

Protocolo para simulação, planejamento e tratamento de crânio com proteção de hipocampo

RTOG 0933

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Tecnóloga em Radiologia – UTFPR

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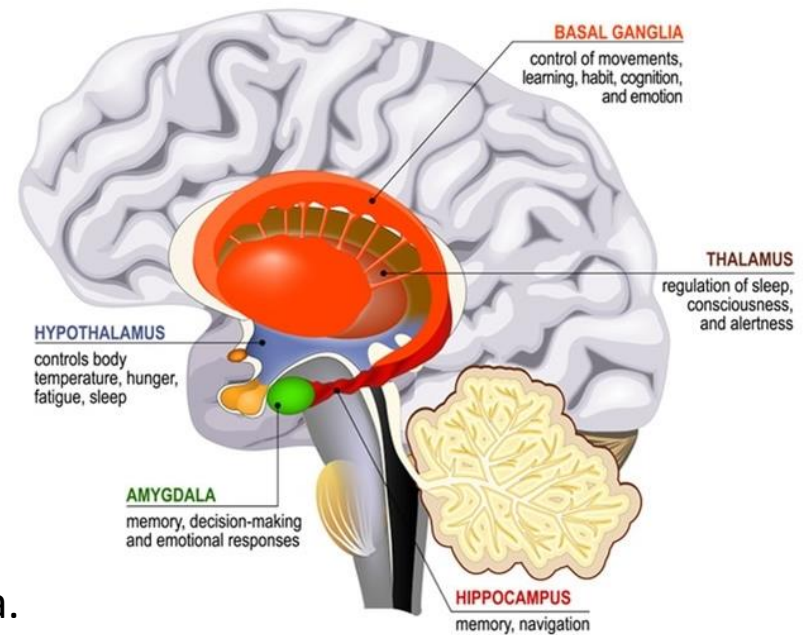
SPR - CNEN



HOSPITAL
MÃE DE DEUS

HIPOCAMPO

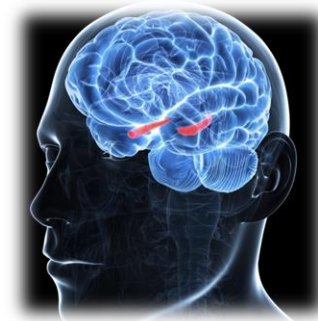
- “Hippos” + “kamos” = monstro marinho
- Localiza-se no aspecto central do lóbulo temporal
- Uma camada de neurônios densa, revestida.



Funções: regulação de emoções, motivação, atividade hormonal, atividade autonômica e formação de memória.



PROTOCOLO RTOG 0933



RADIATION THERAPY ONCOLOGY GROUP

RTOG 0933

A PHASE II TRIAL OF HIPPOCAMPAL AVOIDANCE DURING WHOLE BRAIN RADIOTHERAPY FOR BRAIN METASTASES

Study Chairs (12/5/11)

Co-Principal Investigator/Radiation Oncology Co-Chair

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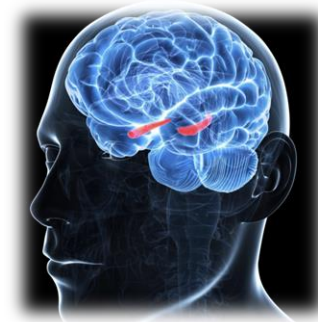
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RESUMO

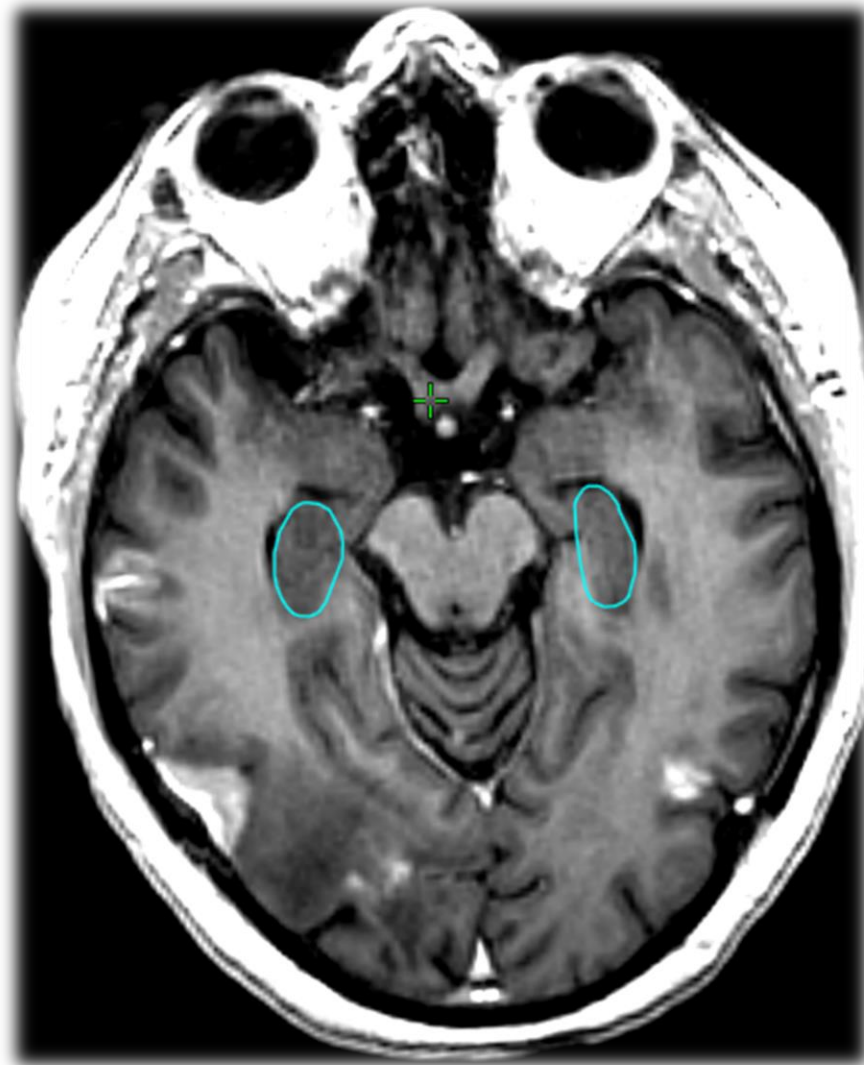


- Estudo fase II
- Avaliar o declínio neurológico, após 4 meses do fim do tratamento de HA-WBRT, utilizando o Hopkins Verbal Learning Test-Revised (HVTL-R)
- Pacientes com metástases cerebrais
 - ✗ Comprometimento de meninge
 - ✗ Mais de dois sítios de metástases além do crânio
 - ✗ Inegibilidade para RMN

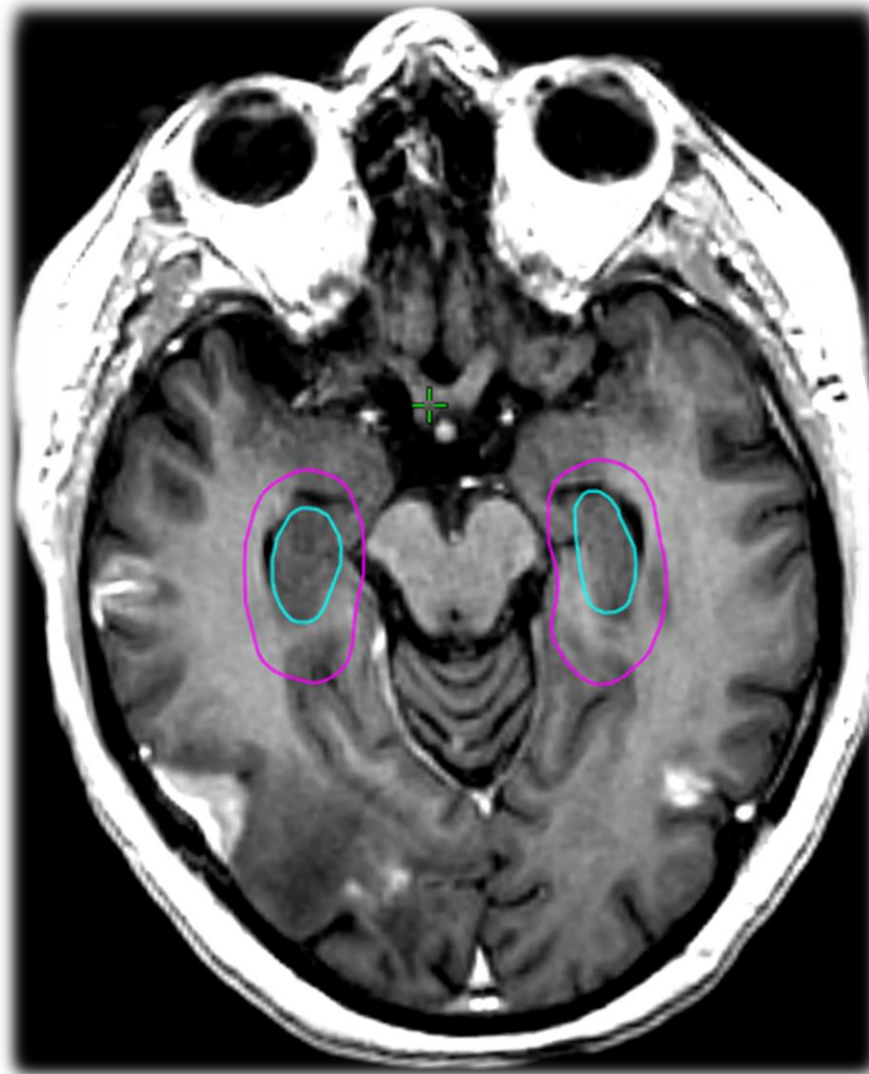
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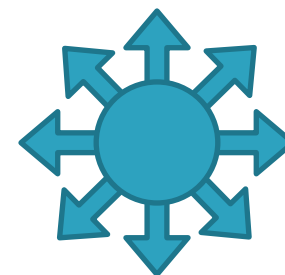
ELIGIBILIDADE



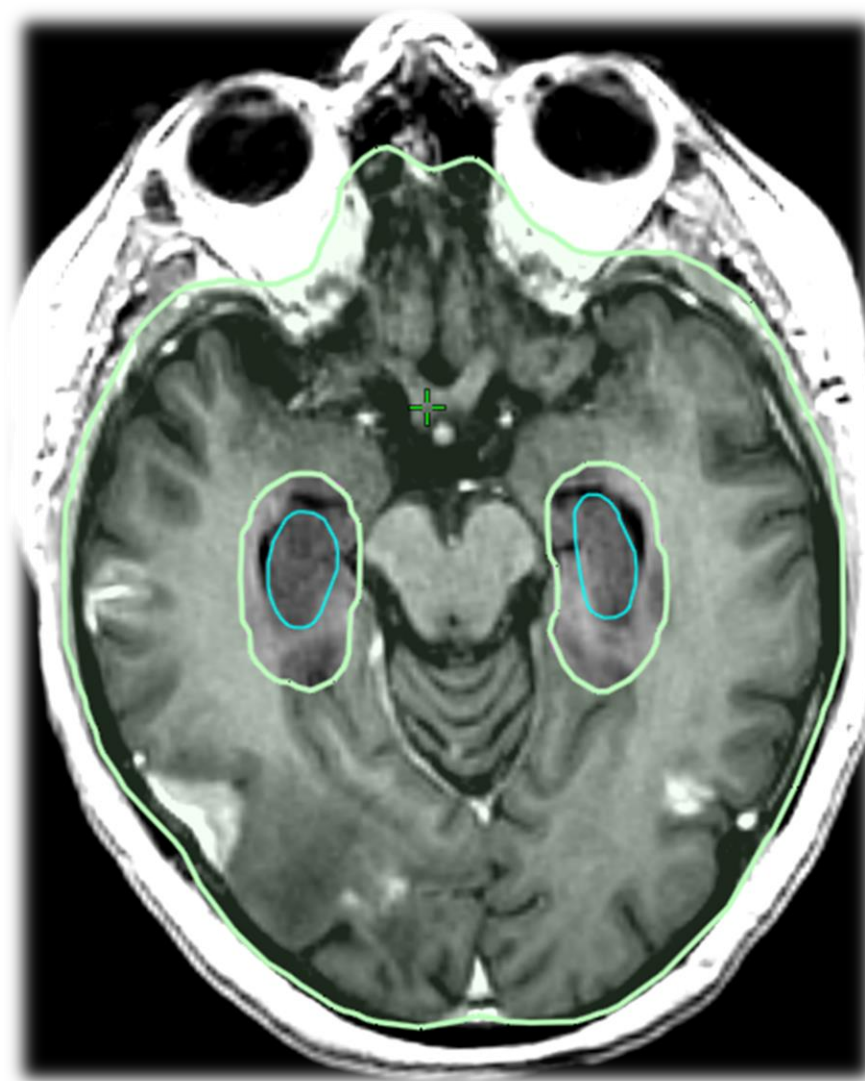
ELIGIBILIDADE



5mm



ELIGIBILIDADE



ELIGIBILIDADE

Distribution of Brain Metastases in Relation to the Hippocampus: Implications for Neurocognitive Functional Preservation

Amol Ghia, M.D., Wolfgang A. Tomé, Ph.D., Sayana Thomas, B.S., George Cannon, M.D., Deepak Khuntia, M.D., John S. Kuo, M.D., Ph.D., Minesh P. Mehta, M.D. 

100 pacientes, 272 metástases:

- 86,4% a mais de 15mm do Hipocampo
- 3,3% a menos de 5mm

Radiother Oncol. 2010 December ; 97(3): 370–376. doi:10.1016/j.radonc.2010.09.013.

Why Avoid the Hippocampus? A Comprehensive Review

Vinai Gondi, M.D.^{*}, Wolfgang A. Tomé, Ph.D.^{*,&}, and Minesh P. Mehta, M.D.^{*}

^{*} Department of Human Oncology, University of Wisconsin, Comprehensive Cancer Center, Madison, Wisconsin, USA

[&] Department of Medical Physics, University of Wisconsin, Comprehensive Cancer Center, Madison, Wisconsin, USA

271 pacientes, 1133 metástases:

- 8,6% a menos de 5mm
- **Conclusão: 91% dos pacientes aptos**



SIMULAÇÃO

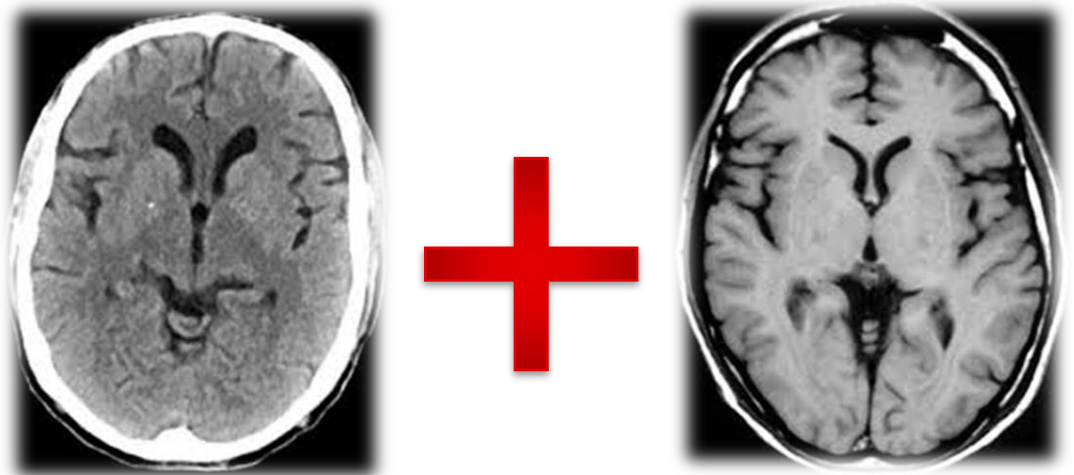
- Posicionamento

- Decúbito dorsal
- Máscara termoplástica



- Imagens

- Tomografia (<2,5mm)
- RMN (<1,5mm) (T1+C e T2)



DELINEAMENTO

Definição de Volumes

- **Hipocampo:**

Desenhado na fusão com RMN, de acordo com protocolo.

- **Região de proteção de Hipocampo:**

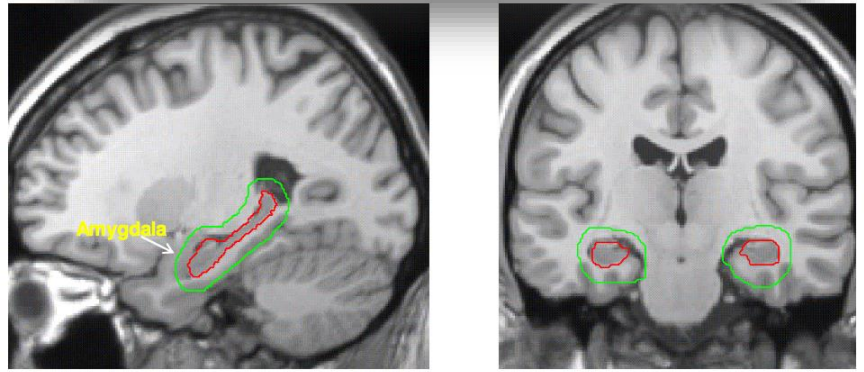
Hipocampo expandido tridimensionalmente 5mm

- **PTV:**

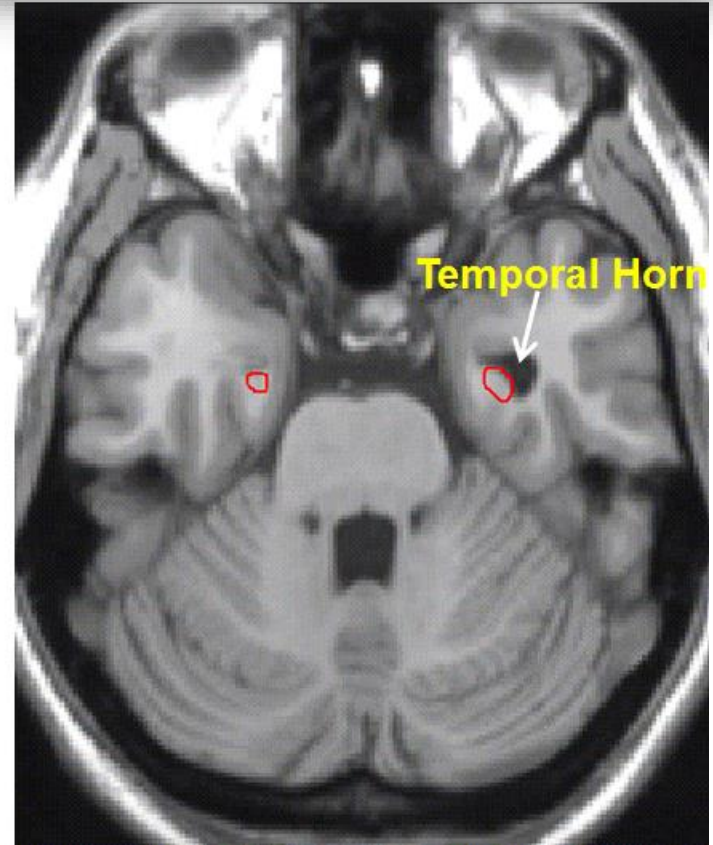
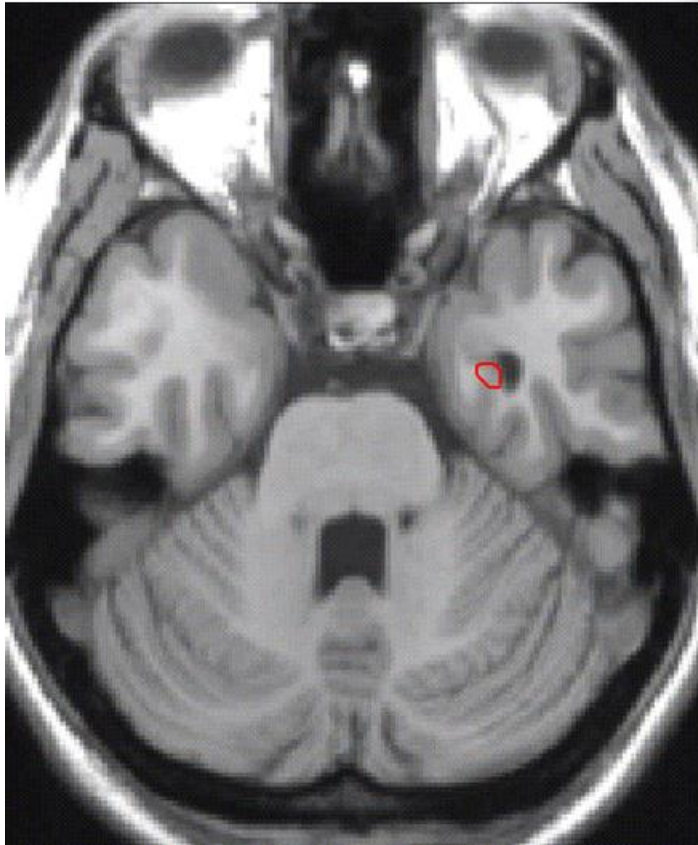
Todo parênquima encefálico ate C1 (C2) excluindo a região de proteção de Hipocampo

- **OARs:**

Cristalinos, nervos ópticos e quiasma



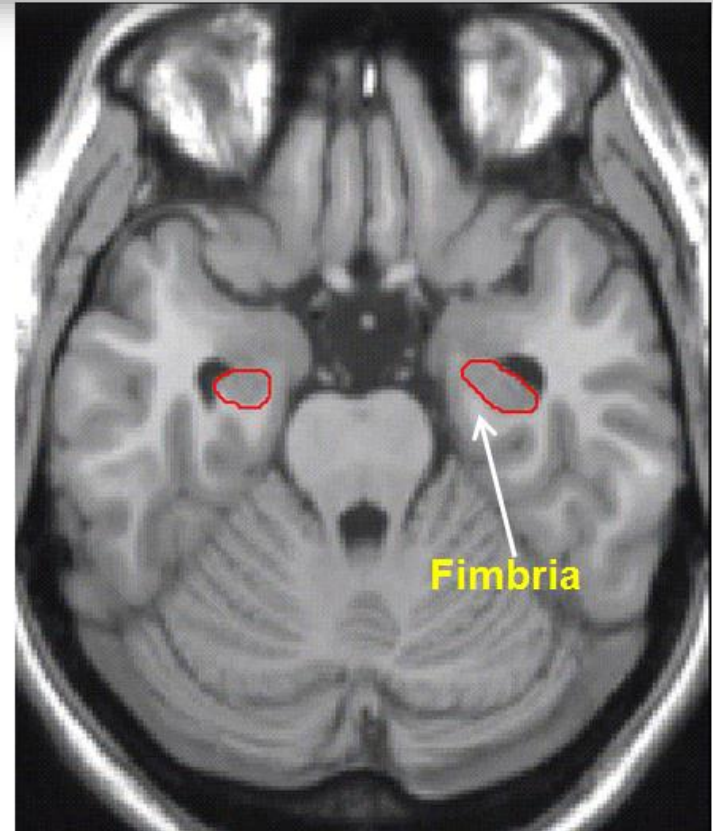
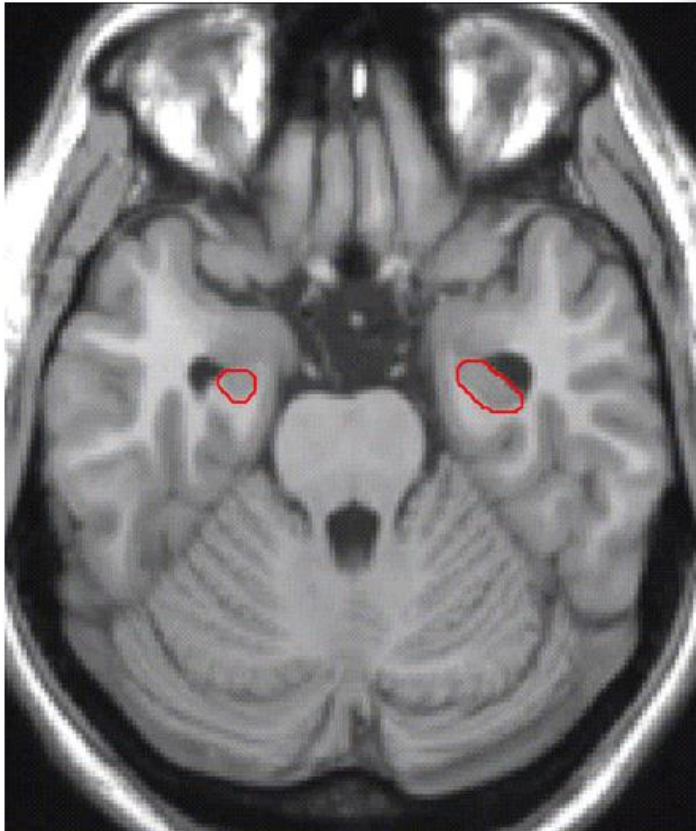
Hippocampal Contouring: A Contouring Atlas for RTOG 0933



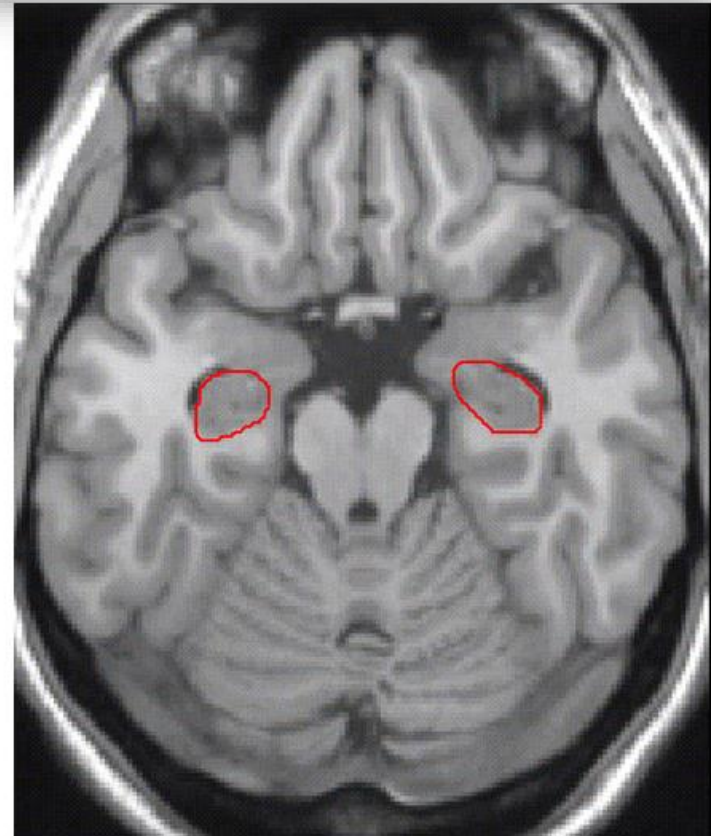
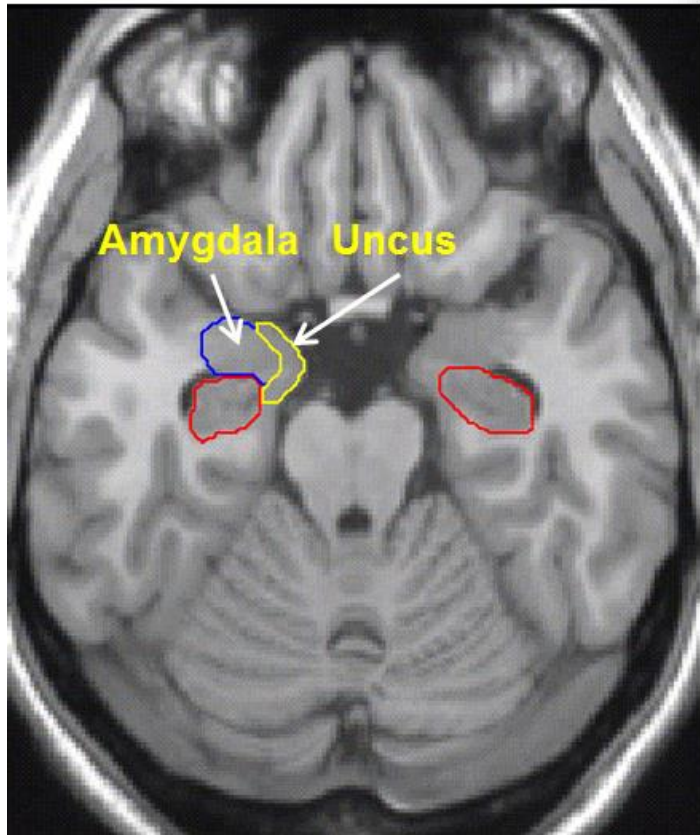
Corno temporal do ventrículo lateral – massa hipointensa



Hippocampal Contouring: A Contouring Atlas for RTOG 0933



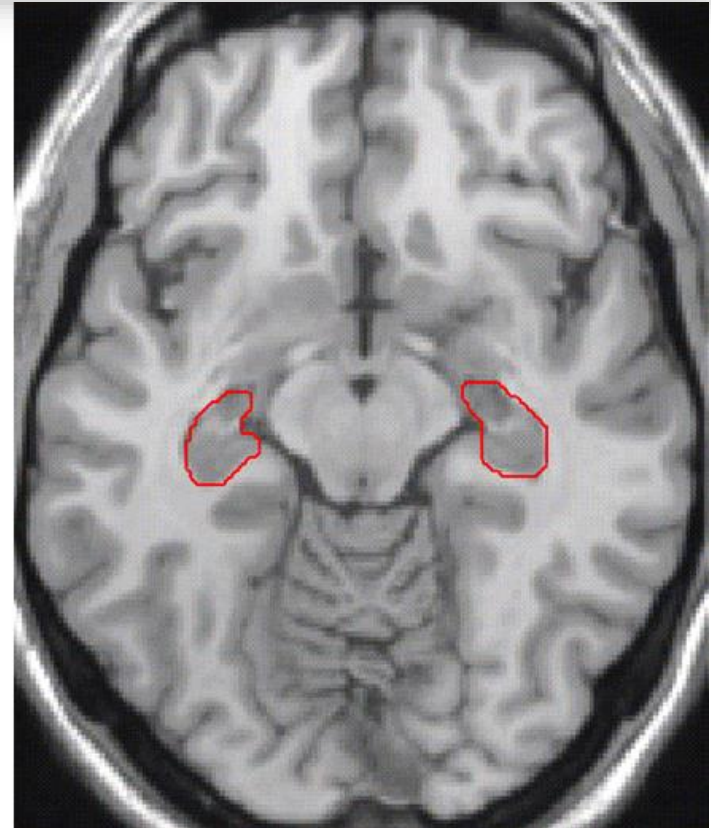
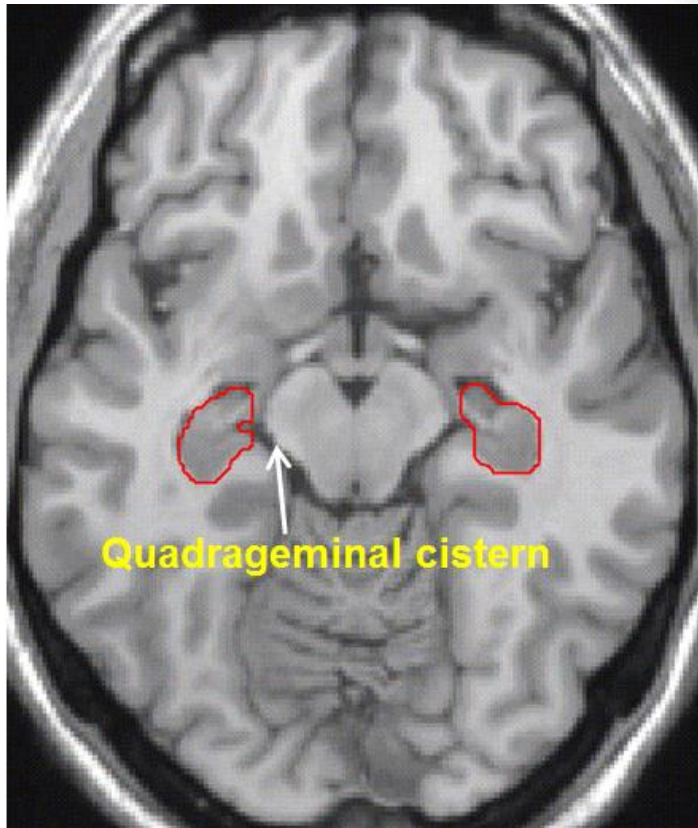
Hippocampal Contouring: A Contouring Atlas for RTOG 0933



Borda anterior do corno temporal



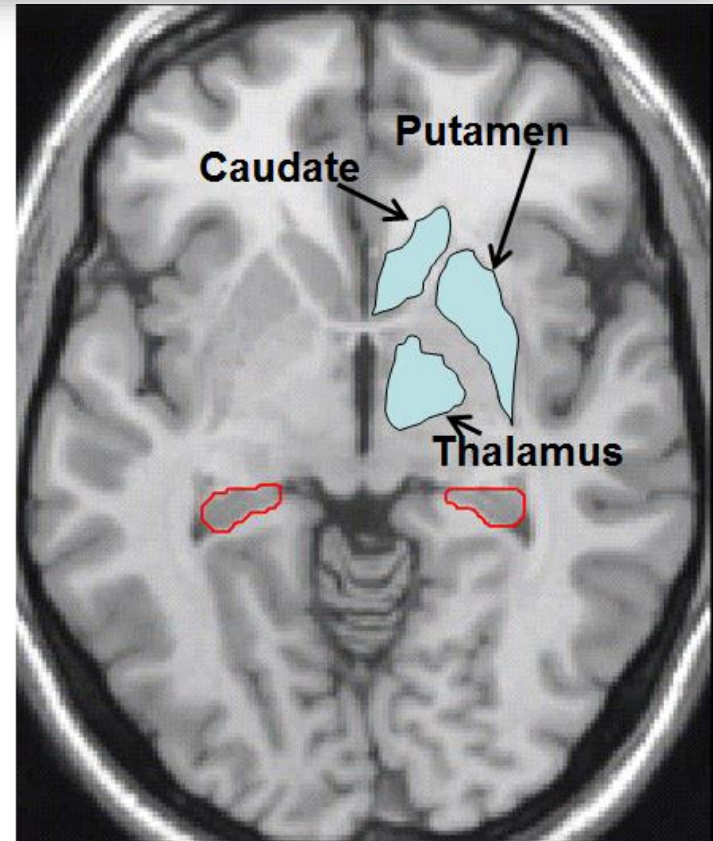
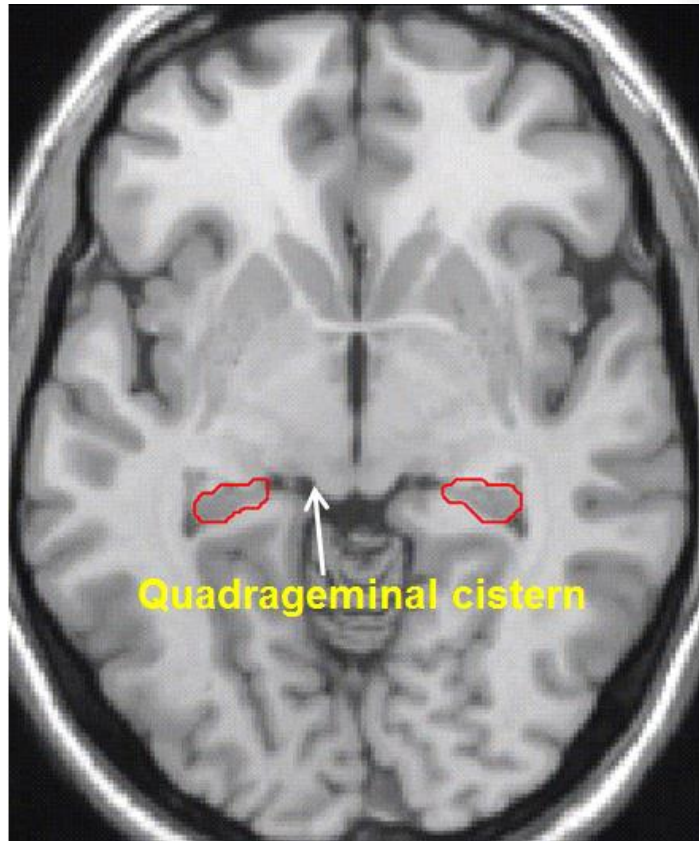
Hippocampal Contouring: A Contouring Atlas for RTOG 0933



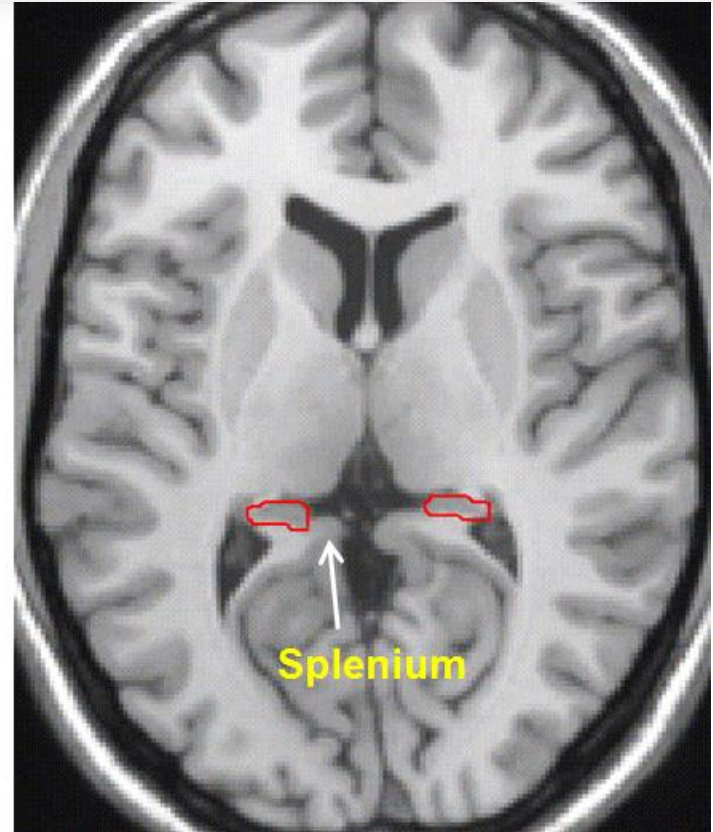
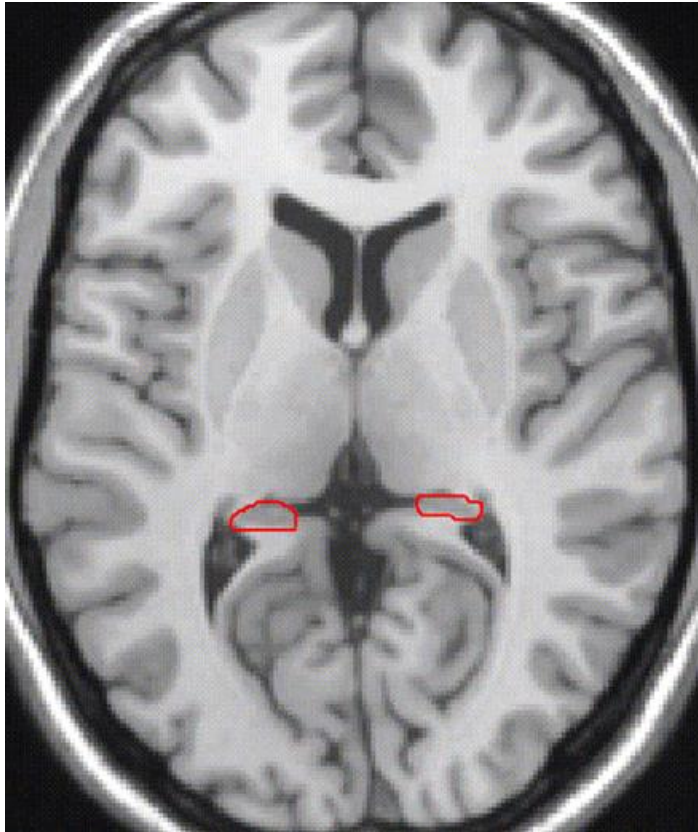
Borda lateral da cisterna quadrigeminal



Hippocampal Contouring: A Contouring Atlas for RTOG 0933



Hippocampal Contouring: A Contouring Atlas for RTOG 0933



Anterior ao esplênio do corpo caloso



PLANEJAMENTO – OBJETIVOS

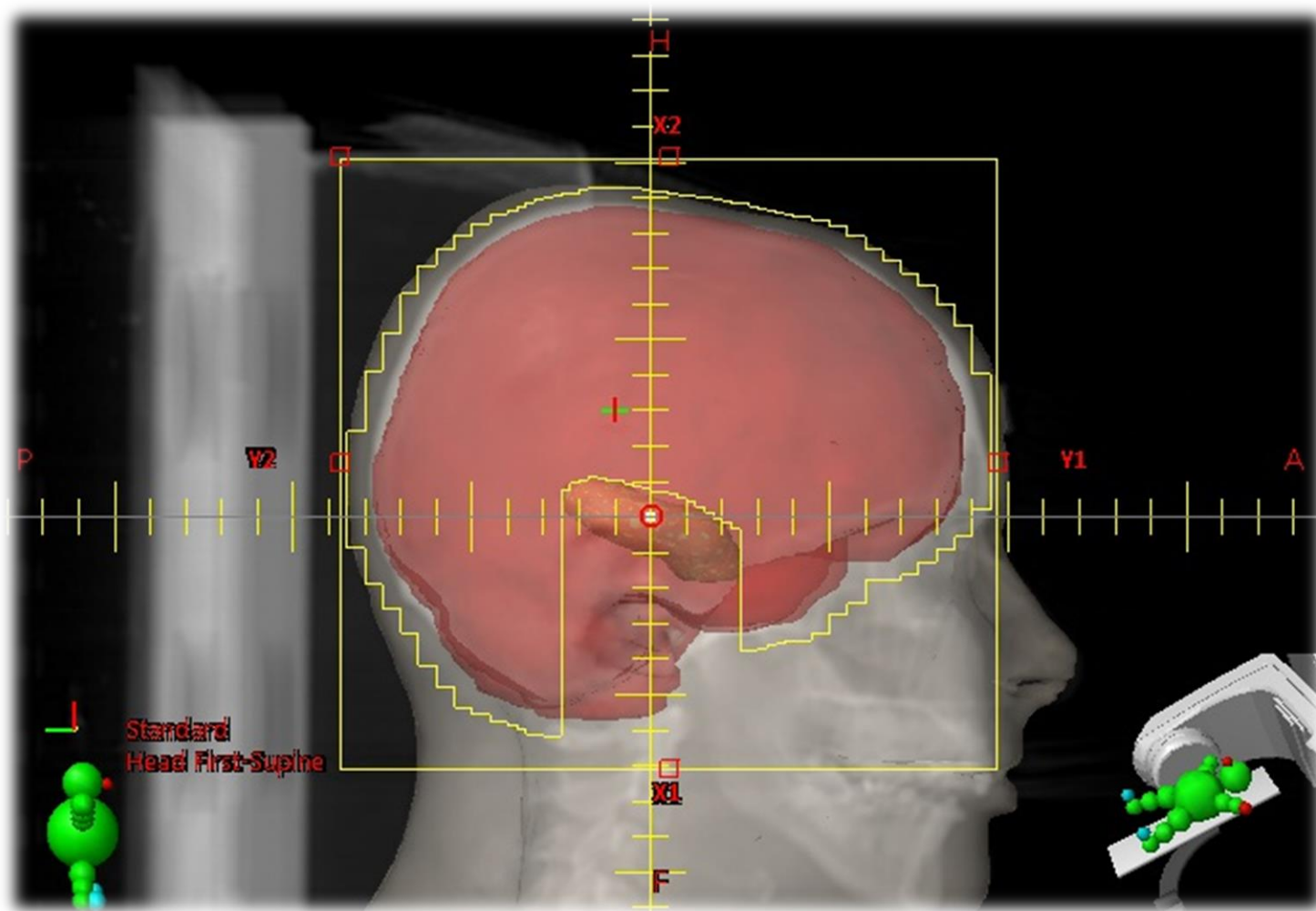
HA-WBRT IMRT Planning	PTV	D2% $\leq$ 37.5 Gy D98% $\geq$ 25 Gy	D2% $>$ 37.5 Gy, $\leq$ 40 Gy D98% $<$ 25 Gy	V30 $<$ 90% D2% $>$ 40 Gy
	Hippocampus	D100% $\leq$ 9 Gy Maximum dose $\leq$ 16 Gy	D100% $\leq$ 10 Gy Maximum dose $\leq$ 17 Gy	D100% $>$ 10 Gy Maximum dose $>$ 17 Gy
	Optic Nerves and Chiasm	Maximum dose $\leq$ 37.5 Gy	Maximum dose $\leq$ 37.5 Gy	Maximum dose $>$ 37.5 Gy

- 90% do PTV - 30Gy
- Restrição de dose: gradiente de 50% da dose em 5mm
- Cobertura “baixa”: $\sim 83\%$ (D_{98})
- Gradiente alto: $\sim 125\%$ (D_2)
- Cristalinos e Órbitas o quanto possível

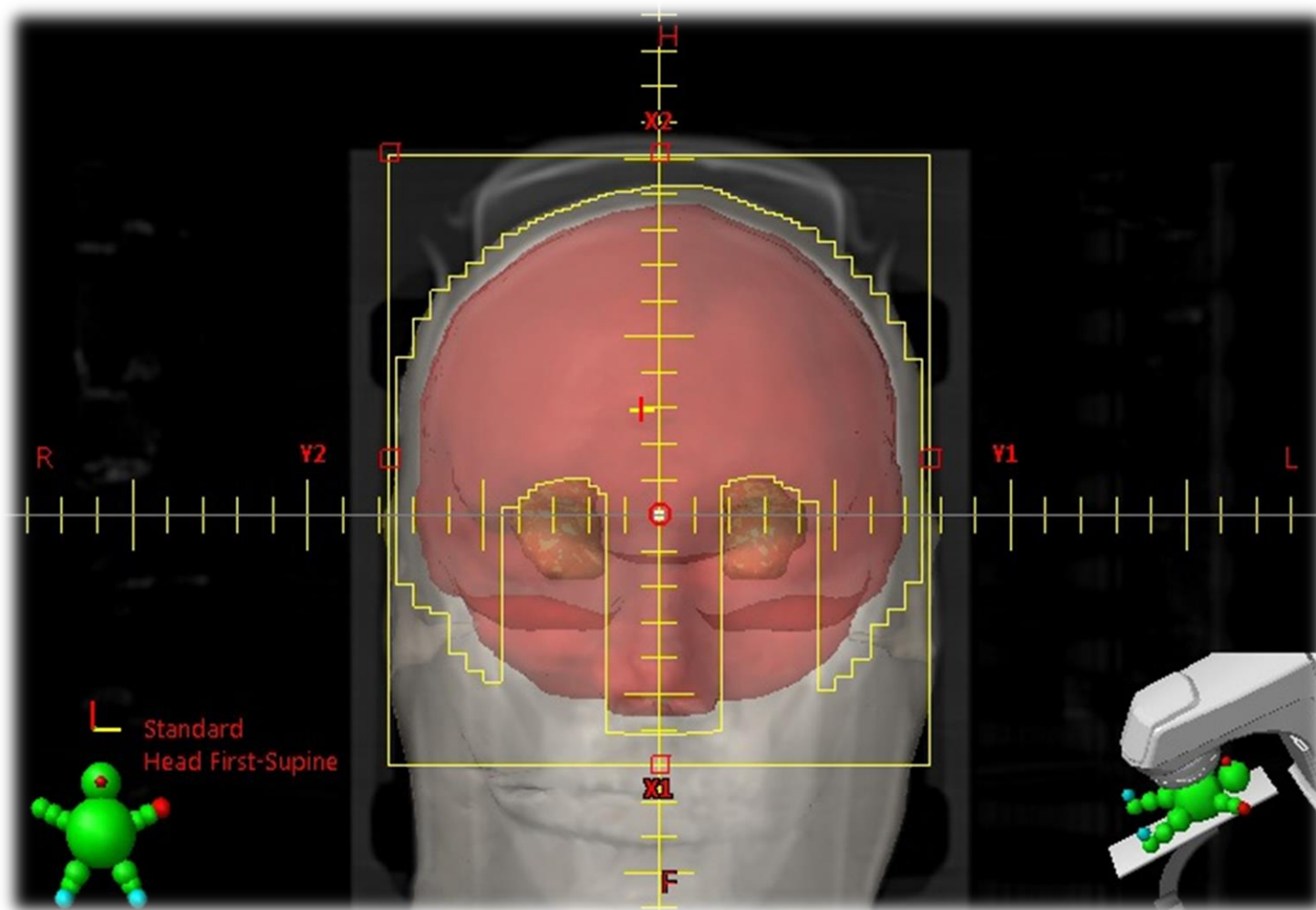




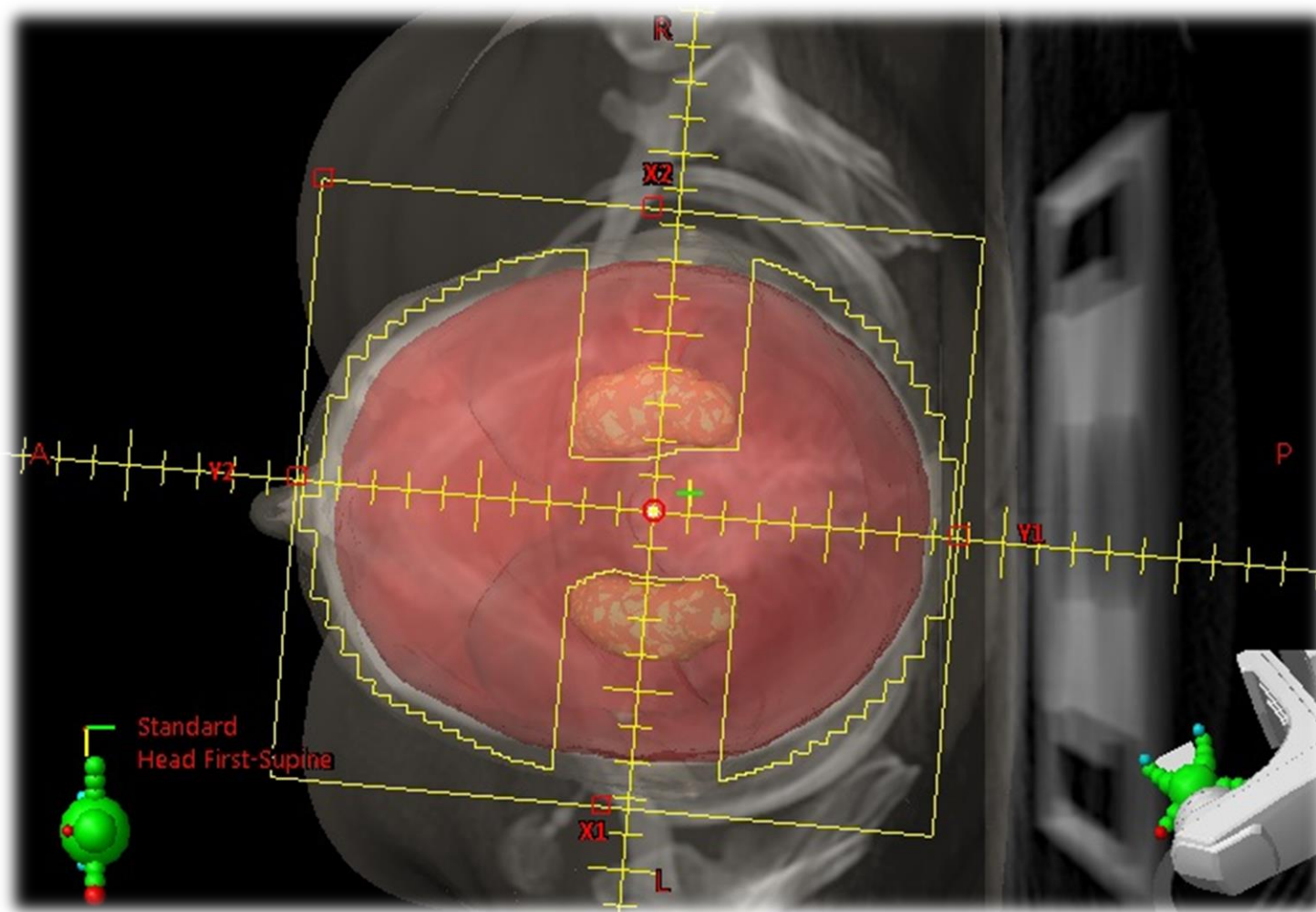
HIPOCAMPO – “GEOMETRIA”



HIPOCAMPO – “GEOMETRIA”



HIPOCAMPO – “GEOMETRIA”



MLC sempre bloqueia região de PTV ao proteger Hipocampo



PLANEJAMENTO – COMO FAZER?

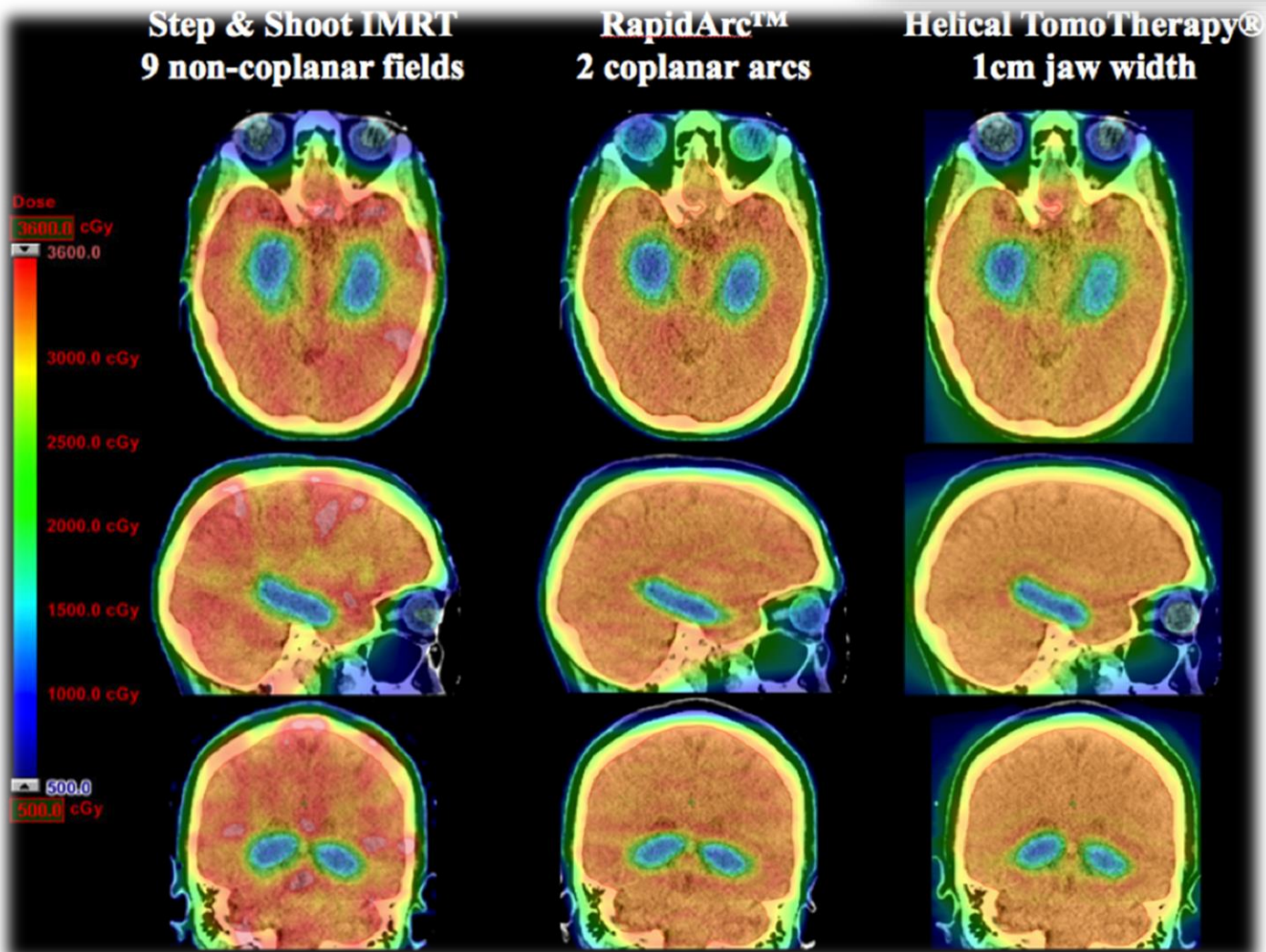
PROTOCOLO EXIGE TÉCNICA MODULADA

✓ **IMRT**

✓ **VMAT**

✓ **TOMOTERAPIA**





Dosimetric Evaluation of Intensity-Modulated Radiotherapy, Volumetric Modulated Arc Therapy, and Helical Tomotherapy for Hippocampal-Avoidance Whole Brain Radiotherapy

Yi Rong, Josh Evans, Meng Xu-Welliver, Cadron Pickett, Guang Jia, Quan Chen , Li Zuo 

Published: April 20, 2015 • <https://doi.org/10.1371/journal.pone.0126222>



Table 1. Average dosimetric values across different brain structures under three types of treatments (Tomo, IMRT and RapidArc).

Structure	Dosimetry Metric (Protocol Criteria)	TomoTherapy	Step & Shoot IMRT	RapidArc
PTV	$V_{30\text{Gy}}(> 95\%)$	$94.4\% \pm 0.6\%$	$94.8\% \pm 0.3\%$	$95.5\% \pm 0.8\%$
	$D_{2\%}(\leq 37.5 \text{ Gy})$	$32.2 \pm 0.6 \text{ Gy}$	$36.3 \pm 0.6 \text{ Gy}$	$33.9 \pm 0.4 \text{ Gy}$
	$D_{98\%}(\geq 25 \text{ Gy})$	$27.5 \pm 0.5 \text{ Gy}$	$27.0 \pm 0.9 \text{ Gy}$	$26.8 \pm 0.9 \text{ Gy}$
	HI	0.15 ± 0.03	0.28 ± 0.04	0.22 ± 0.03
Hippocampus	$D_{100\%}(D_{\min}) \leq 10 \text{ Gy}$	$8.0 \pm 0.3 \text{ Gy}$	$8.7 \pm 0.2 \text{ Gy}$	$8.6 \pm 0.3 \text{ Gy}$
	$D_{\max} \leq 17 \text{ Gy}$	$15.1 \pm 0.8 \text{ Gy}$	$14.9 \pm 0.9 \text{ Gy}$	$13.6 \pm 1.3 \text{ Gy}$
Optic Nerves & Chiasm	$D_{\max} \leq 37.5 \text{ Gy}$	$33.9 \pm 1.1 \text{ Gy}$	$36.6 \pm 0.5 \text{ Gy}$	$34.4 \pm 0.7 \text{ Gy}$
Eyes	$D_{\max}$	$8.5 \pm 0.9 \text{ Gy}$	$8.8 \pm 0.9 \text{ Gy}$	$21.0 \pm 3.3 \text{ Gy}$
	D_{mean}	$4.4 \pm 0.4 \text{ Gy}$	$5.6 \pm 0.3 \text{ Gy}$	$10.5 \pm 2.1 \text{ Gy}$
Lenses	$D_{\max}$	$3.3 \pm 0.3 \text{ Gy}$	$5.1 \pm 0.3 \text{ Gy}$	$8.1 \pm 1.6 \text{ Gy}$
Approximate Delivery Time		18.0 min	15.0 min	2.5 min

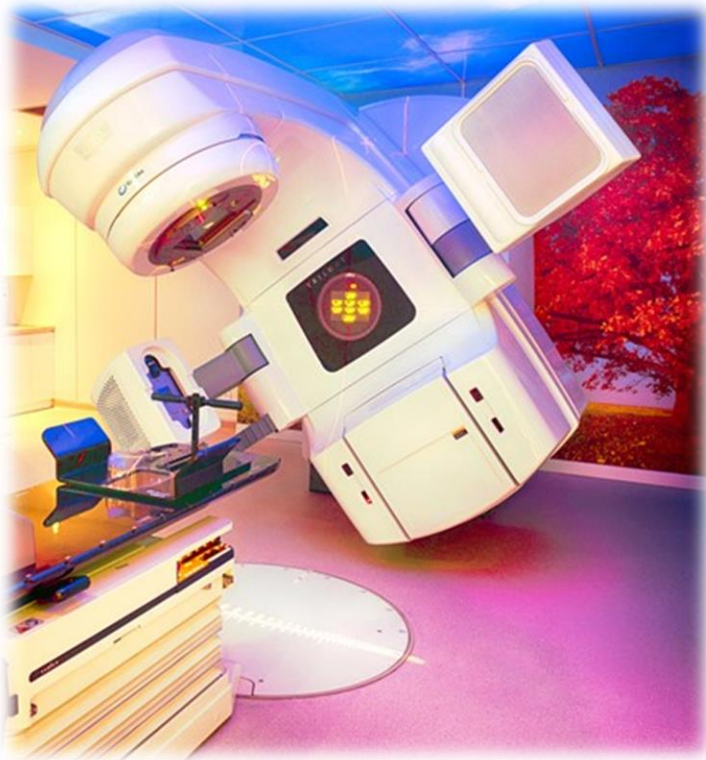
Each value was calculated based on the data from 10 patients. Values are expressed as mean $\pm$ SD.

[doi:10.1371/journal.pone.0126222.t001](https://doi.org/10.1371/journal.pone.0126222.t001)



RADIOTERAPIA - HCMD

Especificações dos tratamentos:

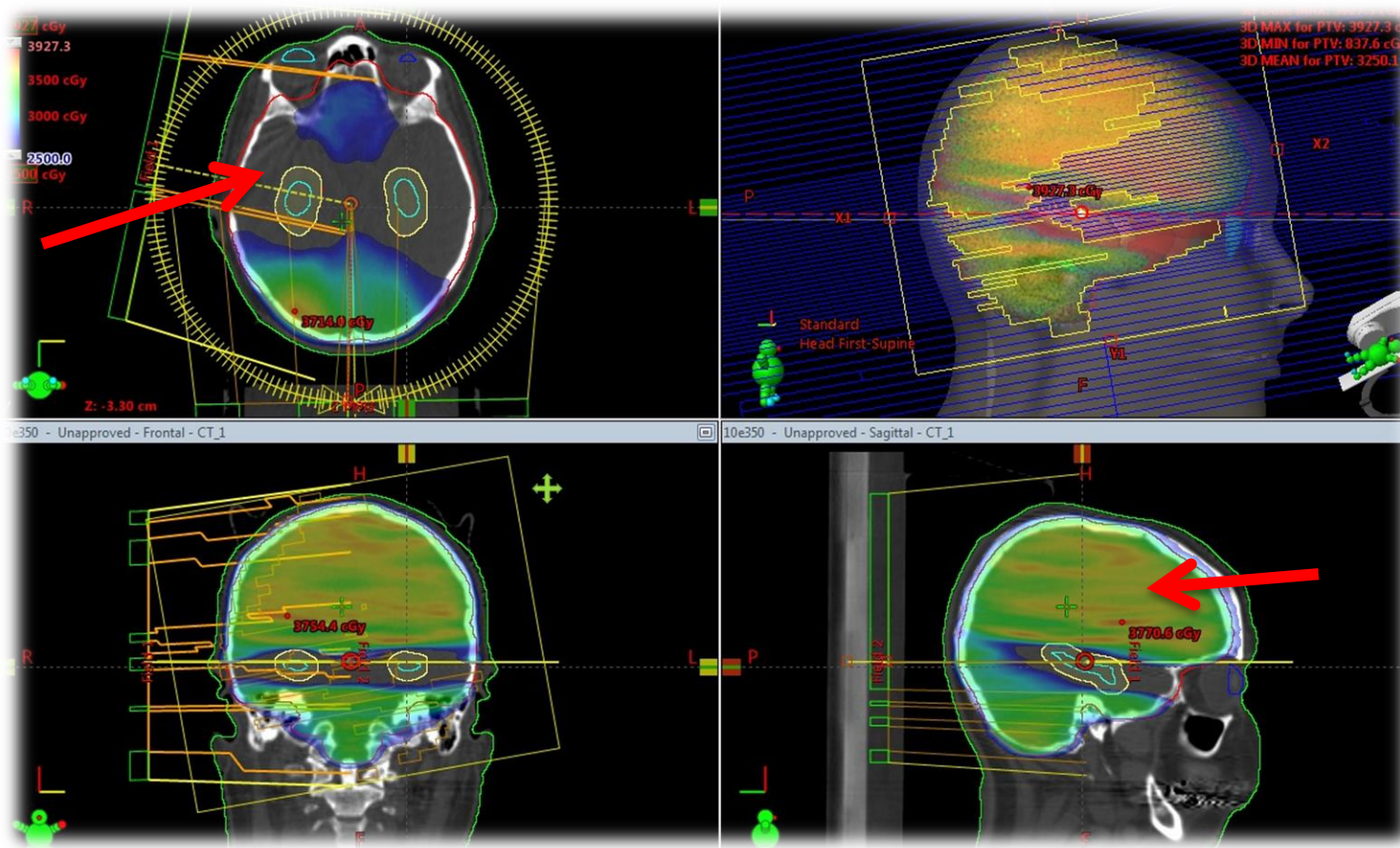


- Trilogy: 6MV / 6SRS
- Eclipse V. 13.6
- RapidArc
- MLC-HD
- Máscara aberta
- CBCT
- PD



VMAT

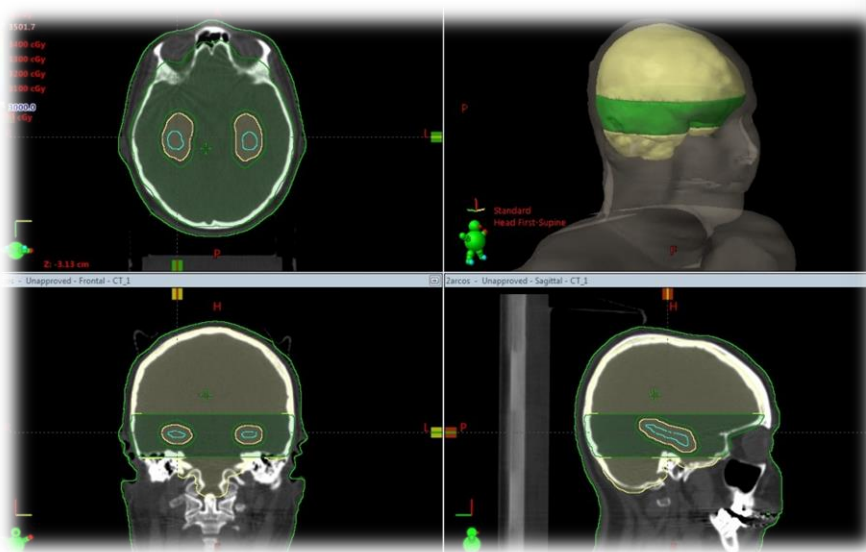
Planejamento convencional: 2 arcos completos, 10° e 350°



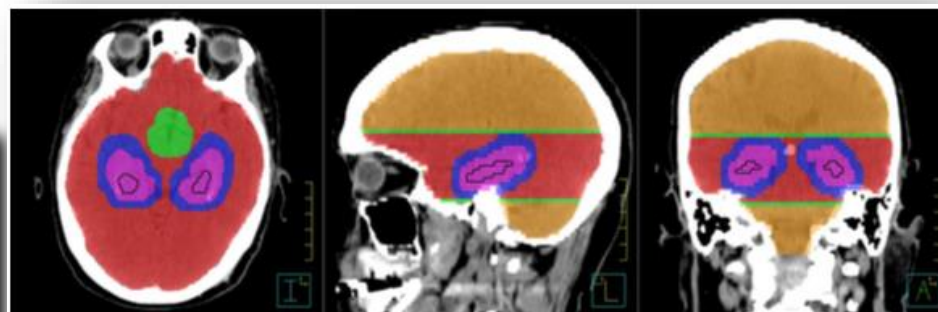
TÉCNICAS E SETUPS

Definição de subvolumes de PTV:

- PTV1: nos cortes de Hipocampo
- PTV2: Região “homogênea” fora da região de HA
- PTV em quiasma (?)



HCMD



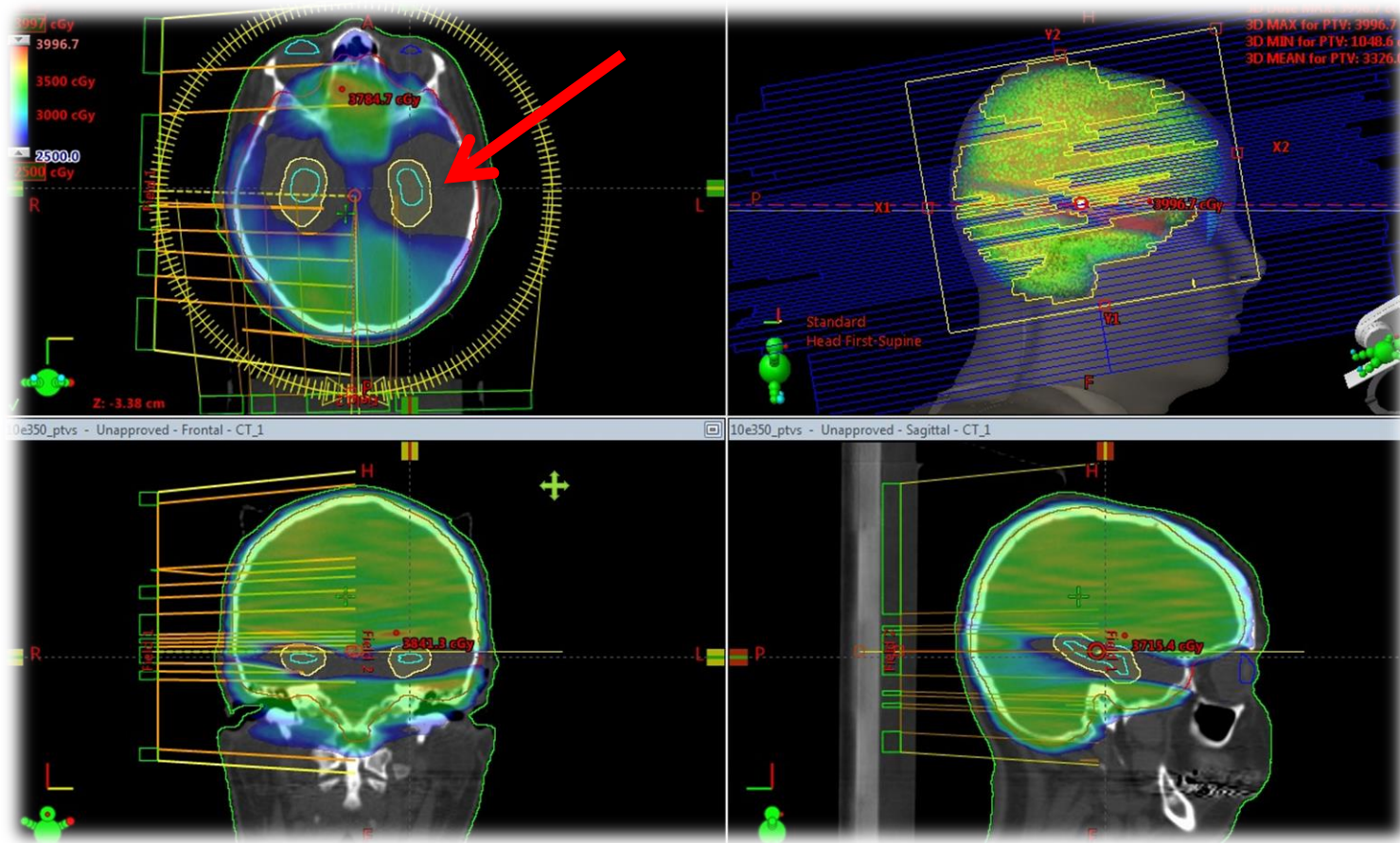
Purple: Hippocampal avoidance volume

- sPTV1 (Blue): PTV in 5mm ring around hippocampal avoidance region
- sPTV2 (Red): PTV in same axial planes as hippocampal avoidance region
- sPTV3 (Orange): PTV not in same axial plane as hippocampal avoidance region
- sPTVu (Green): optic nerve/chiasm + single slice between sPTV2 and sPTV3

Shen et al. Medical Dosimetry, 2015 40(3) 205-209

TÉCNICAS E SETUPS

Planejamento convencional: 2 arcos completos, 10° e 350°



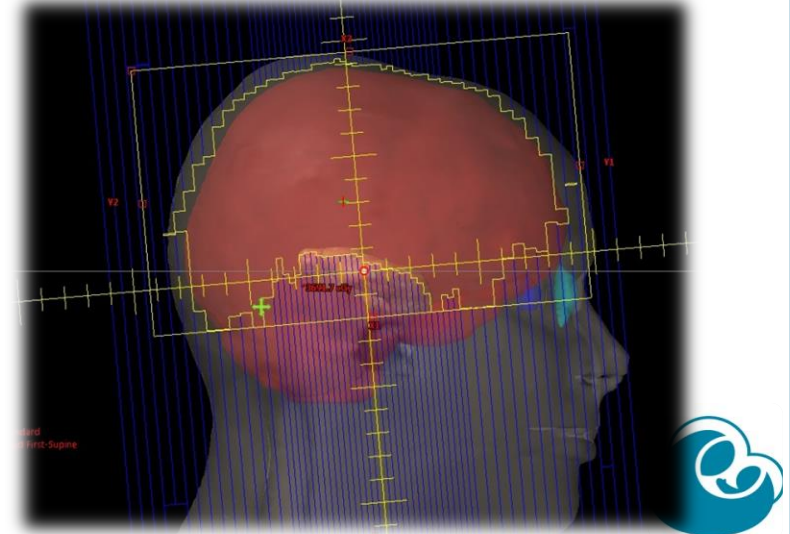
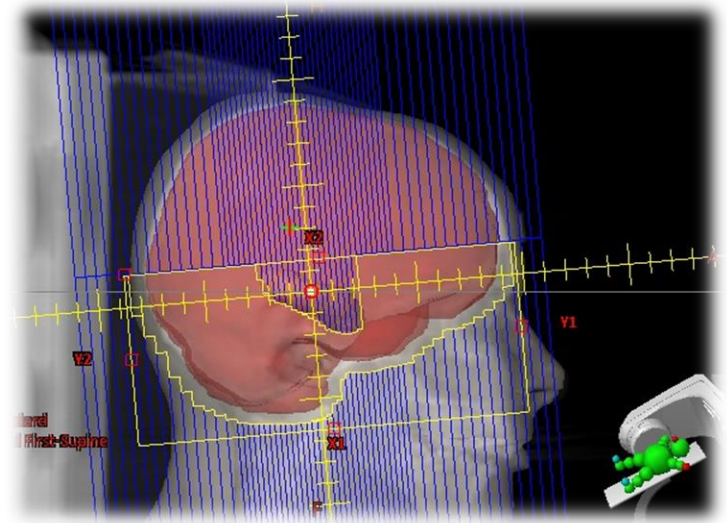
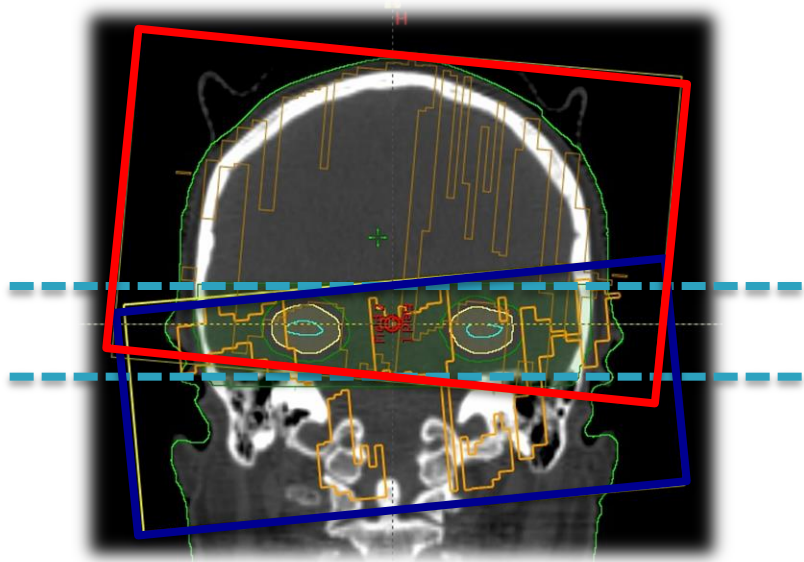
2 arcos: 431 e 282 MUs

Otimizando sub PTVs

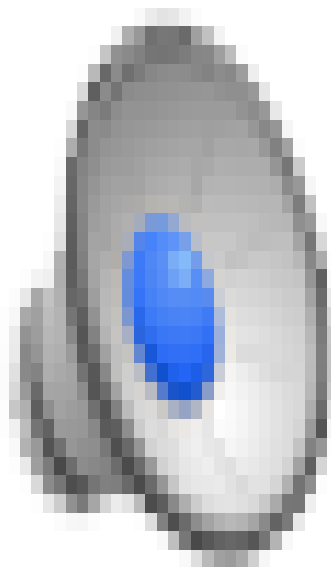


TÉCNICAS E SETUPS - ISOCENTRO

- Utiliza posição de “hemibloqueio”
- Evita geometria “ilha”
- Maior modulação na região que “interessa”
- Ângulos $\sim 90^\circ$

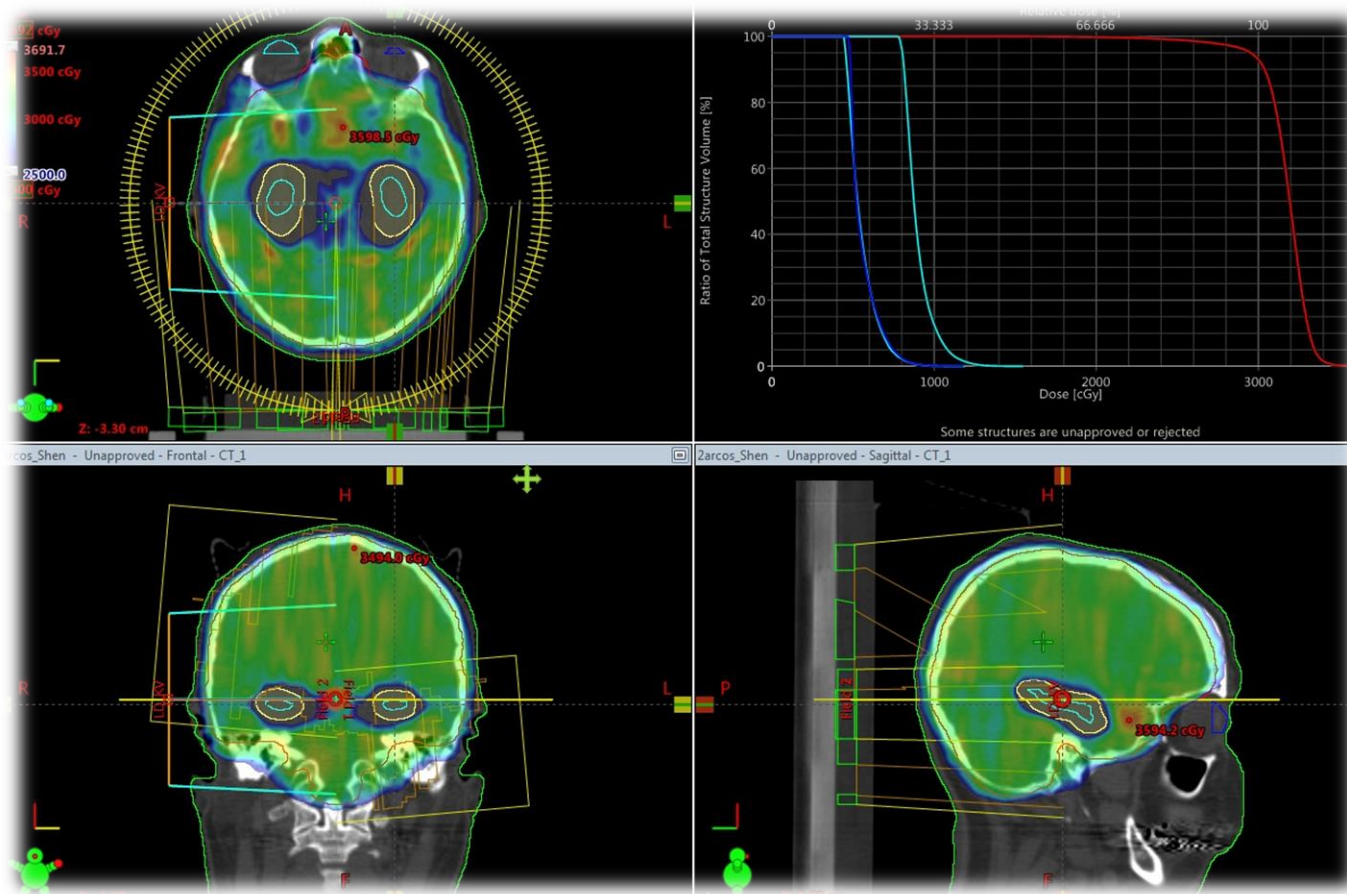


TÉCNICAS E SETUPS - ISOCENTRO



TÉCNICAS E SETUPS

Planejamento com mais modulação: 2 arcos AJUSTADOS, 85° e 95° e 1200MU



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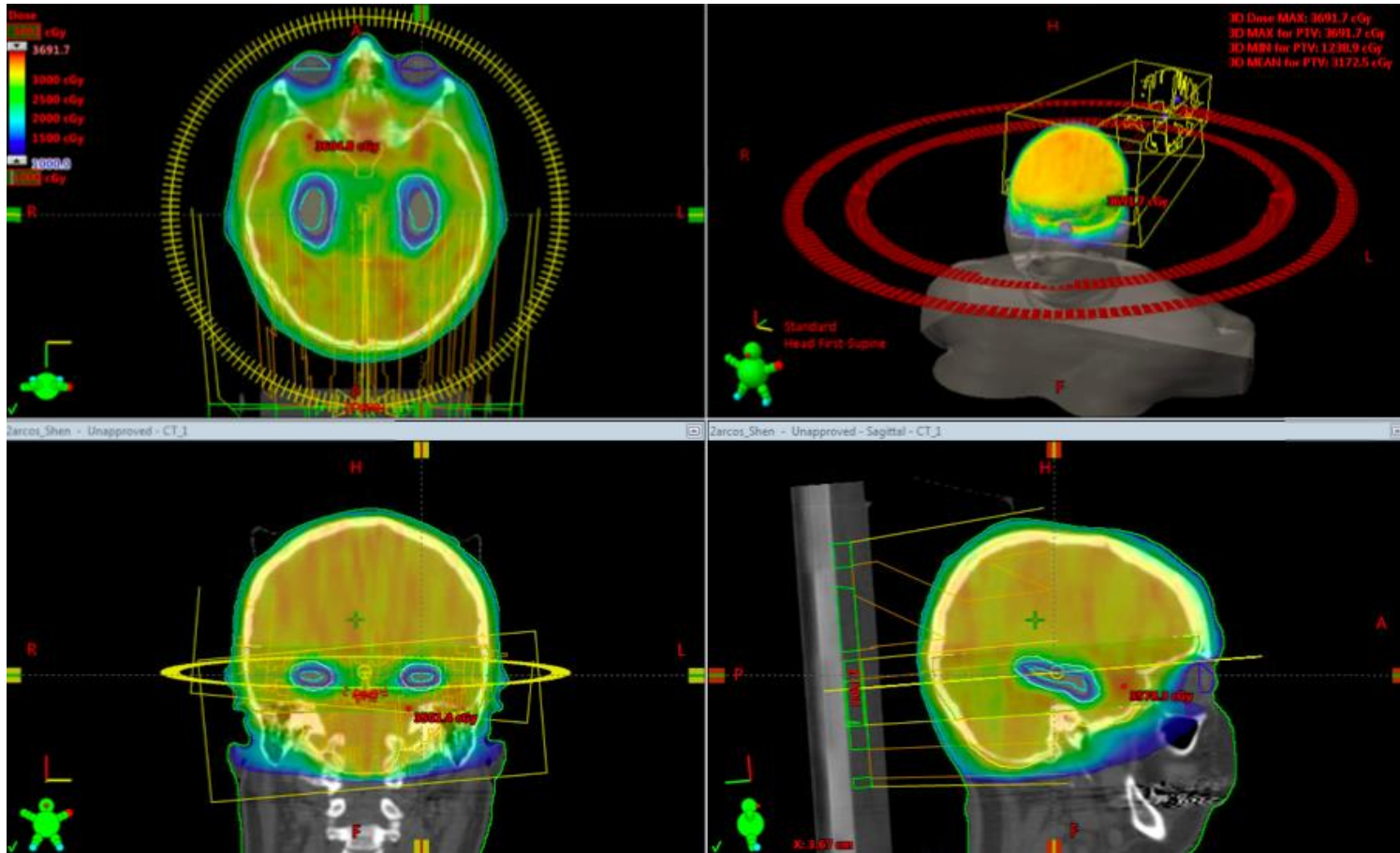
2 arcos: 601 e 556 MUs

Otimizando sub PTVs



TÉCNICAS E SETUPS

Planejamento com mais modulação: 2 arcos ajustados , 85° e 95° e 1200MU

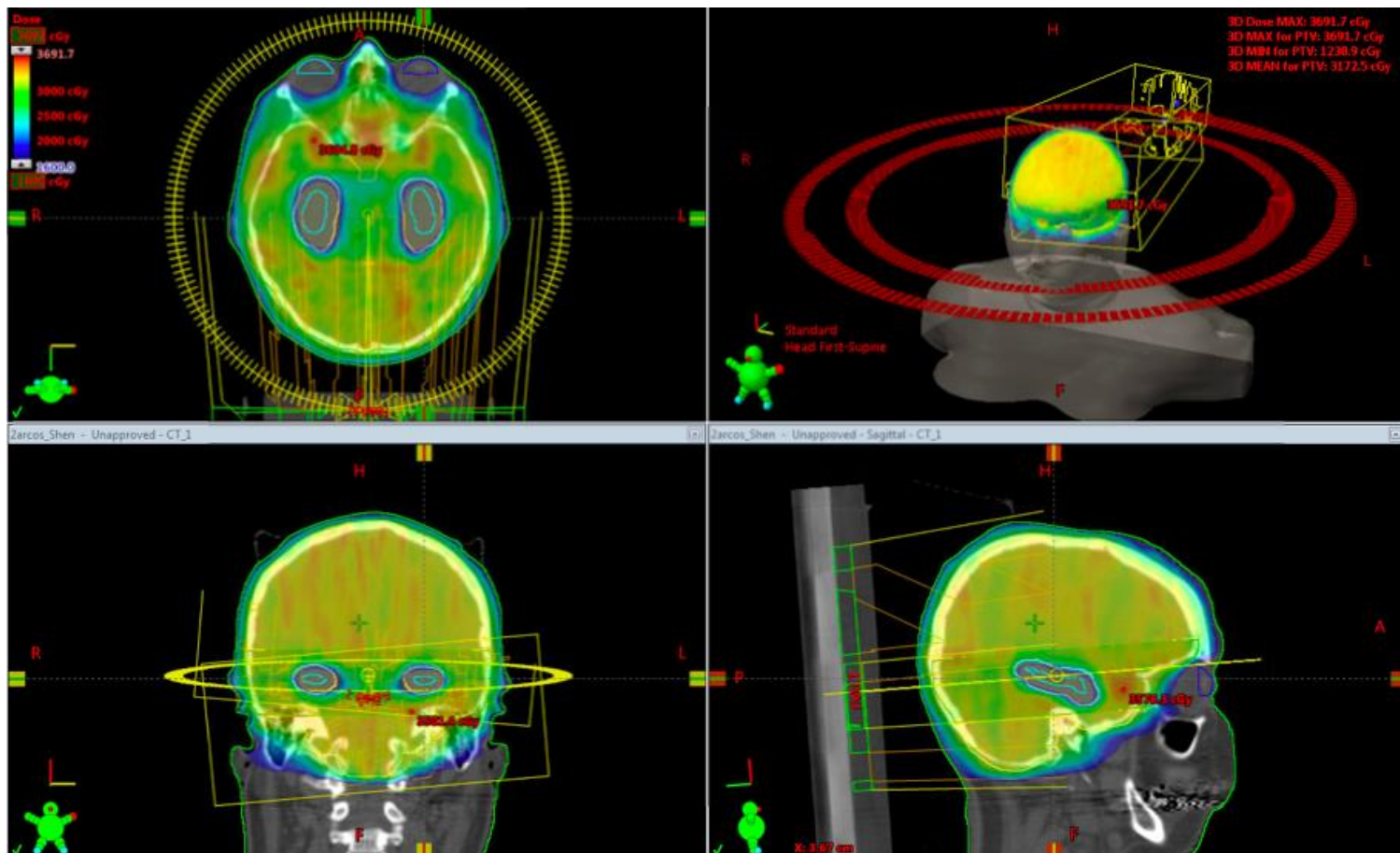


10Gy



TÉCNICAS E SETUPS

Planejamento com mais modulação: 2 arcos ajustados , 85° e 95° e 1200MU

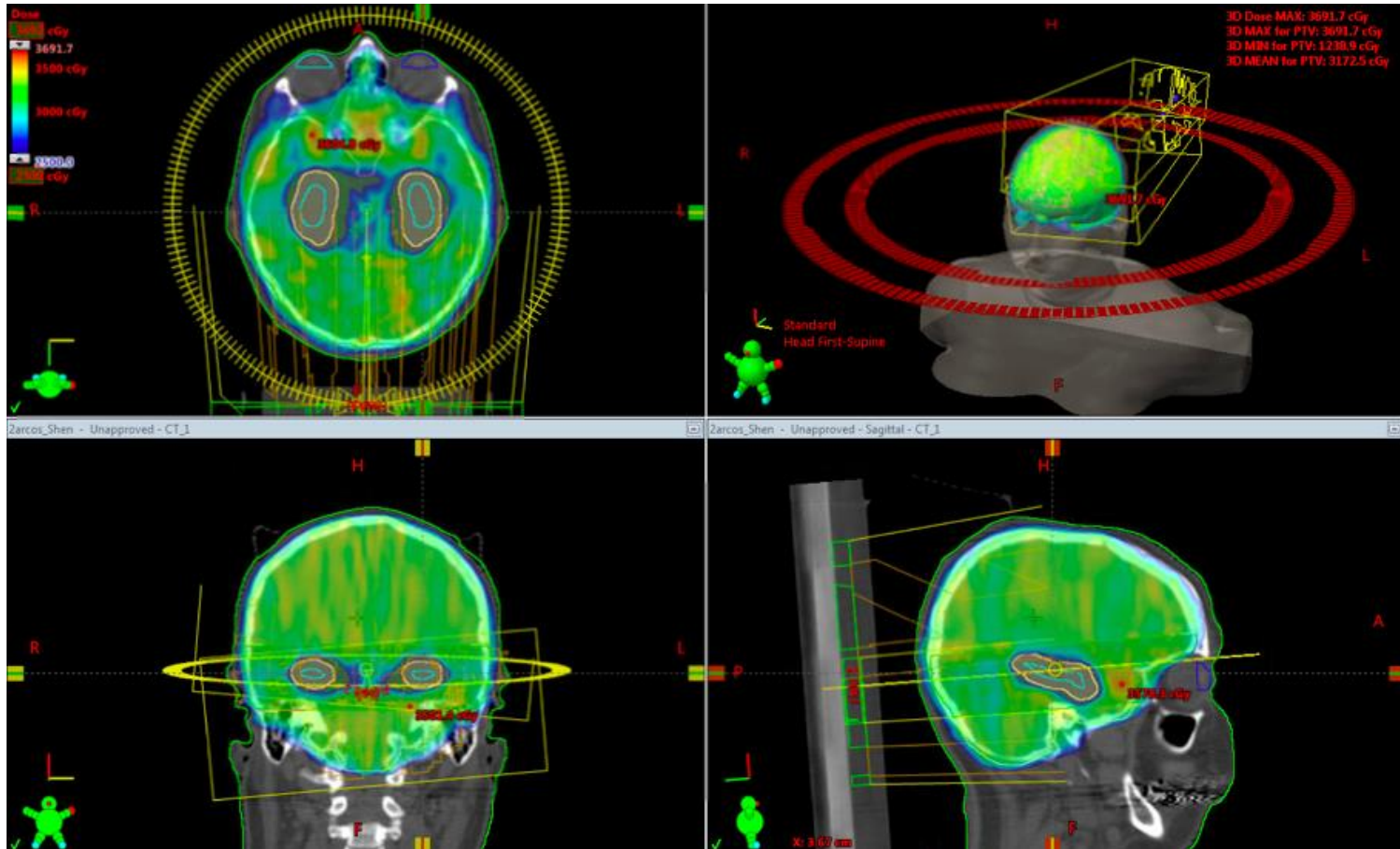


16Gy



TÉCNICAS E SETUPS

Planejamento com mais modulação: 2 arcos ajustados , 85° e 95° e 1200MU



WBRT-HA ± SIB

Whole Brain Radiotherapy with Simultaneous Integrated Boost (WBRT+SIB) for Multiple Brain Metastases (BM) using Volumetric Modulated Arc Therapy

[F.J. Lagerwaard](#), [W.S.C. Eppinga](#), [C.J.A. Haasbeek](#), [P.F. de Haan](#), [B.J. Slotman](#)

VU University Medical Center, Amsterdam, Netherlands

Feasibility of simultaneous integrated boost with forward intensity-modulated radiation therapy for multiple brain metastases

[Lingqin Ni](#)¹ and [Xiaodong Liang](#)^{✉2}

[La radiologia medica](#)

January 2016, Volume 121, [Issue 1](#), pp 60–69

Whole brain radiotherapy with hippocampal avoidance and simultaneous integrated boost for brain metastases: a dosimetric volumetric-modulated arc therapy study



Original Article

Open Access

Dummy Run of Quality Assurance Program before Prospective Study of Hippocampus-Sparing Whole-Brain Radiotherapy and Simultaneous Integrated Boost for Multiple Brain Metastases from Non-small Cell Lung Cancer: Korean Radiation Oncology Group (KROG) 17-06 Study

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Kyu Chan Lee, MD, PhD²
Jin Hee Kim, MD, PhD³
Weon Kuu Chung, MD, PhD⁴
Yang-Gun Suh, MD⁵
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Jae Won Park, MD¹¹
Dong Soo Lee, MD¹²
Jihae Lee, MD¹³
Young Suk Kim, MD¹⁴
Woo-Yoon Park, MD, PhD¹⁵
Min Kyu Kang, MD, PhD¹⁶
Sunmi Jo, MD¹⁷
Yong Chan Ahn, MD, PhD^{1,18}

Purpose

Lung Cancer Subcommittee of Korean Radiation Oncology Group (KROG) has recently launched a prospective clinical trial (KROG 17-06) of hippocampus-sparing whole brain radiotherapy (HS-WBRT) with simultaneous integrated boost (SIB) in treating multiple brain metastases from non-small cell lung cancer. In order to improve trial quality, dummy run studies among the participating institutions were designed. This work reported the results of two-step dummy run procedures of the KROG 17-06 study.

Materials and Methods

Table 1. The treatment planning protocol of KROG 17-06 study

Results

In the first two other 0.522 to after pro additional structure protocol

Table 1. The treatment planning protocol of KROG 17-06 study

Target/Normal structure	Constraint	
	Per protocol	Acceptable
P-GTV ^(a)	$V_{95\%} \geq 40$ Gy	$V_{93\%} \geq 40$ Gy
P-CTV ^(b)	$V_{95\%} \geq 25$ Gy	$V_{90\%} \geq 25$ Gy
Hippocampus	Maximum ≤ 20 Gy	Maximum ≤ 22 Gy
	Maximum to 0.1 cm^3 ≤ 16 Gy	Maximum to 0.1 cm^3 ≤ 18 Gy
	Mean ≤ 12 Gy	Mean ≤ 14 Gy
Optic chiasm	Maximum ≤ 30 Gy	N/A
Optic nerve, both	Maximum ≤ 30 Gy	N/A
P-Lens ^(c) , both	Maximum ≤ 5 Gy	Maximum ≤ 6 Gy
Eyeball, both	Maximum ≤ 10 Gy	Maximum ≤ 12 Gy

^aP-GTV: planning gross tumor volume=gross target volume (GTV)+2 mm margin, ^bP-CTV: planning clinical target volume=whole brain-hippocampal avoiding region (hippocampus+5 mm margin), ^cP-Lens: planning volume for lens=lens+5 mm margin.



WBRT-HA ± SIB – KROG 1706

- Baseado no RTOG 0933
- Avaliar sobrevivência sem progressão intracraniana e função neurocognitiva verbal
- Qualidade de vida
- Desvios inaceitáveis do protocolo demonstram impacto clínico negativo

Conclusion

The dummy run studies demonstrated the notable inter-institutional variability in delineating the hippocampus and treatment plan generation, which could be decreased through feedback from the trial center.

multicenter

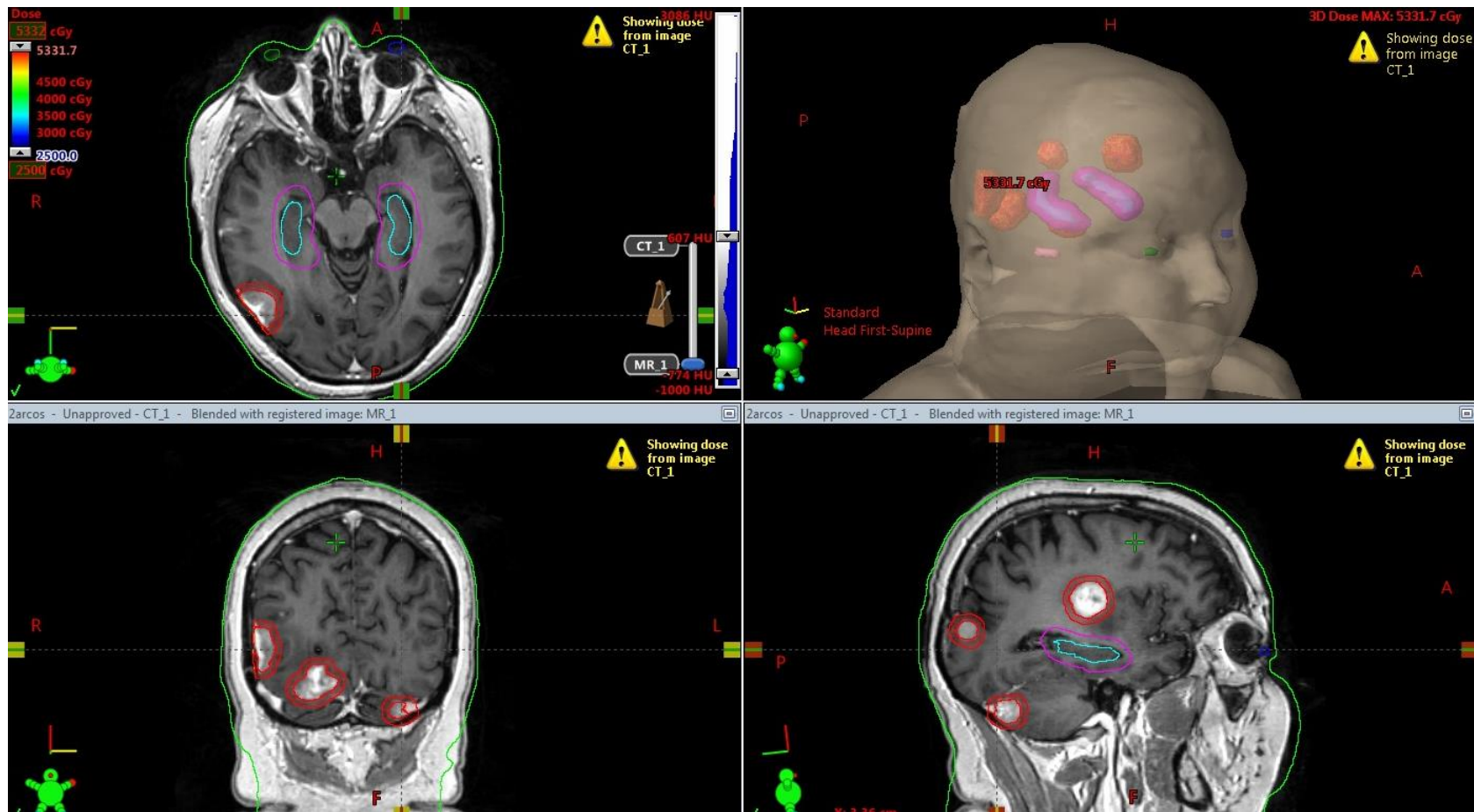
Table 2. Summary of the treatment planning systems and techniques for the dummy run study

	No.
Treatment planning system	
Eclipse	10
Pinnacle ³	1
TomoTherapy	1
Technique	
VMAT	6
Coplanar	3
Non-coplanar	3
IMRT, step and shoot	2
Coplanar	1
Non-coplanar	1
IMRT, dynamic	3
Coplanar	1
Non-coplanar	2
Helical tomotherapy	1

VMAT, volumetric-modulated arc therapy; IMRT, intensity-modulated radiotherapy.



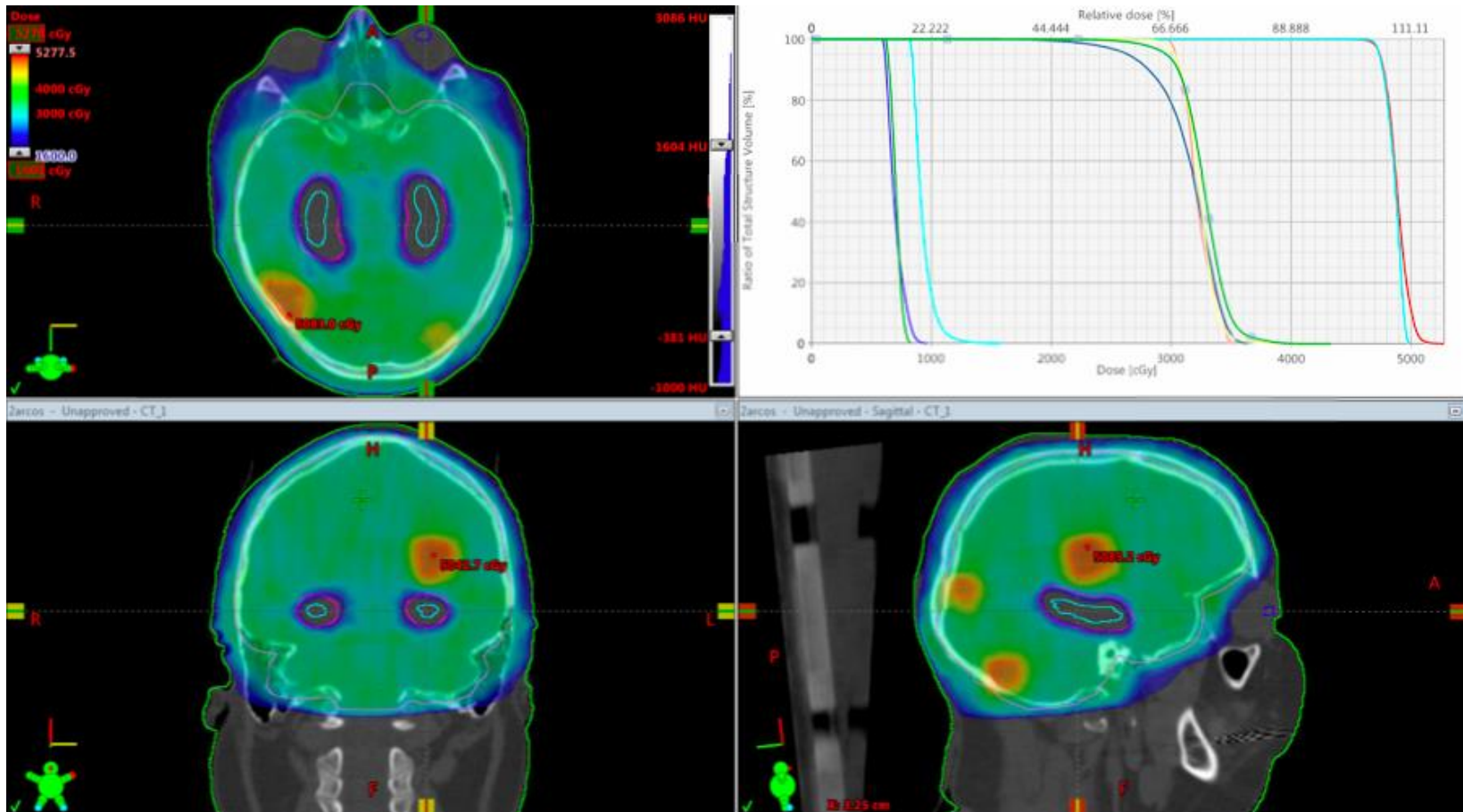
WBRT-HA $\pm$ SiB



- WBRT (30Gy) + Boost integrado nas lesões: 40Gy em 10 frações
- PTV de 3mm



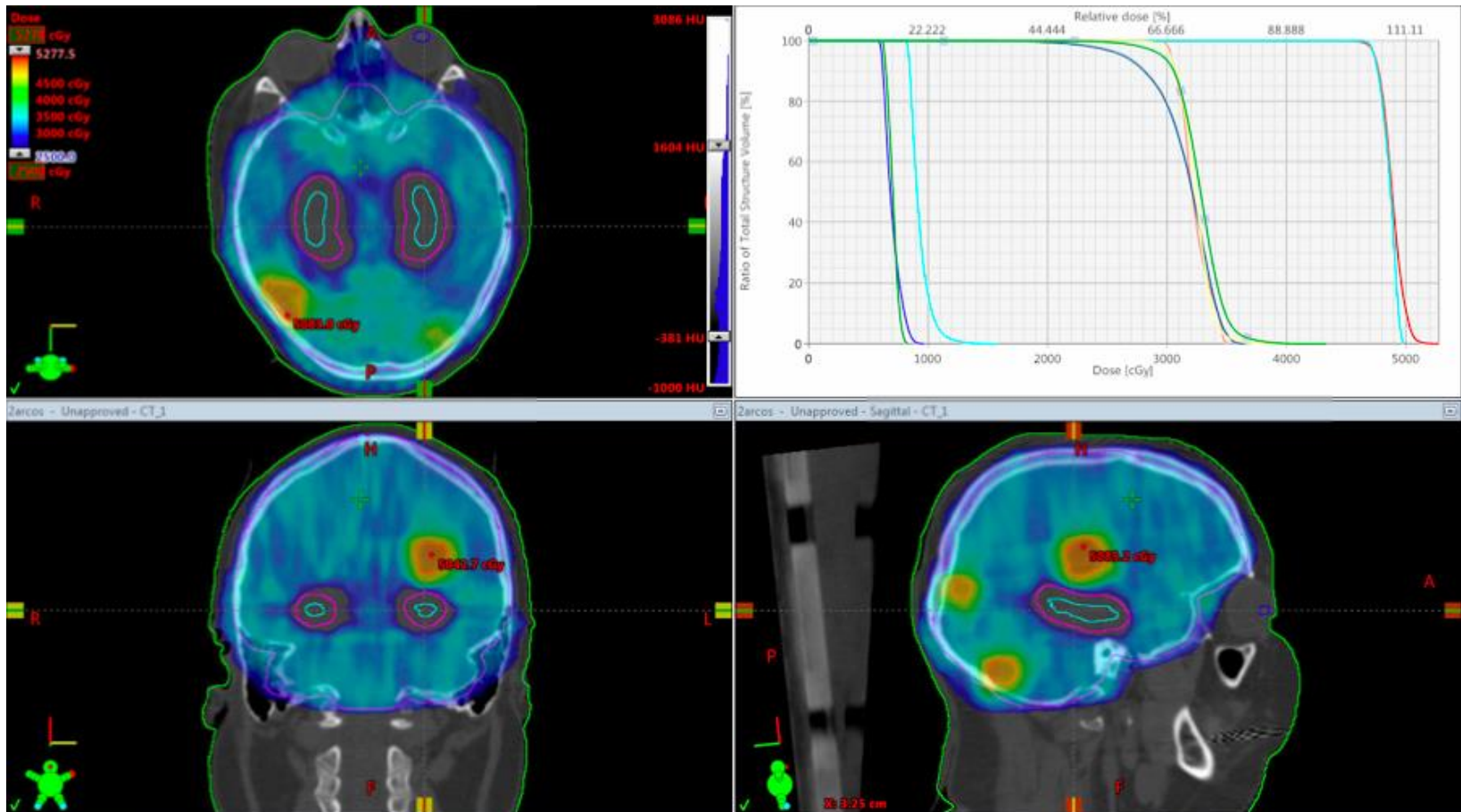
WBRT-HA $\pm$ SiB



- Resultado WBRT+SiB-HA: 16Gy



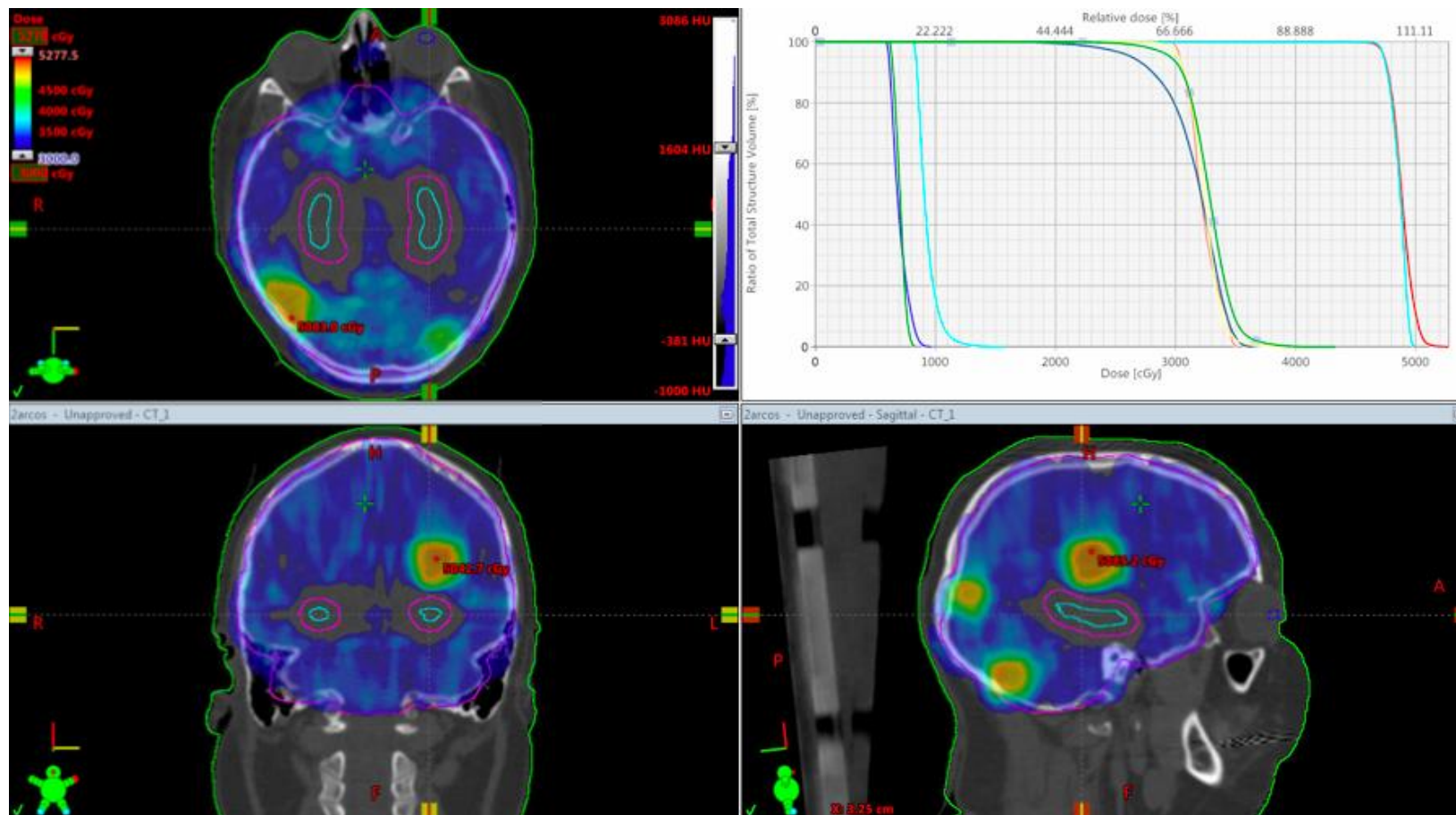
WBRT-HA $\pm$ SiB



- Resultado WBRT+SiB-HA: 25Gy



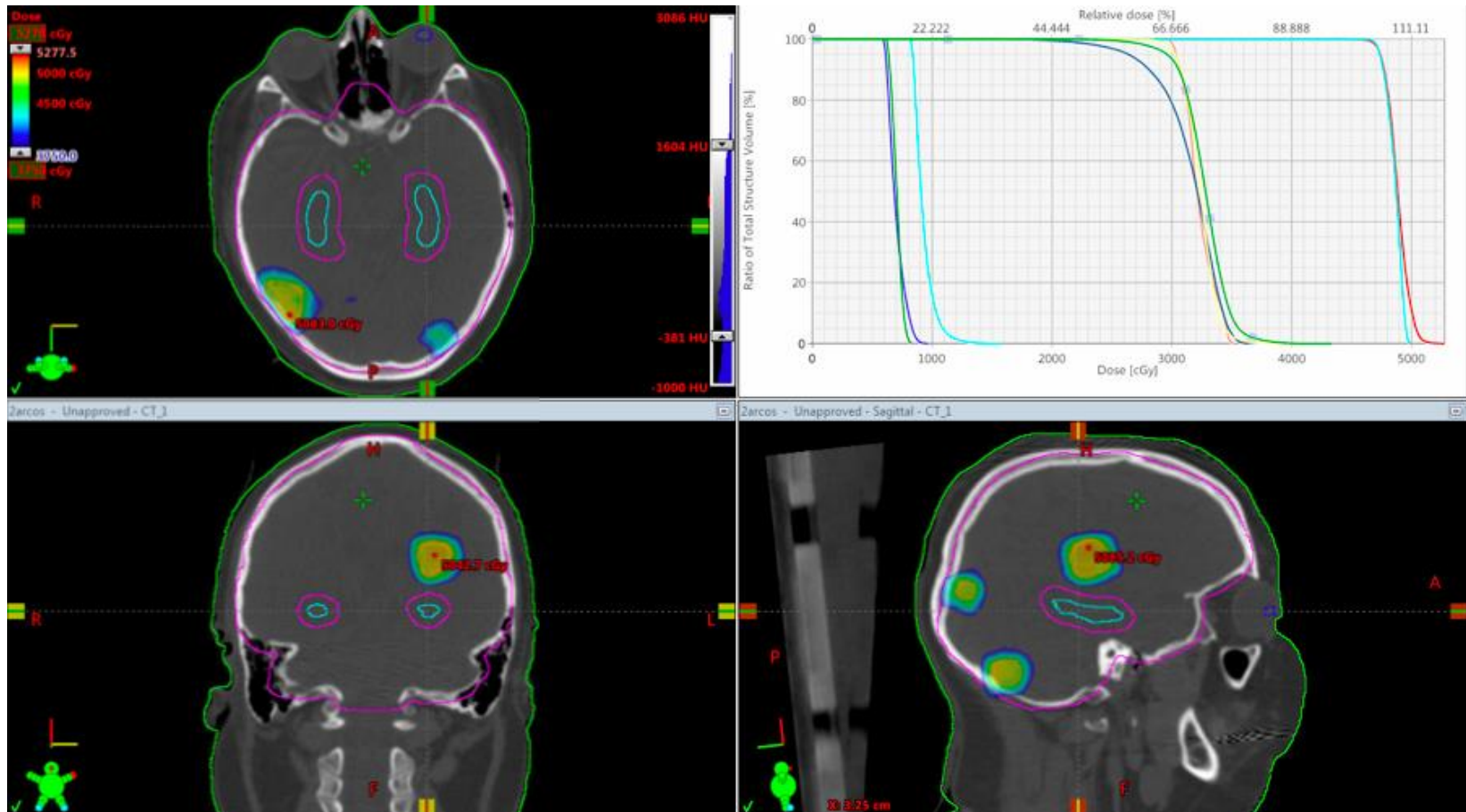
WBRT-HA $\pm$ SiB



- Resultado WBRT+SiB-HA: 30Gy



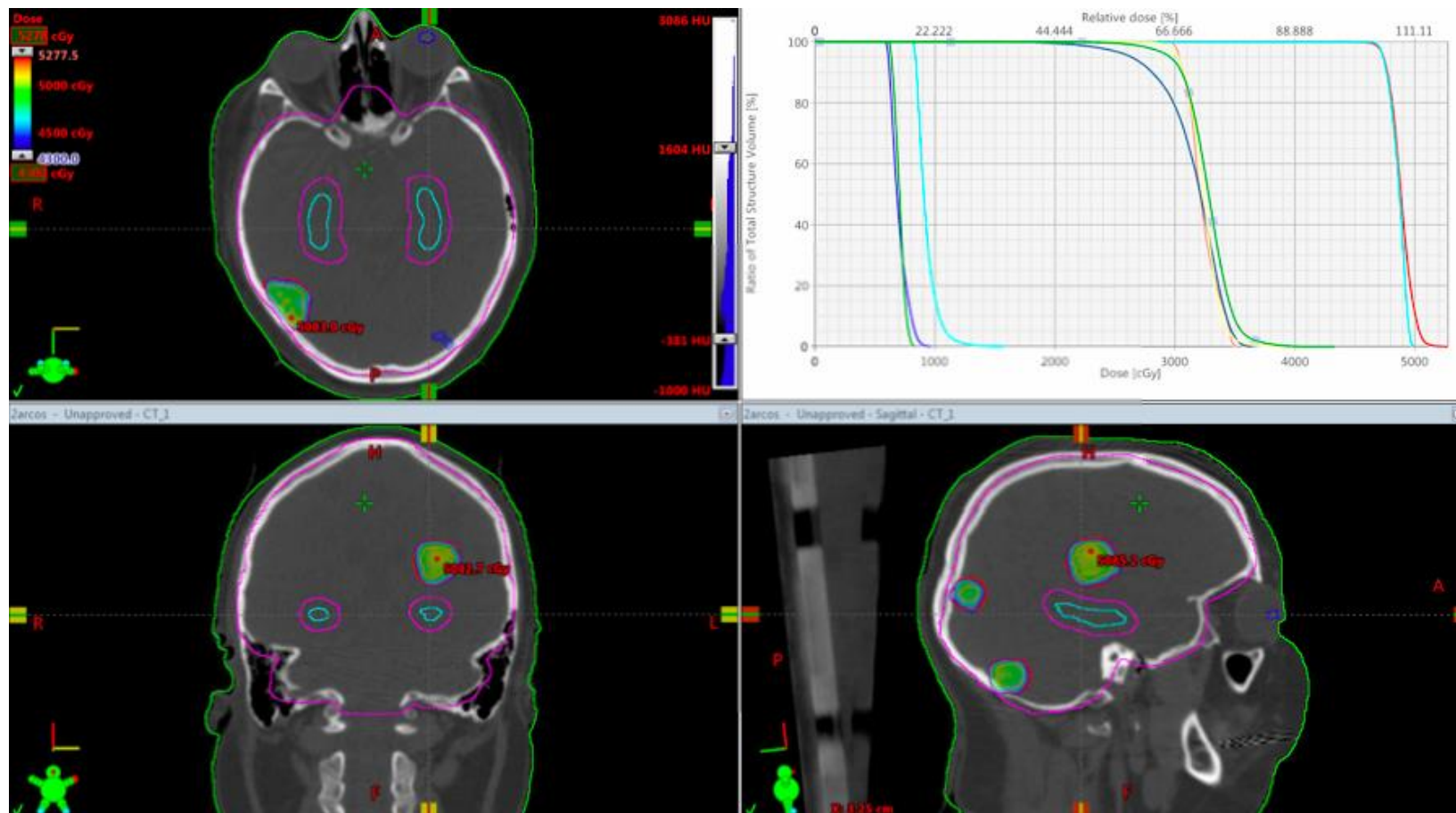
WBRT-HA $\pm$ SiB



- Resultado WBRT+SiB-HA: 37,5Gy (“ponto quente” do WBRT)



WBRT-HA $\pm$ SiB



- Resultado WBRT+SiB-HA: 40Gy



HA EM OUTROS TRATAMENTOS

Hippocampal-sparing and target volume coverage in treating 3 to 10 brain metastases: A comparison of Gamma Knife, single-isocenter VMAT, CyberKnife, and TomoTherapy stereotactic radiosurgery



Isabella Zhang MD ^{a,*}, Jeff Antone CMD ^a, Jenny Li MS ^a, Shyamali Saha MS ^a, Adam C. Riegel PhD ^a, Lili Vijeh CMD ^a, Joe Lauritano CMD ^a, Mihaela Marrero MS ^a, Sussan Salas MD ^b, Michael Schulder MD ^b, Heather Zink MD ^a, April Gosselin MD ^a, Jonathan Knisely MD ^a

SCIENTIFIC REPORTS

OPEN

The Hippocampus Sparing Volume Modulated Arc Therapy does not Influence Plan Quality on Locally Advanced Nasopharyngeal Carcinoma Patients

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Wendong Gu¹, Qilin Li², Dan Xi², Ye Tian², Juncong Mo² & Honglei Pei²

Hippocampal sparing radiotherapy for glioblastoma patients: a planning study using volumetric modulated arc therapy

Jan Hofmaier^{1*}, Steffi Kantz¹, Matthias Söhn¹, Oliver S. Dohm², Stefan Bächle², Markus Alber³, Katia Parodi⁴, Claus Belka¹ and Maximilian Niyazi¹



CONCLUSÃO



- Maioria dos pacientes é elegível ao protocolo
- Benefício em qualidade de vida
- Benefício em controle (SiB)
- Importante o estudo de técnicas e setups
- Utilizar ou não HA para o tratamento de outras regiões??





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**HOSPITAL DO CÂNCER
MÃE DE DEUS**
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2º Encontro Brasileiro de Dosimetristas

7 e 8 de Fevereiro 2020 | Hotel Ibis Santa Felicidade
Curitiba | Paraná

INSCRIÇÕES ABERTAS



ATUALIZAÇÃO

XIX Curso de Radioterapia de Última Geração e Controle da Qualidade

20 a 22 de novembro de 2019



20% de desconto para associados ABD

Um espaço para troca de experiência sobre as inovações na radioterapia e atualização sobre as recomendações para controle de qualidade nos serviços de radioterapia.

Público-alvo:

Radio-oncologistas, físicos, residentes, tecnólogos, técnicos em radioterapia, estudantes e todos profissionais envolvidos na especialidade

Coordenação

Dr. João Luís Fernandes da Silva
Física Cecília Kalil Haddad

Plano de Desenvolvimento da Radioterapia para a Próxima Década

2020



2030

RT|20|30

PLANO DE DESENVOLVIMENTO DA RADIOTERAPIA PARA A PRÓXIMA DÉCADA