



Planejamento de HDR 3D – Otimização e Avaliação das incertezas

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REALIZAÇÃO



SBRT
SOCIEDADE BRASILEIRA
DE RADIOTERAPIA

GERENCIAMENTO



AGÊNCIA OFICIAL



Declaração de Conflito de Interesse

Dr (a). Camila Pessoa de Sales afirma não ter conflito de interesse a declarar



Resumo



Otimização

Melhor
cobertura
GTV

Menor dose
OAR

Planejamento 3D

TC/RM

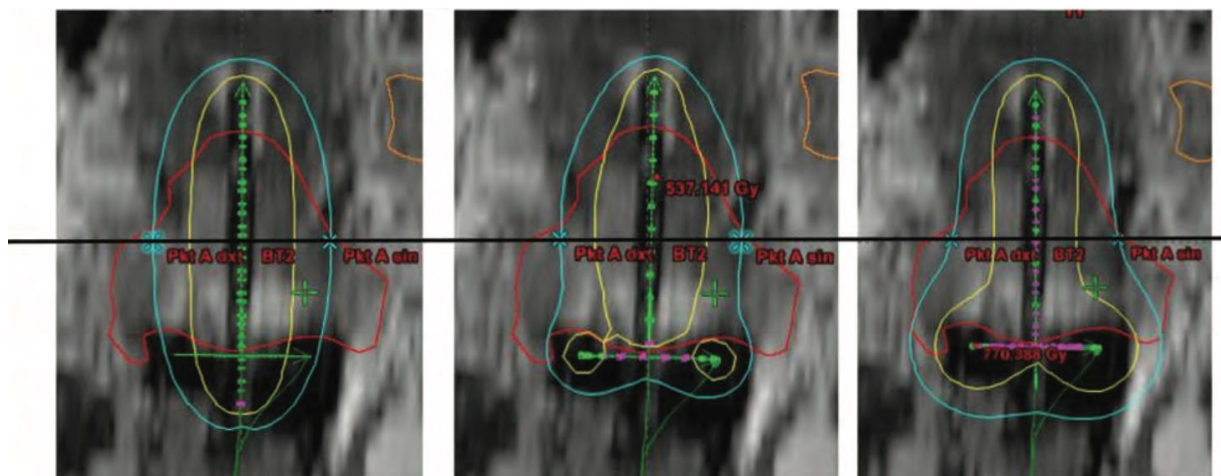


Otimização

Formalismo de
cálculo: TG 43



Correção de
heterogeneidade



Otimização

Prescrição nos ptos A

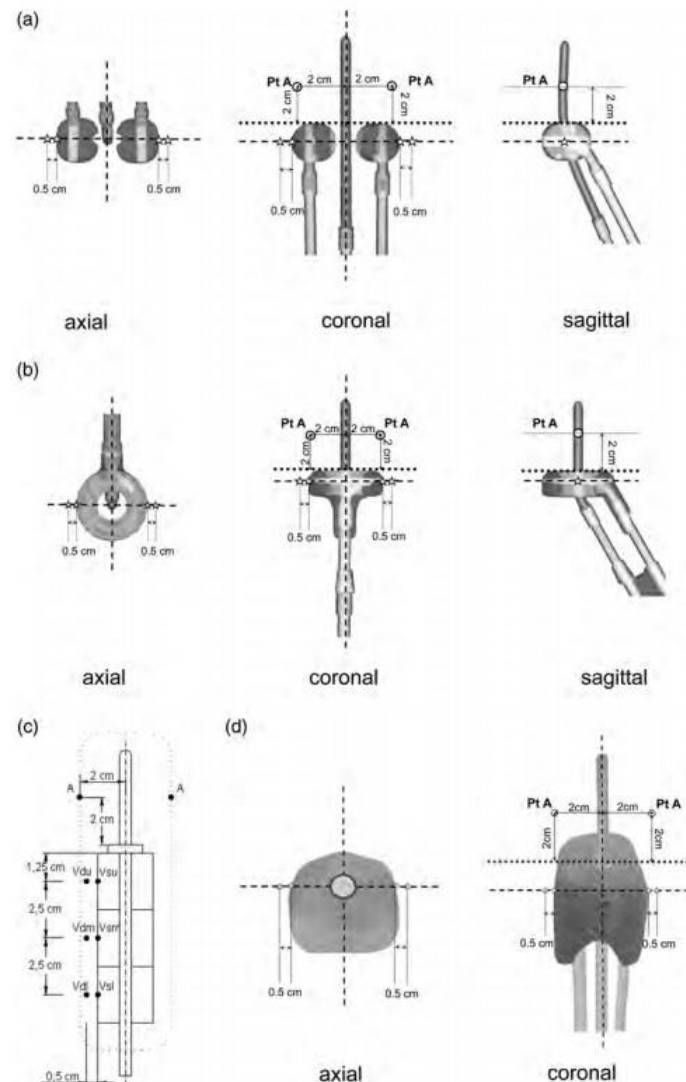
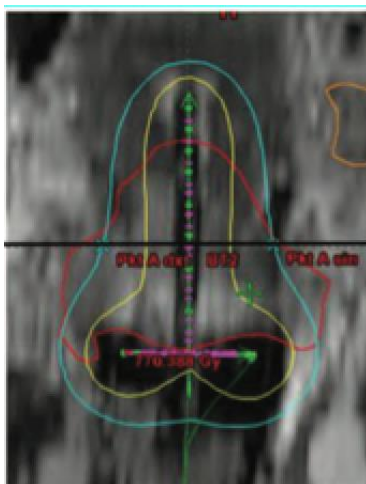


Figure 10.1. Diagrams showing the location of Point A for tandem ovoids (a), tandem ring (b), cylinder (c), and mould (d) applicators, respectively. In addition the locations of vaginal points on the surface and 5 mm from the surface are illustrated.



Otimização

Avaliação de doses EQD2

TELETERAPIA				TUMOR		OAR
	dose por fração	1,8		$D_{iso} [\alpha/\beta=10Gy]$		$D_{iso} [\alpha/\beta=3Gy]$
	fração sem bloco central	25		44,3		43,2
	fração sem bloco central			0,0		0,0
	dose total	45,0		44,3		43,2

Braquiterapia

dose em + A esq	7,0	7,0	5,5	7,0				
$A_{esq} - D_{iso} [\alpha/\beta=10Gy]$	9,9	9,9	7,1	9,9	0,0	0,0	36,9	81,1
dose em - A dir	7,0	7,0	5,5	7,0				
$A_{dir} - D_{iso} [\alpha/\beta=10Gy]$	9,9	9,9	7,1	9,9	0,0	0,0	36,9	81,1
dose média em A	7,0	7,0	5,5	7,0	0,0	0,0		
$A_{média} - D_{iso} [\alpha/\beta=10Gy]$	9,9	9,9	7,1	9,9	0,0	0,0	36,9	81,1

BEXIGA [cm³]	2cm³ - dose	6,1	6,1	6,1	6,1			
	$2cm³ - D_{iso} [\alpha/\beta=3Gy]$	11,1	11,1	11,1	11,1	0,0	0,0	44,4 87,6

RETO [cm³]	2cm³ - dose	2,0	2,0	2,0	2,0			
	$2cm³ - D_{iso} [\alpha/\beta=3Gy]$	2,0	2,0	2,0	2,0	0,0	0,0	8,0 51,2

SIGMOIDE [cm³]	2cm³ - dose	3,9	3,9	3,9	3,9			
	$2cm³ - D_{iso} [\alpha/\beta=3Gy]$	5,4	5,4	5,4	5,4	0,0	0,0	21,5 64,7

Tolerância: D_{2cc}

- Reto e Sigm: 75 Gy
- Bexiga: 90 Gy



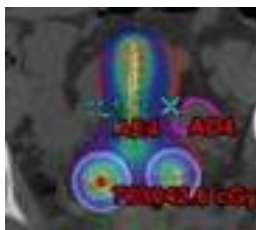
Útero

- HR-CTV: 90 Gy
- IR-CTV: 70 Gy

Otimização

Manual

Volumétrica



Geométrica

Pontos



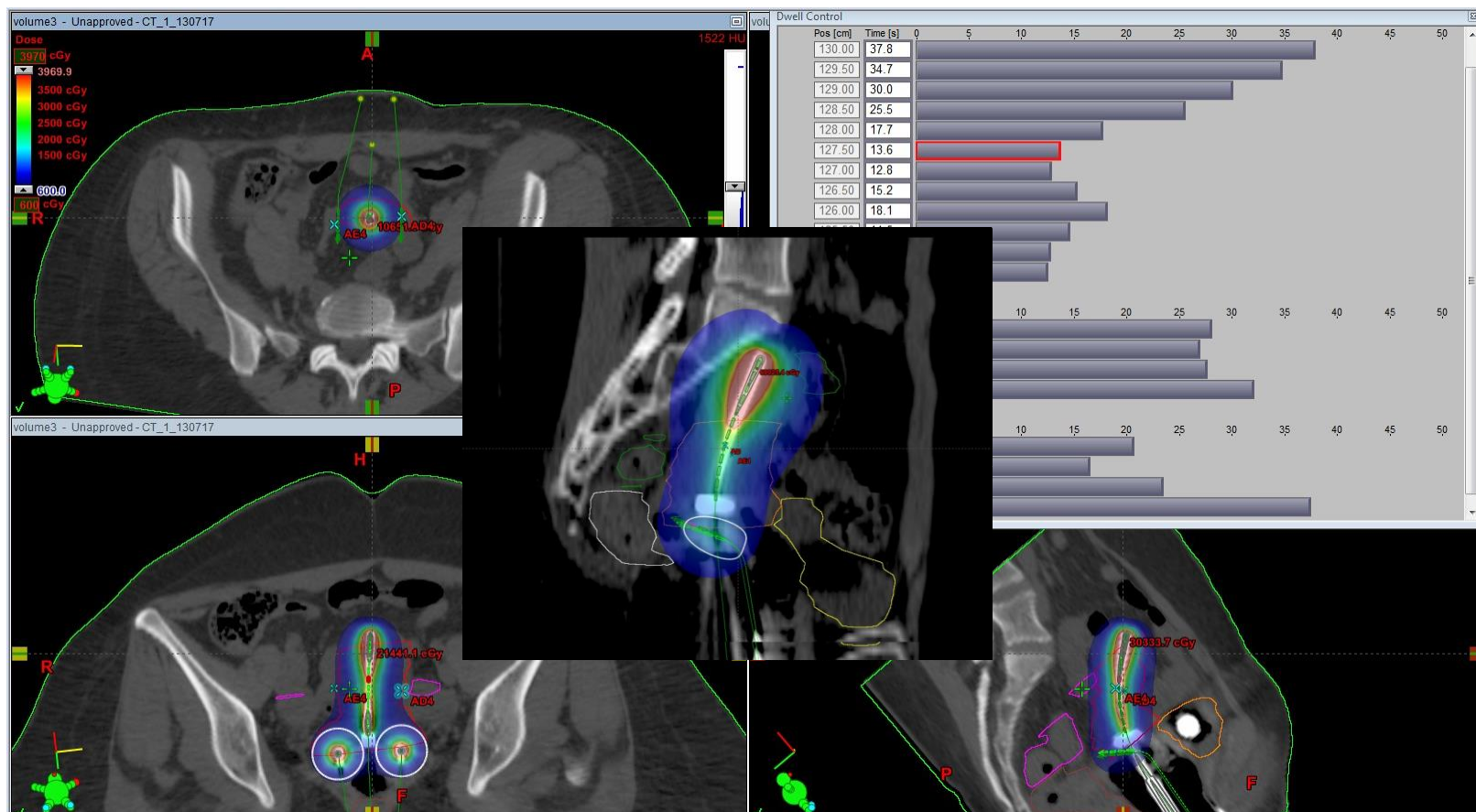
Otimização

Manual



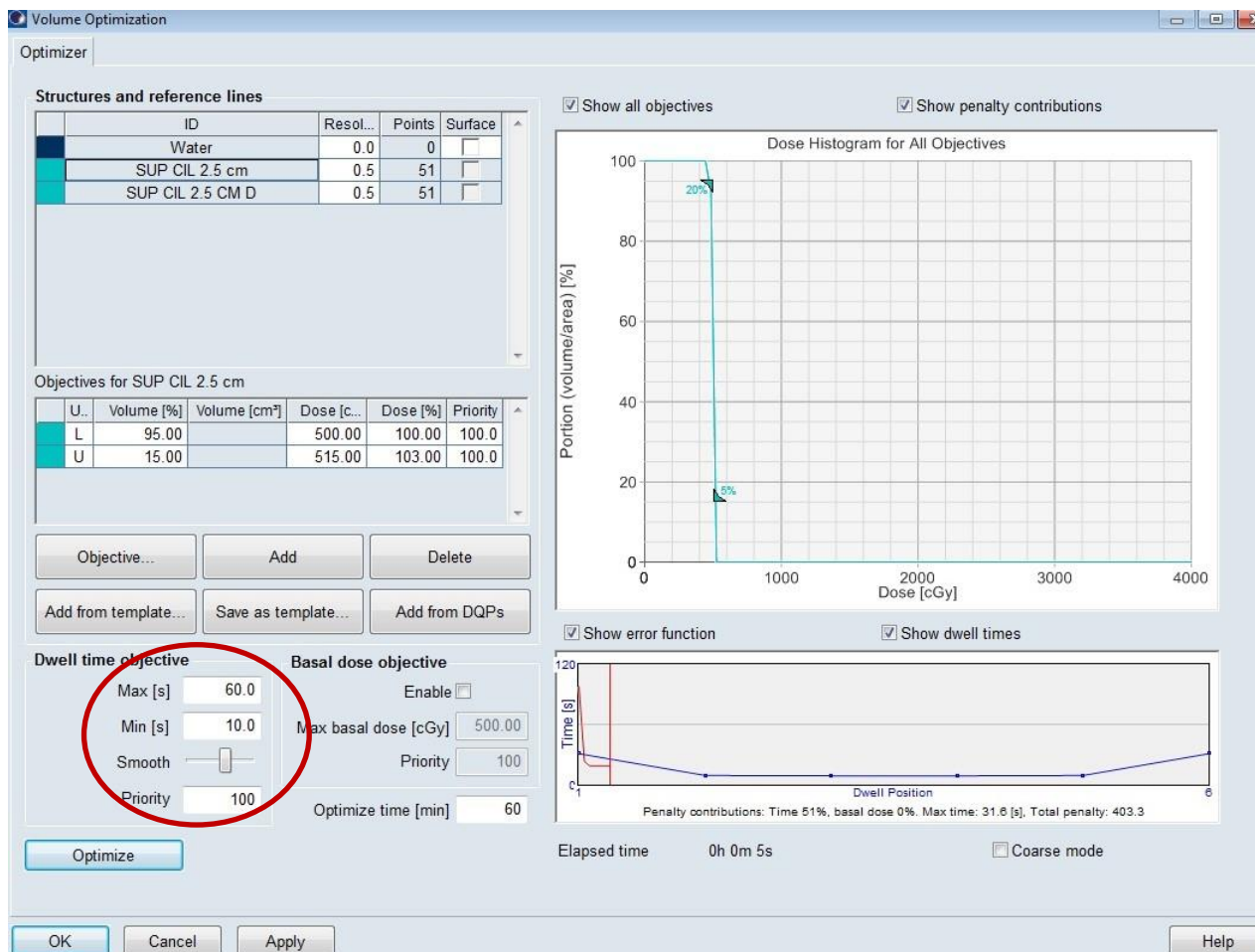
Otimização

Volumétrica



Otimização

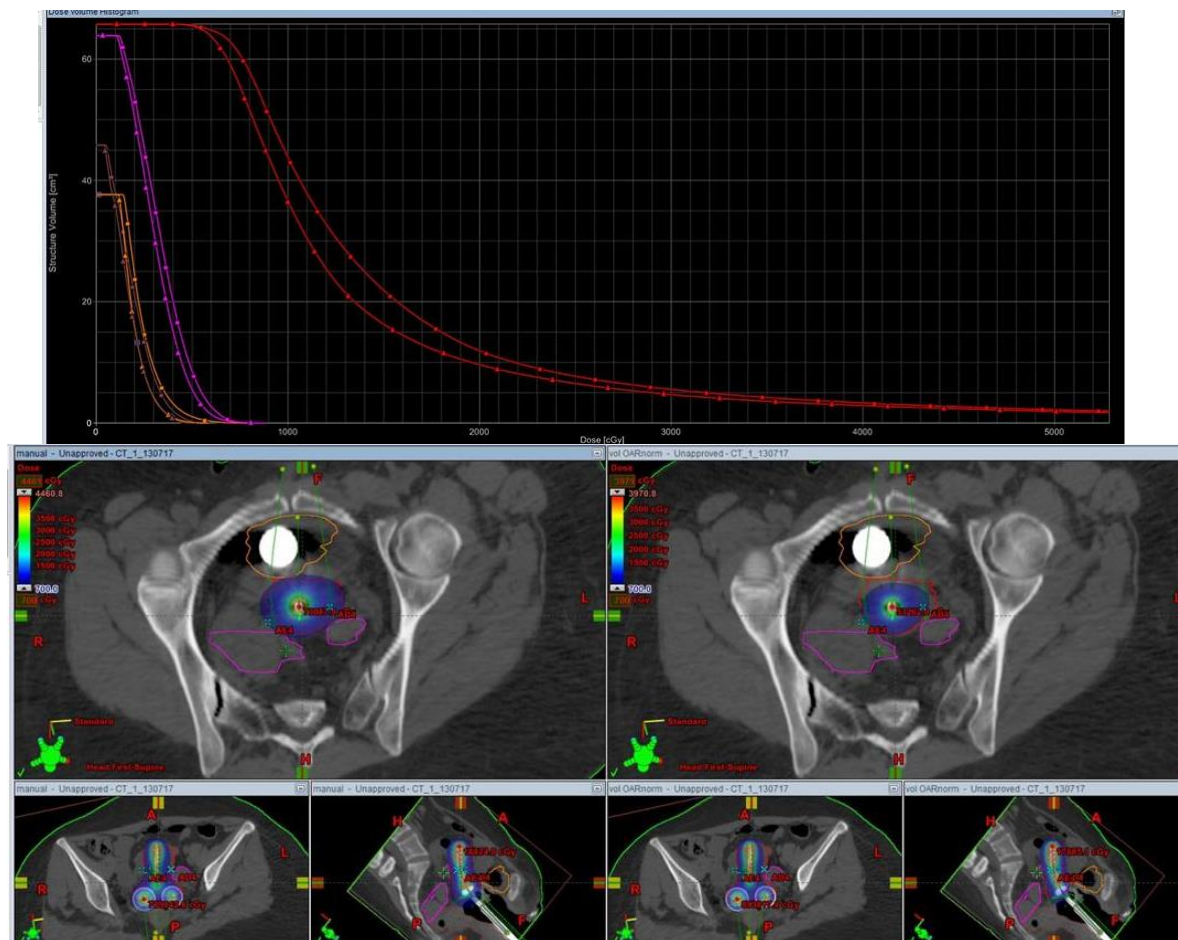
Volumétrica



Otimização

Manual com melhor cobertura

Manual x Volumétrica



Otimização

Dosimetric comparison of graphical optimization and inverse planning for brachytherapy

Bin Tang, MSc^{1,2*}, Xiangyu Liu, MSc¹,
Lucia Clara Orlandini, PhD¹

Optimization Planning

Pei Wang, MSc¹, Jie Li, MSc¹,
Bin Tang, MSc^{1,2*}

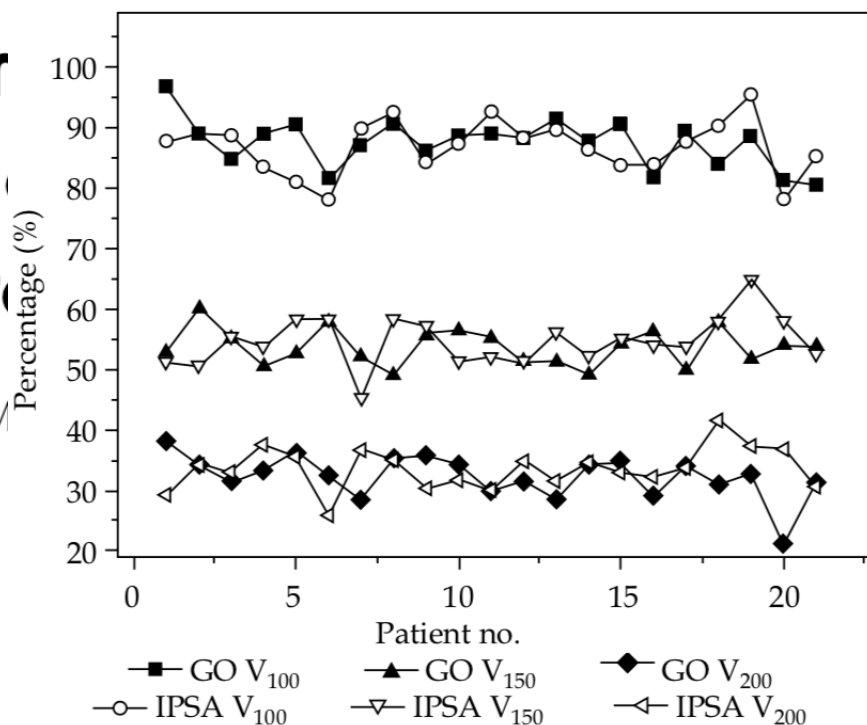


Fig. 1. Clinical target volume (CTV) V_{100} , V_{150} , and V_{200} obtained with graphical optimization (GO) and inverse planning simulated annealing (IPSA) optimization techniques



Tang, B. et al. *J Contemp Brachytherapy*. 2019;11, 4:379-383

Otimização

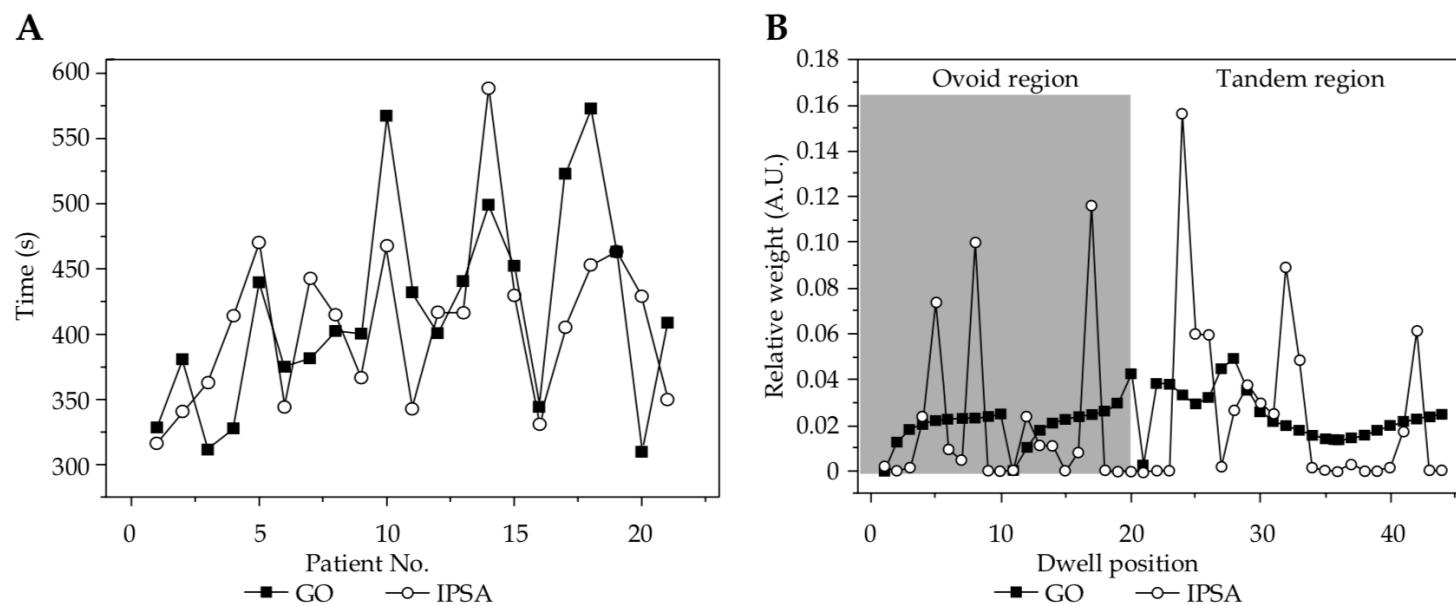


Fig. 3. The comparison of irradiation time (A) between graphical optimization (GO) and inverse planning simulated annealing (IPSA), and the dwell time distribution for a particular patient (B)



Tang, B. et al. *J Contemp Brachytherapy*. 2019;11, 4:379-383

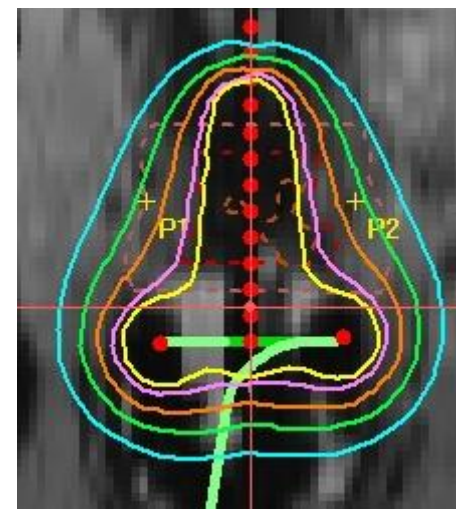
Otimização

Tumor pequeno e central

HR-CTV							
HR-CTV	100.00	700.00	100.01	10.20			
HR-CTV	236.21	1653.44	50.00	5.10			
HR-CTV	152.10	1064.71	90.00	9.18			

Active Dwell Positions							
Name	X [mm]	Y [mm]	Z [mm]	Coord....	Act. Dos...	Act. ...	
P1	2.8	-20.2	83.4	Patient	692.34	98.91	
P2	41.2	-14.3	75.0	Patient	707.66	101.09	

Otimização



HR-CTV							
HR-CTV	100.00	700.00	99.76	10.17			
HR-CTV	196.43	1375.01	50.00	5.10			
HR-CTV	124.23	869.58	90.00	9.18			
HR-CTV	108.74	761.18	98.00	9.99			

Plans							
Name	X [mm]	Y [mm]	Z [mm]	Coord....	Act. Dos...	Act. ...	
P1	2.8	-20.2	83.4	Patient	549.78		
P2	41.2	-14.3	75.0	Patient	562.84		



Otimização



Avaliação de incertezas

Review of clinical brachytherapy uncertainties: Analysis guidelines of GEC-ESTRO and the AAPM

Table 2
Example 2 – HDR ^{192}Ir source for intracavitary, image-guided cervical cancer BT.

Category	Typical level (%)	Assumptions
Source strength	2	PSDL traceable calibrations
Treatment planning	3	Reference data with the appropriate bin width
Medium dosimetric corrections	1	Applicator without shielding and CTV inside pelvis (concerning for scatter); an advanced dose calculation formalism should be used if this assumption false
Dose delivery including registration of applicator geometry to anatomy	4	Accurate QA concept for commissioning and constancy checks, especially for source positioning and applicator/source path geometry, appropriate imaging techniques (either small slice thickness, 3D sequences or combination of different slice orientations), applicator libraries (either by using software solutions or manual)
Interfraction/Intrafraction changes (including contouring uncertainties)	11	For one treatment plan per applicator insertion but several subsequent fractions – if only one fraction is applied the remaining uncertainty between imaging and dose delivery should be at least smaller than this interfraction variation
Total dosimetric uncertainty (including contouring uncertainties) ($k = 1$)	12	For treatment delivered with the same BT source – note that in cervix cancer BT, both HDR and PDR schedules consist of several fractions, reducing the random uncertainties (see text)



Avaliação de incertezas

A multicentre comparison of the dosimetric impact of inter- and intra-fractional anatomical variations in fractionated cervix cancer brachytherapy

Table 2

Observed dosimetric variations for the bladder, rectum, sigmoid/bowel and HR CTV. Relative differences between dose parameters (D_{2cm^3} or D_{90}) from two images/structure sets were calculated as $\Delta D = (D_i - D_{ref})/D_{ref}$ (on reference image and subsequent image number $i = 1-4$). Mean and SD of the variations are given in % of physical dose. A positive value means that the dose obtained for image set i was higher than on the reference image.

Structure	ΔD_{2cm^3} between 2 acquisitions [%] (fixed plan, variable anatomy)					
	Intra-application only		Inter-application only		Total	
	Mean	SD	Mean	SD	Mean	SD
Bladder	1.3	± 17.7	-0.1	± 21.2	0.6	± 19.5
Rectum*	3.8	± 20.5	4.3	± 22.8	4.1	± 21.7
Sigmoid	-2.3	± 23.5	6.8	± 30.2	1.6	± 26.8
HR CTV	ΔD_{90} between 2 acquisitions [%] (fixed plan, variable anatomy)					
	Intra-application only		Inter-application only		Total	
	Mean	SD	Mean	SD	Mean	SD
HR CTV	-2.5	± 10.8	0.4	± 15.1	-1.1	± 13.1

* 3 Extreme outliers ($\Delta D_{2cm^3} = 119-240\%$) were excluded from the overall analysis. Inclusion would result in $11.2 \pm 38.3\%$ (mean $\pm$ SD) for rectum for intra-application group and $7.7 \pm 31.4\%$ for total sample.

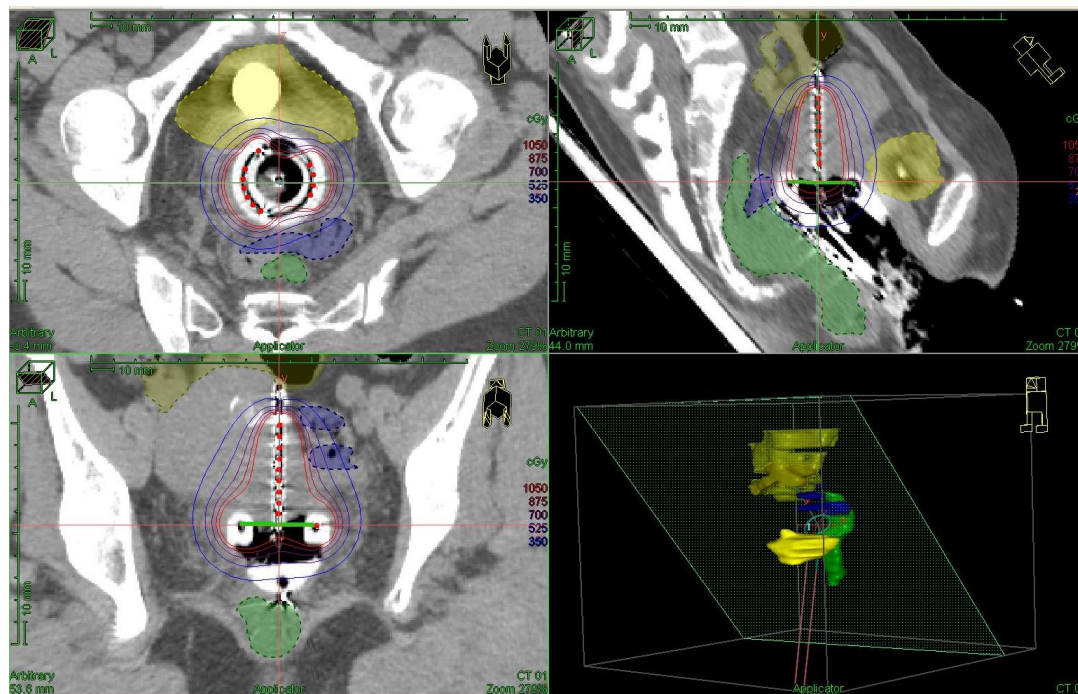


Avaliação de incertezas

Planejamento

TC

Reconstrução
ao aplicador



Avaliação de incertezas

Planejamento

RM
(T2)

Visualização
do tumor



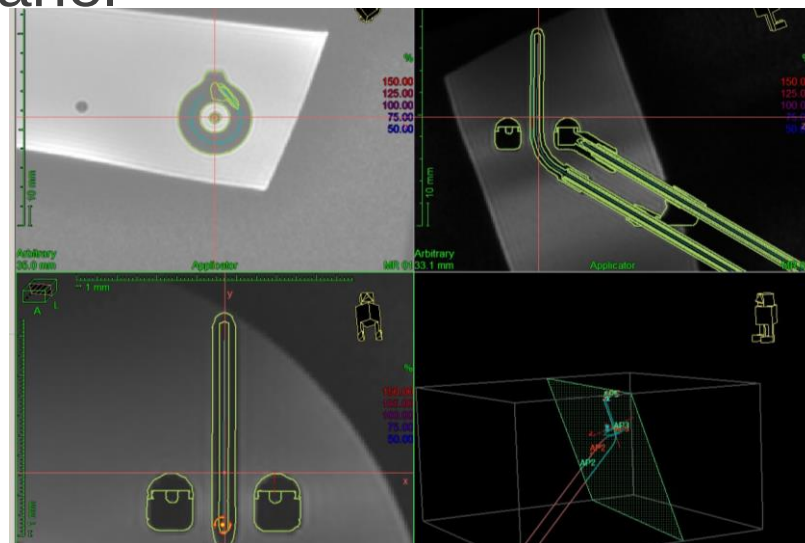
Avaliação de incertezas

Reconstrução dos aplicadores

- Aplicador CT&RM sonda e anel

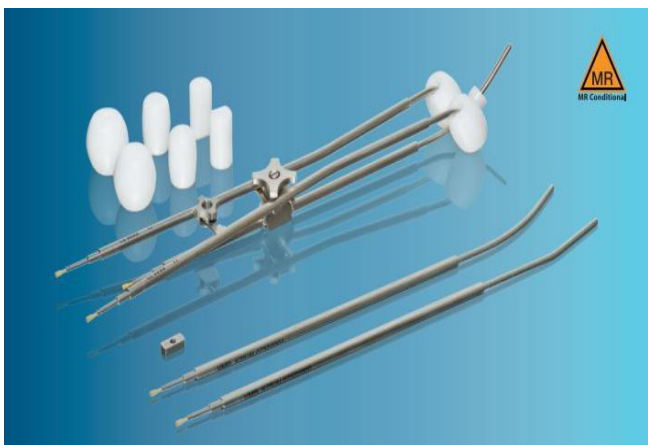


Sonda&anel: Fibra de carbono

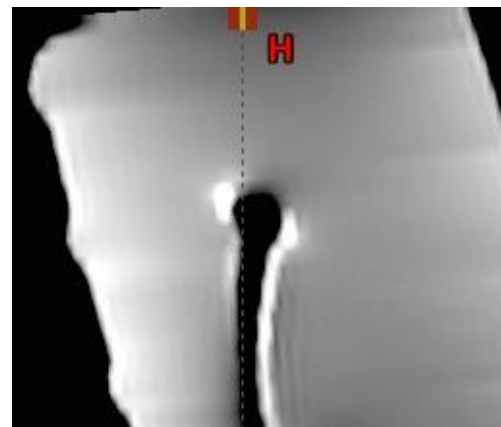
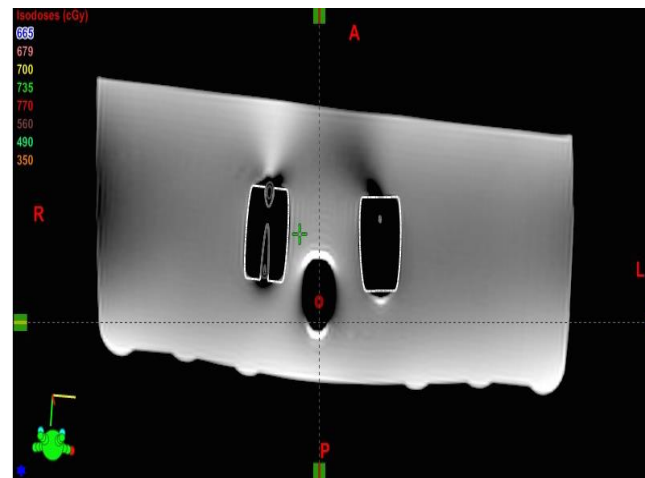


Avaliação de incertezas

Reconstrução dos aplicadores



Sonda&ovóide: Titânio



Avaliação de incertezas

Reconstrução dos aplicadores

Accurate applicator reconstruction procedures are required as the error in DVH-parameter calculation is from 5 % to 8 % mm^{-1} of reconstruction error.

- Registro TC e RM aumenta incerteza do planejamento
- Utilização de autoradiografia sobreposta à imagem
- Reconstrução dos aplicadores em RM com biblioteca de aplicadores.



Avaliação de incertezas

Reconstrução dos aplicadores

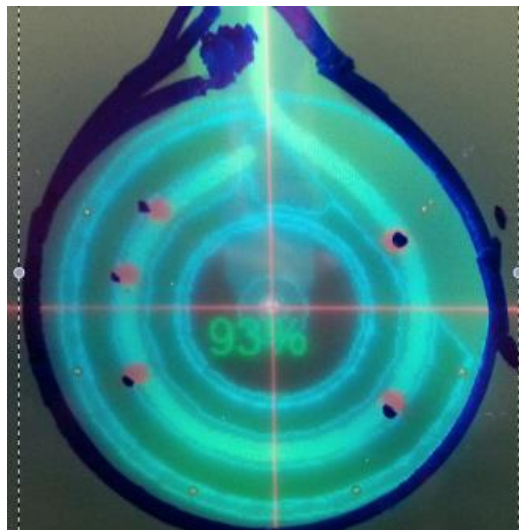
- Registro TC e RM aumenta incerteza do planejamento
- Utilização de autoradiografia sobreposta à imagem
- Reconstrução dos aplicadores em RM com biblioteca de aplicadores.



Avaliação de incertezas

Reconstrução dos aplicadores

- Utilização de transparência:
 - Impressão do aplicador em transparência e sobreposição na tela



Berger D. et al. *Radiother Oncol.* 2009;93:347–351

Avaliação de incertezas

Reconstrução dos aplicadores

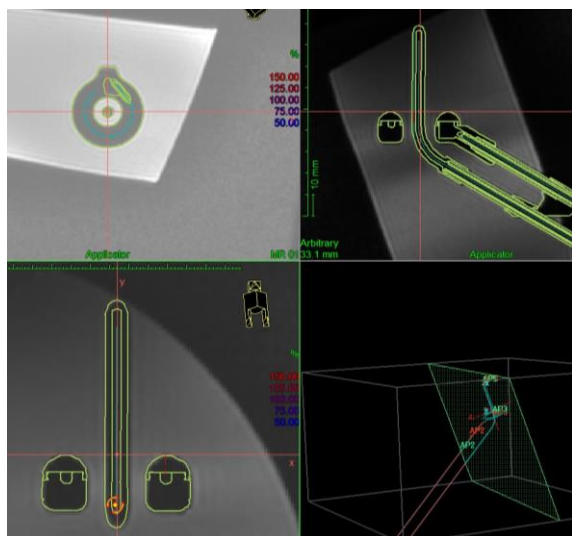
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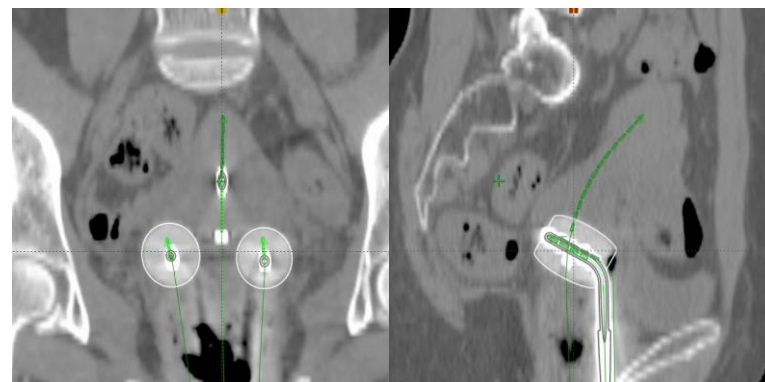
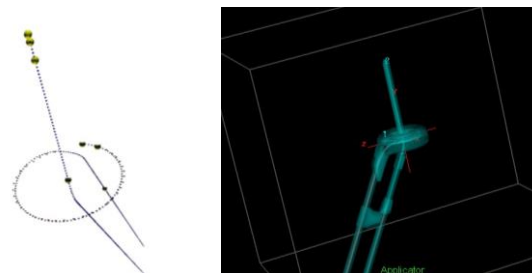
Avaliação de incertezas

Reconstrução dos aplicadores

- Biblioteca de aplicadores



Aplicador sonda e anel

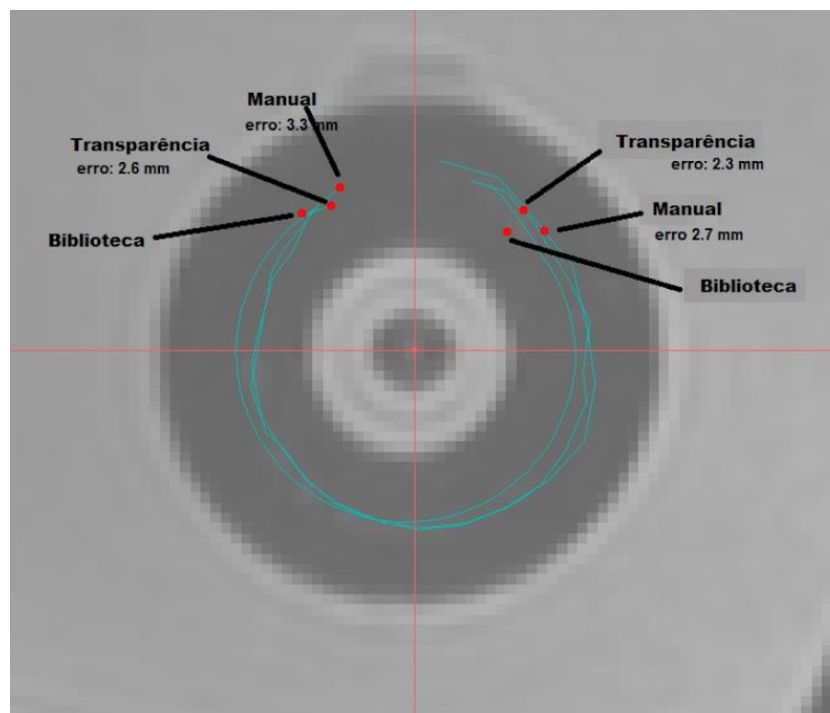


Aplicador sonda e ovóide

Avaliação de incertezas

Reconstrução dos aplicadores

Comparação dos
métodos de
reconstrução



Avaliação de incertezas

Imobilização

Vac-fix



Garantir posicionamento entre imagem e tratamento

Fixação dos aplicadores



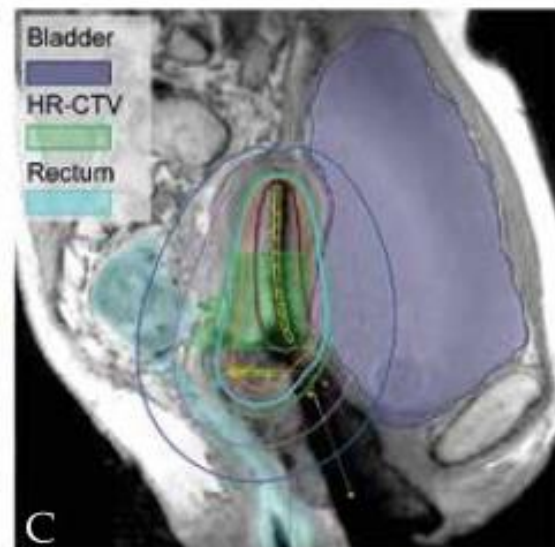
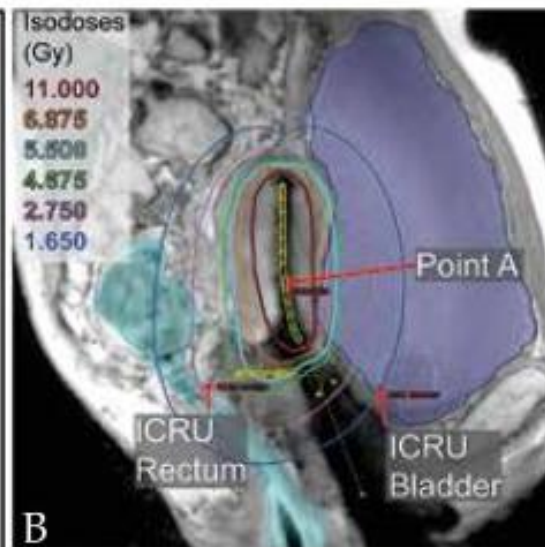
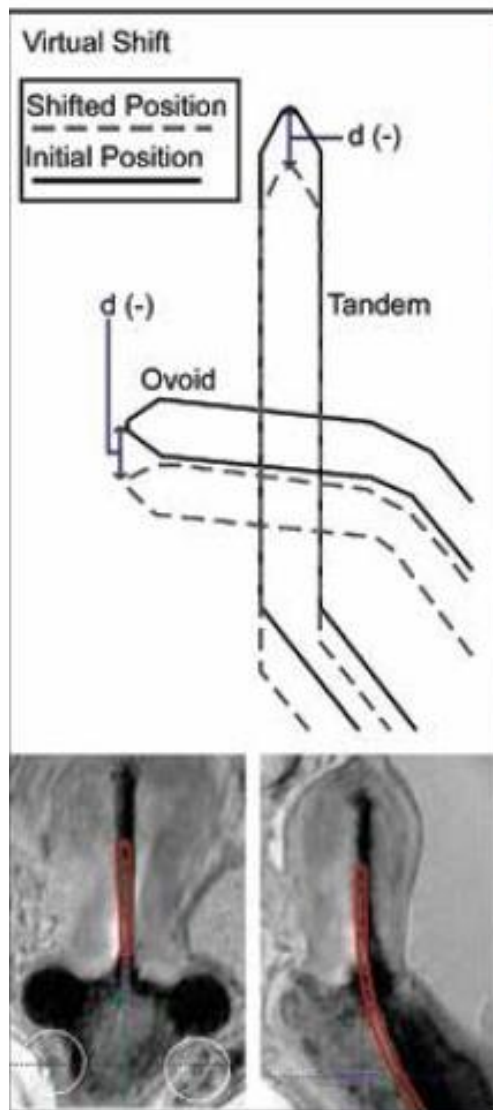
Tamponamento com gaze



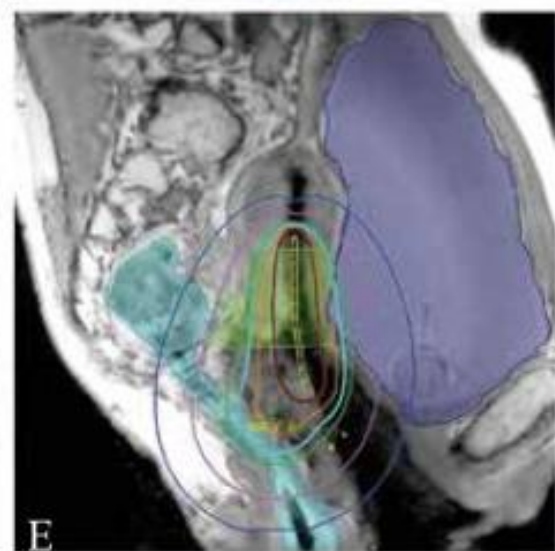
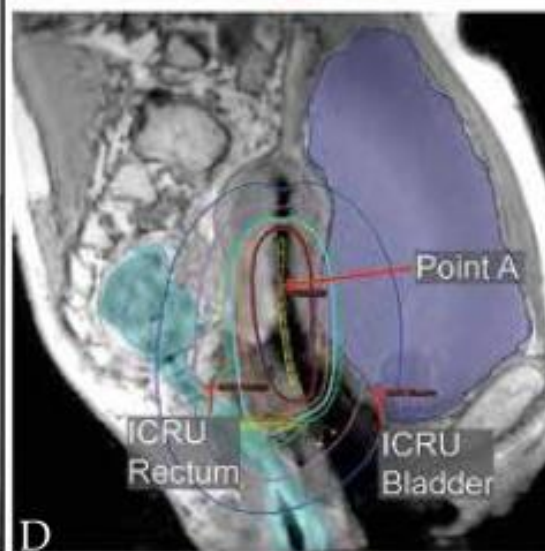
A

Conventional plan

Conformal plan



Original unshifted plan



-20 mm shifted plan



Avaliação de incertezas

Erros comuns

Paciente errado

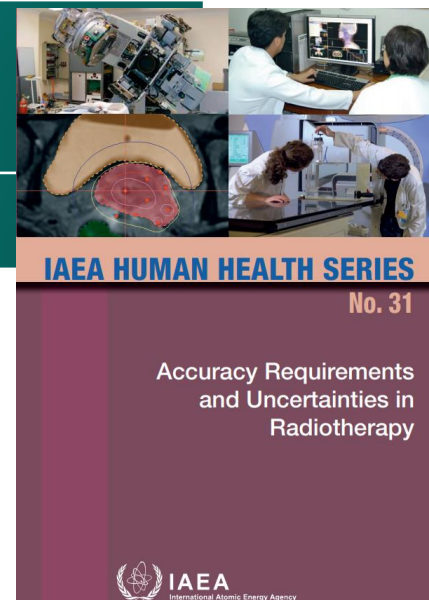
Ordem invertida de paradas de fontes

Posição da primeira parada errada

Curva acentuada no catéter

Erro na parada da fonte (passo inadequado)

Erro no comprimento do catéter

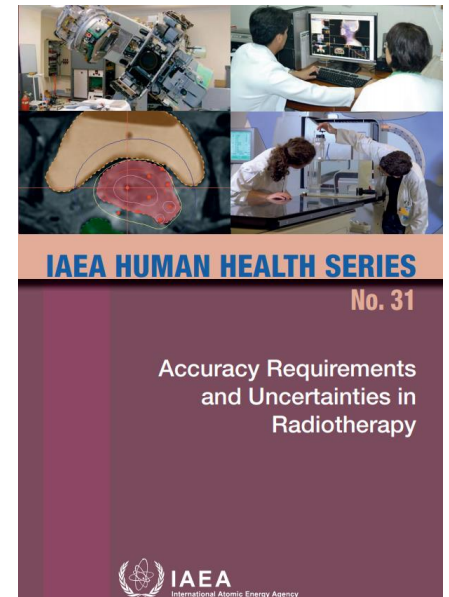


Redução de incertezas

Definição de
protocolos e
guias

Documentação

Educação
continuada





OBRIGADA!

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