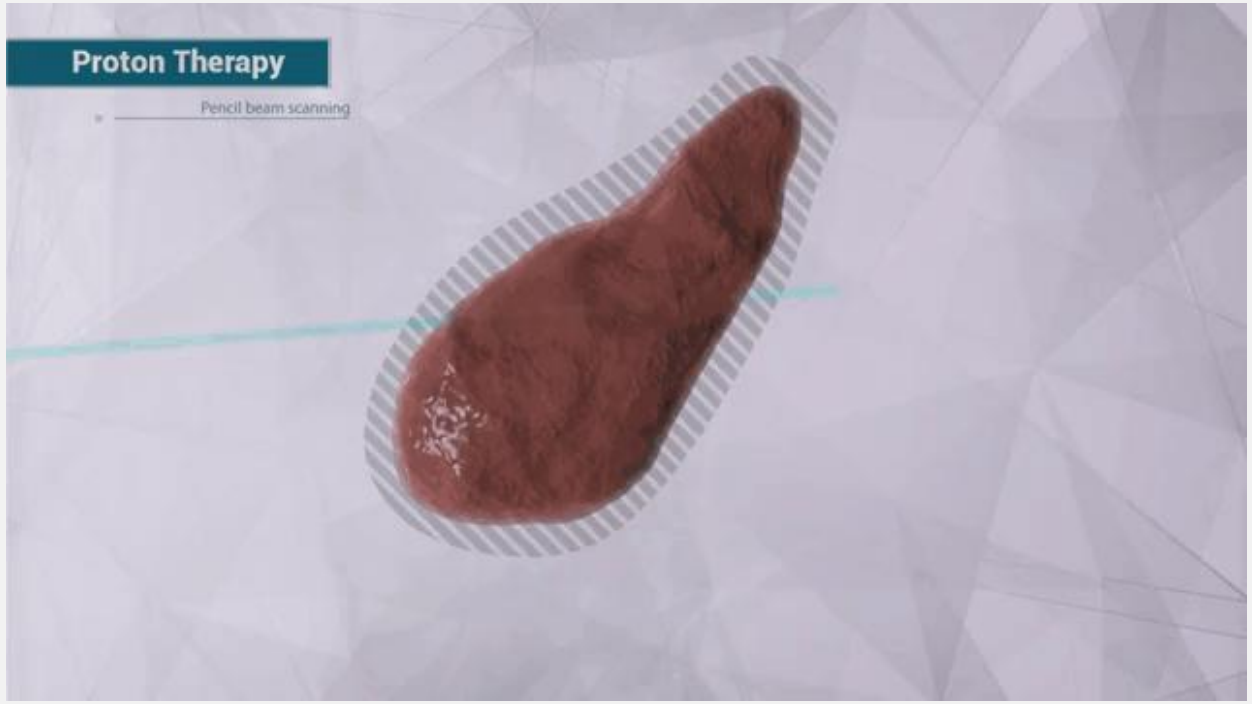
INDICATIONS OF RADIATION IN PEDIATRIC/AYA GROUP

Diagnosis	Indication of Radiation	Dose
Medulloblastoma	All	High Dose
Ependymoma	All	High Dose
Ped Gliomas	Posterior fossa, high grade gliomas, DMG, others	Moderate to high dose
RMS	Almost all, (Exceptions)	Moderate to high Dose
Ewing's Sarcoma	Not all but nearly half of them or more	Moderate to high Dose
Neuroblastoma	All high-risk ones	Moderate dose
Wilm's Tumor	Nearly 1/4th	Moderate dose
Craniopharyngioma	Nearly 50%	High dose
Germ cell tumors	Most intracranial ones	Moderate to high dose
Epithelial Tumors	Almost all	High dose
Mesenchymal Tumors	Almost all	High dose
Lymphoma	Diminishing but 1/5th-1/3rd	Moderate dose

WHY/WHY NOT PROTON THERAPY ?

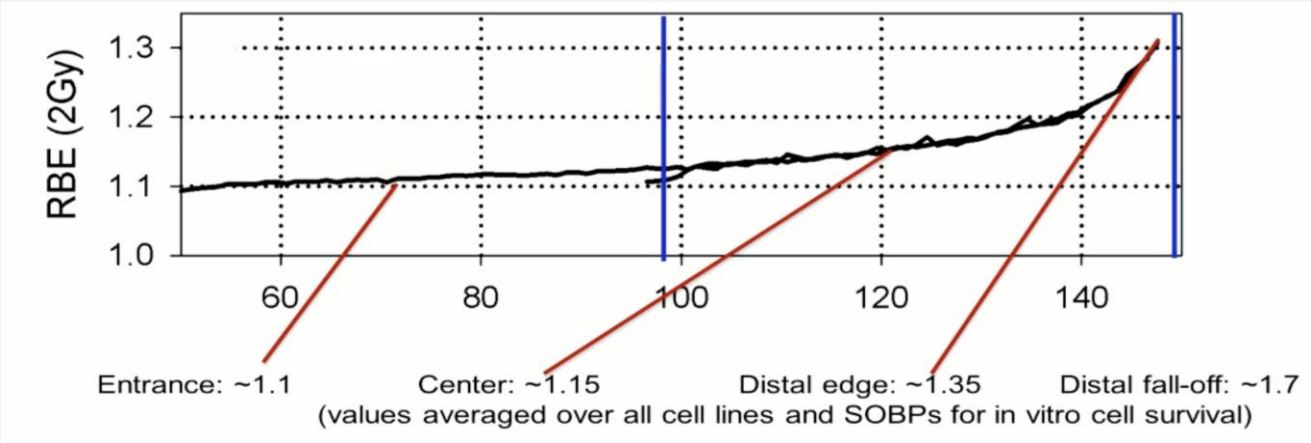
Physical Advantage of Proton Therapy





Almost universally, there is some dosimetric advantage with Proton therapy when compared to conformal photon techniques

Biological advantage of Proton Therapy



Dense concentration of DNA damage vs. Sparsely distributed DNA damage

Greater complexity of damage - requires different mechanisms for DNA repair

Protons may result in greater down regulation of certain genes that could impact metastases

Girdhani, et al. Radiation Research 2013, Amundsen et al IJPT 2018

PROTONS VS. PHOTONS COST

	Photons	Protons (single room)
Initial Setup	x	15x
Maintenance	x	12x
Electricity	x	10x
Throughput	x	0.5x
Manpower	x	2x therapist 2x physicists 2x radiation oncologists

Maintenance cost per year =/> Cost of latest Linac

BEST EVIDENCE SUPPORTING PROTON THERAPY

- Multiple phase 2 prospective & retrospective studies- Establish safety and efficacy of PT
- Multiple cohort studies of direct/indirect comparison for late effects- Superiority of PT
- Real and modelling studies comparing secondary cancers- Superiority of PT in reducing second cancers
- Comparative studies of QOL between modalities- Superiority of PT in improving QOL
- Multiple cost-effectiveness studies- PT in children for several indications is cost effective

Universal consensus regarding need for more evidence- clinical &. pre-clinical data

SAFETY/EFFICACY- MEDULLOBLASTOMA

1010 Neuro-Oncology
24(6), 1010–1019, 2022 | https://doi.org/10.1093/neuonc/noab257 | Advance Access date 12 November 2021

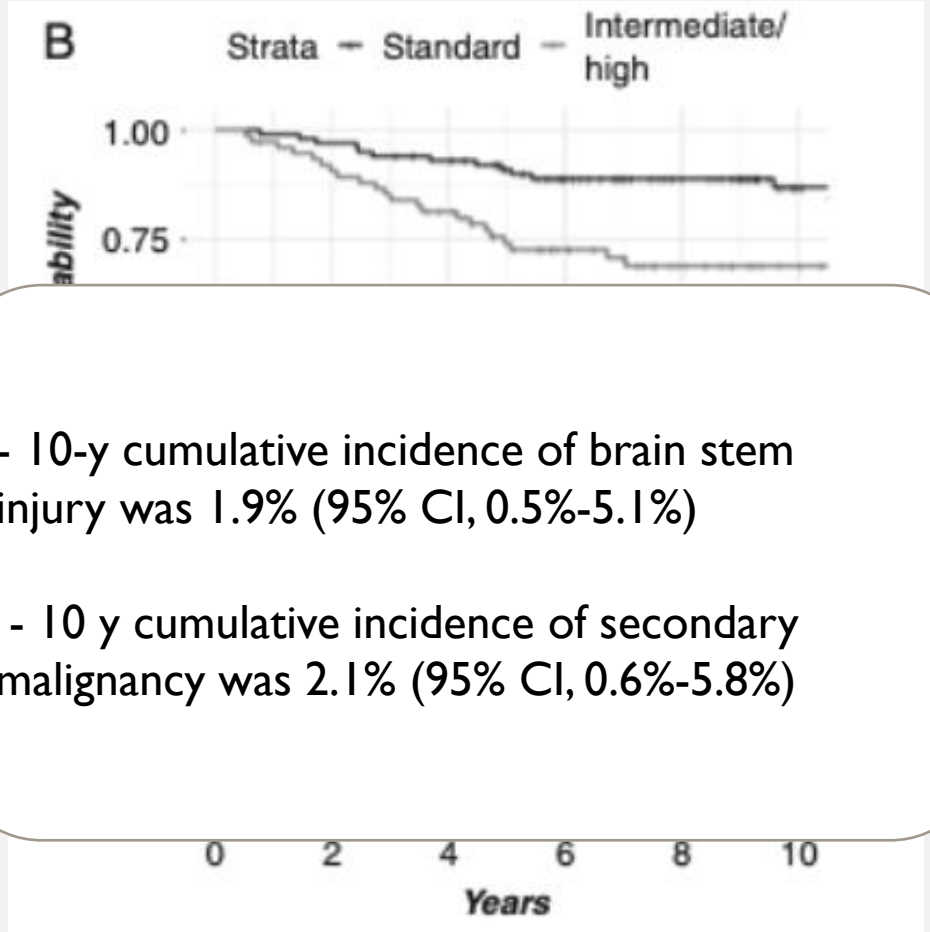
Decade-long disease, secondary malignancy, and brainstem injury outcomes in pediatric and young adult medulloblastoma patients treated with proton radiotherapy

Sujith Baliga, Sara Gallotto, Benjamin Bajaj, Jacqueline Lewy, Elizabeth Weyman, Miranda P. Lawell, Beow Y. Yeap, David E. Ebb, Mary Huang, Paul Caruso, Alisa Perry, Robin M. Jones, Shannon M. MacDonald, Nancy J. Tarbell, and Torunn I. Yock

OS (10 y): 79.3% (95% CI, 73.1%-85.9%)

OS (10 y) standard risk: was 86.9% (95% CI, 79.9%-94.4%)

OS (10 y) IR/HR was 68.9% (95% CI, 58.7%-80.8%)



- 10-y cumulative incidence of brain stem injury was 1.9% (95% CI, 0.5%-5.1%)

- 10 y cumulative incidence of secondary malignancy was 2.1% (95% CI, 0.6%-5.8%)

International Journal of Radiation Oncology biology • physics
www.redjournal.org

SAFETY/EFFICACY- EPENDYMOMA

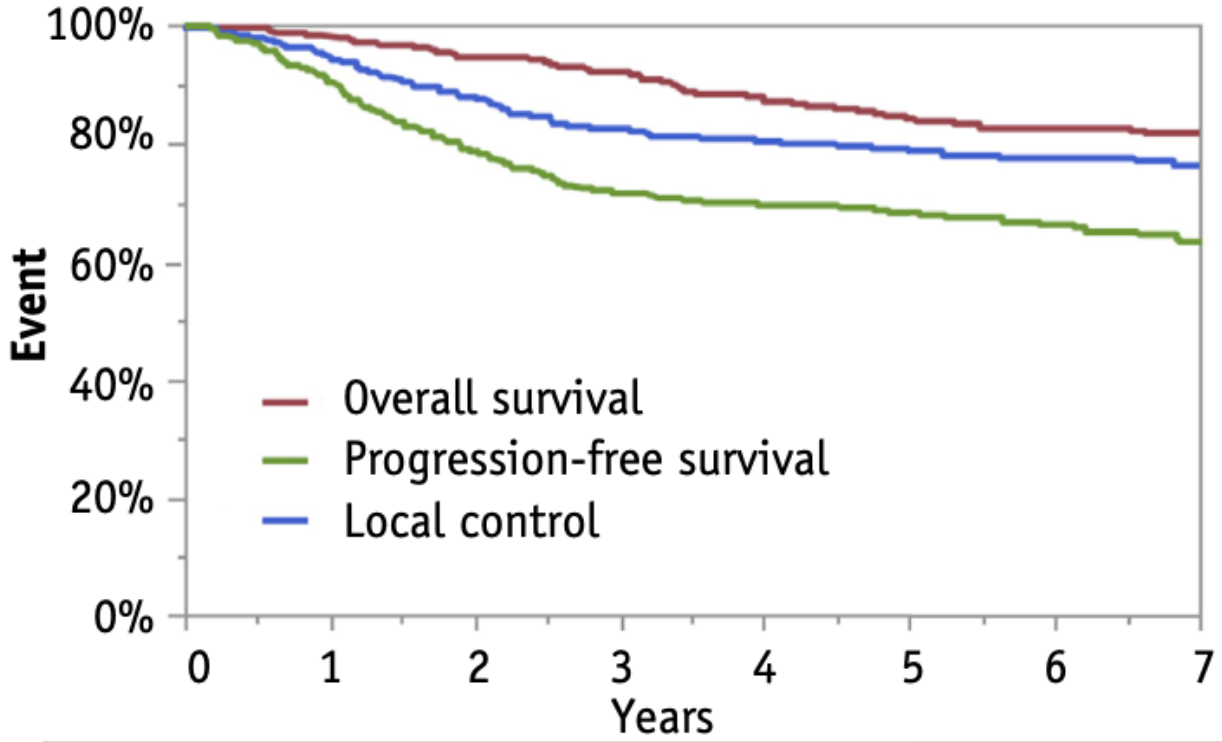
Proton Therapy for Pediatric Ependymoma: Mature Results From a Bicentric Study

Daniel J. Indelicato, MD,* Myrsini Ioakeim-Ioannidou, MD,† Julie A. Bradley, MD,* Raymond B. Mailhot-Vega, MD, MPH,* Christopher G. Morris, MS,* Nancy J. Tarbell, MD,† Torunn Yock, MD,† and Shannon M. MacDonald, MD†

**Department of Radiation Oncology, University of Florida College of Medicine, Jacksonville, Florida; and †Department of Radiation Oncology, Harvard Medical School, Boston, Massachusetts*

Received Oct 21, 2020, and in revised form Dec 17, 2020. Accepted for publication Jan 20, 2021.

- 386 patients
- Grade 2/3
- Median f.u: 5 yr



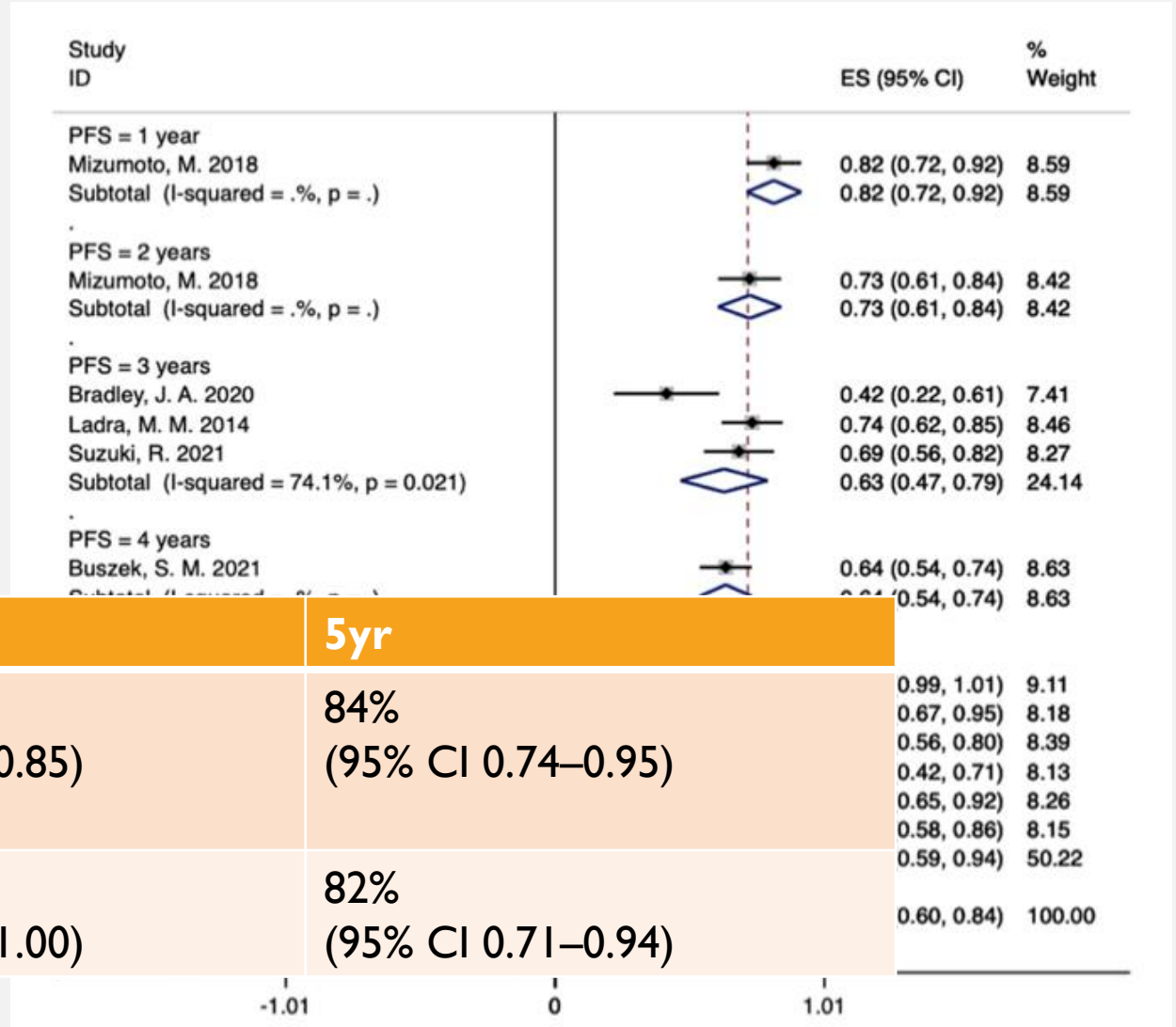
Number of patients at risk							
Endpoint (years)	1	2	3	4	5	6	7
Overall survival	374	337	283	229	193	167	139
Progression-free survival	342	277	221	187	164	142	116
Local control	358	308	246	202	172	150	124

SAFETY/EFFICACY- RMS

REVIEW Open Access

Efficacy and safety of proton beam therapy for rhabdomyosarcoma: a systematic review and meta-analysis

Meng Dong[1,2,3†], Jianrong Wu[1†], Renhua Wu[1], Dandan Wang[2,3], Ruifeng Liu[3,4,5], Hongtao Luo[3,4,5], Yuhang Wang[2,3], Junru Chen[2,3], Yuhong Ou[2,3], Qiuning Zhang[3,4,5*] and Xiaohu Wang[2,3,4,5*]



- 544 patier
- 392 Embr

	3yr	5yr
Local control	78% (95% CI 0.71–0.85)	84% (95% CI 0.74–0.95)
OS	93% (95% CI 0.86–1.00)	82% (95% CI 0.71–0.94)

SAFETY/EFFICACY- EWING'S SARCOMA

Table 4 Literature review regarding local control after radiation therapy for pelvic Ewing sarcoma

Local Control				
Series, year	Median follow-up, y	Modality	No. of patients	3-y local control, %
Yock, 2006[6]	4.4	S	12	75
		S + RT	19	89.5
		RT	44	75
Indelicato, 2008[5]	4	S + RT	9	100
		RT	26	80*
Ahmed, 2017[7]	8.3	S	8	87
		S + RT	8	100
		RT	31	75-80*
Ahmed, 2017[1]	NR	S	51	96.1
		S + RT	39	94.9
		RT	86	77.6
Uezono, 2019 (current series)	2.5	S + PT	9	100
		PT	26	91

Abbreviations: PT = proton therapy; RT = radiation therapy; S = surgery.
* Estimated from the Kaplan-Meier curve.

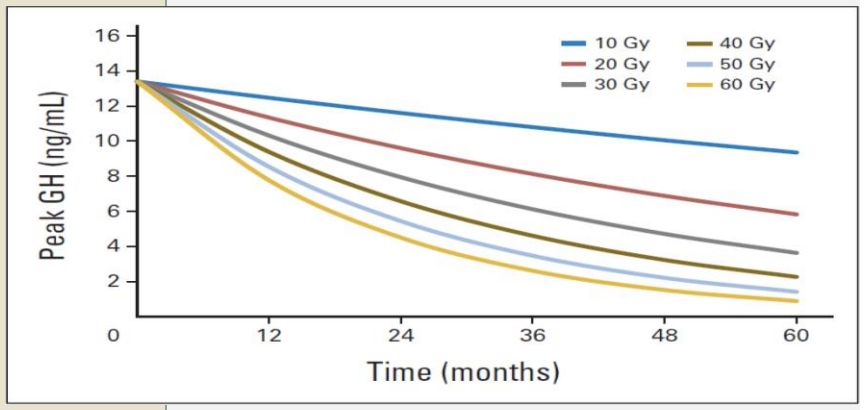
H Uezono, et al IJROBP 2020

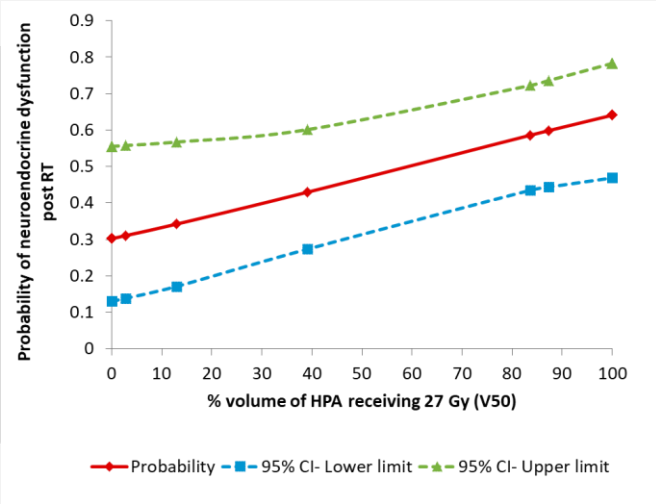
LATE EFFECTS SUMMARY

- Hearing loss
- Impaired Cognition
- Impaired academic performance
- Endocrine Dysfunction
- Growth abnormalities
- Vasculopathy- CVA
- Brain stem necrosis
- Optic pathway dysfunction
- Social issues
- Psychological issues
- Impaired overall QOL
- Second Malignant neoplasms

Most are dose dependent- deterministic

CSF shunting and increased cochlear dose (>32Gy) enhance the effect of ototoxic chemotherapy.

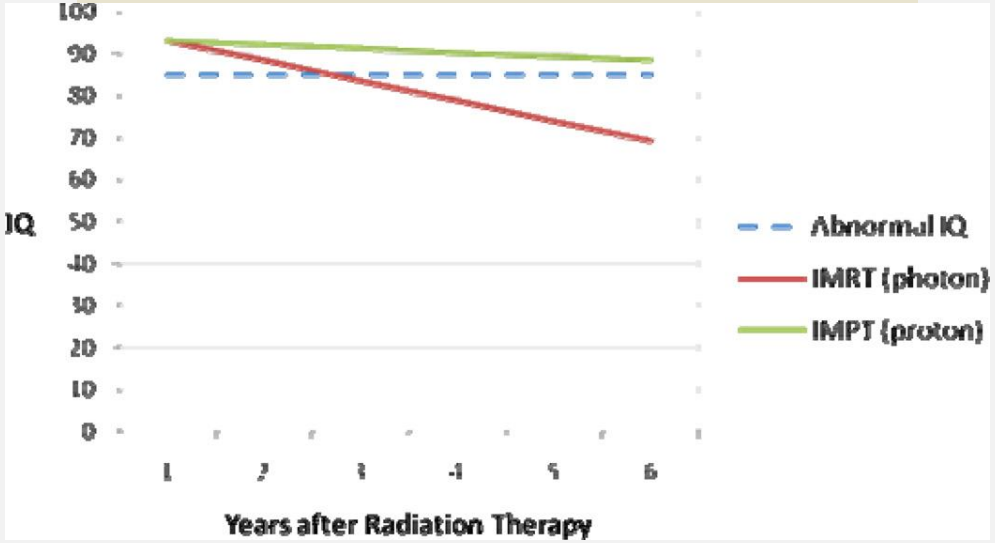




JCO 2016,JCO 2011, R Jalali, et al PRO 2019

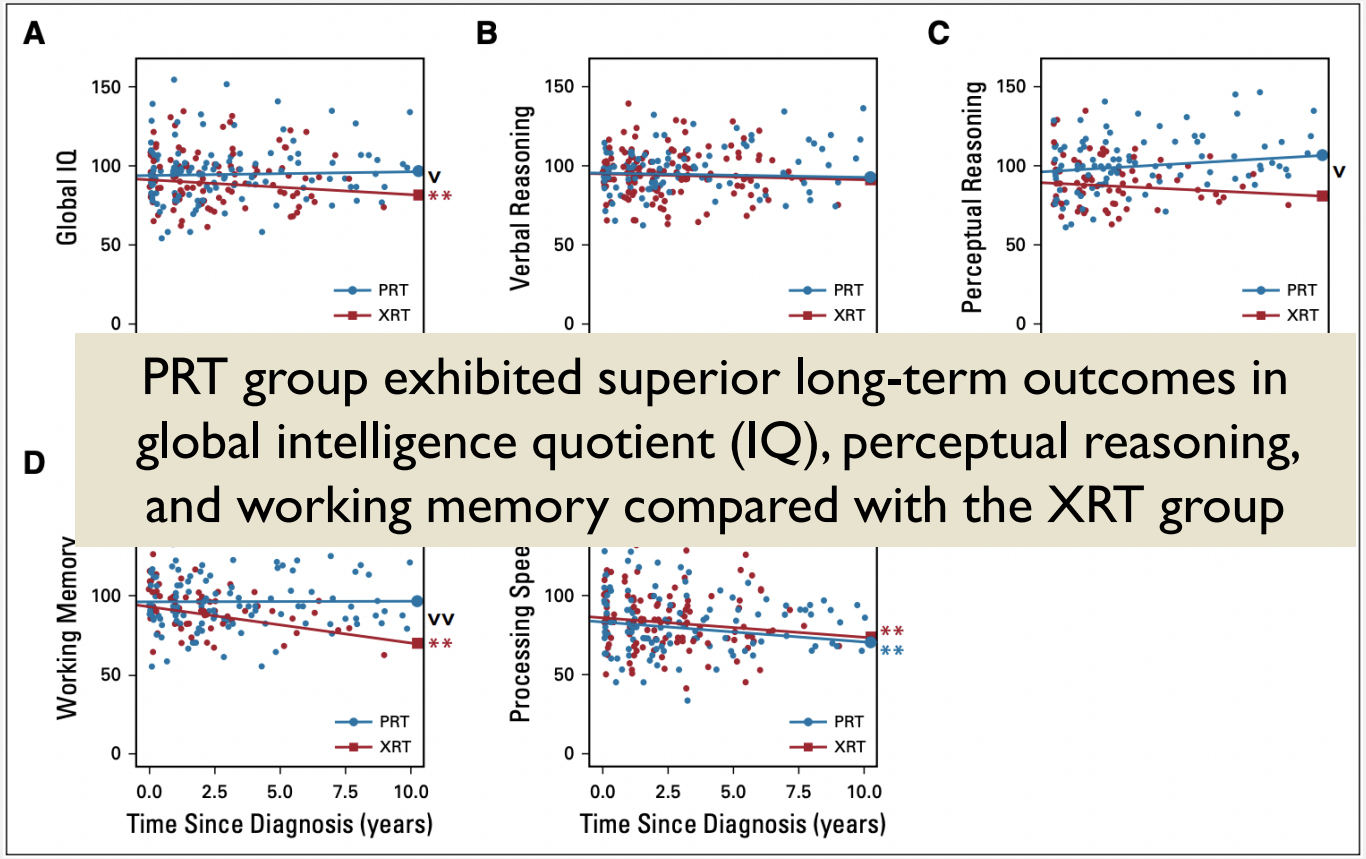
LATE EFFECTS COMPARISON- NEUROCOGNITIVE OUTCOMES

Modelling Study based on Dosimetry



TE Merchant, et al
Seminars in Radiation Oncology 2013

Superior Intellectual Outcomes After Proton Radiotherapy Compared With Photon Radiotherapy for Pediatric Medulloblastoma



PRT group exhibited superior long-term outcomes in global intelligence quotient (IQ), perceptual reasoning, and working memory compared with the XRT group

Kahalley, et al JCO 2020

LATE EFFECTS COMPARISON- ENDOCRINE OUTCOMES

77 patients, Medulloblastoma std. risk

3 yrs of Endocrine screening

Median follow up of 5.8 yrs

Endocrine axis	X-ray	Proton	P value
Hypothyroidism	69%	23%	0.01
Sex hormone deficiency	19%	3%	0.02
Any hormone replacement	78%	55%	0.03
Height SDS score	-2	-1.19	0.02

Eaton, et al
Neuro Oncol 2016, JCO 2019

LATE EFFECTS COMPARISON- EXTRACRANIAL LATE TOXICITIES

Table 3. Late toxicities associated with head and neck radiotherapy for pediatric cancers.[a]

Organ and types of toxicities	Rates of toxicities, cumulative mean (Range), %		Types of toxicities	Reported dose when toxicity observed, Gy
	Photon radiotherapy	Proton radiotherapy		
Dental abnormalities	35 (32-100)	7 (3-30)	Tooth, agenesis, microdontia, enamel dysplasia, xerostomia, TMJ dysfunction, osteoradionecrosis	20
Craniofacial malformations	77 (5-97)	25 (21-70)	Bone and soft tissue hypoplasia	Bone: 30 Soft tissue: 4
Hypopituitarism: GH deficiency	19 (5-40)	19 (13-22)	Decreased height, decreased bone mineralization	GH: 18
Other endocrinopathy	9 (7-9)	10 (5-10)	Delayed puberty, sexual dysfunction, subclinical hypothyroidism	GnRH: 40 ACTH: 24 TSH: 24
Optic toxicities	23 (10-83)	10 (0-14)	Cataract Keratinization Retinopathy Optic neuropathy	2 30 45 50
Hearing toxicities	19 (17-75)	7 (0-11)	High frequency hearing loss	45
Secondary cancers	3 (2-10)	1 (0-6)	Breast cancer, meningioma	1.8

Spiotto, et al IJPT 2020

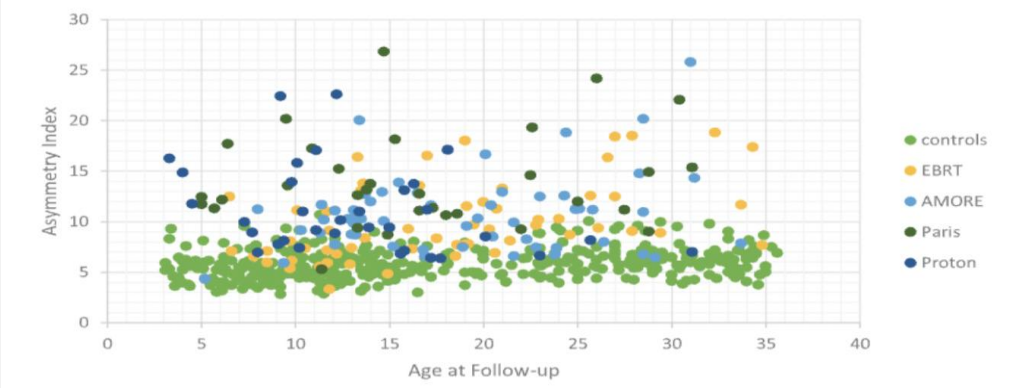
Facial Deformation in HN RMS

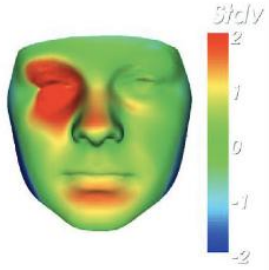
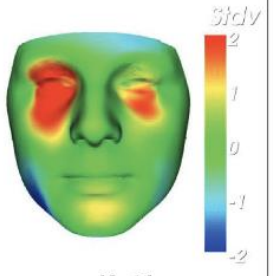
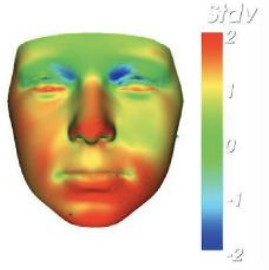
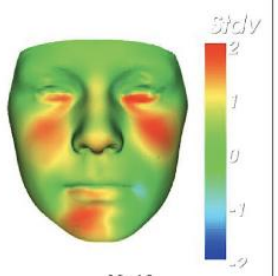
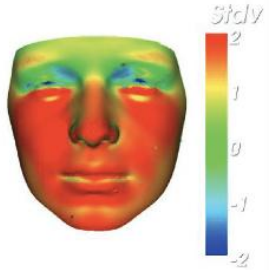
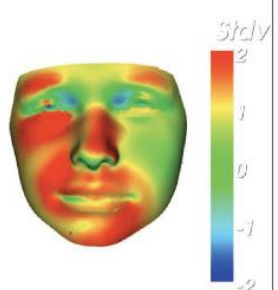
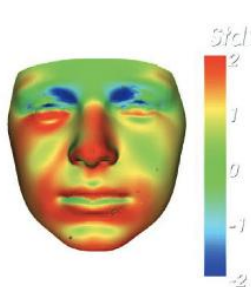
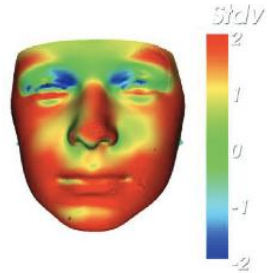
Cross Sectional study
173 HN RMS pts across 4 European & NA Centres

Four modalities Compared:

- Radiation
- AMORE-Ablative Surgery, Moulage Brachy, Reconstructive Surgery
- Proton Therapy (PBT)
- Paris Method- Limited Surgery, less adjuvant radiation dose & volume

<u>PBT – significantly lesser deformities</u>



	RT	AMORE	PROTON	PARIS
ORBIT	 N= 15	 N= 16	*No mean – not large enough group*	*No mean – not large enough group*
MEAN SW (range)	193.67 (126.8 – 330.4) *p=0.04639 EBRT vs. AMORE*	146.18 ((87.2 – 311.7)		
Non Para Meningeal	 N=13	 N=13	*No mean – not large enough group*	*No mean – not large enough group*
MEAN SW (range)	211.68 (84.0 – 346.7) *p=0.660 EBRT vs. AMORE*	226.79 (97.0 – 368.9)		
Para meningeal	 N=30	 N=20	 N=16	 N=22
MEAN SW (range)	255.22 (127.8 – 482.1) *	229.42 (101.3 – 393.8)	189.66 (90.5 – 349.7) */**	269.51 (100.8 – 485.1) **

Hol M, et al PBC 2023

Second Cancer Risk After Primary Cancer Treatment With Three-Dimensional Conformal, Intensity-Modulated, or Proton Beam Radiation Therapy

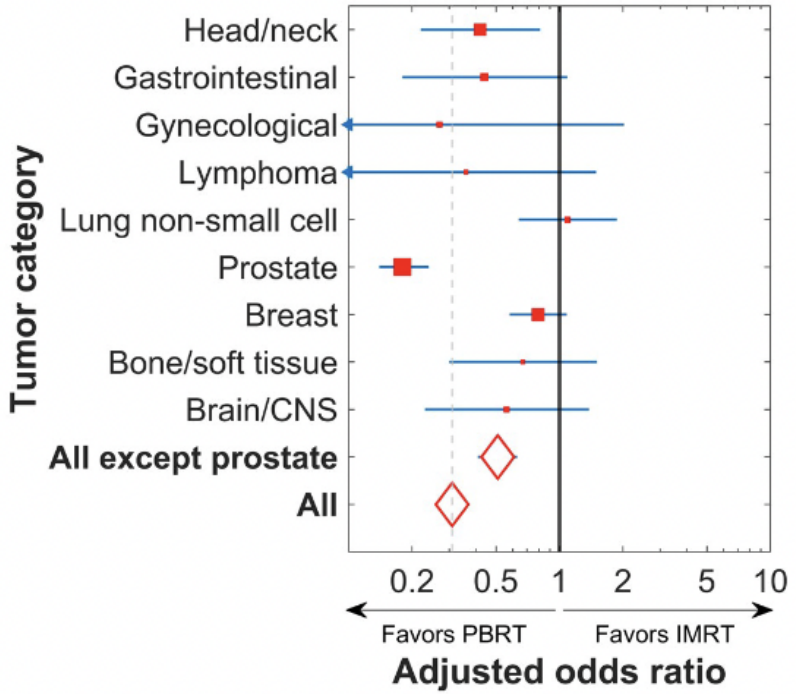
Michael Xiang, MD, PhD [1,2]; Daniel T. Chang, MD [1]; and Erqi L. Pollom, MD, MS [1,2]

No. of Patients (%)

TABLE 2. Overall Second Cancer Risk for Intensity-Modulated Radiation Relative to Three-Dimensional Conformal Radiation and Proton Beam Radiation Relative to Intensity-Modulated Radiation[a]

Cohort and Adjustment Method(s)	Adjusted OR (95% CI)	*P*
IMRT relative to 3DCRT		
Nonmatched, multivariable	1.00 (0.97-1.02)	.75
Matched, univariable	1.03 (1.00-1.06)	.04
Matched, multivariable	1.00 (0.98-1.03)	.75
PBRT relative to IMRT		
Nonmatched, multivariable	0.31 (0.26-0.36)	<.0001
Matched, univariable	0.30 (0.26-0.36)	<.0001
Matched, multivariable	0.29 (0.24-0.35)	<.0001

Stage 0 or I	72,545 (48)	66,199 (23)	1432 (24)
Stage II	44,039 (29)	128,589 (44)	3353 (57)
Stage III	26,227 (17)	46,546 (16)	417 (7)
Stage IV	2317 (2)	33,397 (11)	134 (2)
Not applicable or unknown	5892 (4)	18,755 (6)	531 (9)
Race			
Non-Hispanic white	125,072 (83)	233,455 (80)	4824 (82)
Black	14,606 (10)	35,526 (12)	331 (6)
Hispanic	5725 (4)	12,901 (4)	368 (6)
Asian/Native American/Pacific Islander	4011 (3)	7509 (3)	226 (4)
Other or unknown	1606 (1)	4095 (1)	118 (2)



Patient cohort of 4.5 lakh patients
>25 lakh patient-years of cumulative follow-up

Cancer 2020

QOL studies

Table 4. Details regarding quality of life studies of pediatric neoplasms treated with proton beam therapy*

Reference	No.	Tumor status	Dose, Gy RBE	QOL/PRO parameters	End points	Conclusions
Kuhlthau et al., 2012 (41)	142	Primary brain tumors, most commonly PNET (35%), ependymoma (22%), LGG (14%); CSI in 43% PBT only (7%), PBT/surgery (31%), PBT/chemo (9%), trimodality (53%)	≥45 (96%)	PedQoL: core (functioning), brain tumor (sensorimotor, neurocognitive), cancer modules (psychosocial) Also utilized Wechsler IQ scale, BASC and SIB-R (behavioral), and cross-comparison with scores provided by both parents and children Measured during the first and last weeks of PBT and annually thereafter	QOL rose from start to end of PBT in both CSI and non-CSI, but comparatively less rise from end of PBT to 3 y post-PBT During treatment, lowest scores for school and emotional functioning, anxiety/worry, communication, physical health Worse QOL scores at start statistically correlated with baseline IQ and behavioral tests, PNET/germ cell histology, posterior fossa irradiation, CSI, any chemo receipt, and PBT only/trimodality	QOL increases during PBT Noteworthy clinical factors associated with poorer QOL scores
Weber et al., 2015 (42)	15	Primary ATRT, resection in 93%, concurrent chemo in 47%	54	PedQoL: physical, emotional, social, school, psychosocial, composite Measured before PBT and compared with measurement at 2 mo	Numerically higher physical, emotional, school scores Numerically lower social score	QOL does not deteriorate at median 33 mo after PBT
Leiser et al., 2016 (43)	93	Rhabdomyosarcoma, concurrent chemo in 89%, anesthesia in 66%	54	PedQoL measured at baseline and 2 mo post-PBT, and annually thereafter; matched with proxy normal population Questionnaire given to 34 patients	Lower QOL at beginning of PBT vs normal population QOL improves (all domains) at 2 mo post-PBT and continues to 2 y; most notable improvement in first year post-PBT At 2 y, most QOL parameters comparable (or higher) with normal population	QOL increases after PBT

Neuro-Oncology
22(9), 1379–1387, 2020 | doi:10.1093/neuonc/noaa042 | Advance Access date 17 February 2020

Long-term health-related quality of life in pediatric brain tumor survivors receiving proton radiotherapy at <4 years of age

Neuro-Oncology
22(9), 1243–1244, 2020 | doi:10.1093/neuonc/noaa173 | Advance Access date 17 July 2020

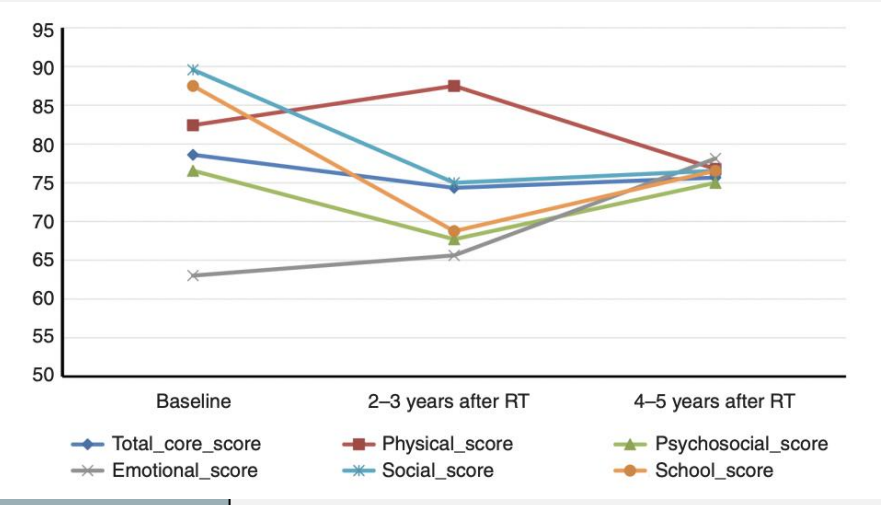
Reassuring quality of life in younger childhood (<4 y) brain tumor survivors treated with proton beam therapy

Srinivas Chilukuri and Rakesh Jalali

Table 1 Patient demographics and clinical variables

59 patients

	n Median (range)
Age at radiotherapy	2.5 years (0.3–3.8)
Age at follow-up	9.1 years (5.5–18.0)



- one-third of the children reported scores comparable to healthy children
- 90% of them could function in a regular school (albeit often with some additional support)
- Mean child and parent HRQoL scores in the study cohort were inferior to those of healthy children but comparable to the reference cohort with other chronic health conditions.

Eaton B, et al Neuro Oncology 2020

COST-EFFECTIVENESS

Comparative Study > Cancer. 2005 Feb 15;103(4):793-801. doi: 10.1002/cncr.20844.

Cost-effectiveness of proton radiation in the treatment of childhood medulloblastoma

Jonas Lundkvist [1], Mattias Ekman, Suzanne Rehn Ericsson, Bengt Jönsson, Bengt Glimelius

52% reduction in SMNs
33% reduction in cardiac and non-cardiac mortality
88% risk reduction for hearing loss, hormone insufficiencies, osteoporosis and IQ loss.
Authors reported a gain of 0.68 QALY/child with an estimated ICER of € 34,622 EUR.

TABLE 2
Radiation-Induce

Variable						
Conventional radiation						
Proton radiation	1.4	2.7	0.1	2.0	0.7	0.38
Difference	10.5	13.6	0.3	15.1	0.5	1.53

TABLE 1
Cost and Clinical Outcome per Patient for the Base-Case Assumptions

	Proton ...tion	Conventional radiation	Difference
	...7.9	4239.1	5978.8
	...8	33857.1	−29625.3
	...9.7	38096.2	−23646.5
LYG	13.866	13.600	0.266
QALY	12.778	12.095	0.683

Proton therapy for Medulloblastoma is cost-effective and cost-saving

ACCESS TO PROTON THERAPY

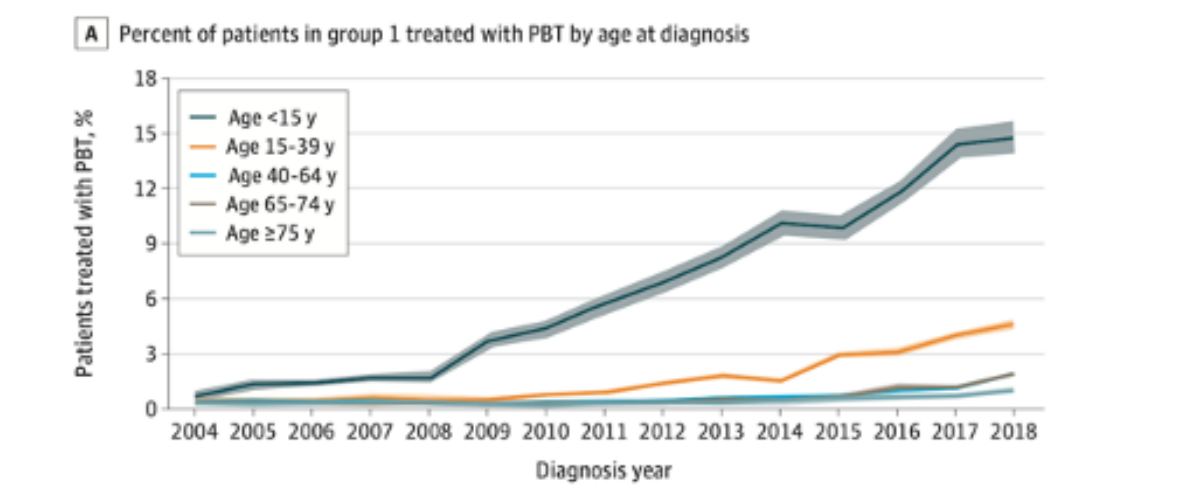


Table 4
Estimated proportion of patients <22 years of age treated with protons for a malignant disease among all patients receiving radiotherapy in 2016 in the United States.

	Projected number of U.S. patients treated with protons	Proportion of all patients receiving radiotherapy
Rhabdomyosarcoma	145	54%
Medulloblastoma	134	50%
Ependymoma*	118	68%
Ewing Sarcoma	82	53%
Neuroblastoma	51	30%
Hodgkin lymphoma	69	18%
Atypical teratoid rhabdoid tumor	25	62%
Nasopharyngeal carcinoma	13	46%
Primitive Neuroectodermal tumors	10	17%

RADIATION ONCOLOGY

Proton Therapy in LMICs: Is the Need Justified?

JCO® Global Oncology

1

Srinivas Chilukuri, MD[1]; Pankaj Kumar Panda, MSc[1]; and Rakesh Jalali, MD[1]

JCO Global Oncol 8:e2100268.

commenta

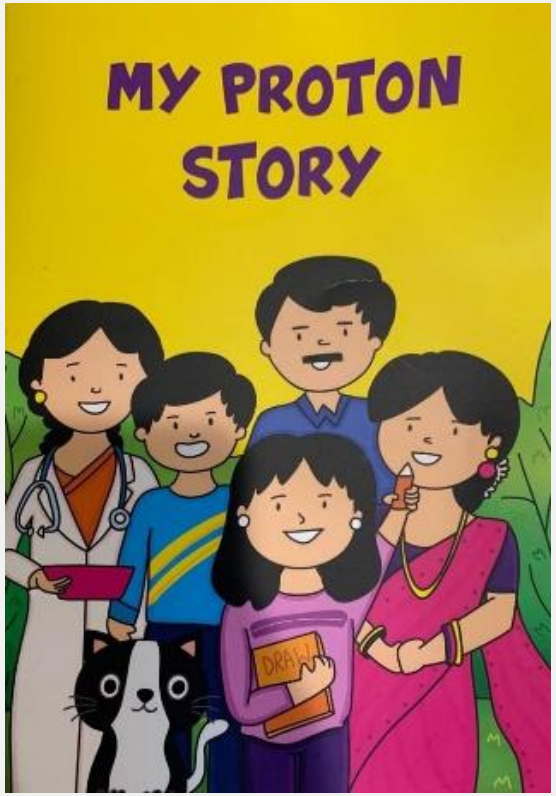
80% of medulloblastomas diagnosed in the world belong to LMICs

Table 2. Clinical indications for proton therapy in paediatric patients

Clinical Indication	COUNTRY/REGION †UK[18]	‡United States[22]	§Canada[21]	§Netherlands[20]	‡Australia & New Zealand[19]
Chordoma base of skull/spinal					
Chondrosarcoma base of skull/spine					
Craniopharyngioma					
Ependymoma					
Ewing sarcoma					
Intracranial germ cell tumour					
Optic pathway and other selected low-grade glioma					
Rhabdomyosarcoma	<10year				
Medulloblastoma	NR				
Pelvic sarcoma					NR
Pineal parenchymal tumours (*excluding pineoblastoma*)					NR
Retinoblastoma			NR		
Intraocular melanoma	NR			NR	
Primitive neuroectodermal tumours	NR			NR	NR
Re-irradiation			NR		
Spinal/paraspinal bone and soft tissue sarcoma (non-Ewing)			NR	NR	
Children with NF1 and any other cancer predisposition syndrome requiring RT			NR	NR	NR
Esthesioneuroblastoma		NR		NR	NR
Intracranial arteriovenous malformation	NR	NR		NR	NR
Lymphoma	NR			NR	
Nephroblastoma	NR	NR	NR		NR

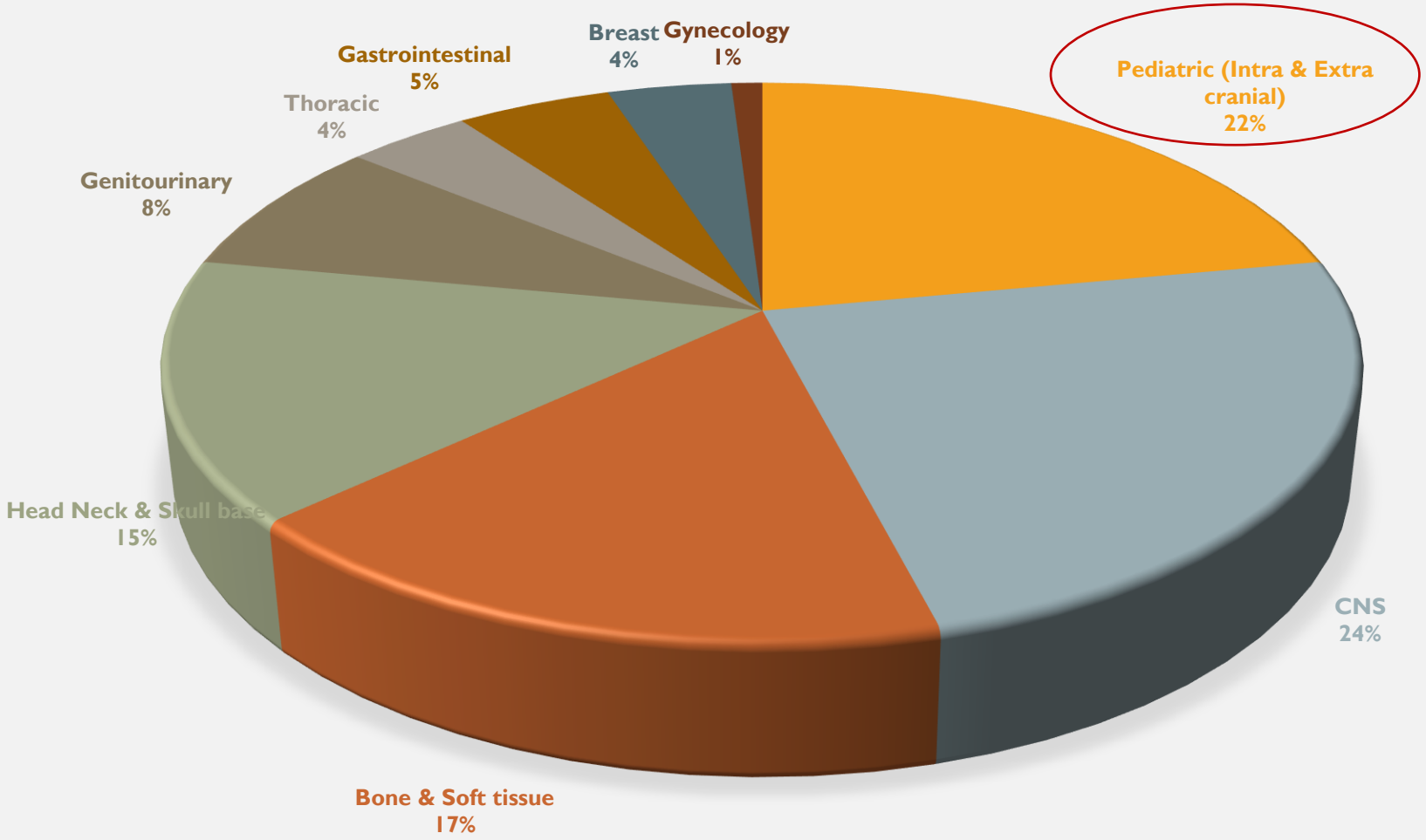
APCC EXPERIENCE
DEDICATED PEDIATRIC SERVICE

Tour to PROTON Gantry



Coloring Masks
(Child's favorite super-hero)

INDICATIONS AT APCC



2000+ Patients,

3/4 patients belong to these sites

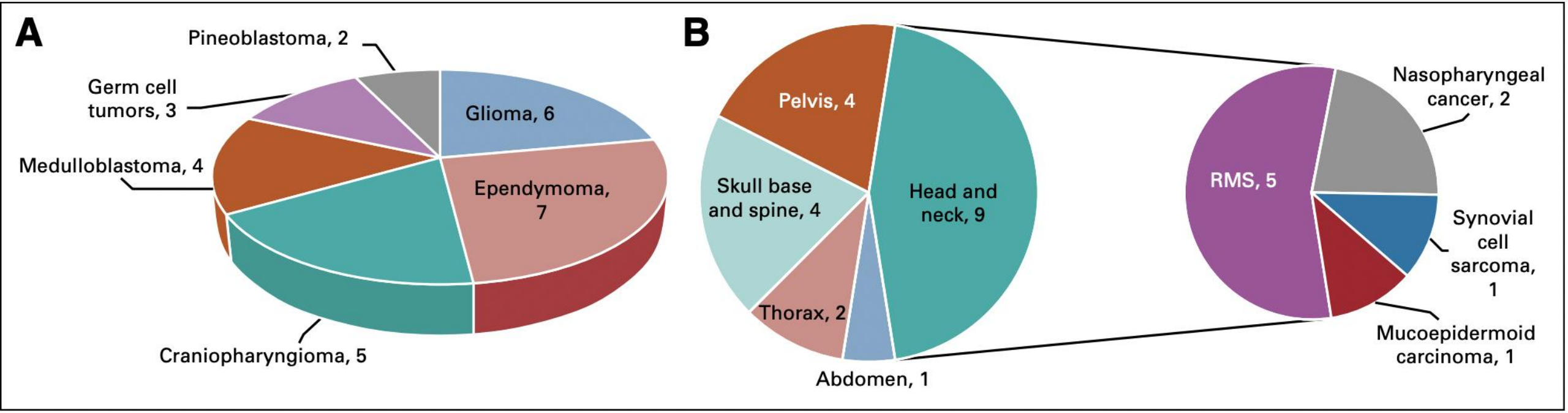
- Neuro
- Peds
- Musculoskeletal/BST
- HN & Skull base

PEDIATRIC ONCOLOGY

original reports

Preliminary Experience of Treating Children and Young Adults With Image-Guided Proton Beam Therapy in India

Srinivas Chilukuri, MD, MBBS[1]; Nagarjuna Burela, MD, DNB[1]; Ramya Uppuluri, MD, FNB[1]; D. Indumathi, MD[1]; Sapna Nangia, MD[1]; Pankaj Kumar Panda, BDS, MSc[1]; Dayananda Sharma Shamurailatpam, PhD[1]; Revathi Raj, DCH, MRCP, FRCPath[2]; Thirumalai Raja, MD, DM[1]; and Rakesh Jalali, MD[1]



LOW ACUTE TOXICITIES & EXCELLENT LOCAL CONTROL

Toxicity (Grade ≥2) NCI CTC version 4.0	**CNS (n, %)**	**Non-CNS (n, %)**	**Total (n,%)**
Fatigue	8 (29.6)	4 (20)	12 (25.5)
Aloepecia	27 (100)	4 (20)	31 (65.9)
Dermatitis	9 (33.3)	16 (80)	25 (53.1)
Nausea	5 (18.5)	5 (25)	10 (21.2)
Vomiting	10 (37)	4 (20)	14 (29.7)
Mucositis	5 (18.5)	11 (55)	16 (34)
Dysphagia	5 (18.5)	10 (50)	15 (31.9)
Bowel	0 (0)	1 (5)	1 (2)
≥Grade 2 neutropenia	10 (37)	7 (35)	17 (36.1)

- 50% of our patients presented at the time of recurrence
- 22% at second recurrence
- 20% received prior radiation therapy

Contents lists available at ScienceDirect

Clinical Oncology

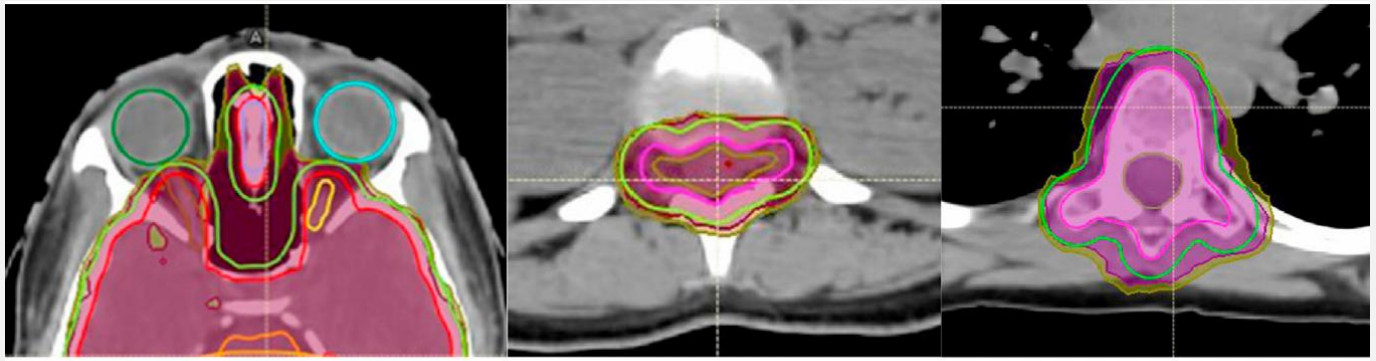
journal homepage: www.clinicaloncologyonline.net

Original Article

Critical Appraisal of Paediatric Embryonal Cancers Treated with Image-guided Intensity-modulated Proton Therapy

D.S. Sharma [*], N.M. Padanthaiyil [*], G. Krishnan [*], M. Arjunan [*], A.K. Reddy [†], S. Mahammood [*], S. Gayen [*], R. Thiyagarajan [*], U. Gaikwad [†], R.T. Sudarsan [†], S. Chilukuri [†], R. Jalali [†]

[*] *Department of Medical Physics, Apollo Proton Cancer Centre, Chennai, Tamil Nadu, India*
[†] *Department of Radiation Oncology, Apollo Proton Cancer Centre, Chennai, Tamil Nadu, India*



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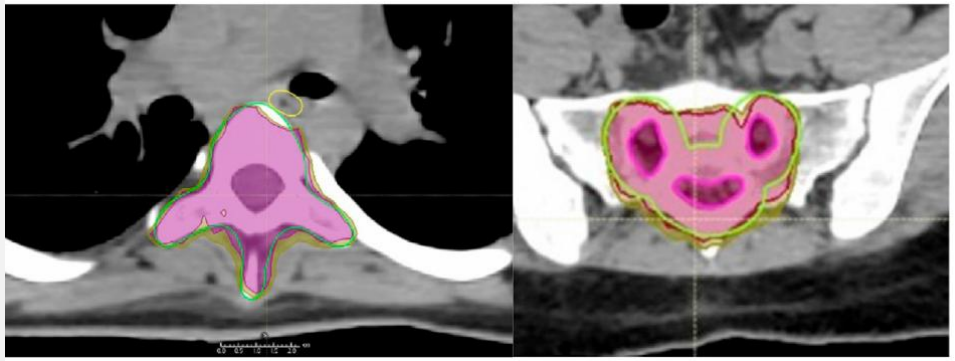


Parameters	Observation
Total number of patients	45
Median (range) age in years	7.50 (2–18) years
Sex ratio (male: female)	34:11
Diagnosis and staging (% of patients)	Medulloblastoma (56%), Recurrent ependymoma (19%) Pinealoblastoma (5%) Germ cell tumour (5%) Diffuse leptomeningeal glioneunoral tumour (3%) Others (12%)
Skeletally immature patients	
Boys ≤15 years	67.45%
Girls ≤13 years	20.93%
Presence of stent	35%
Patient requiring anaesthesia	36%
PTV-CS lengths	Median 57.56 cm; range 39.06 –79.59 cm
Proton beam therapy dose regimen	
Craniospinal irradiation dose (GyRBE)	21–25 GyRBE (37.38% of patients) 30–35 GyRBE (62.62% of patients) Median dose: 34.94 GyRBE Range 21.6–40.08 GyRBE
Boost dose (GyRBE)	10.2–19.8 GyRBE (55.56% of patients) >20 GyRBE (44.44% of patients)
Total dose (GyRBE)	Median of 54 GyRBE Range 36–59.81 GyRBE
Original beam geometry gantry; patient positioning system (G; PPS) in degree	(150; 330) and (210; 30) for the cranial and 1–2 direct posterior (180; 0) for spine
New beam geometry (G; PPS) in degree	(60; 0), (300; 0), and (180; 0) degree for the cranial and upper spine and 1–2 direct posterior fields (180; 0) for the middle and lower spine.
Percentage of patients treated with original beam geometry	87.20%
New beam geometry	12.80%
Percentages of patients treated with	
2 isocentres/3 or 4 fields	43.60%
3 isocentres/4 or 5 fields	48.70%
4 isocentres/5 or 6 fields	7.70%

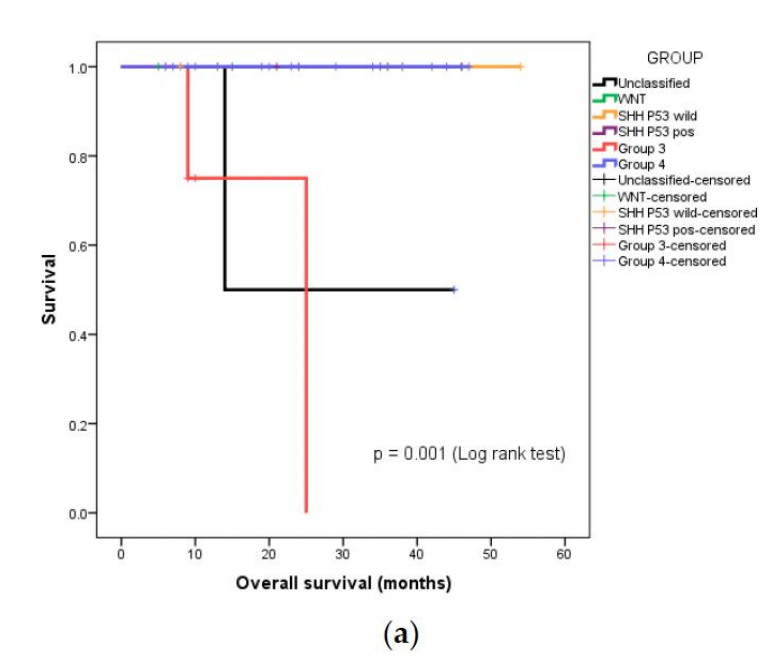
diagnostics

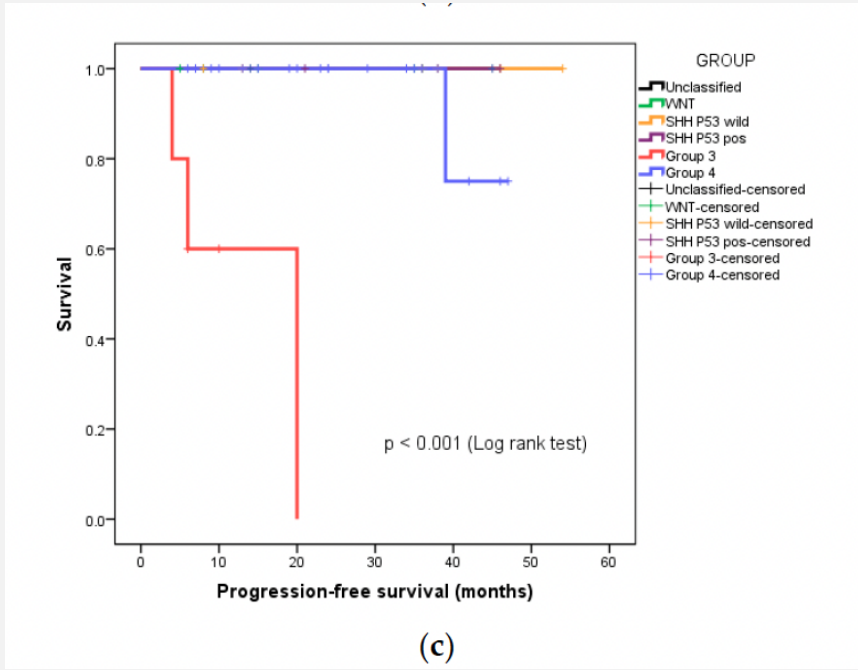
MDPI

Article

Successful Implementation of Image-Guided Pencil-Beam Scanning Proton Therapy in Medulloblastomas

Anindita Das [1], Utpal Gaikwad [1], Ganapathy Krishnan [2], Adhithyan Rajendran [3], Sushama Patil [4], Preethi Subramaniam [1], Uday Krishna [1], Manoj G. Wakde [1], Srinivas Chilukuri [5] and Rakesh Jalali [1,*]





The 3-year OS, DSS, and PFS of this group of patients were 88.5%, 91.7%, and 90.8%, respectively.

Anindita Das, et al Diagnostics 2023

Encouraging Experience with Image-Guided Pencil Beam Scanning Proton Therapy in Craniopharyngioma—First Case Series From India

Nagarjuna Burela[1], Anindita Das[1], Ganapathy Krishnan[2], Adhithyan Rajendran[3], Srinivas Chilukuri[1], Roopesh Kumar VR[4], Chandrashekhar E. Deopujari[5], Dayananda S. Sharma[2], Rakesh Jalali[1]

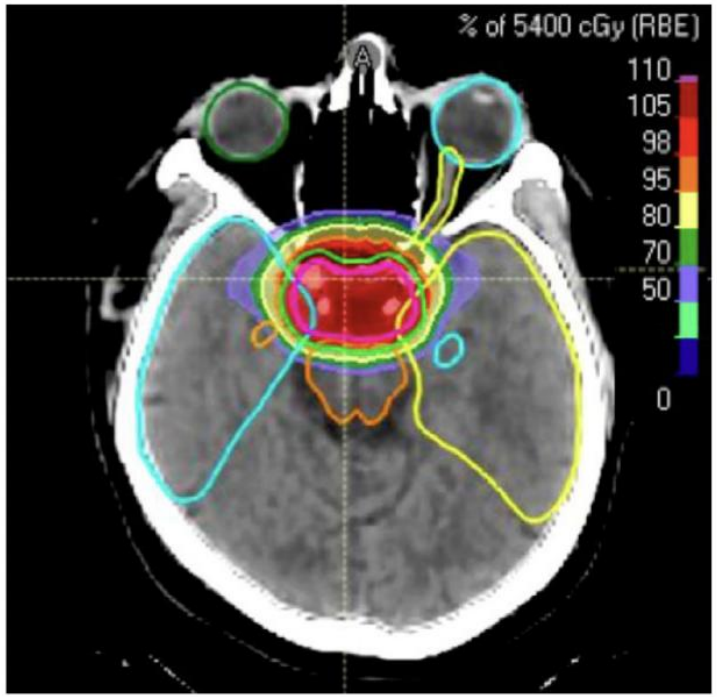
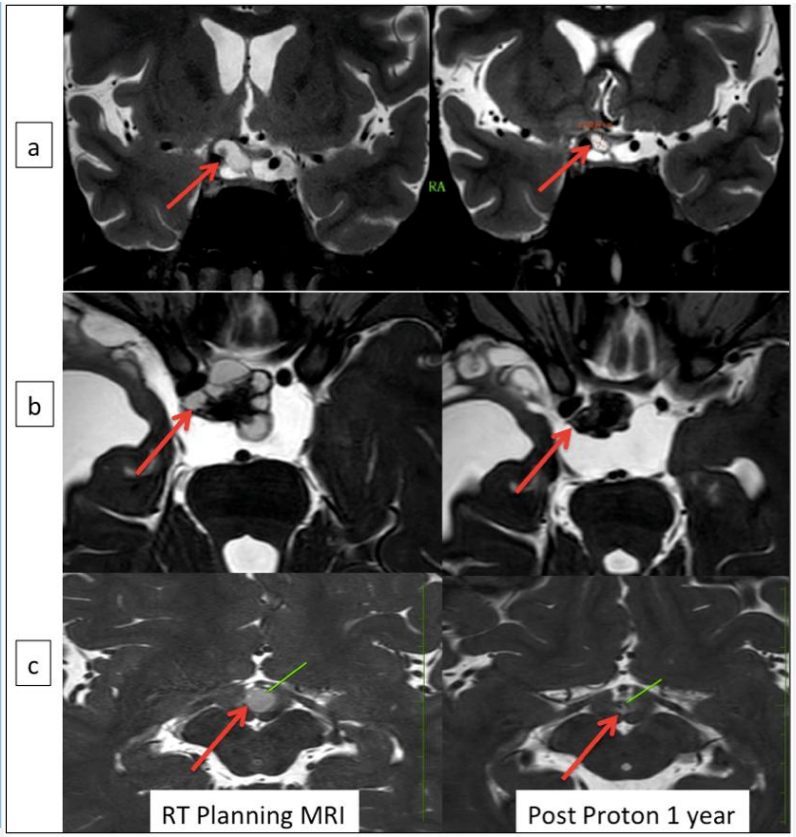


Figure 1. Isodose distribution of intensity-modulated proton therapy plan—axial view.



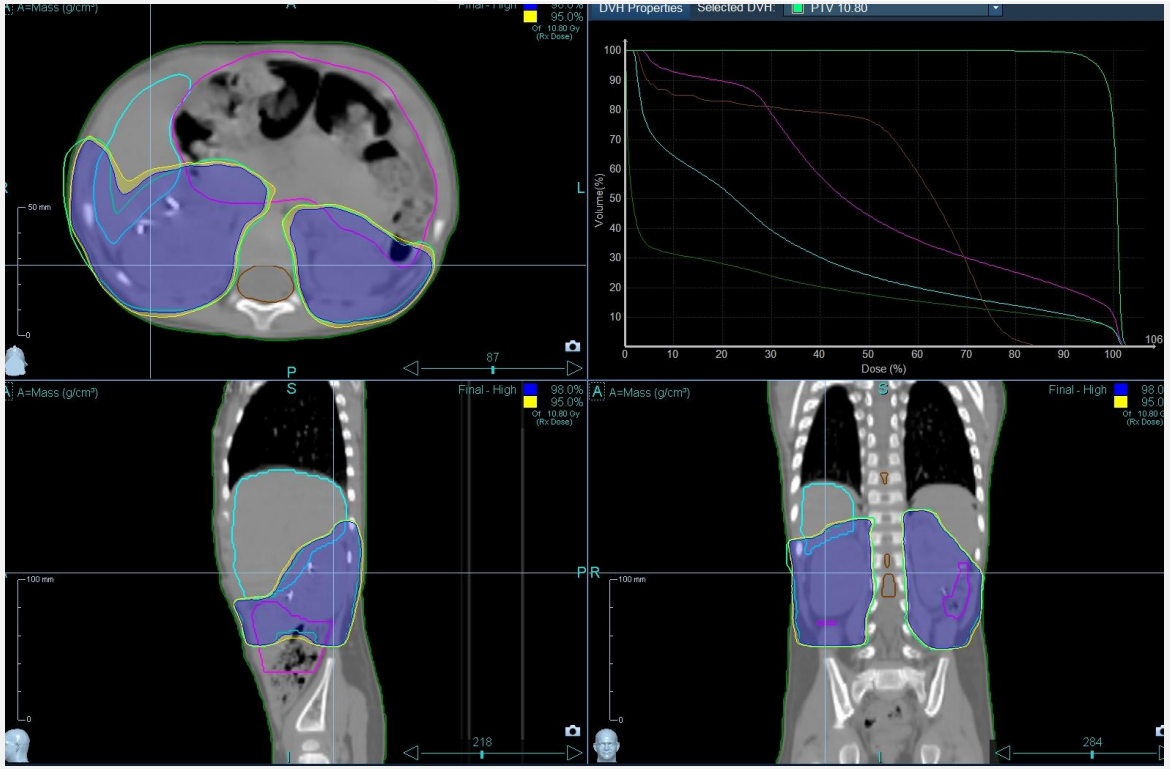
Our preliminary experience with modern PBS-PBT and image guidance for craniopharyngioma is encouraging. Proton therapy in our cohort was well tolerated, resulting in limited toxicity and promising early outcomes.

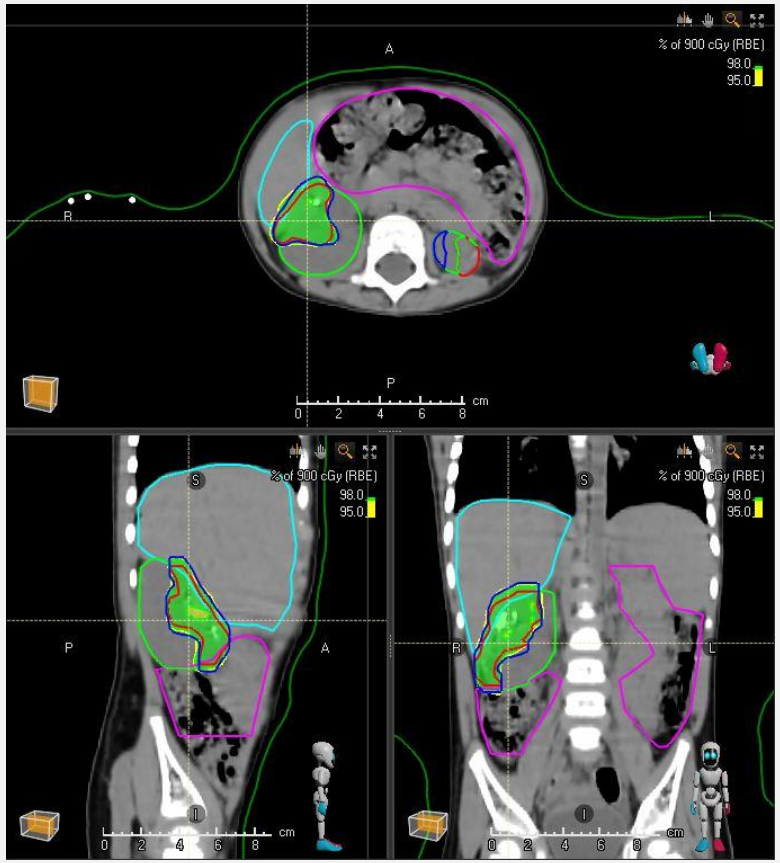
World Neurosurgery 2024

Case report

Preoperative three-dimensional modelling and virtual reality planning aids nephron sparing surgery in a child with bilateral Wilms tumour

Avijit Banerjee ,[1] Ramesh Babu,[2] Dhaarani Jayaraman,[3] Srinivas Chilukuri[4]





BMJ Case Reports 2024

INDIAN PEDIATRICS

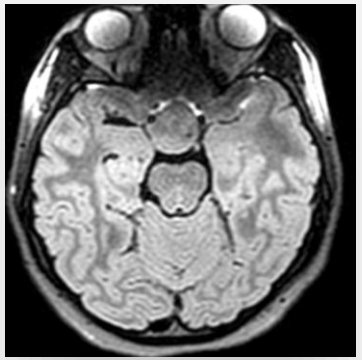
Introduction of Proton Beam Therapy in Intracranial Germ Cell Tumors in India

Rishan Thimma Sudarsan,[1] Srinivas Chilukuri,[1] Noufal Manthala Padannayil,[2] Pankaj Kumar Panda[3] and Rakesh Jalali[1*]

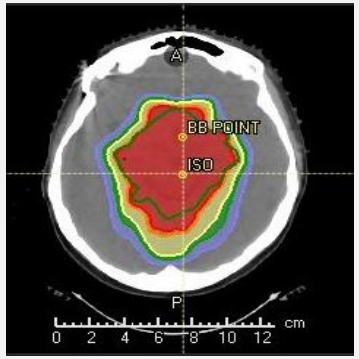
From Departments of [1]Radiation Oncology, [2]Medical Physics, and [3]Clinical Research, Neuro-Oncology Cancer Management Team, Apollo Proton Cancer Centre, Taramani, Chennai, Tamil Nadu, India.

**rjalali@apollohospitals.com*

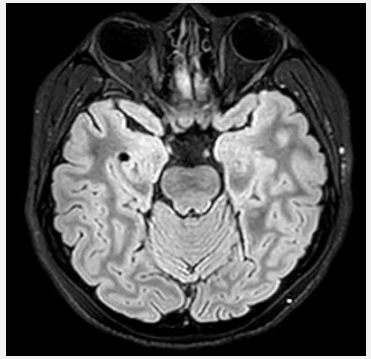
VOLUME 58—FEBRUARY 15, 2021



Pre surgery & Pre Proton



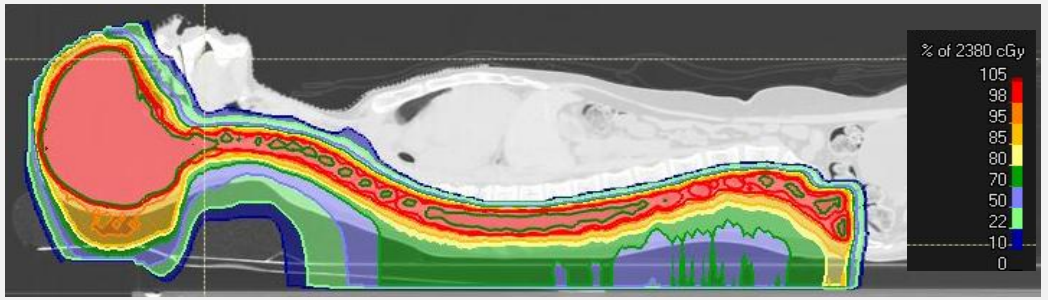
Proton plan

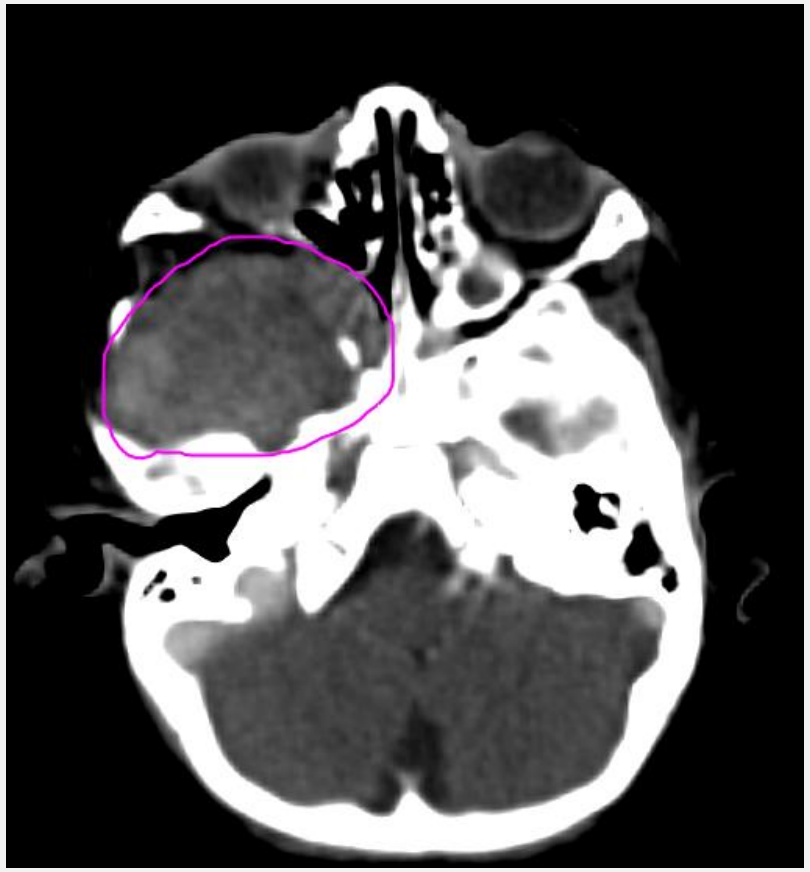


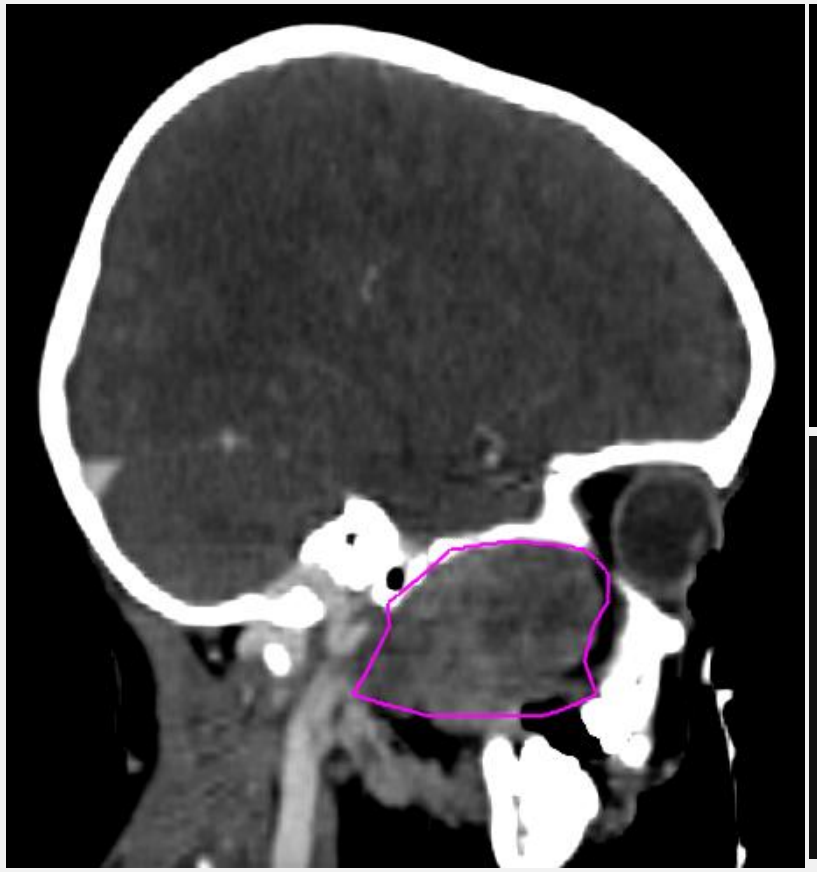
Post Proton 12 months

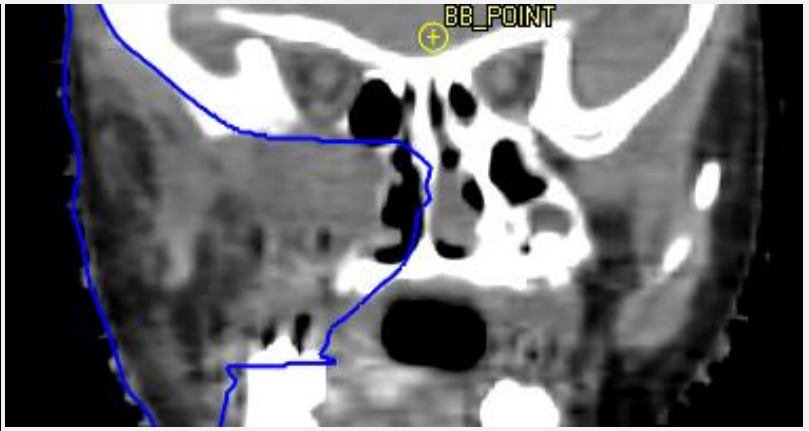
- 2-year follow-up - no residual disease.
- Tumour markers within normal limits.

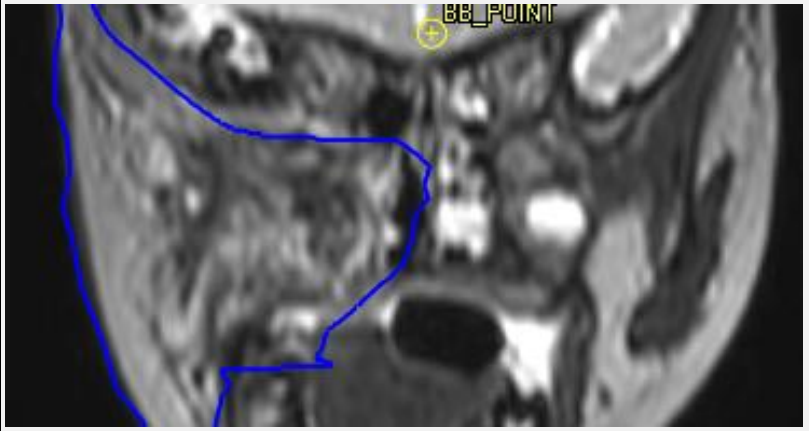
IMPT: 40 GyE in 23 fractions (**23.4GyE in 14# CSI and 16.2GyE in 9# boost**)

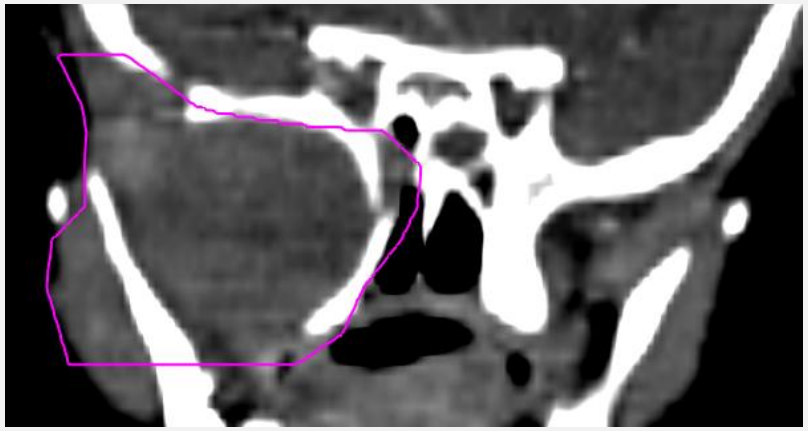




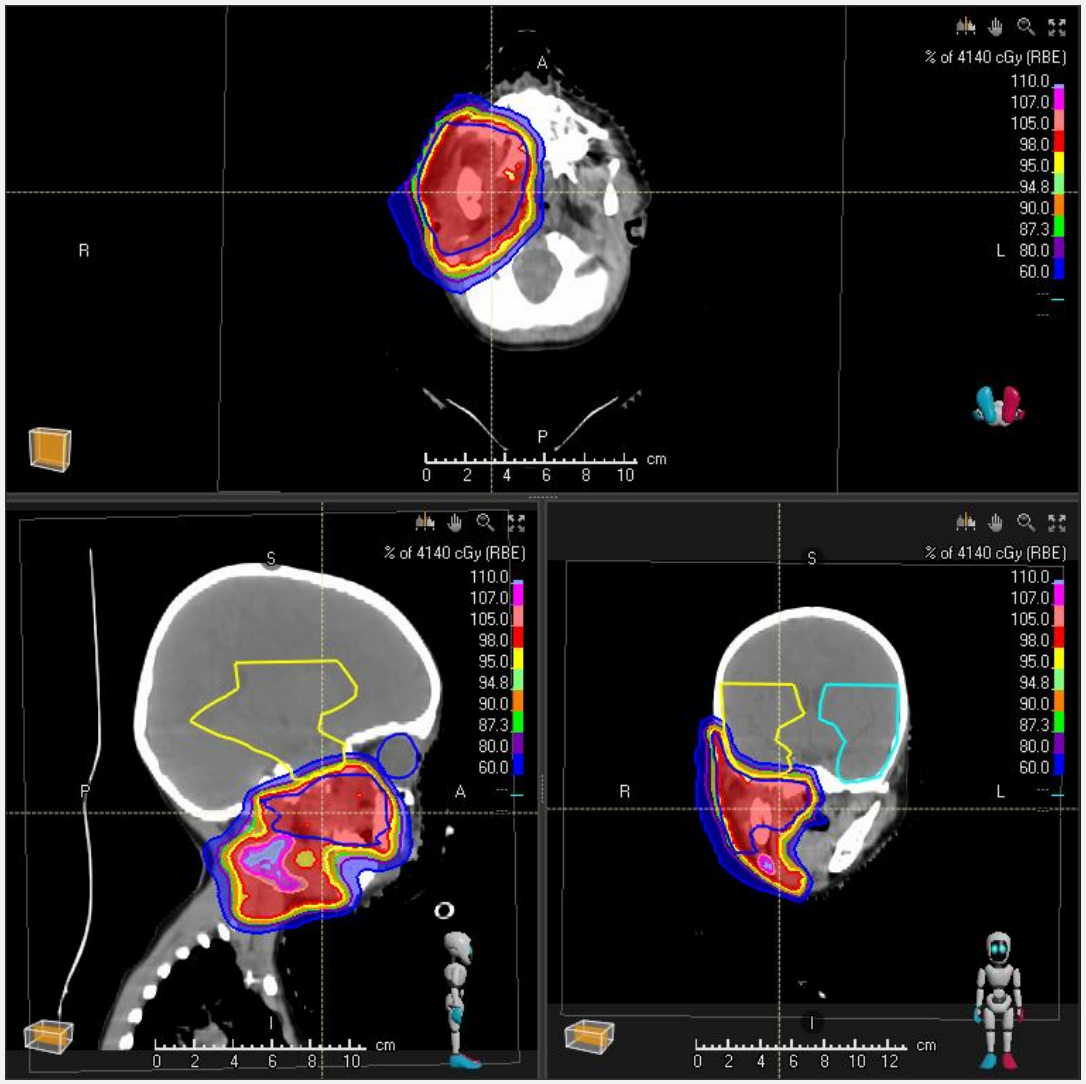


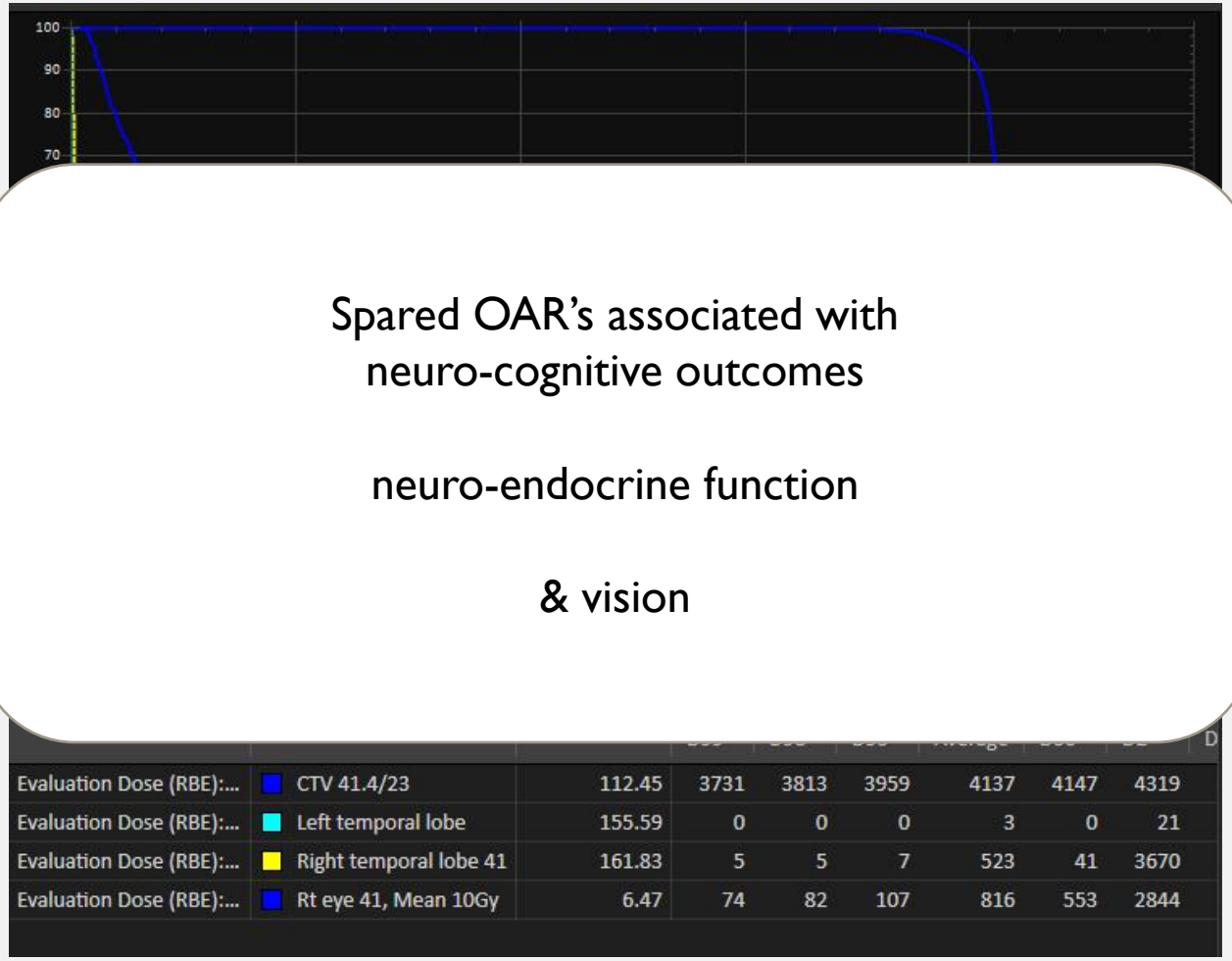






2 YR OLD WITH RMS, POST 12 WEEKS OF VAC AND SURGERY





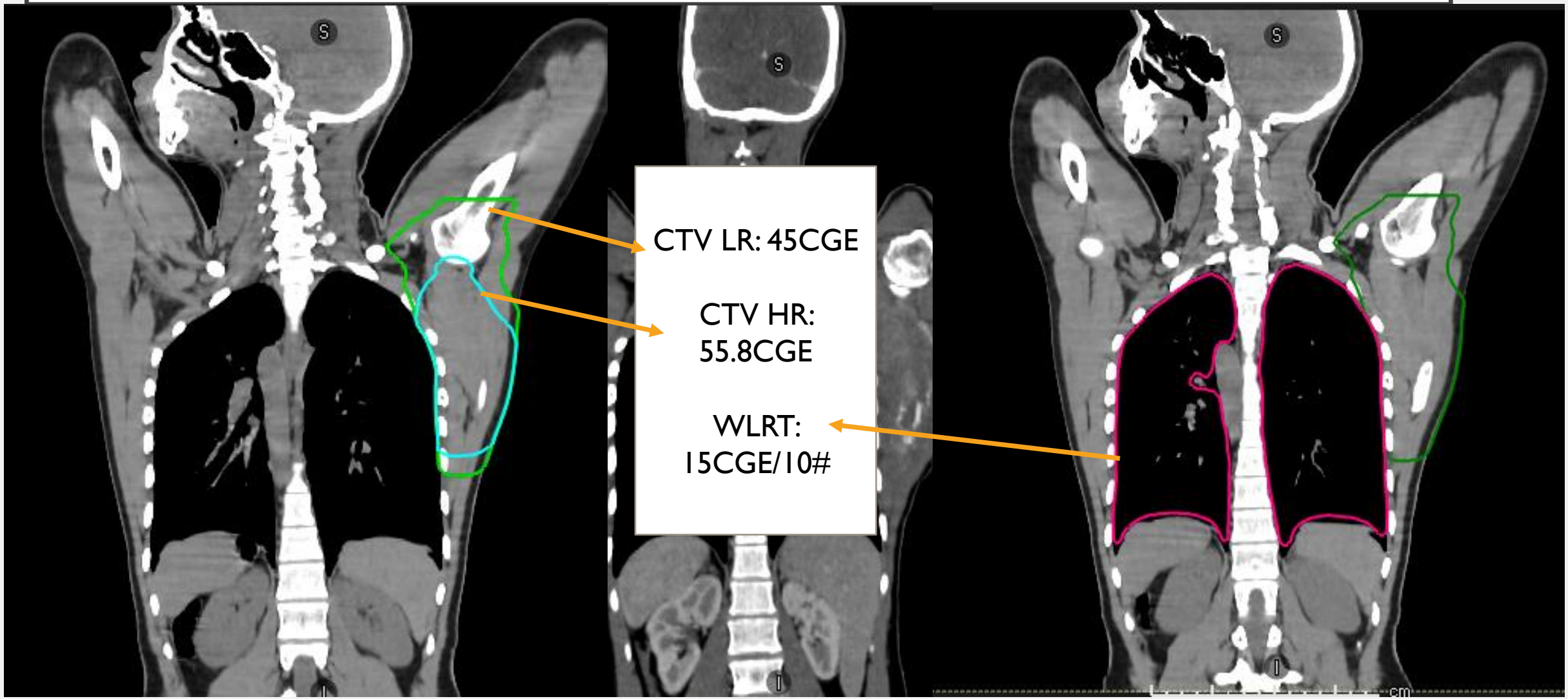
Spared OAR's associated with neuro-cognitive outcomes

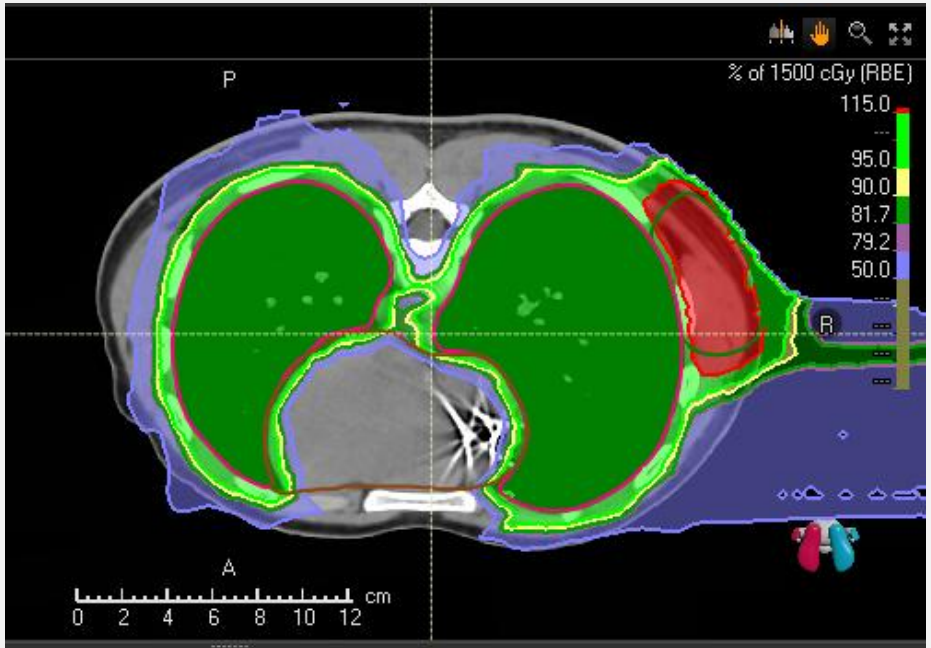
neuro-endocrine function

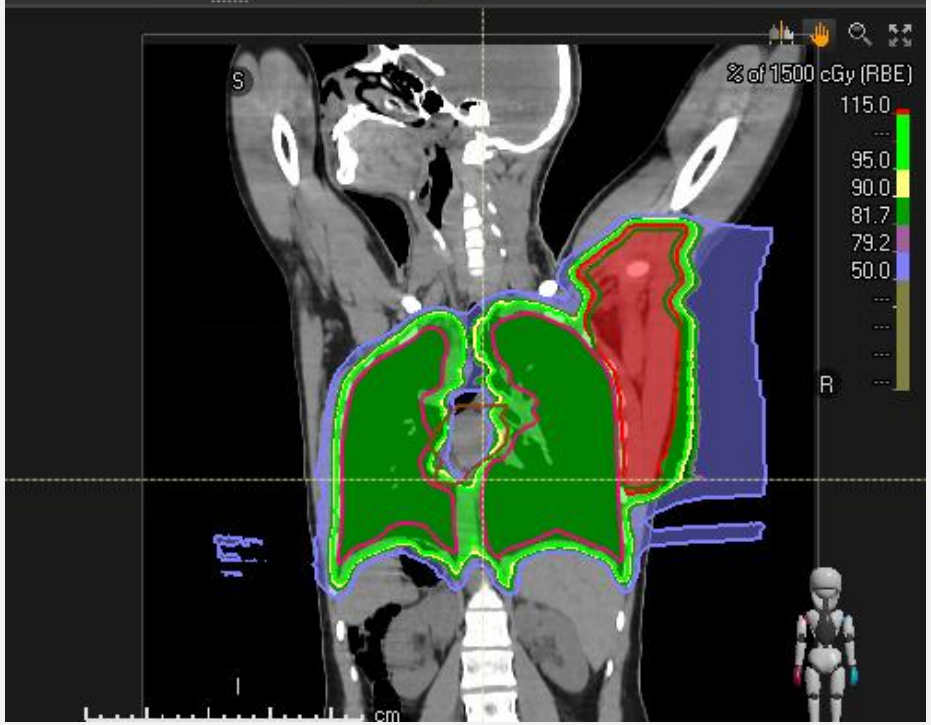
& vision

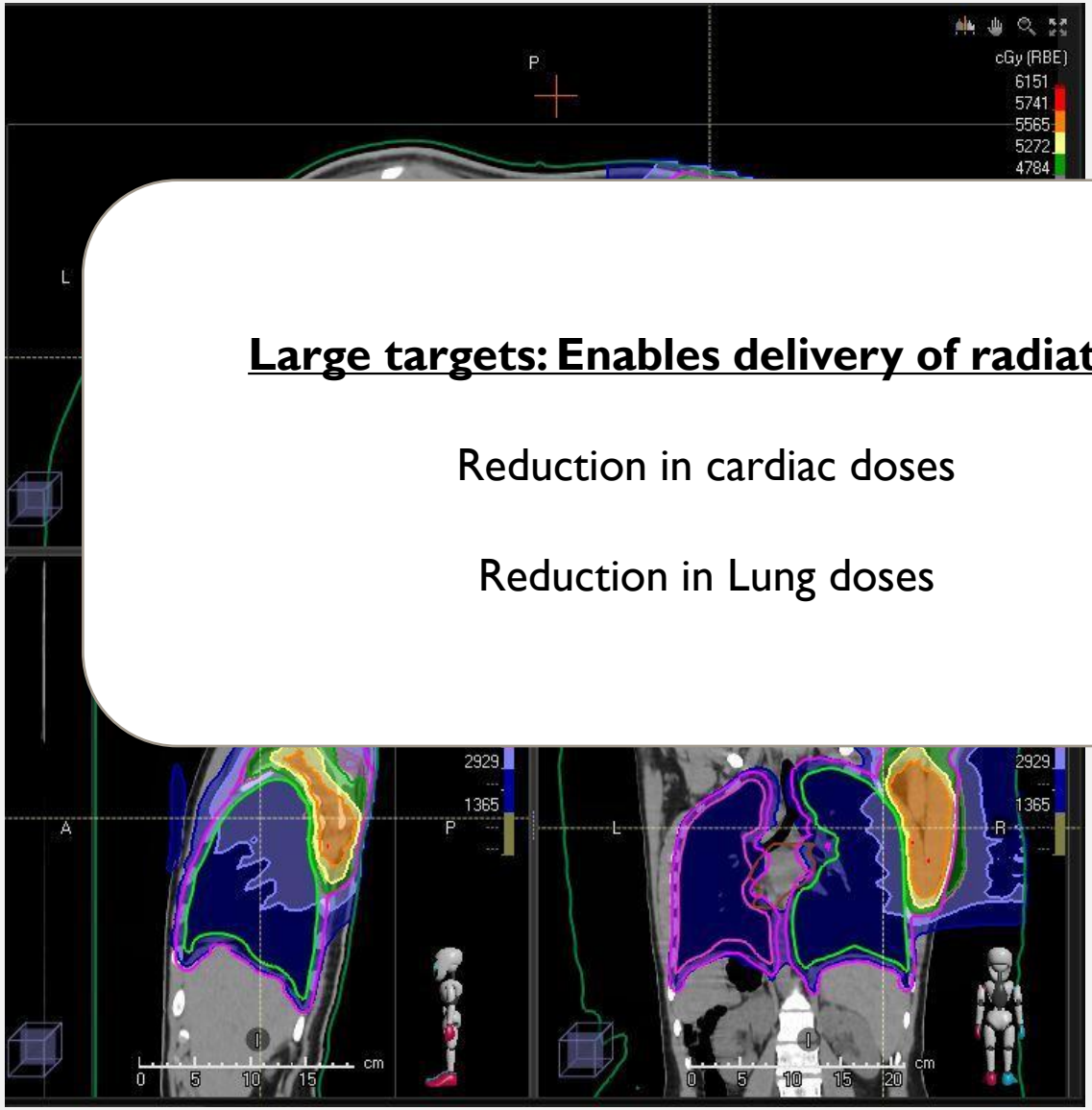
2 YR OLD, POST 12 WEEKS OF VAC AND SURGERY

DEFINITIVE RADIATION THERAPY WITH WLI: 17 YEAR OLD WITH CHEST WALL EWING SARCOMA







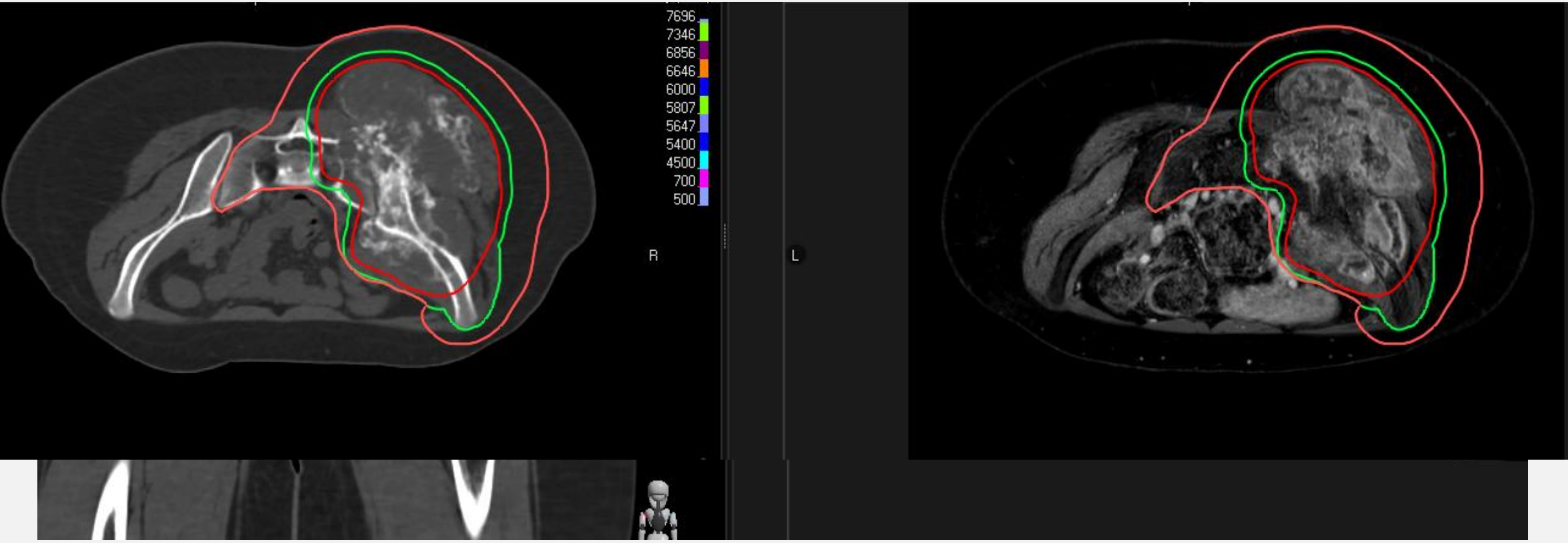


<u>Large targets: Enables delivery of radiation</u>

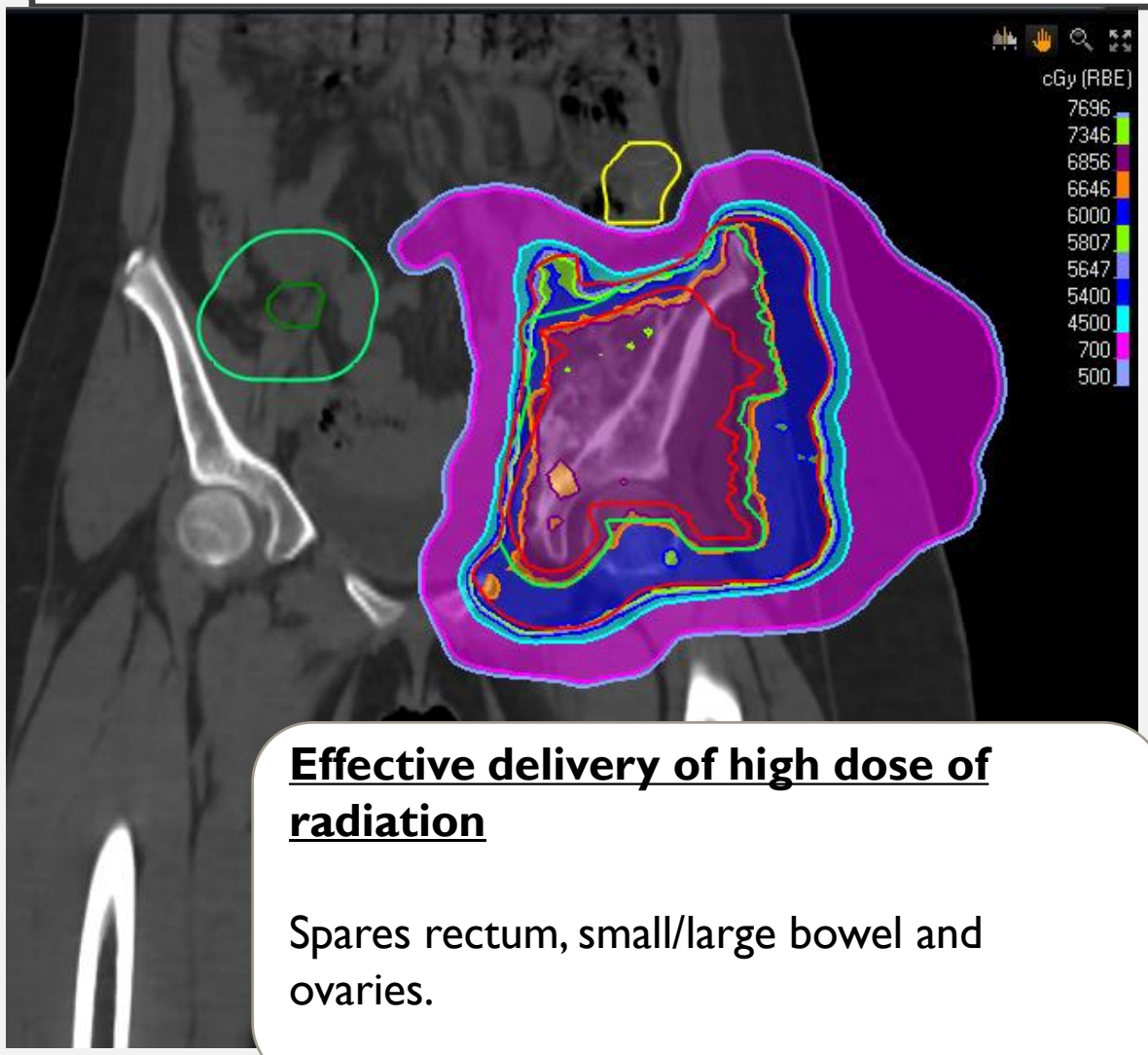
Reduction in cardiac doses

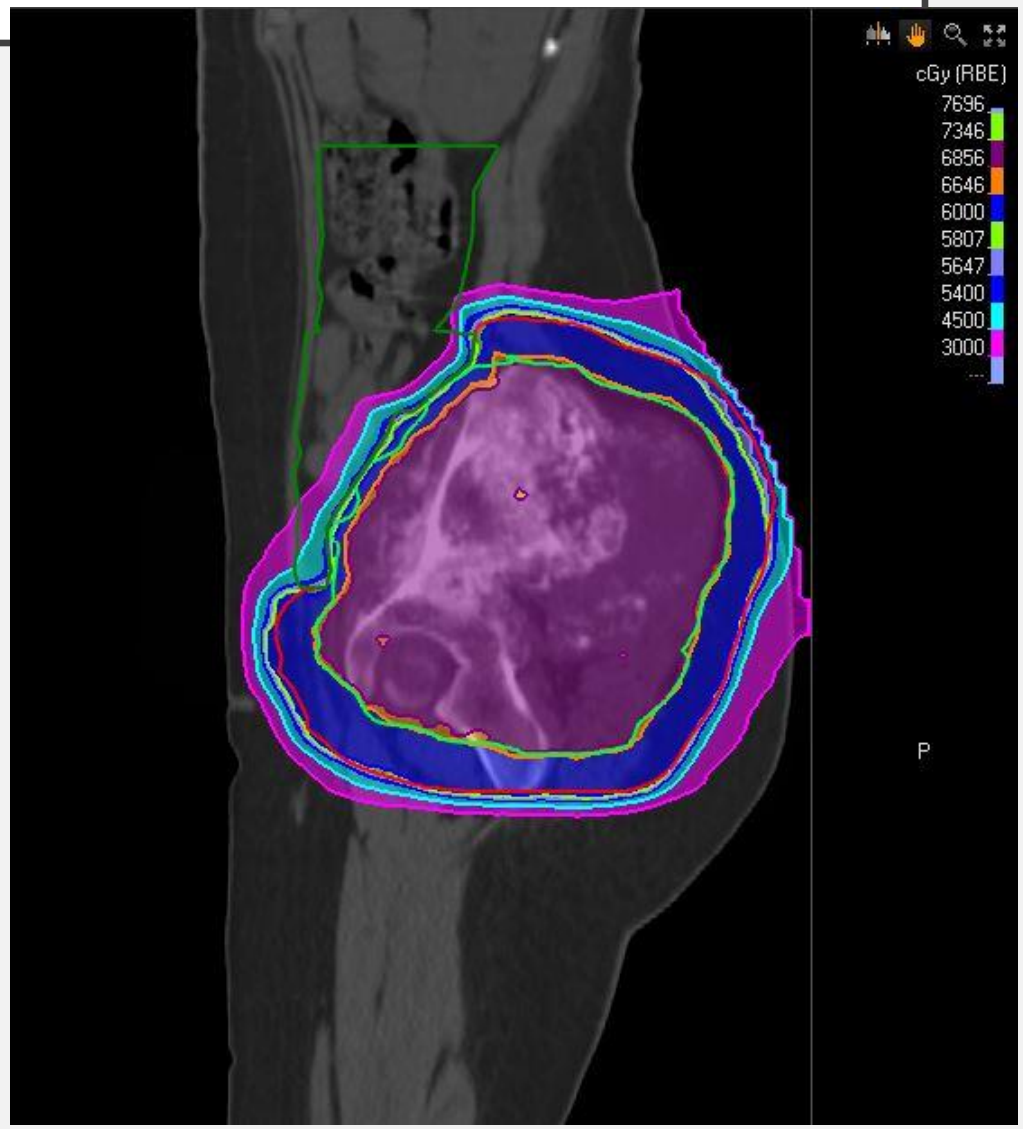
Reduction in Lung doses

15 YR OLD, CHONDROBLASTIC OSTEOSARCOMA, POST MAP CHEMOTHERAPY



OVARIAN SPARING

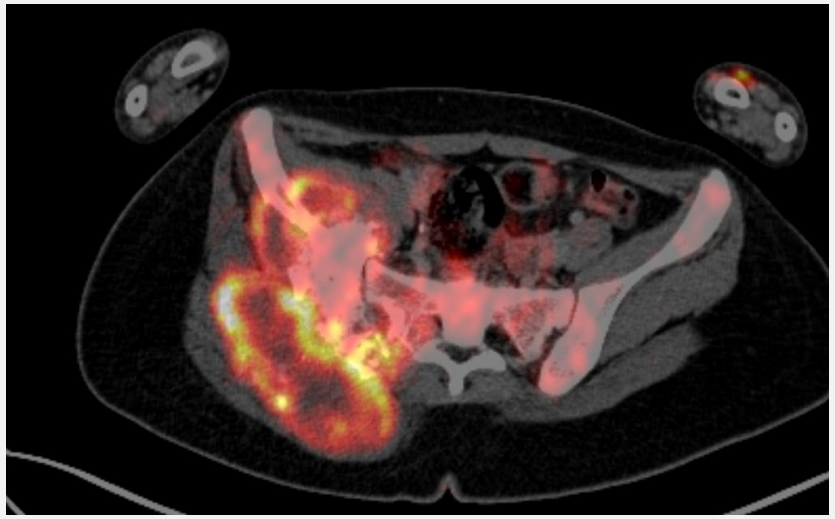


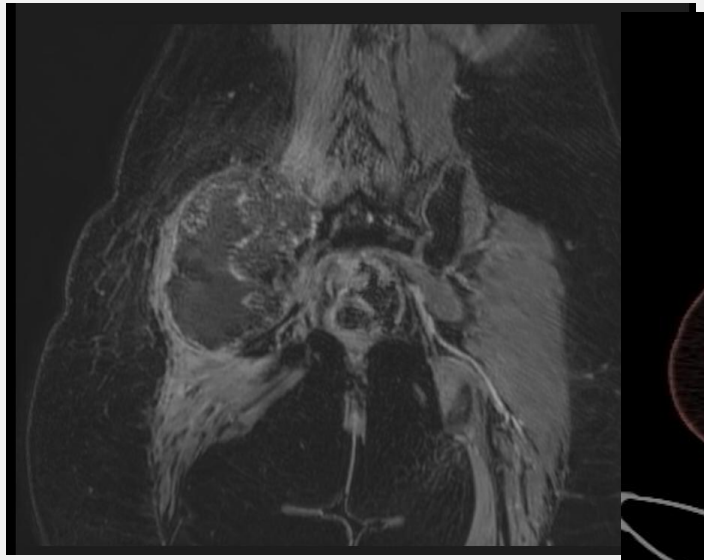


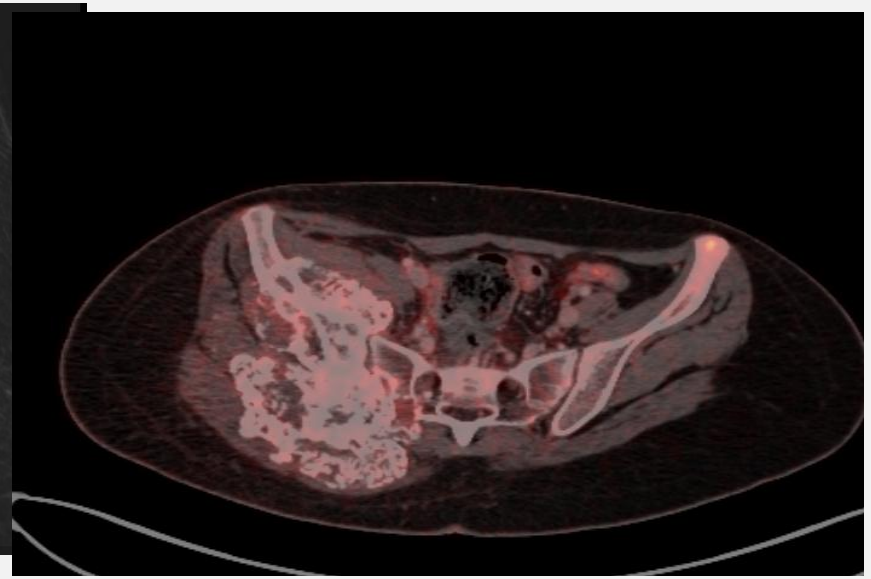
<u>Effective delivery of high dose of radiation</u>

Spares rectum, small/large bowel and ovaries.

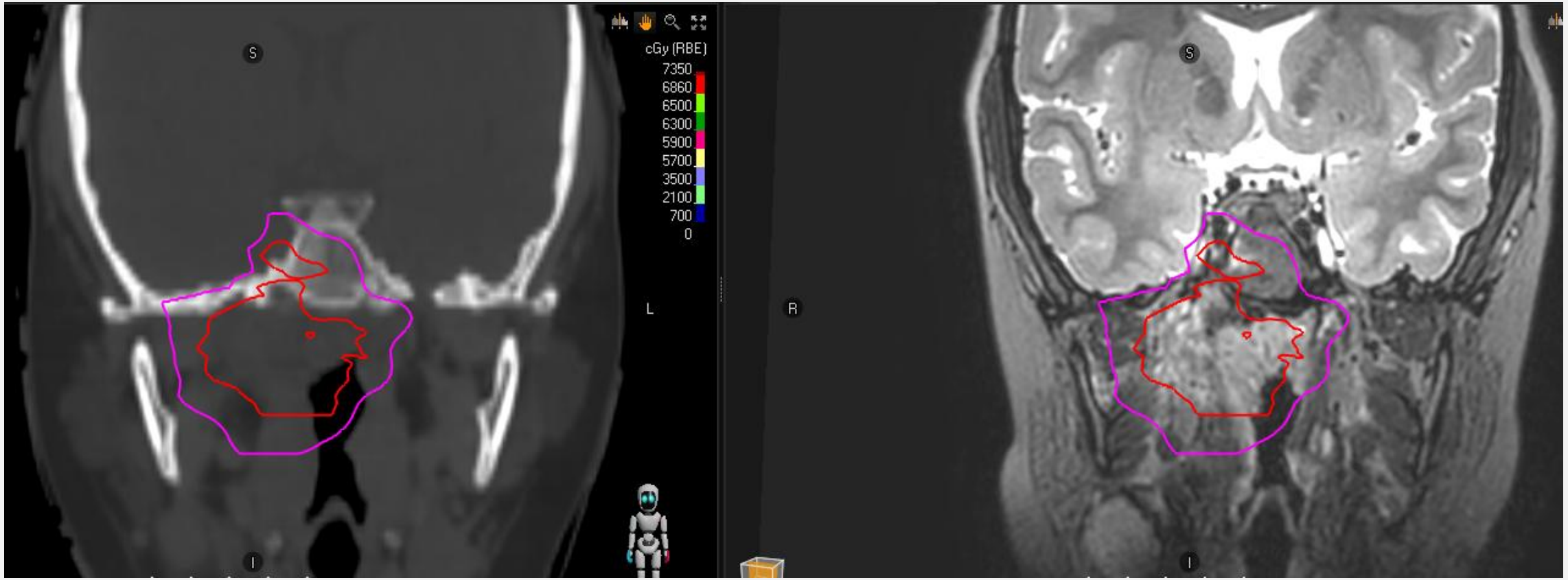
FOLLOW UP IMAGE (24 MONTHS)



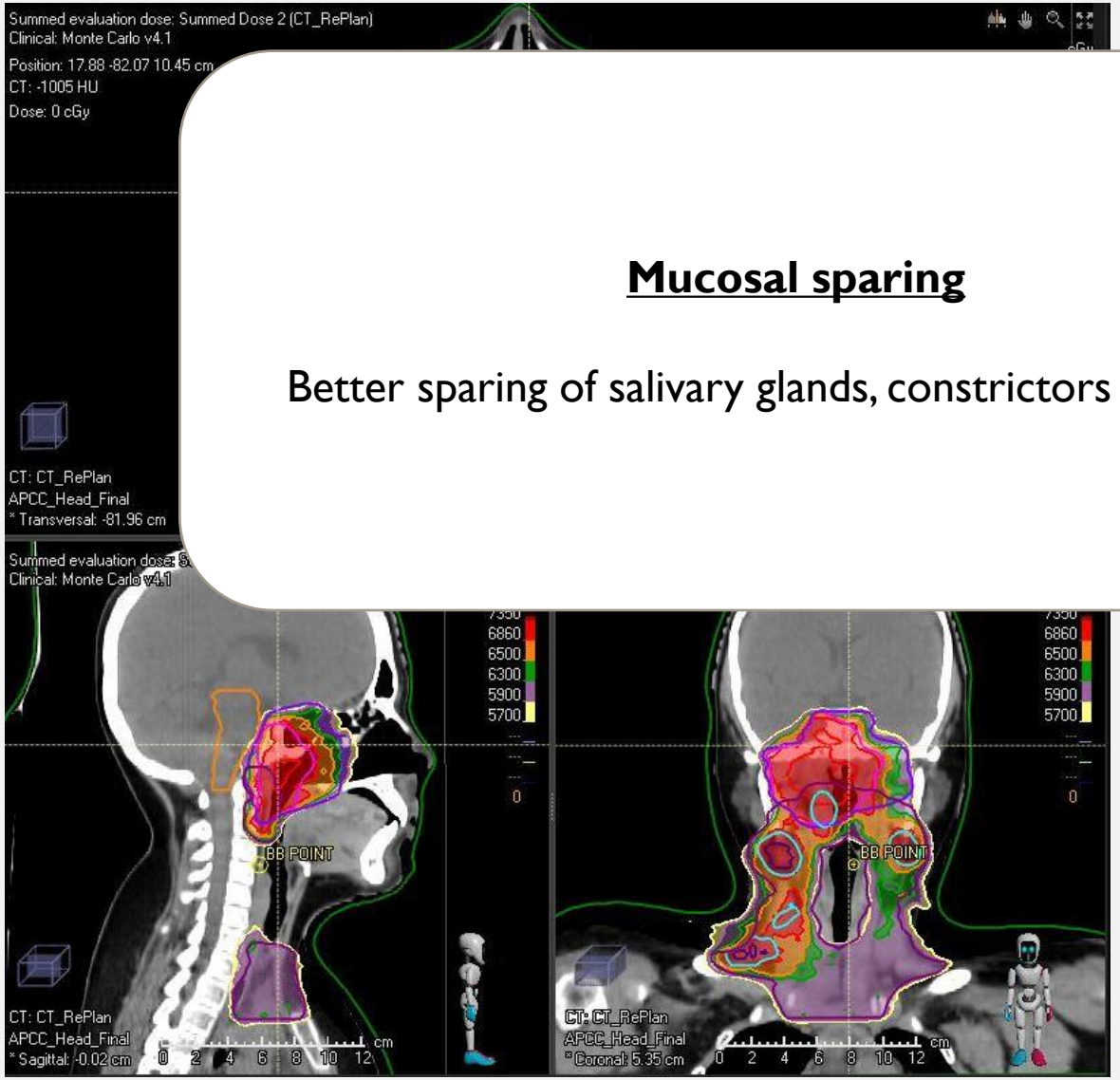




13 YR, EBV DNA POSITIVE, UNDIFFERENTIATED NASOPHARYNGEAL CARCINOMA

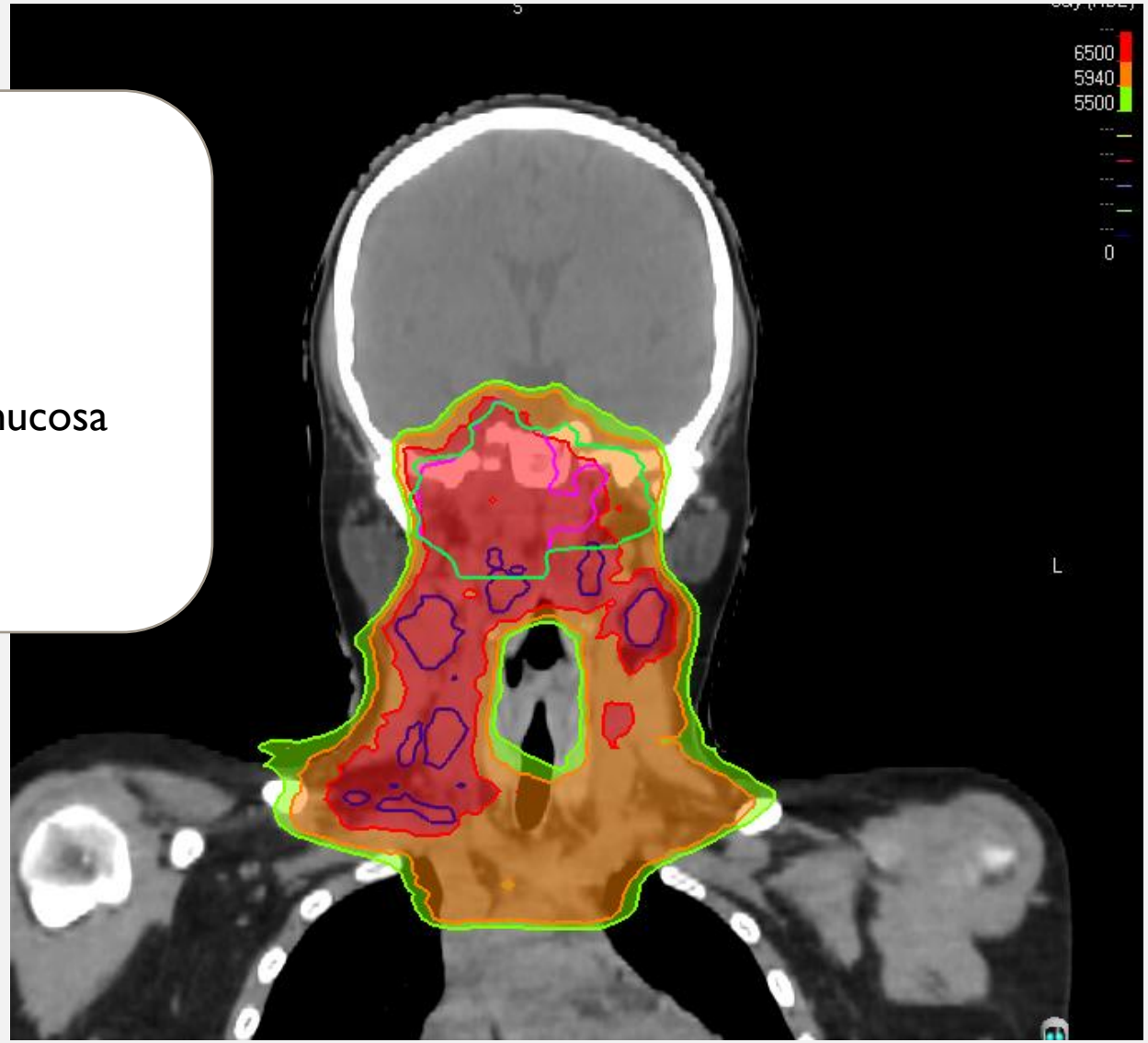


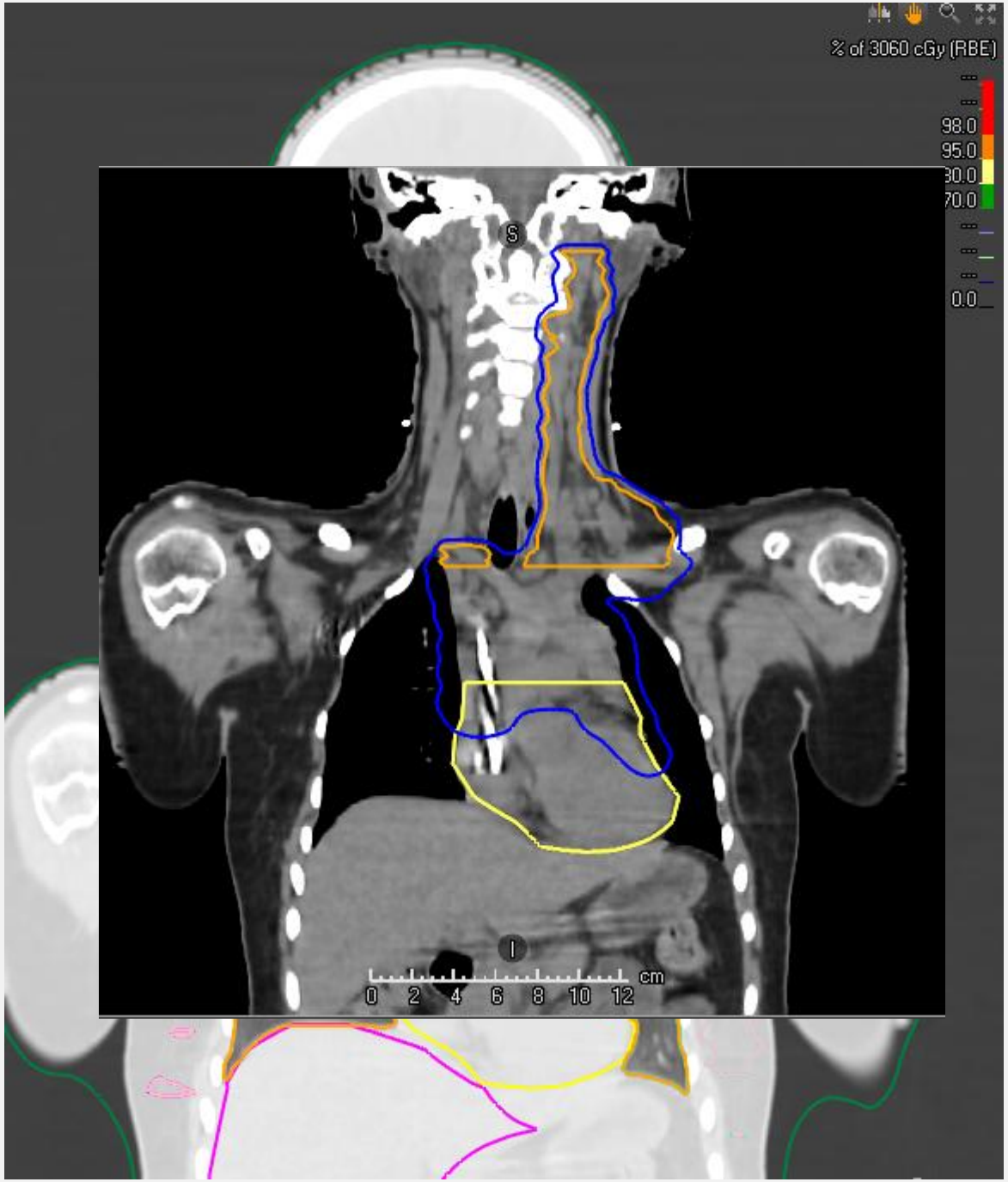
DOSE DISTRIBUTION



Mucosal sparing

Better sparing of salivary glands, constrictors & mucosa





- 15 yr old
- Relapsed Hodgkins lymphoma
- Post transplant

Reduction in doses to
mucosa, breast, thyroid, heart & lungs

9
Posts

2x hodgkins lymphoma survivor
sg-dxb-la|USC ‘27

TEDx Youth@DIA

x = independently organized TED event

This event occurred on
October 30, 2021

Dubai, Dubayy
United Arab Emirates

Peer Review

APCC Clinical Checklist for Proton Patients

{Patient.NameLFI@M} Sex Choose an item.

UHID#: {Ident.IDA} DOB:{Admin.Birth_Date@d2b}

RT#: {Ident.IDB} Doctor's Name :{Admin.Attending_MD_ID*PnP.NameFL}

Diagnosis: {Admin.Adm_Diag*Topog.Description@M}

			Done	Date	Participants
1.	**Clinical OP/IP Consultation**				
2.	**Relevant investigations and managements**				
3.	**Histopathology / Image review**				
	a.	Slide and block review			
	b.	Additional tests - IHC/molecular studies			
4.	**Social / Psychological / Nutritional assessment**				
	a.	Assessment			
	b.	Treatment			
5.	**APCC MDT Discussion**				
	a.	Diagnosis			
	b.	Clinical history and investigations			

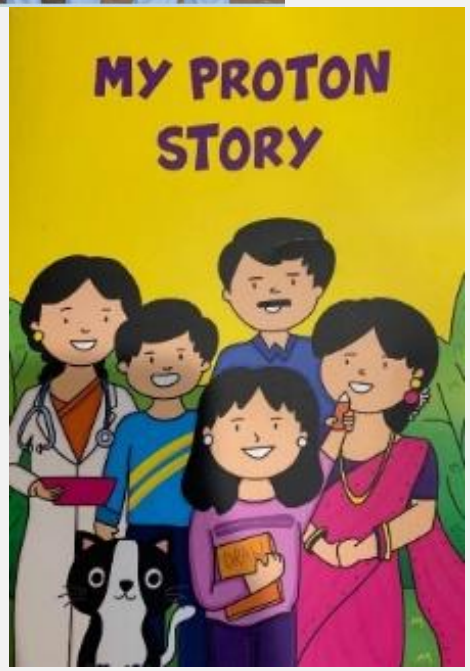
CONCLUSION

- 22% of patients treated at our centre were children less than 18 years old
- Most procedures in children have been standardized to ensure safe practices.
- Peer review system is robust to encourage best practices
- Promising early outcomes
- Children will be recruited to prospective registry and will be followed up for long term.

Paediatric Cancer Management Team

Paediatric Surgical Oncology
Radiation Oncology
Paediatric (Medical) Oncology
Pathology
Radiology
Physiotherapy/Occupational Therapy
Endocrinologist
Paediatrician
Clinical Psychologist Nutrition Nursing Trial Coordinators Social Workers Interpreter & Translators Service Excellence Coordinator

Ped CMT



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