Evolution of brachytherapy in providing conformal plans – from 2D to 3D IGABT, IPSA and HIPO

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Disclosures & Acknowledgements

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- *Teaching Faculty for the ESTRO GYN TCs (2016 onwards).*
- *Certified International trainer for Gyn Brachy by Eckert and Ziegler Bebig GmBH.*
- *Co-author : IBS Guidelines for Cervical Cancer and Member Co-ordination Committee of AROI for AROI ESTRO Gyn TCs.*
- *Teaching material from GYN GEC ESTRO Teaching Courses (2012 – 2020).*
- *Prof. Richard Poetter, Prof. Kari Tanderup, Prof. Christine Haie Meder, Prof. Umesh Mahantshetty and Prof. Jamema Swamidas.*
- *Present and previous faculty members, residents, nursing personnel and staff at The Departments of Radiation Oncology, RGKMCH, Kolkata and BMCH, Burdwan.*

BRACHYTHERAPY : WHAT?

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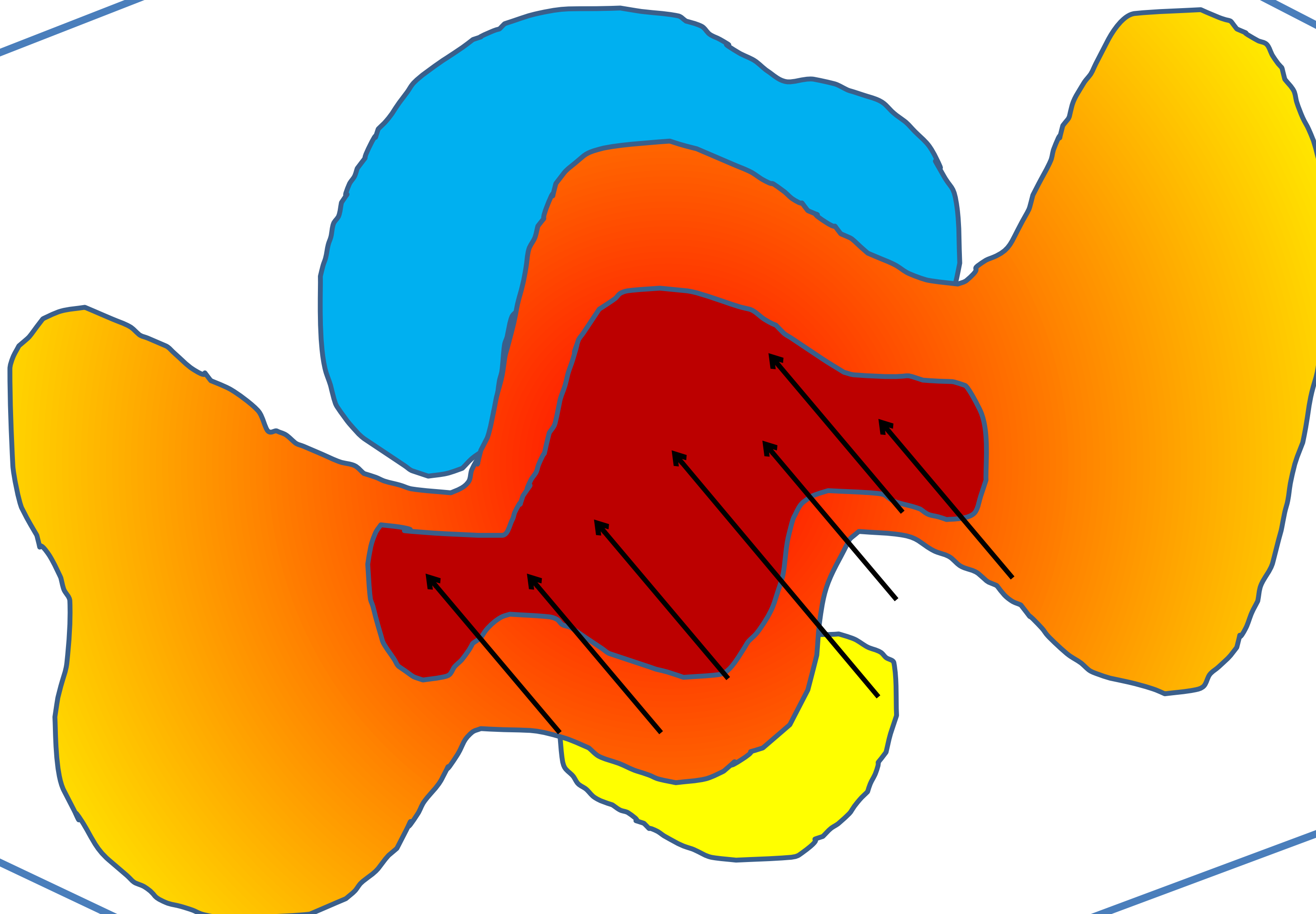
EBRT vs BT



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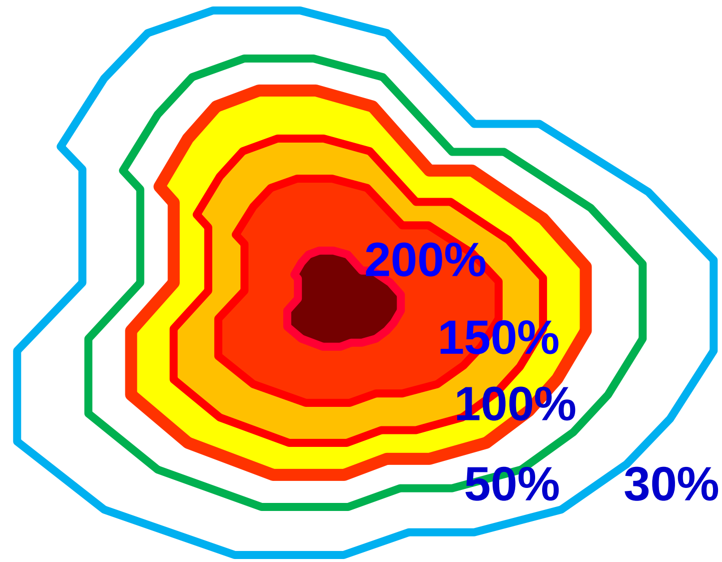
Advantages of BT

- Conforms to irregular tumor volumes.
- Avoids geographical miss - moves with the tumor.
- Rapid dose fall off.
- Center of tumor (hypoxic / radio-resistant area) actually receives much higher dose.



Adapted from Nag, S.

BRACHYTHERAPY IN CARCINOMA CERVIX : WHY?

Burdwan Medical College

Advantages of BT : Eg : Cervix

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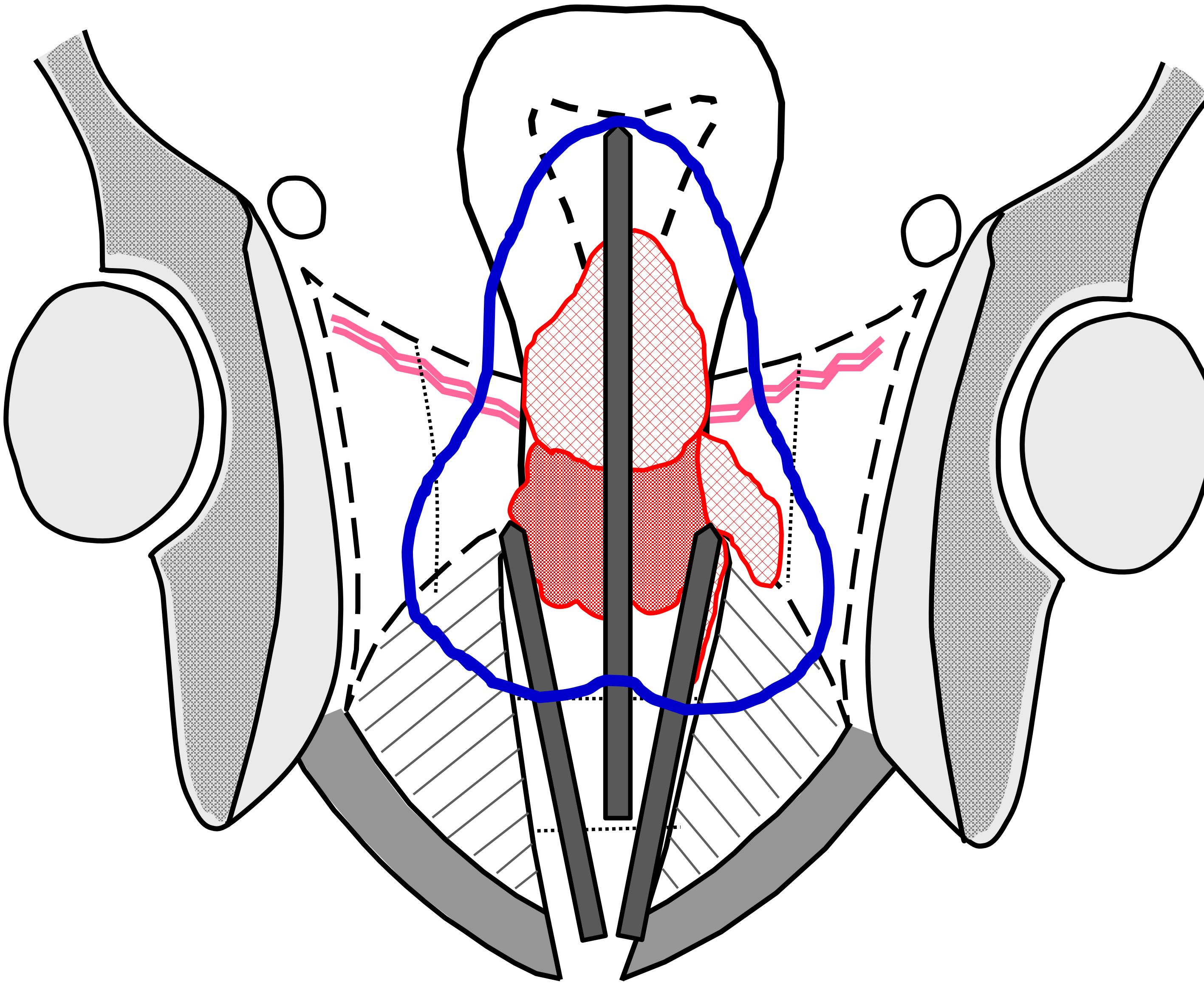
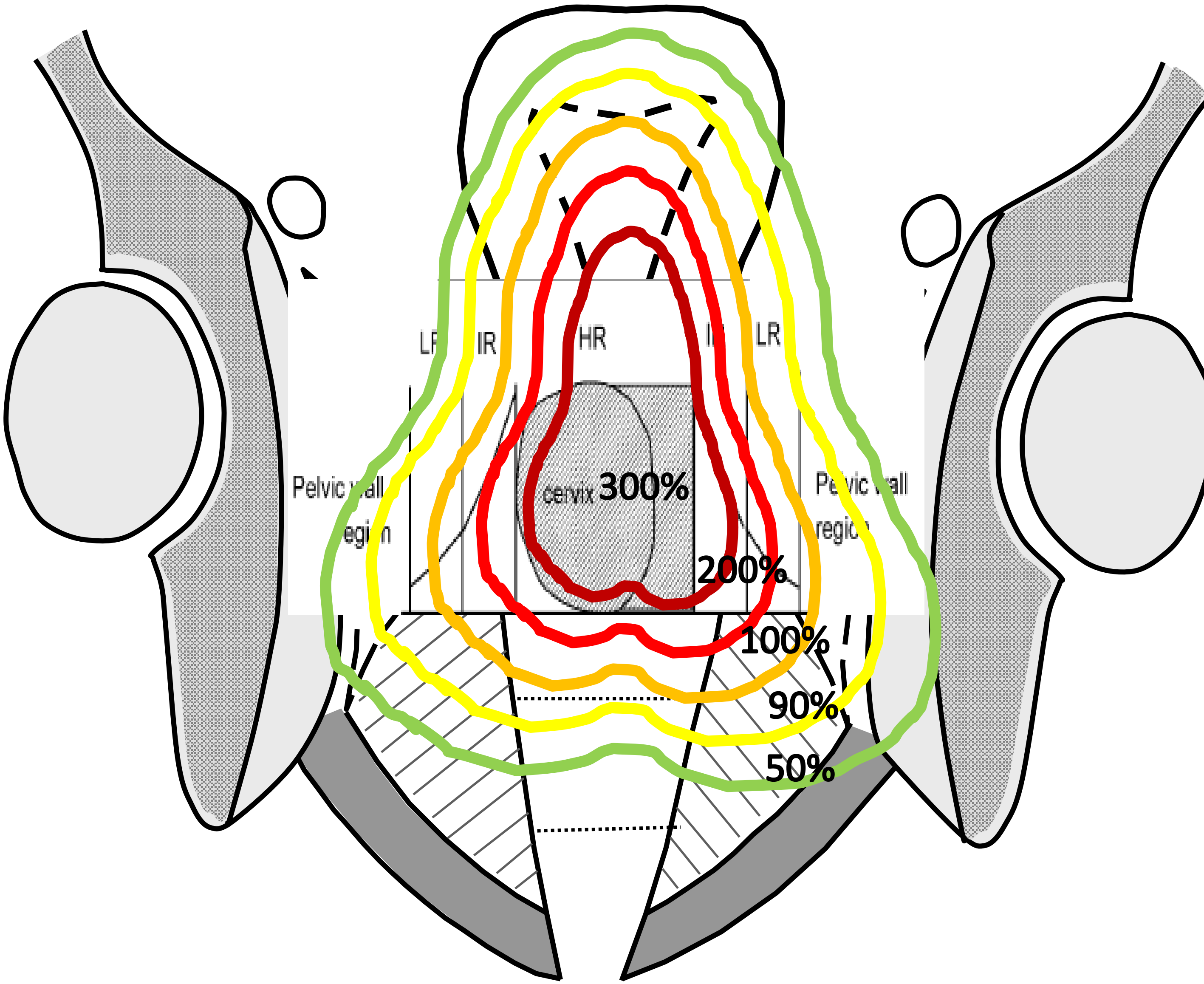
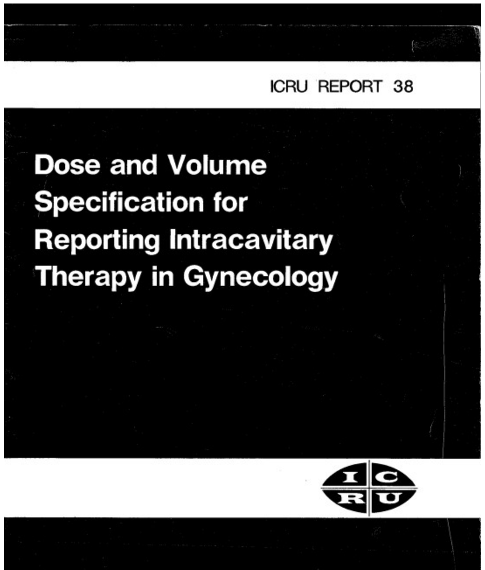


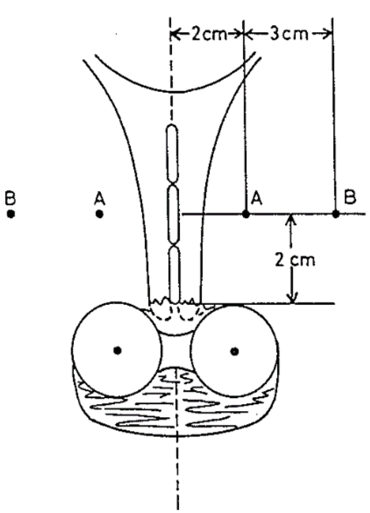
Advantages of BT : Eg : Cervix

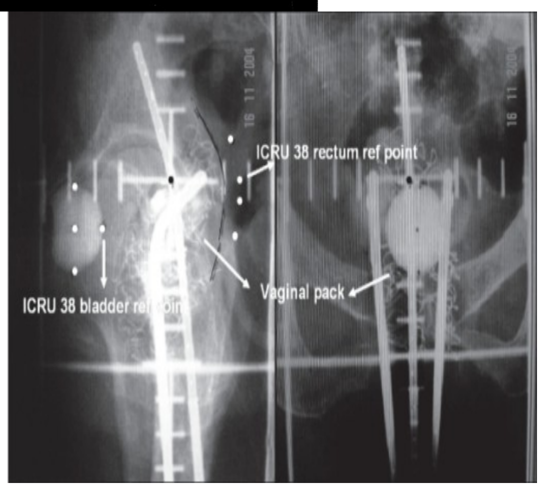


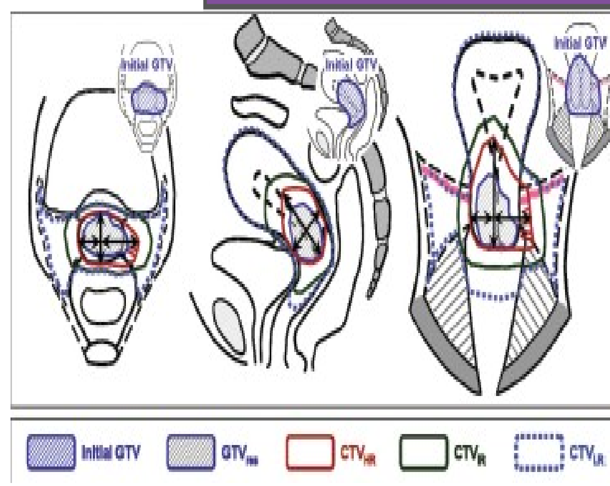
BRACHYTHERAPY : EVOLUTION

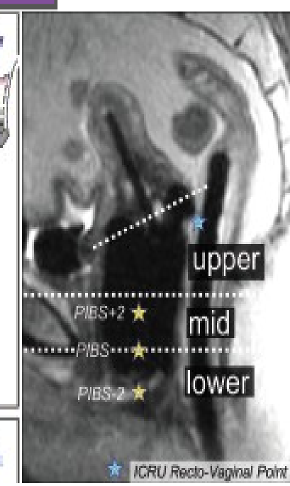
Journey from 2D to 3D



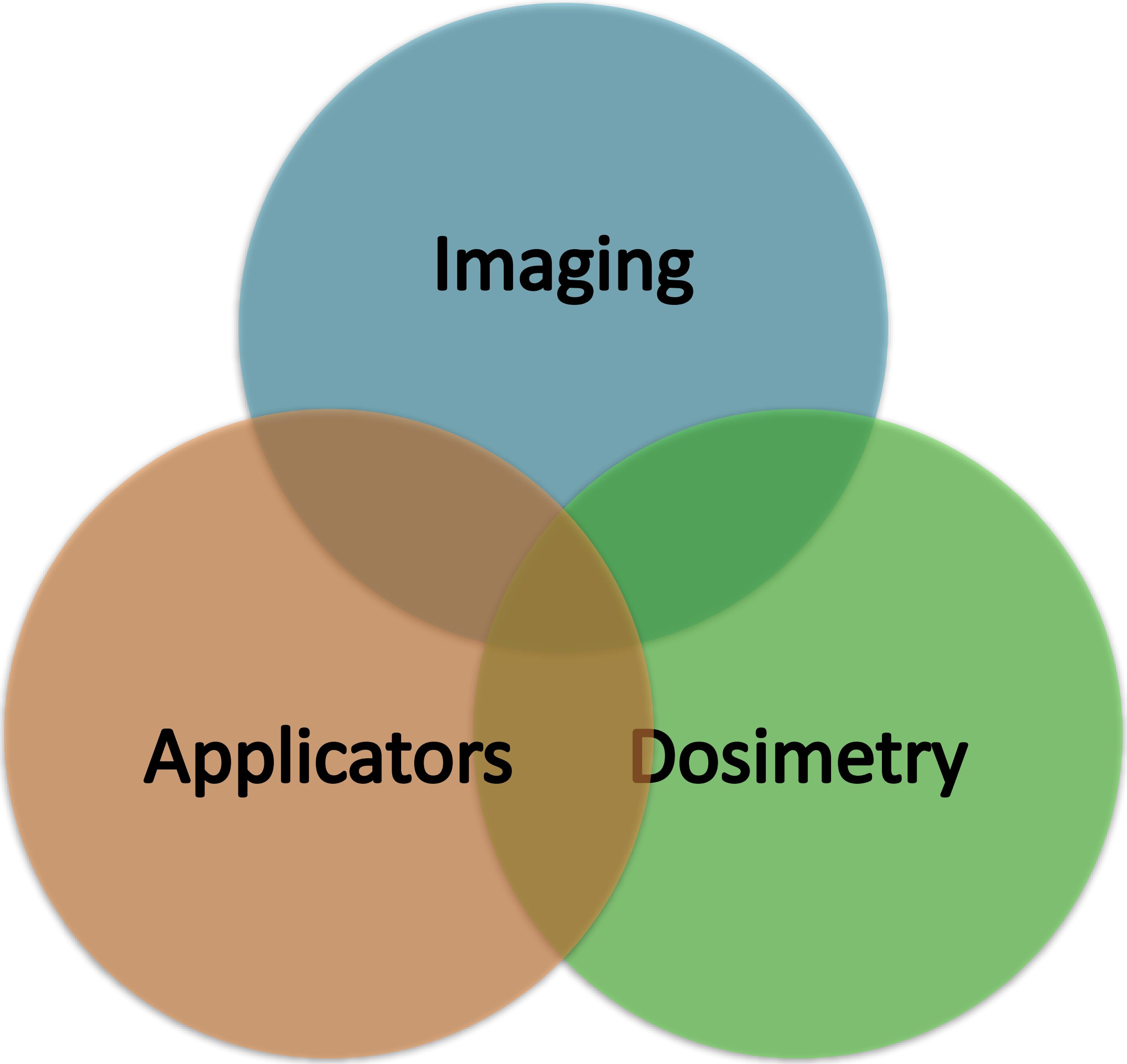








Journey from 2D to 3D



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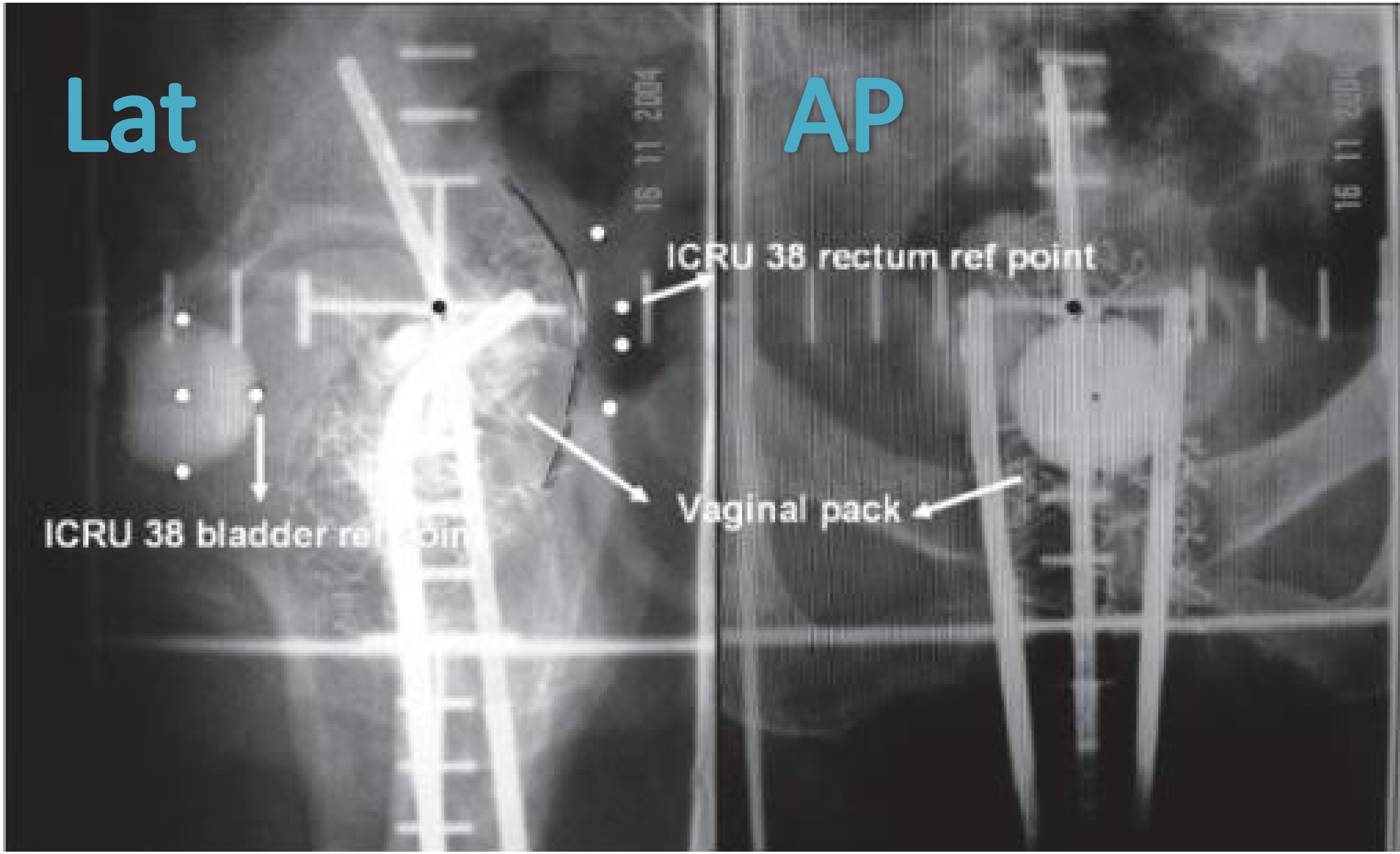
BRACHYTHERAPY : EVOLUTION IMAGING

2D Orthogonal X-ray based concept



Assessment modalities

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	Clinical	USG	CT	MRI
Availability				
Cost				
Standard	*Gold*	Silver+	Silver	Gold

	Pre EBRT Correlation (Pearson's correlation coefficients)		
	MRI-CLINICAL	**MRI-USG**	**MRI-CT**
Antero-Posterior	**0.48**	**0.49**	**0.73**
Medio-Lateral	**0.18**	**0.14**	**0.62**
Supero-Inferior	**0.23**	**0.45**	**0.66**

RGKMCH study

Journey from 2D to 3D
The GYN GEC ESTRO I – IV recommendations

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ELSEVIER

Radiotherapy and Oncology 74 (2005) 235–245

RADIOTHERAPY & ONCOLOGY
JOURNAL OF THE EUROPEAN SOCIETY FOR THERAPEUTIC RADIOLOGY AND ONCOLOGY

www.elsevier.com/locate/radonline

Recommendations from Gynaecological (GYN) GEC-ESTRO Working Group☆ (I): concepts and terms in 3D image based 3D treatment planning in cervix cancer brachytherapy with emphasis on MRI assessment of GTV and CTV

Christine Haie-Meder[a,*], Richard Pötter[b], Erik Van Limbergen[c], Edith Briot[a],

Radiotherapy and Oncology 78 (2006) 67–77
www.thegreenjournal.com

ESTRO project

Recommendations from gynaecological (GYN) GEC ESTRO working group (II): Concepts and terms in 3D image-based treatment planning in cervix cancer brachytherapy—3D dose volume parameters and aspects of 3D image-based anatomy, radiation physics, radiobiology

Richard Pötter[a,*], Christine Haie-Meder[b], Erik Van Limbergen[c], Isabelle Barillot[d],

Radiotherapy and Oncology 96 (2010) 153–160

Contents lists available at ScienceDirect

Radiotherapy and Oncology

journal homepage: www.thegreenjournal.com

GEC-ESTRO Recommendations

Recommendations from Gynaecological (GYN) GEC-ESTRO Working Group: Considerations and pitfalls in commissioning and applicator reconstruction in 3D image-based treatment planning of cervix cancer brachytherapy

Taran Paulsen Hellebust[a,*], Christian Kirisits[b], Daniel Berger[b], José Pérez-Calatayud[c],

Radiotherapy and Oncology 103 (2012) 113–122

Contents lists available at SciVerse ScienceDirect

Radiotherapy and Oncology

journal homepage: www.thegreenjournal.com

GEC-ESTRO Recommendations

Recommendations from Gynaecological (GYN) GEC-ESTRO Working Group (IV): Basic principles and parameters for MR imaging within the frame of image based adaptive cervix cancer brachytherapy

Johannes C.A. Dimopoulos[a], Peter Petrow[b], Kari Tanderup[c], Primoz Petric[d], Daniel Berger[e],

Journey from 2D to 3D
The Indian Brachytherapy Society recommendations

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Educational Article

Original paper

Indian Brachytherapy Society Guidelines for radiotherapeutic management of cervical cancer with special emphasis on high-dose-rate brachytherapy

Umesh Mahantshetty, MD[1], Shivakumar Gudi, MD[1], Roshni Singh, MD[1], Ajay Sasidharan, MD[1], Supriya (Chopra) Sastri, MD[1], Lavanya Gurram, MD[1], Dayanand Sharma, MD[2], Selvaluxmy Ganeshrajah, MD[3], Janaki MG, MD[4], Dinesh Badakh, MD[5], Abhishek Basu, MD[6], Francis James, MD[7], Jamema V Swamidas, PhD[8], Thayalan Kuppuswamy, PhD[9], Rajendra Bhalavat, MD[10]

[1]Department of Radiation Oncology, Tata Memorial Centre, Homi Bhabha National Institute, Mumbai, India, [2]Department of Radiation Oncology, All India Institute of Medical Sciences, New Delhi, India, [3]Department of Gynecology Oncology, Cancer Institute (WIA), Chennai, India, [4]Department of Radiation Oncology, M.S. Ramaiah Memorial Hospital, Bangalore, India, [5]Department of Radiation Oncology, Siddhivinayak Cancer Hospital, Miraj, India, [6]Department of Radiation Oncology, R.G. Kar Medical College and Hospital, Kolkata, India, [7]Department of Radiation Oncology, Regional Cancer Centre, Thiruvananthapuram, India, [8]Department of Medical Physics, Tata Memorial Centre, Homi Bhabha National Institute, Mumbai, India, [9]Medical Physics Division, Dr. Kamakshi Memorial Hospital, Chennai, India, [10]Department of Radiation Oncology, Jupiter Hospital, Mumbai, India

MRI protocol

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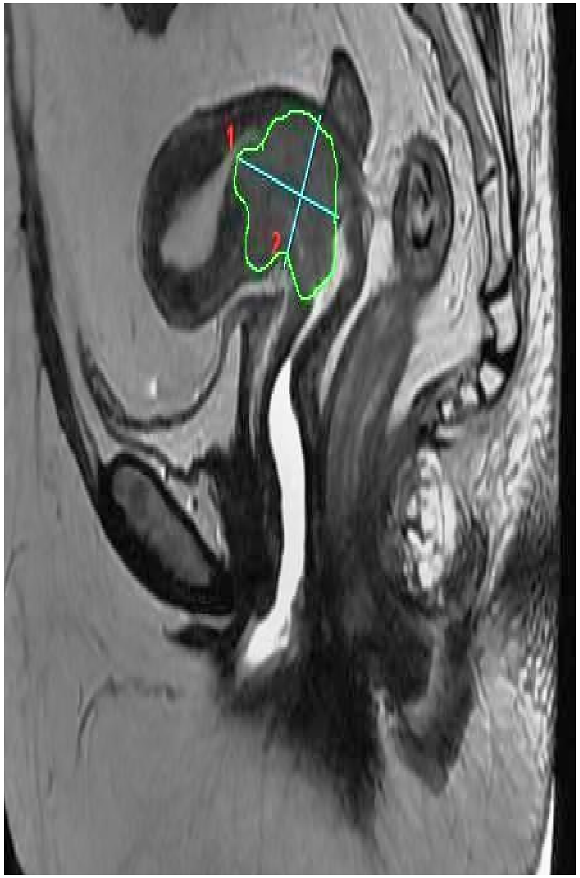

- T2w FSE sequences
- Vaginal jelly
- Para images

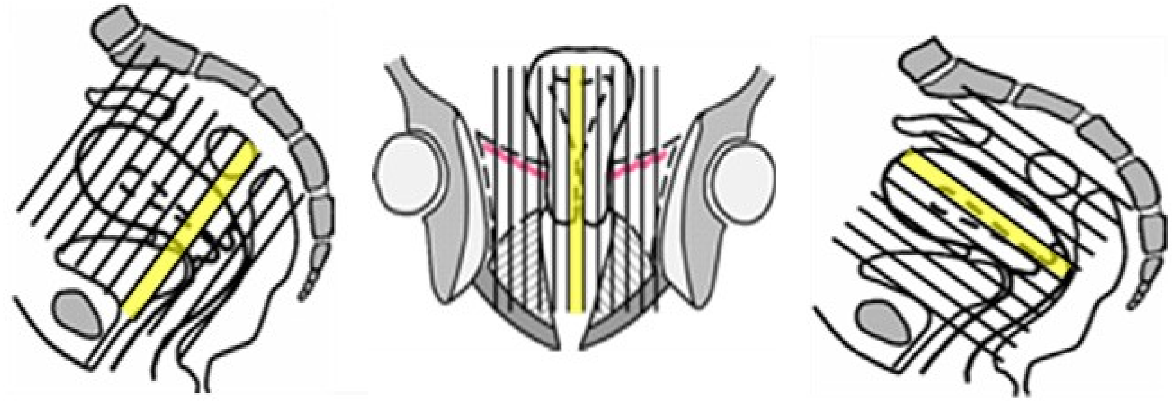

Table 1
Image acquisition protocols for pre-RT MRI scan and BT MRI scan. This table summarises the important information regarding sequence, plane orientation, coverage/borders for each of the different MRI sequences.

Protocol	Number	Mandatory (M)/ optional (O)	Sequence	Plane orientation	Coverage/borders
Pre-RT MRI scan	1	M	T2 FSE	Para-axial (according to cervix uteri)	Above uterine corpus – inferior border of symphysis pubis/entire vagina if distal vaginal involvement
	2	M	T2 FSE	Sagittal	Pelvic side wall (obturator muscle)
	3	M	T2 FSE	Para-coronal (according to cervix uteri)	Uterine corpus – cervix – vagina – tumour
	4	M	T2 FSE	Axial	Discus L4–L5 – inferior border of symphysis pubis/entire vagina and inguinal regions if distal vaginal involvement
	5	O	T1 FSE or 3D GRE without contrast[a]	Axial	Discus L4–L5 – inferior border of symphysis pubis/entire vagina and inguinal regions if distal vaginal involvement
	6	O	T1 FSE with contrast[a]	Sagittal	Pelvic side wall (obturator muscle)
	7	O	T1 FSE or 3D GRE with contrast[a]	Axial (isotropic 3D GRE)	Uterine corpus – cervix – vagina – tumour
BT MRI scan	8	M	T2 FSE	Para-axial (according to cervix uteri)	Above uterine corpus – 3 cm below lower surface of vaginal applicator/ entire vagina if distal vaginal involvement
	9	M	T2 FSE	Para-sagittal (according to cervix uteri)	Pelvic side wall (obturator muscle)
	10	M	T2 FSE	Para-coronal (according to cervix uteri)	Uterine corpus – cervix – vagina – tumour
	11	O	T2 FSE	Axial	Above uterine corpus – 3 cm below lower surface of vaginal applicator/ entire vagina if distal vaginal involvement
	12	O	3D T2 FSE isotropic	Coronal or axial with reconstructions	Large coverage inherent in this sequence
	13	O	T1 FSE, FLASH, T1 GRE 3D	As appropriate	At least entire applicator

[a] When contrast series are applied (6 and/or 7): use same T1 sequence for pre-contrast and lymph node evaluation.

Different 3D environments

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Environments	At diagnosis	Before Brachytherapy	At Brachytherapy
MR – MR	MR + Clinical	Clinical ± MR	MR* + Clinical
MR – CT	MR + Clinical	MR + Clinical	CT* + Clinical
CT – CT	CT + Clinical	Clinical ± CT	CT + Clinical

* - at least for the first fraction

CT Imaging protocol

- Bladder filling with dilute contrast.
- IV contrast – arterial phase – blush!
- Axial 2-3 mm slices.
- MR compatible applicators.

CT based target delineation

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Radiotherapy and Oncology 160 (2021) 273–284

Contents lists available at ScienceDirect

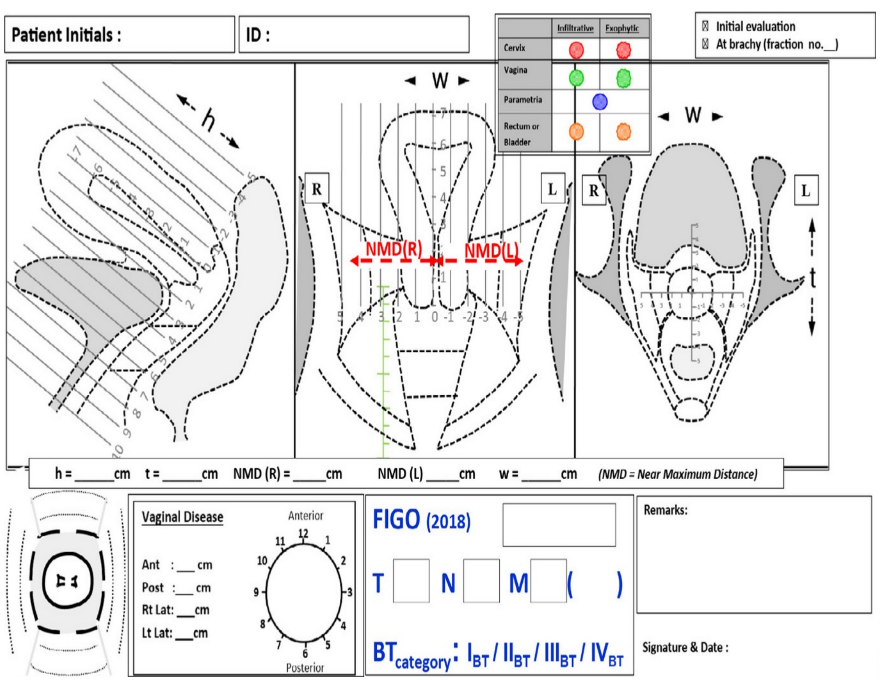
Radiotherapy and Oncology

journal homepage: www.thegreenjournal.com

Original Article

IBS-GEC ESTRO-ABS recommendations for CT based contouring in image guided adaptive brachytherapy for cervical cancer

Umesh Mahantshetty [a,*], Richard Poetter [b,*], Sushil Beriwal [c], Surbhi Grover [d], Gurram Lavanya [e], Bhavana Rai [f], Primoz Petric [g], Kari Tanderup [h], Heloisa Carvalho [i,j], Neamat Hegazy [k], Sandy Mohamed [l], Tatsuya Ohno [m], Napapat Amornwichet [n]



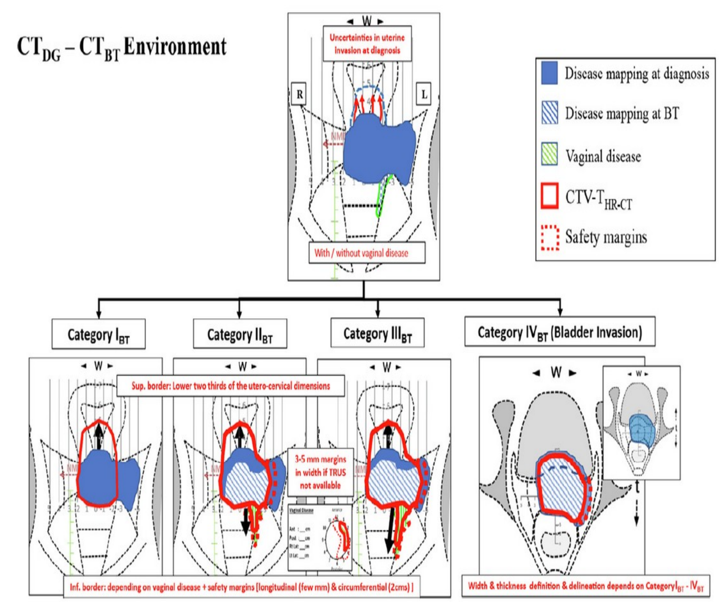


Fig. 2. Schematic diagram showing definition of CTV- T_{HR-CT} for CT_{DG} – CT_{BT} Environment based on the disease at diagnosis (cervix and parametrium in blue fill & vaginal disease in green lines), residual disease at BT (blue oblique lines), CTV-T_{HR} (in red continuous lines) and safety margins (red dotted lines). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Journey from 2D to 3D

The Indian Brachytherapy Society recommendations

BURDWAN MEDICAL COLLEGE

Educational Article

Original paper

Indian Brachytherapy Society Guidelines for radiotherapeutic management of cervical cancer with special emphasis on high-dose-rate brachytherapy

Umesh Mahantshetty, MD[1], Shivakumar Gudi, MD[1], Roshni Singh, MD[1], Ajay Sasidharan, MD[1], Supriya (Chopra) Sastri, MD[1], Lavanya Gurram, MD[1], Dayanand Sharma, MD[2], Selvaluxmy Ganeshrajah, MD[3], Janaki MG, MD[4], Dinesh Badakh, MD[5], Abhishek Basu, MD[6], Francis James, MD[7], Jamema V Swamidas, PhD[8], Thayalan Kuppuswamy, PhD[9], Rajendra Bhalavat, MD[10]

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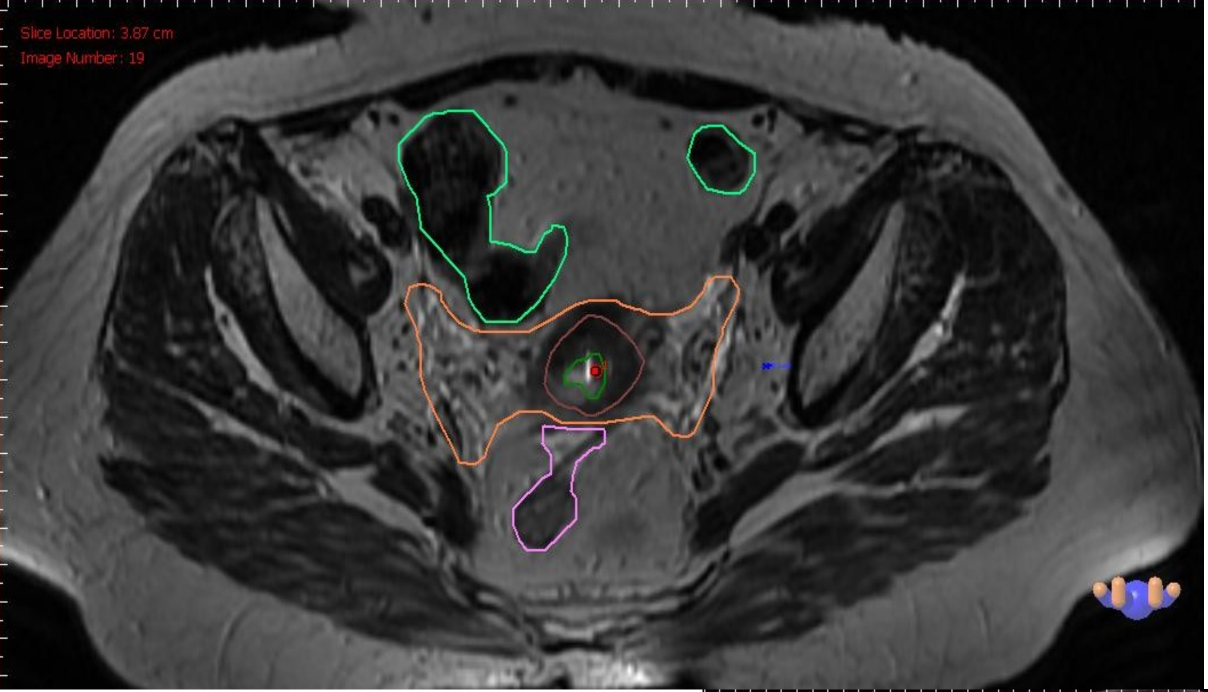
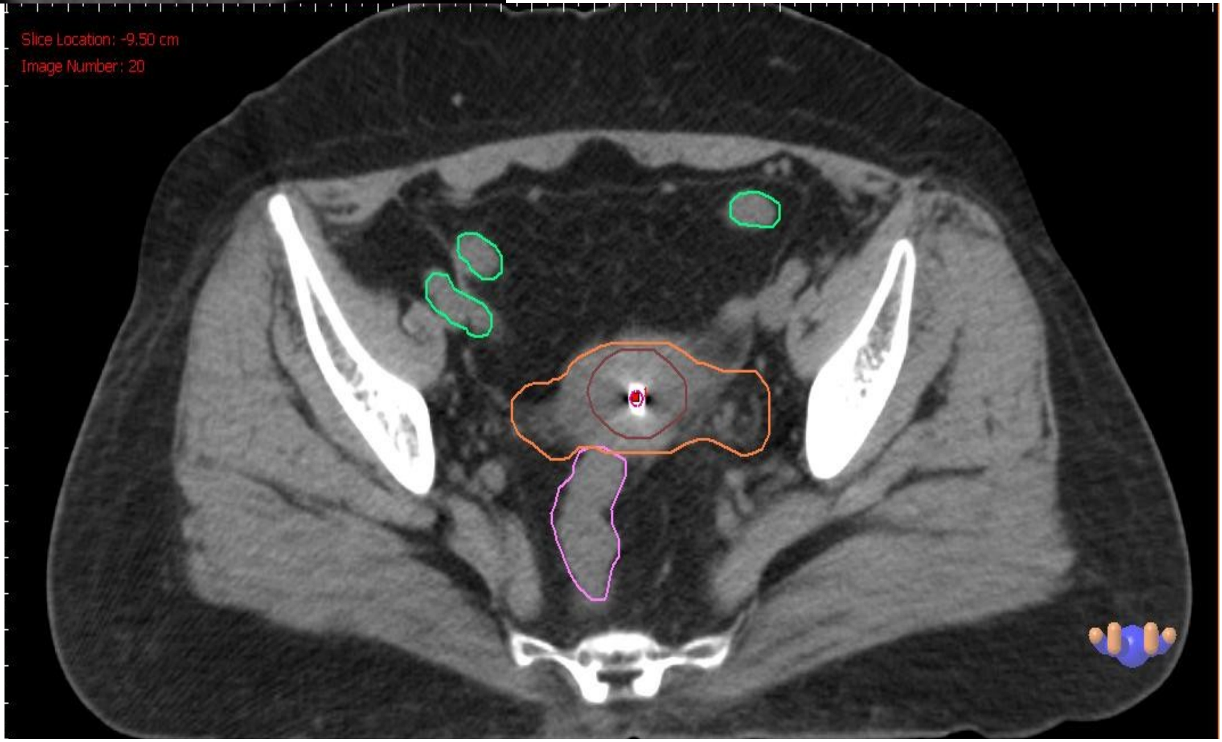


T2w MRI

CT



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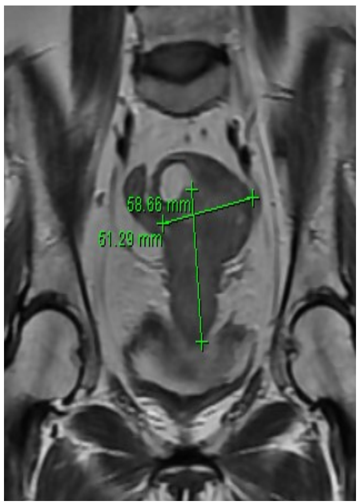
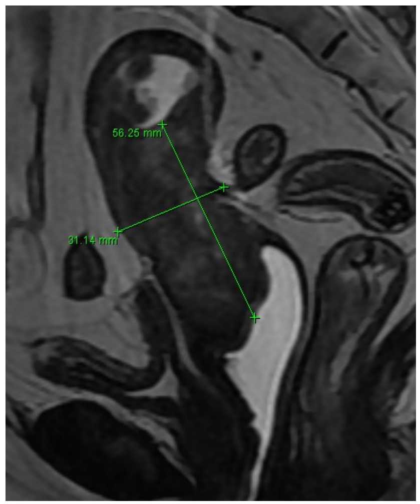
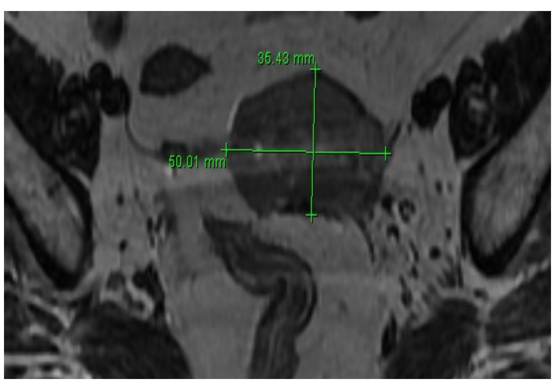
Documentation

At Diagnosis

- Mrs. MS, 66 yr, HTN, white discharge with spotting 4 months.





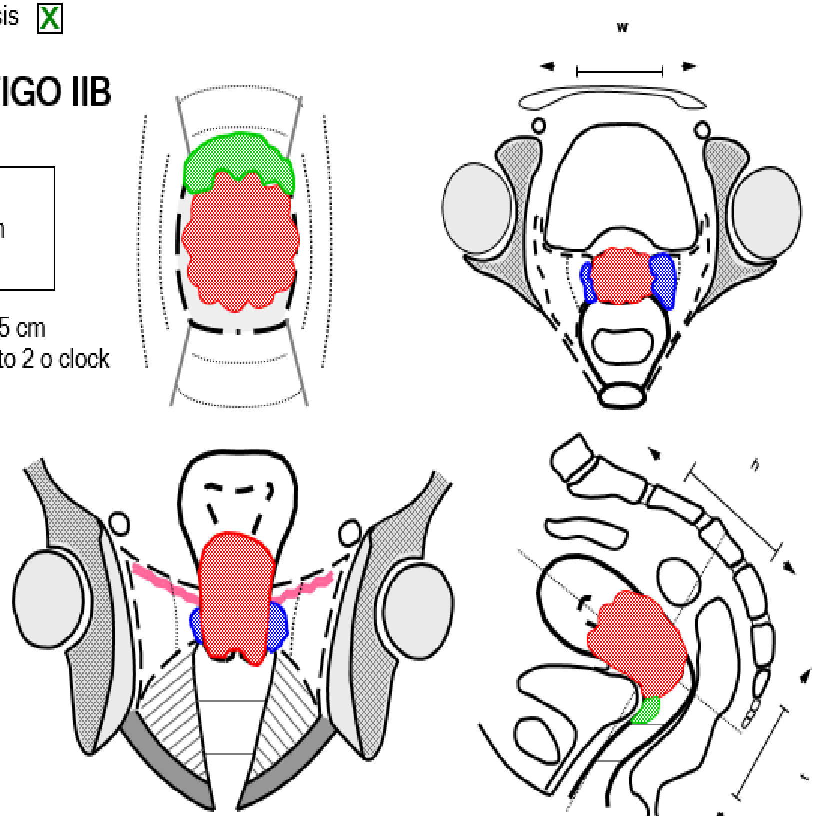


At Diagnosis X

Stage FIGO IIB

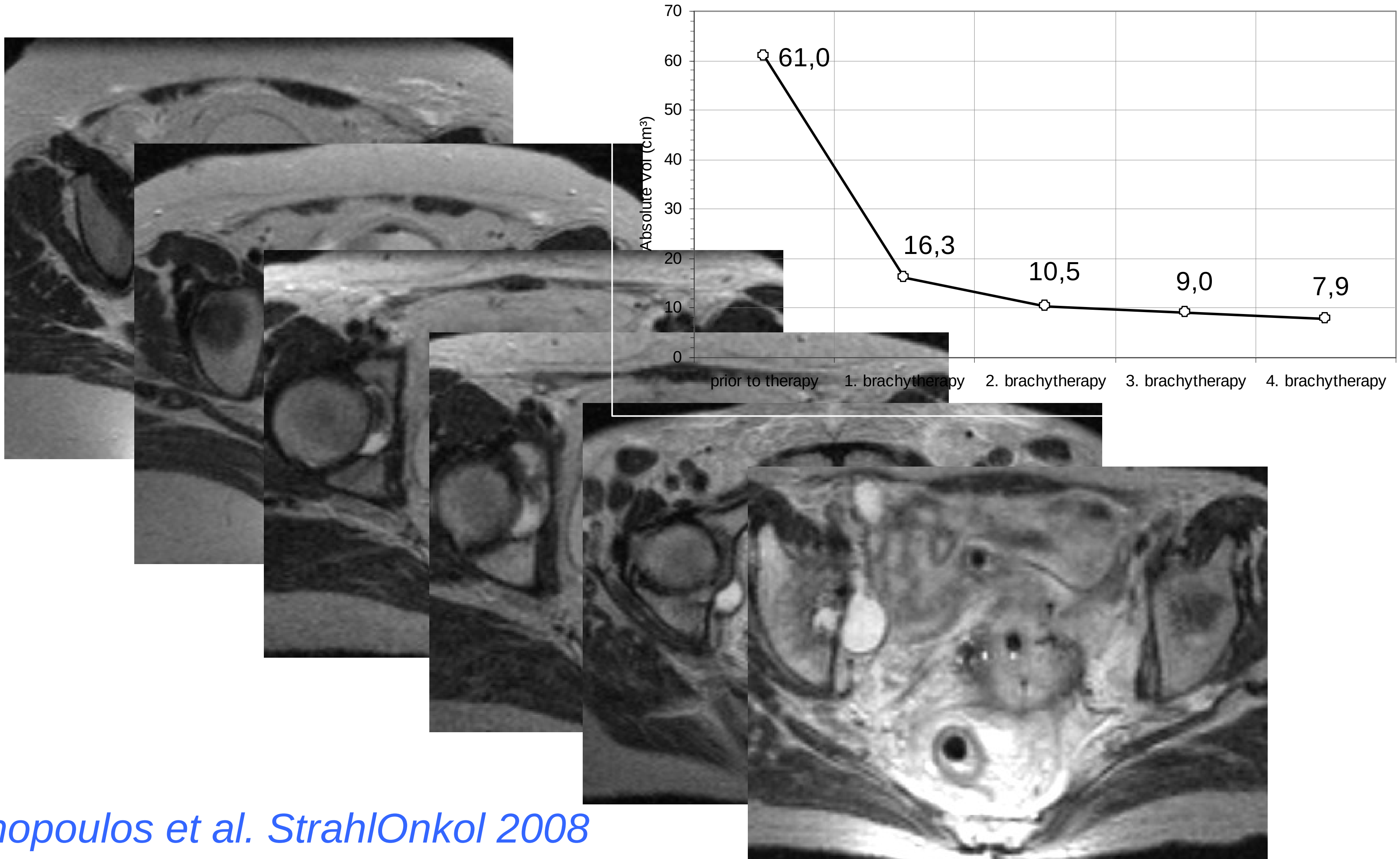
w = 5 cm
h = 4.5 cm
t = 3 cm

Vagina: 2.5 cm
10 o clock to 2 o clock



Case MR ; Name : MS RT/2190/18

Adaptive MRI based planning : 4D RT



Dimopoulos et al. StrahlOnkol 2008

TRUS Guided Prostate Brachytherapy : 4D

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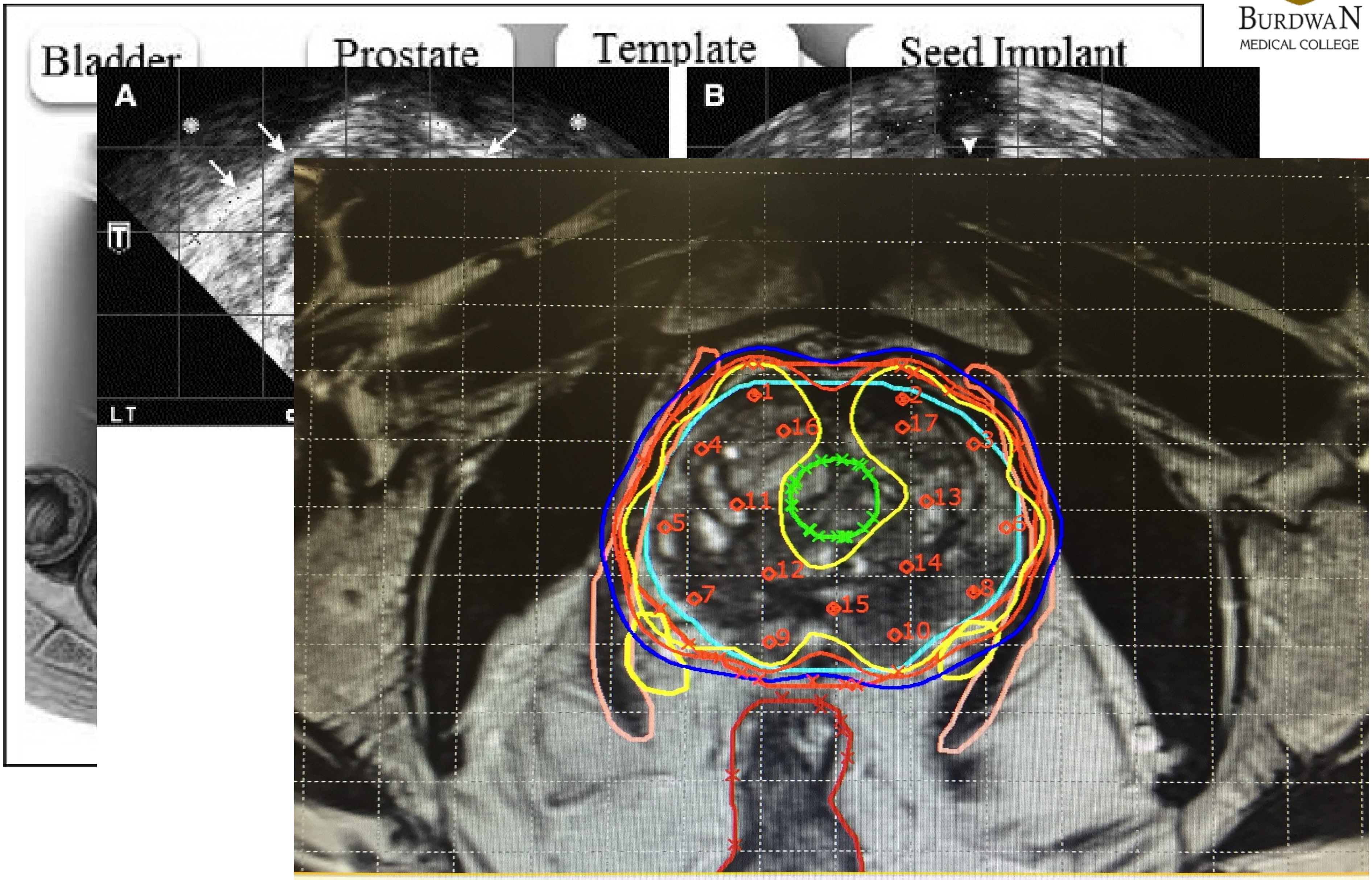
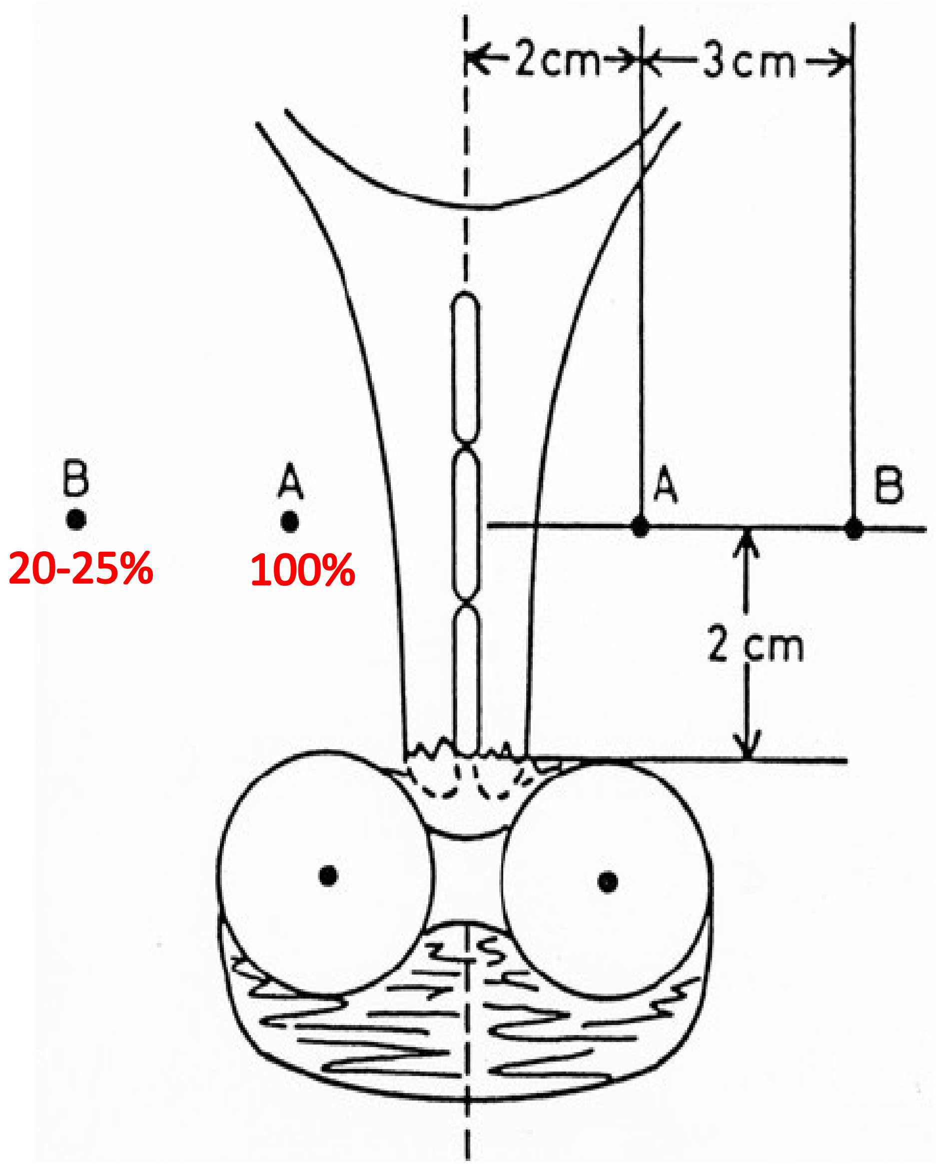


BRACHYTHERAPY : EVOLUTION TARGET CONCEPTS

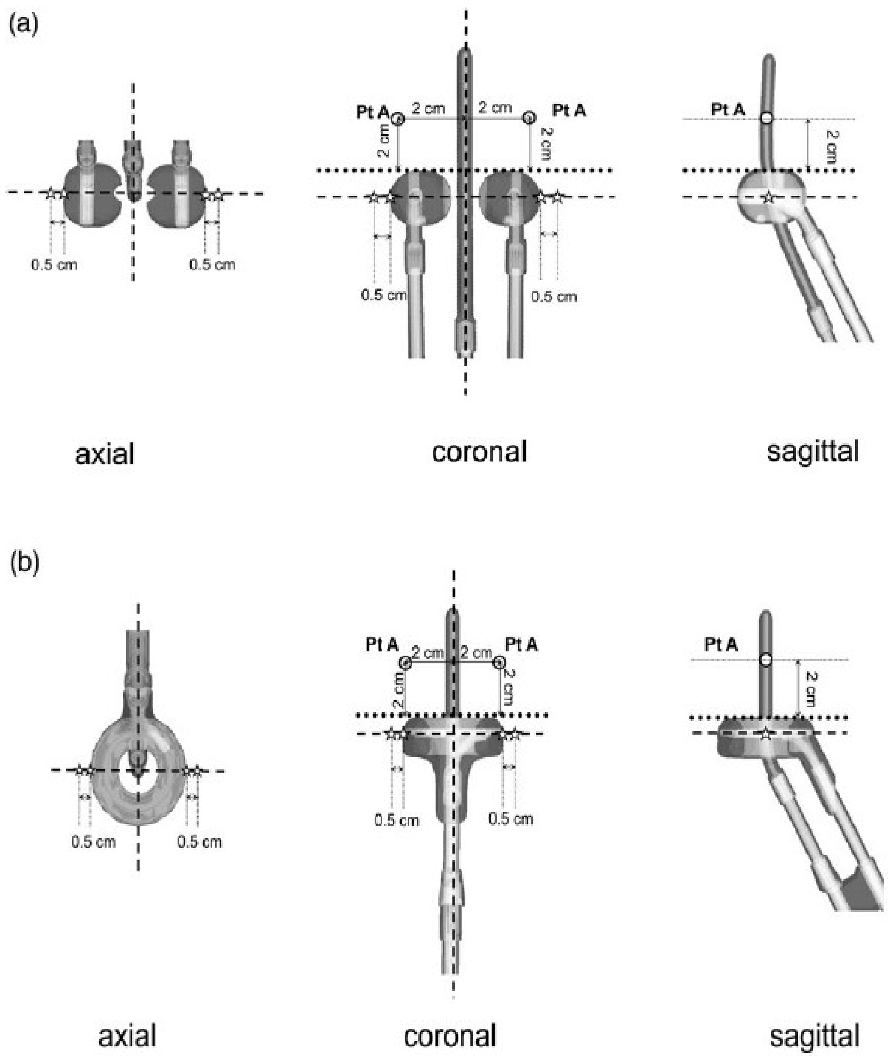
The concept of Point A and B

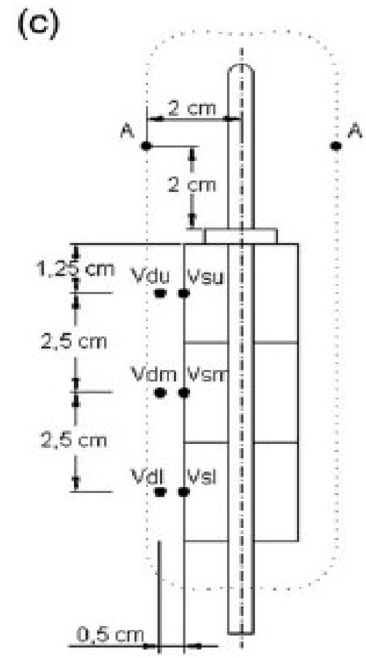
- Lateral throw-off of dose
- Obturator node

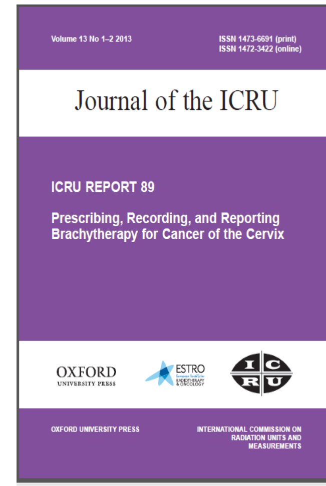
- Nodal dose ~ 3Gy for 4
- # of 7 Gy each

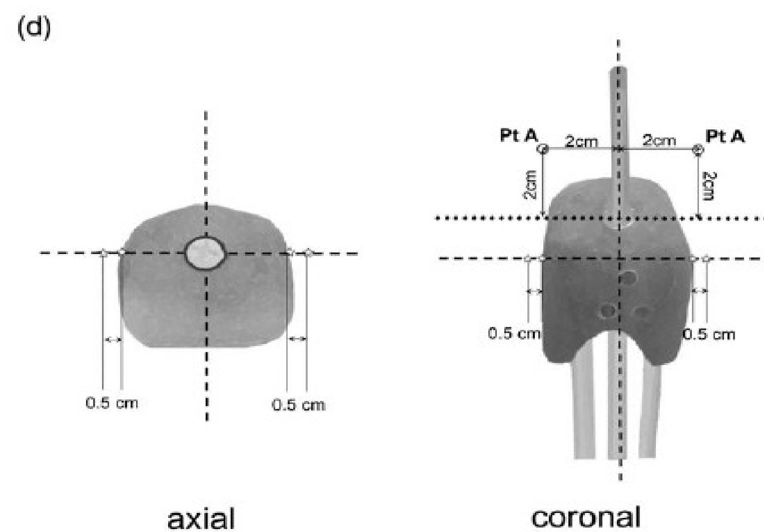


Modifications of Point A









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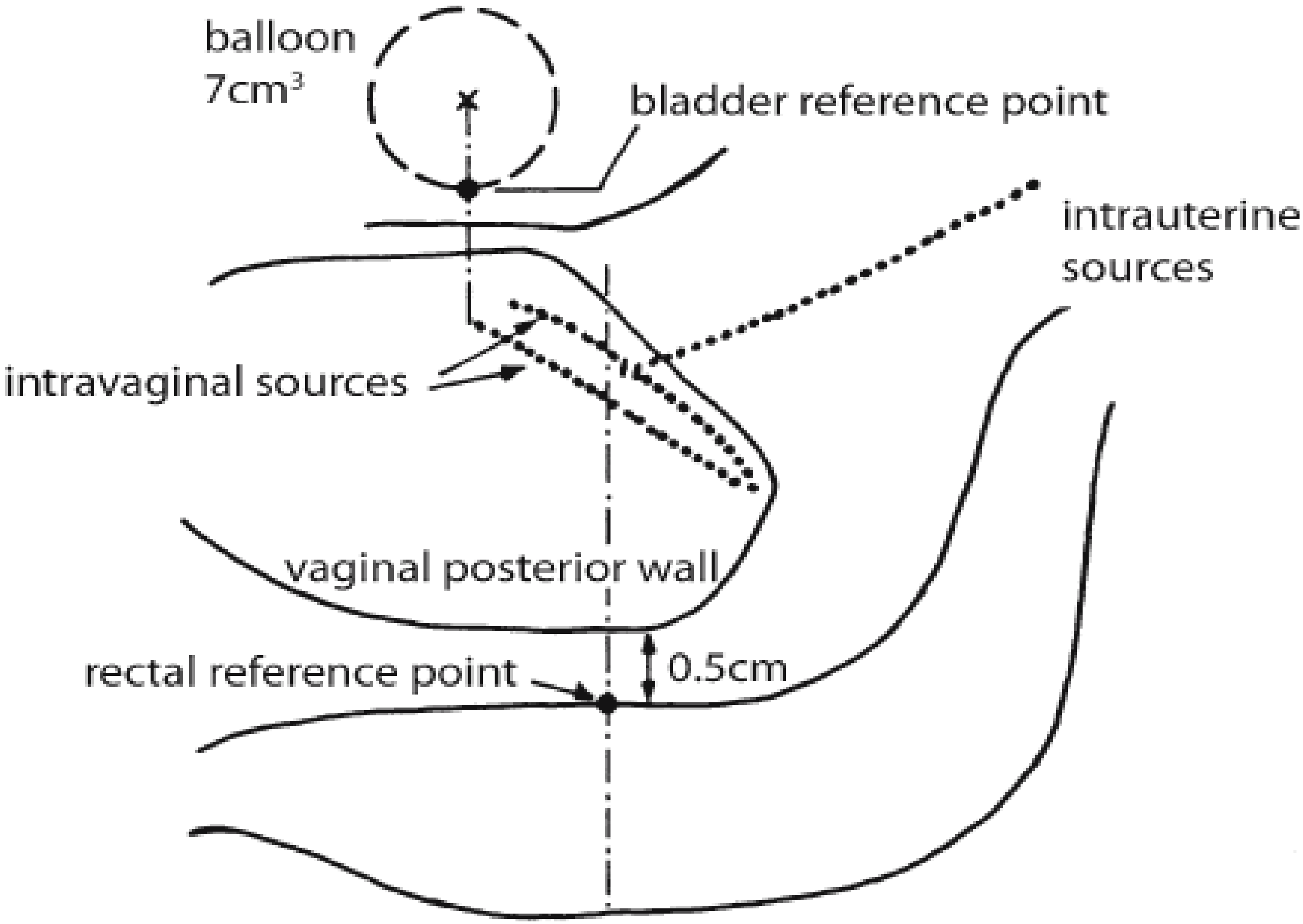
The ICRU Bladder and Rectal Points



GYN GEC ESTRO concepts

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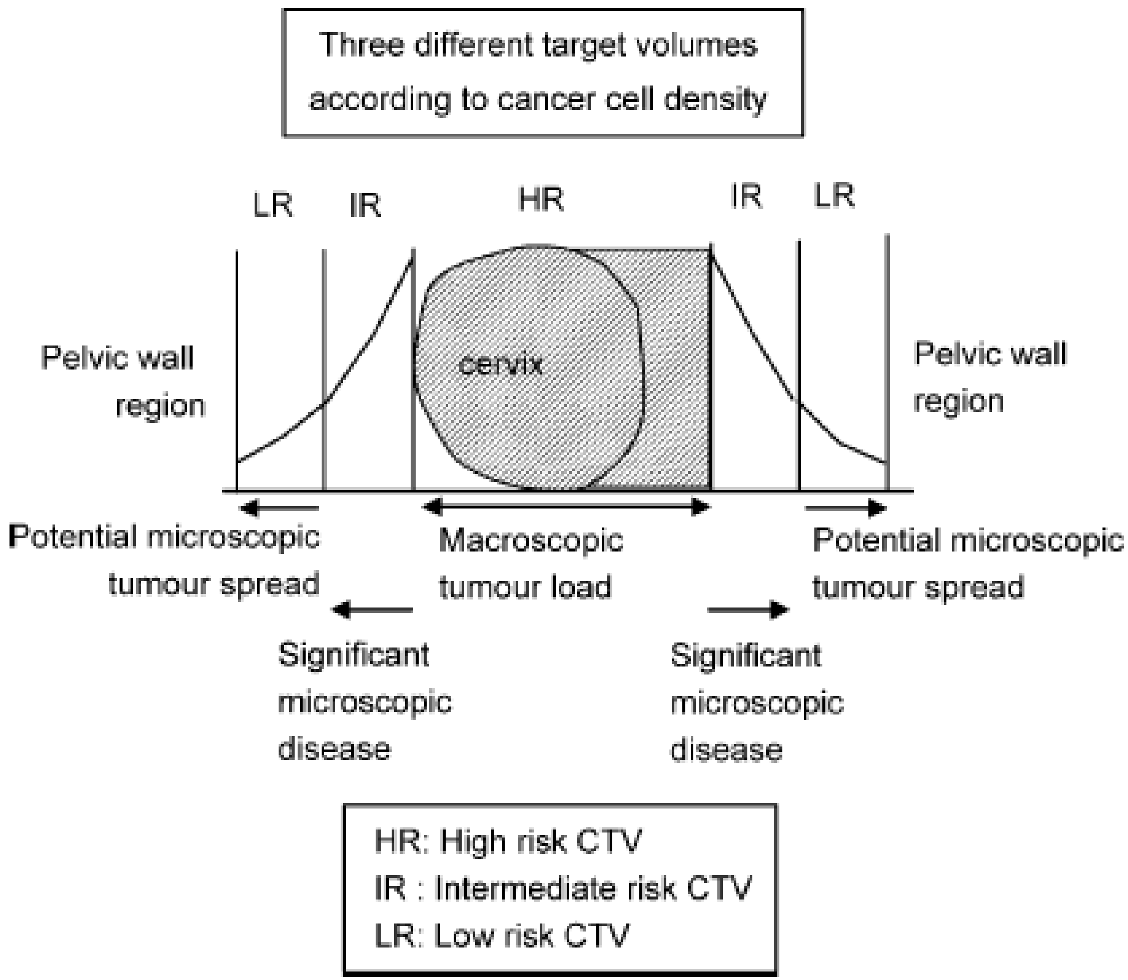
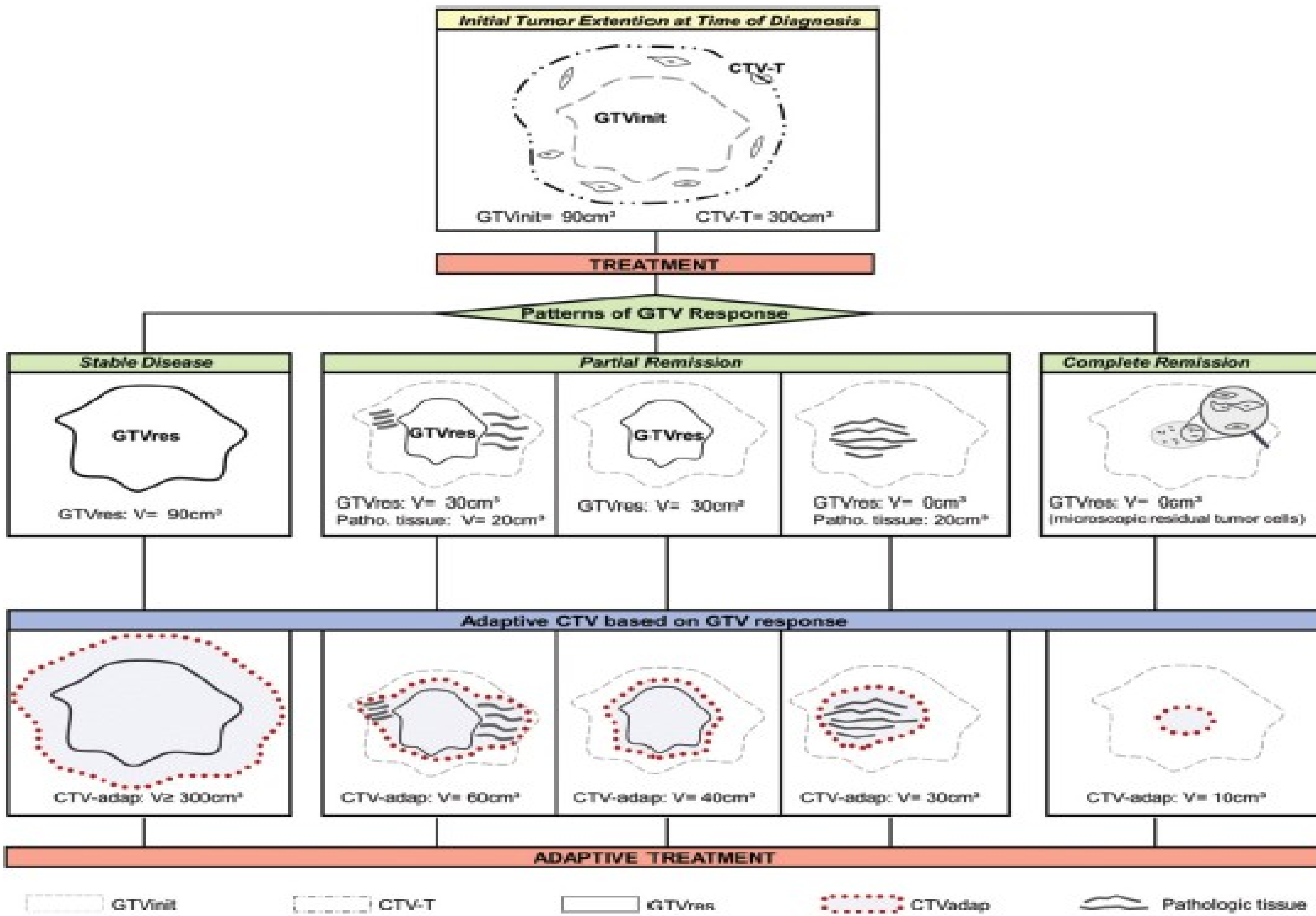


GES ESTRO recommendations 2005

ICRU 89 concepts : CTV



GEC ESTRO II and ICRU 89 Fig. 5.3

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Morbidity related anatomical reference points and volumes for important OARs

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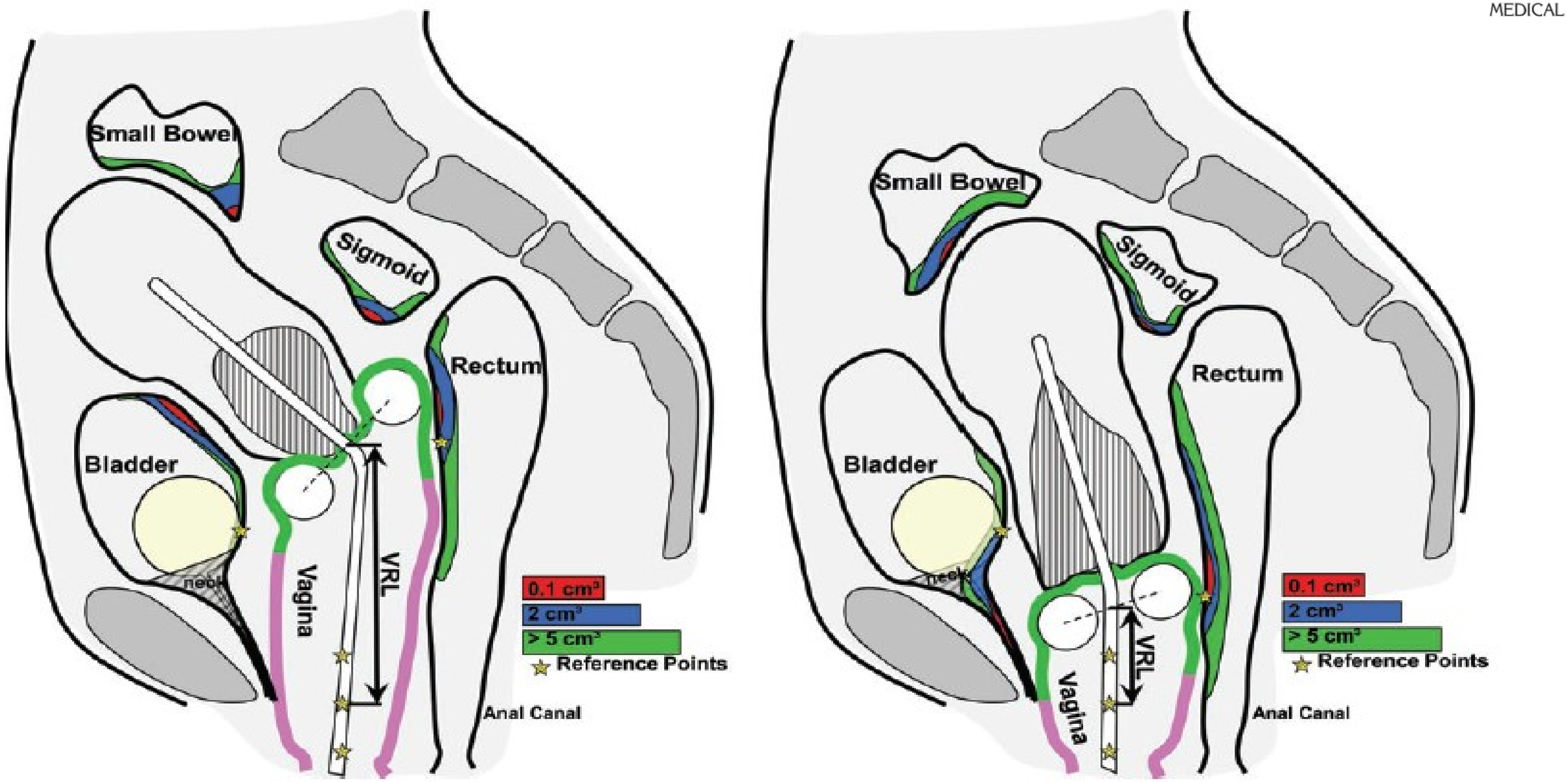


Figure 6.4. Schematic anatomical diagrams (sagittal view) showing two different positions of the vaginal part of the utero-vaginal applicators, the cervix tumor, the uterus, and the reference volumes of OARs in two different patients. The most irradiated-tissue volumes adjacent to the applicator, *i.e.*, the reference volumes 0.1 cm^3, 2 cm^3, and 5 cm^3, are illustrated for the various adjacent organs such as the bladder (neck), rectum (anus), sigmoid, and small bowel (see Section 8.4.1). The two panels show the different locations of the 0.1 cm^3 and 2 cm^3 reference volumes in the adjacent OARs [modified from GEC ESTRO Recommendations II; see also Westerveld *et al.* (2013)]. Reference points are indicated for the bladder (ICRU, 1985), the rectum and upper vagina (ICRU, 1985), and the mid- and lower vagina (PIBS ± 2 cm). The vaginal reference length (VRL) (PIBS to midpoint between the vaginal sources) can serve as an indicator to assess the varying position of the vaginal sources relative to the surrounding normal-tissue structures (Westerveld *et al.*, 2013).

Westerveld et al 2013; ICRU 83 Section 6.2

BRACHYTHERAPY : EVOLUTION APPLICATORS

The slides in this section are courtesy of Dr. Primoz Petric and Prof. Richard Poetter.

The “systems”

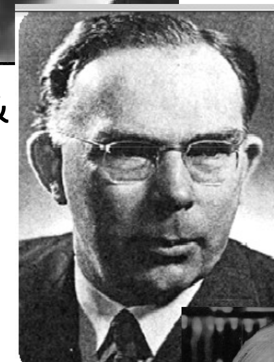
Gosta Forssell
Stockholm System

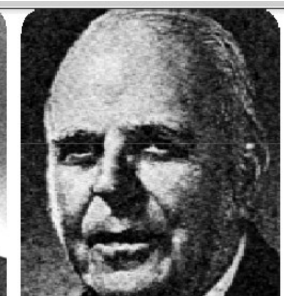
Claude
Regaud
Paris
System

M.C.Todd
W.J. Meredith
Manchester
System

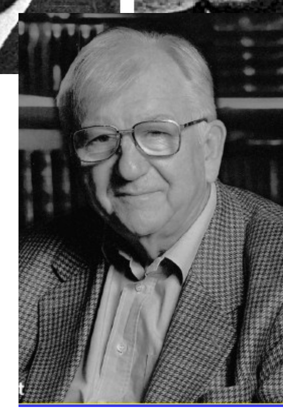
Edith Quimby
Quimby System

R. Paterson &
H.M Parker
Manchester
System





B .Pierquin &
A. Dutreix
Paris System

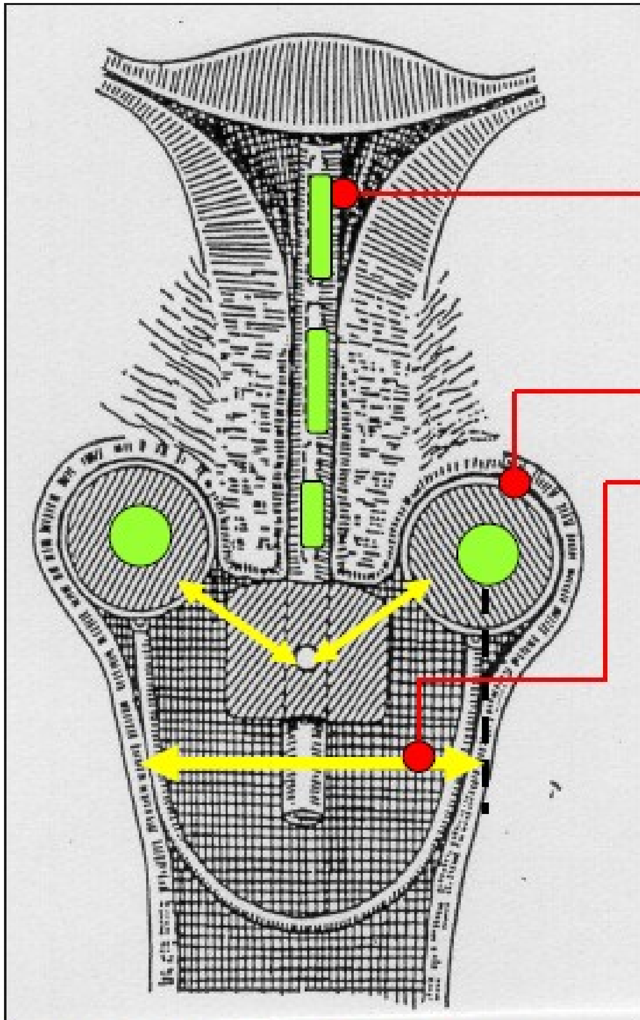


Intracavitary systems

Interstitial systems

Historical Paris Technique

1910-1920: Curie Institute, Paris, France



GEC ESTRO *Handbook of Brachytherapy*

Applicator:

- Rubber tandem
- Cork colpostats (paraffin coated)

Rubber tandem and cork colpostats → not connected → no fixed geometry

Distance – colpostats: not fixed → no fixed geometry

^{226}Ra preloading

- X mg of ^{226}Ra for Y hours

Typical application

- ≈ 5 days (*120 h*)
- 7000-8000 mgh

Claude Regaud

Classical Stockholm method

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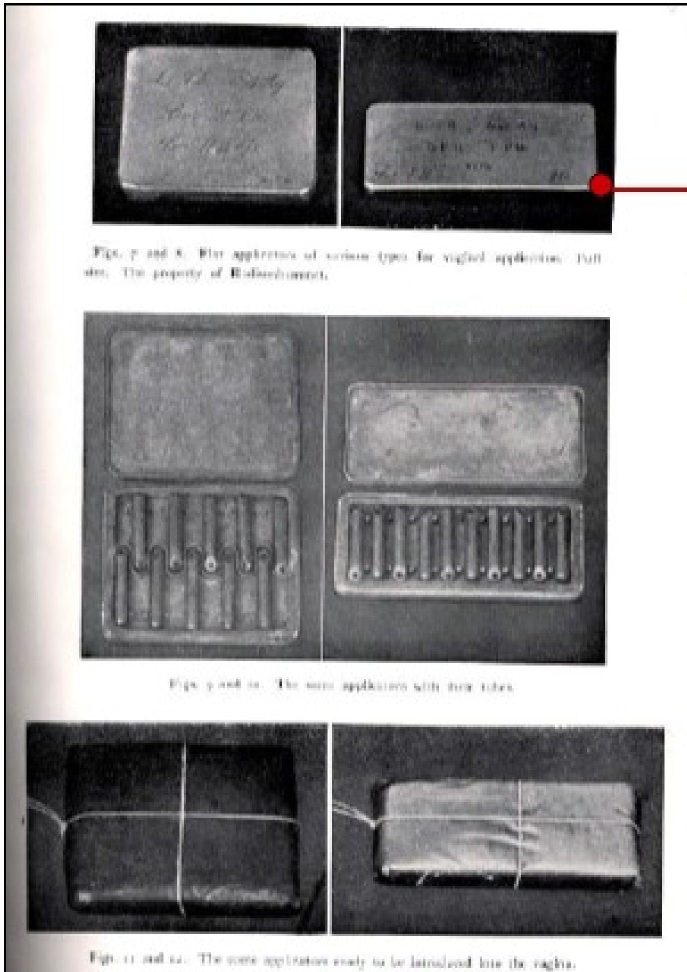
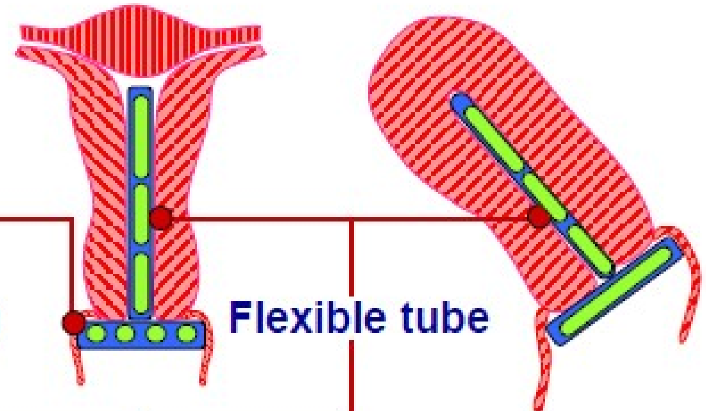
1913-1914: Radiumhemmet, Stockholm, Sweden



Applicator:



Flat box (plate)

Flexible tube

not connected → No fixed geometry

^{226}Ra preloading

- X mg of ^{226}Ra for Y hours

Typical treatment

- 2 – 3 applications (á 20-30 h)
- ≈ 7000 mgh

Gosta Forssell

Historical Manchester System

Related to historical Paris technique

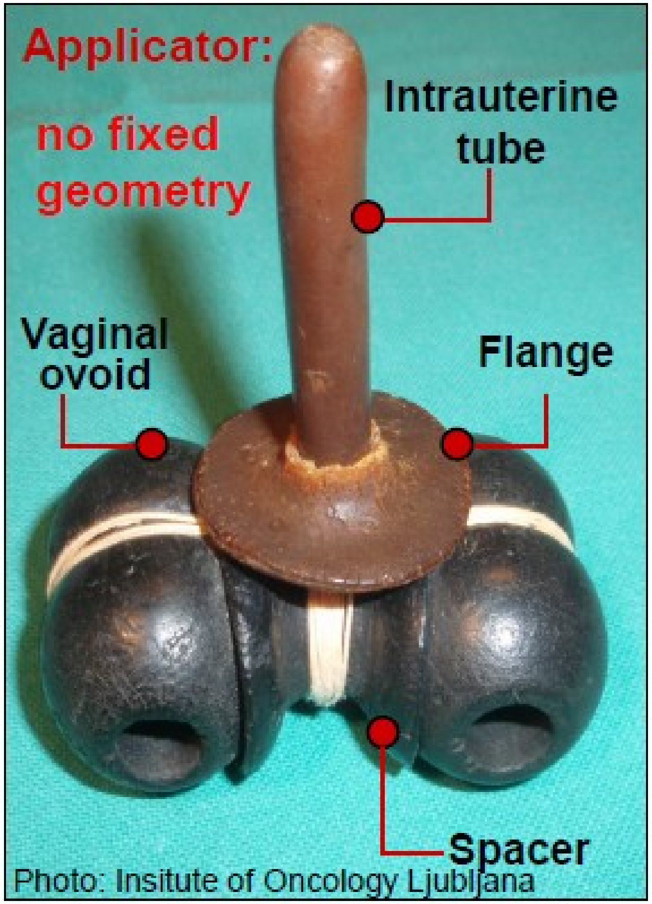
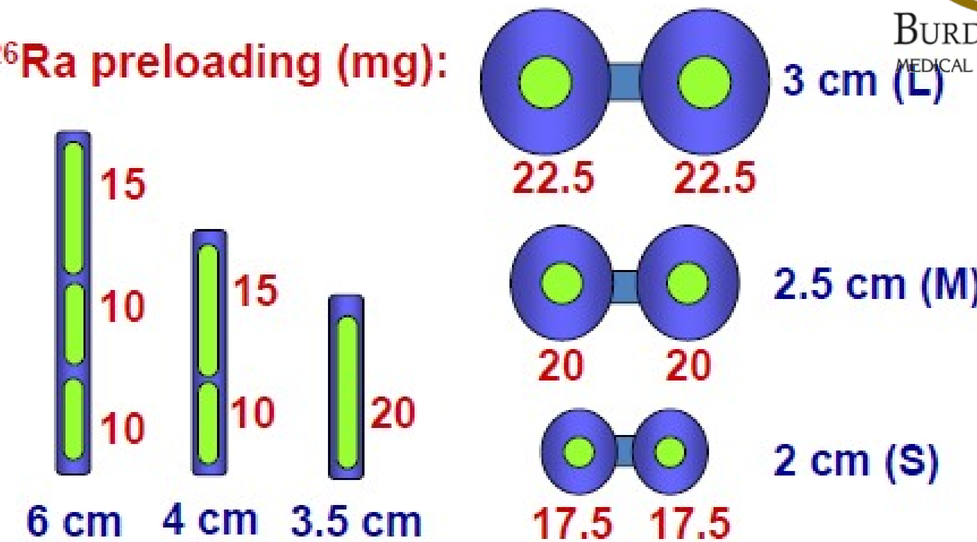
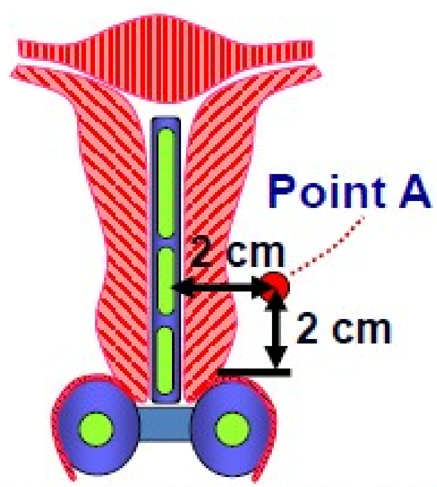


Photo: Insitute of Oncology Ljubljana

^{226}Ra preloading (mg):



TYPICAL TREATMENT:
140 hours for 7500 R at point A
(dose rate 53 R/h)



Given tumour volume

↓

A set of rules

- Geometry
- mg of ^{226}Ra
- Duration

↓

Certain point A dose

Meredith WJ, ed.. Radium dosage. The Manchester system. Edinburgh;1947.

Modern Intracavitary Techniques

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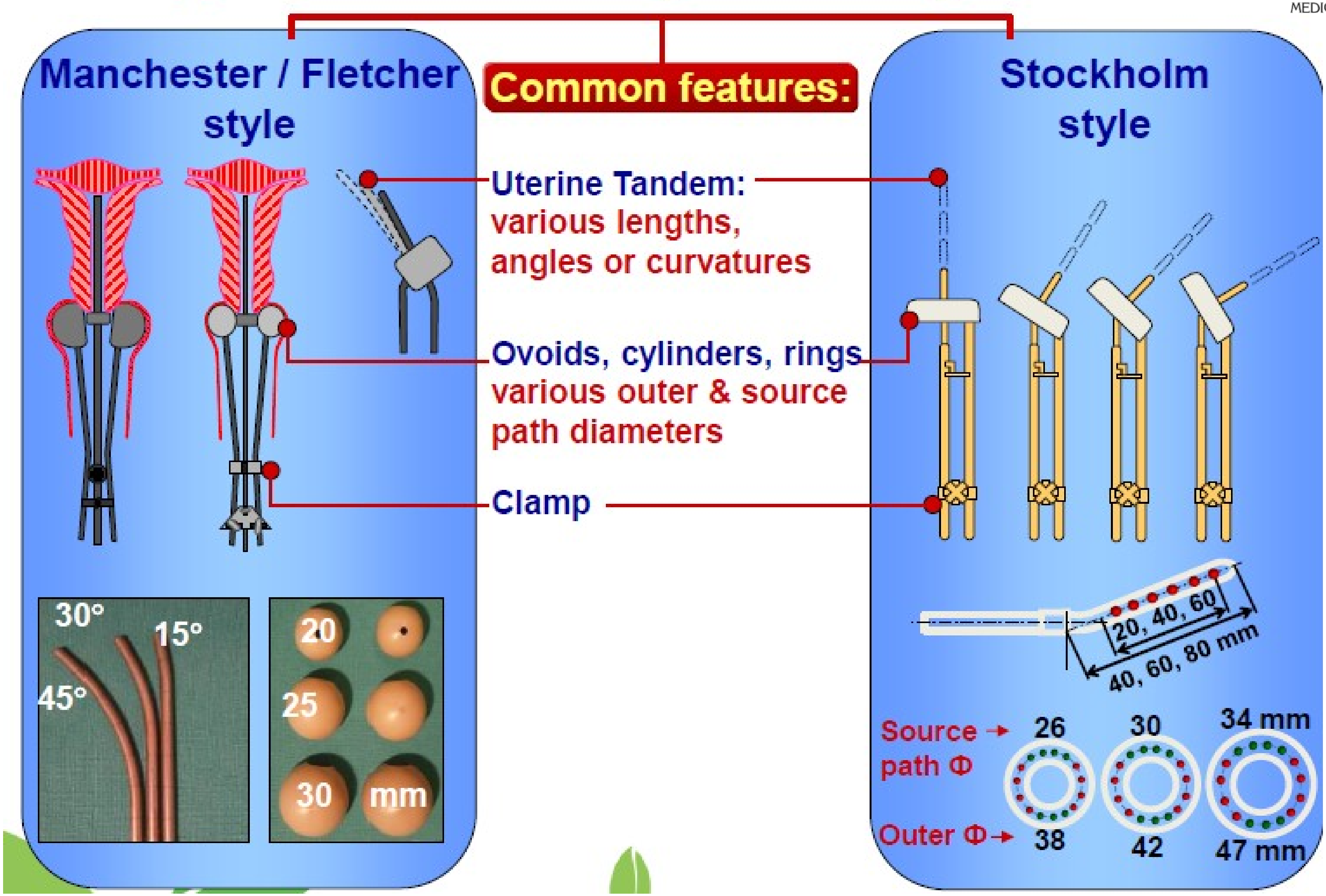
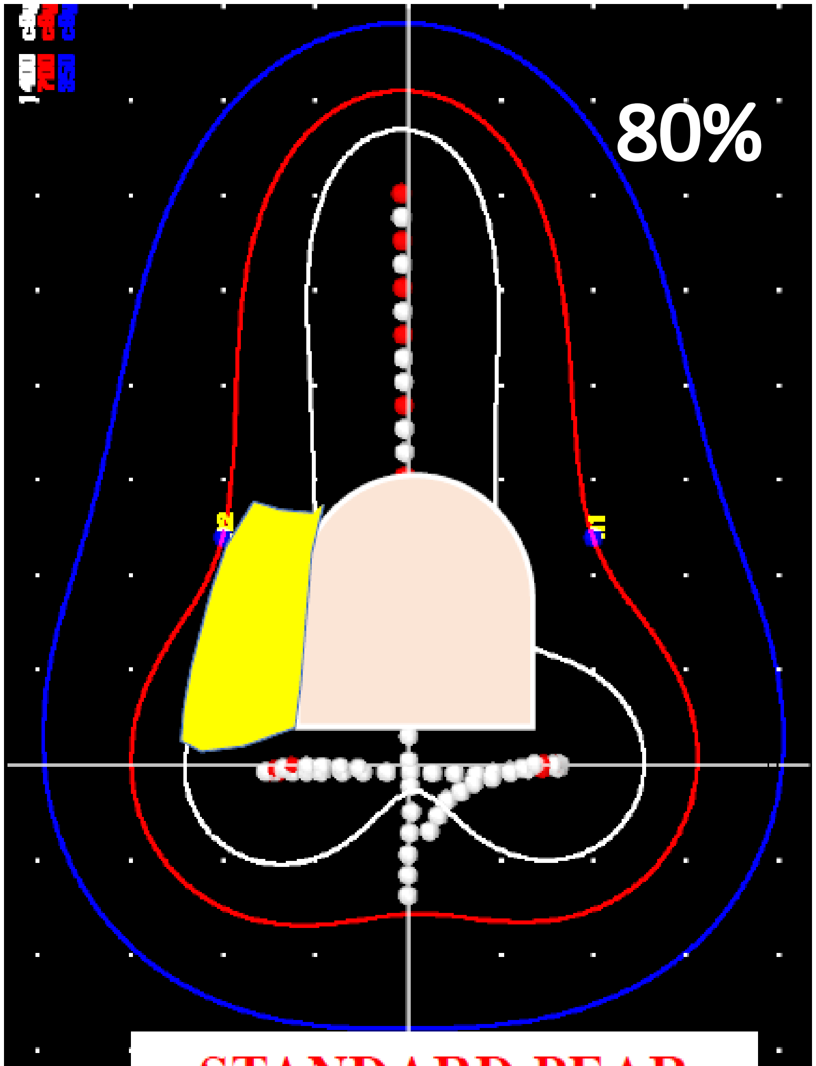
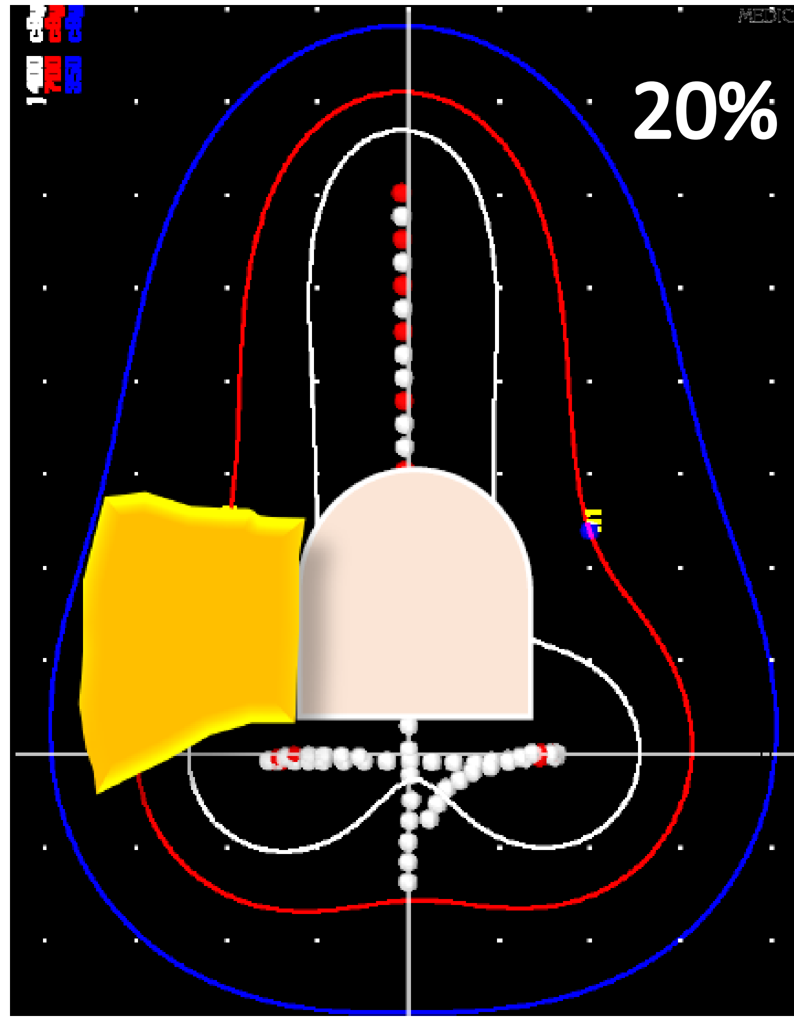
Applicators: mimicking historical geometries



Applicator selection
based on tumour topography



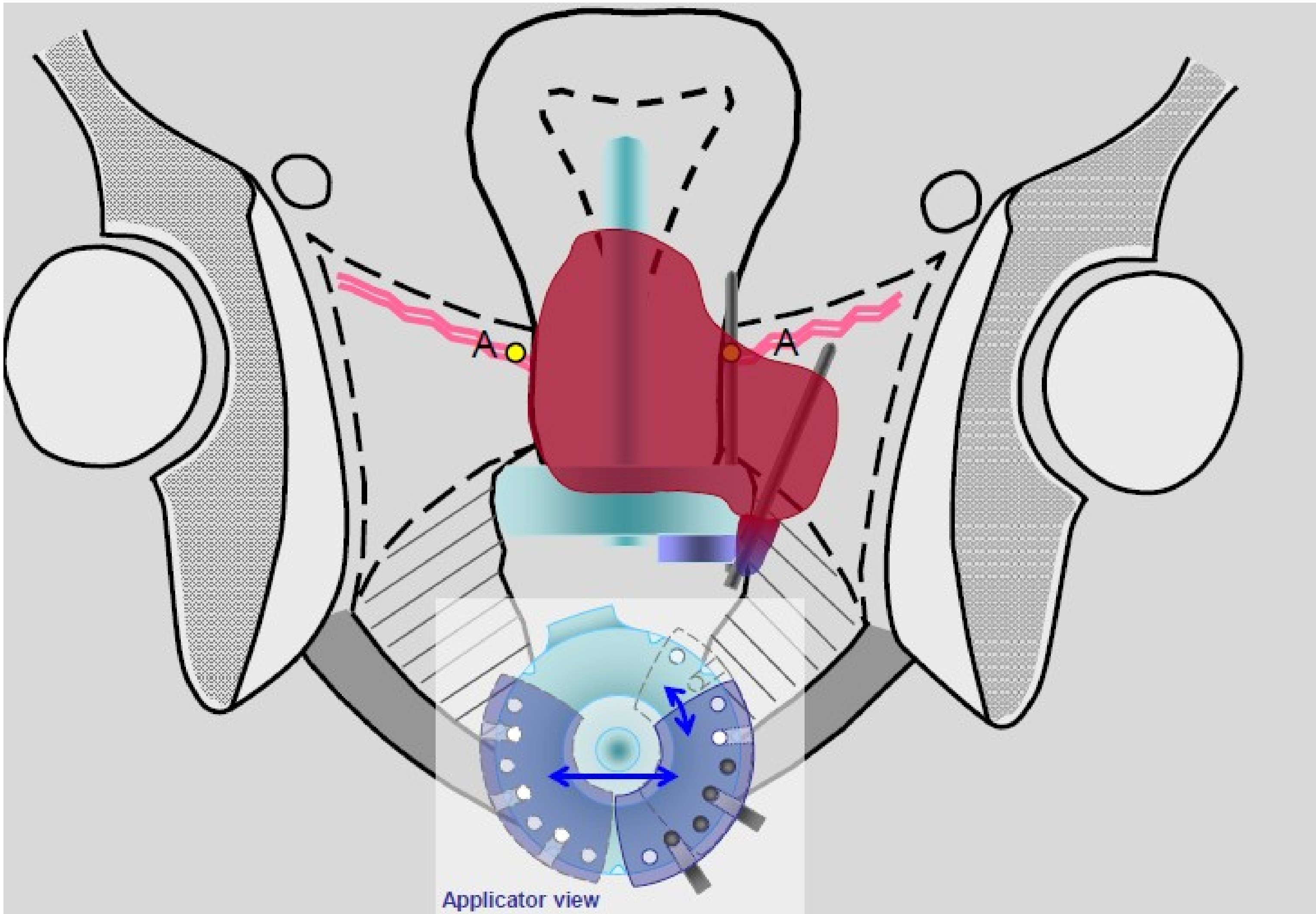
STANDARD PEAR



LIMITATION OF STANDARD PEAR

Courtesy of Daniel Berger and Primoz Petric

Applicator selection based on tumour topography



Courtesy of Daniel Berger and Primoz Petric

Advanced brachytherapy applicators

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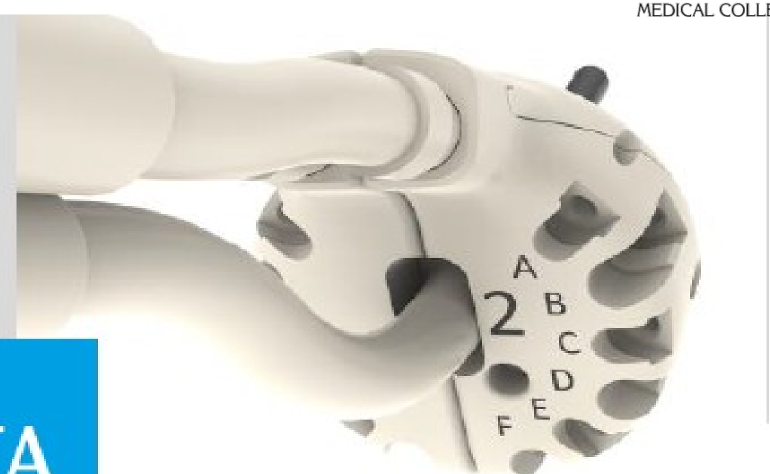
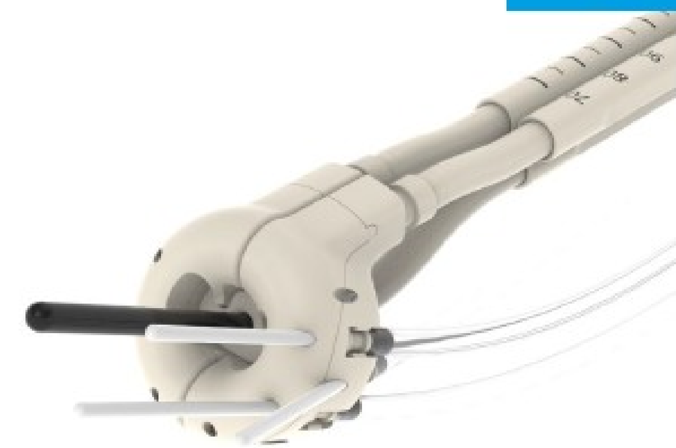


ELEKTA



Courtesy of Daniel Berger and Primoz Petric

BRACHYTHERAPY : EVOLUTION DOSIMETRY

2 D BT		3 D IGABT
Clinical	Preplanning	Clinical + MR Adaptive
Traditional IC	Applicator selection	MR compatible IC, IC+IS, IS
Insertion, packing	Brachy procedure	Protocols, USG guided insertion, packing
Orthogonal X Rays	Imaging	MR (CT)
Not possible	Contouring	Vital – Target, OARs
X Ray markers	Applicator reconstruction	Dedicated protocols, applicator commissioning
Point A, B, ICRU Bladder, Rectal points	Definition of dose points	Point A, ICRU Bladder, Rectovaginal points
Standard loading, MO	Planning	Standard loading, MO, GO, IP
Doses to Point A, B, ICRU Bladder, Rectal points	Plan Evaluation	GYN GEC ESTRO DVH, LQ spreadsheet, EQD2
LDR / HDR / PDR	Treatment delivery	HDR / PDR

Optimal geometry

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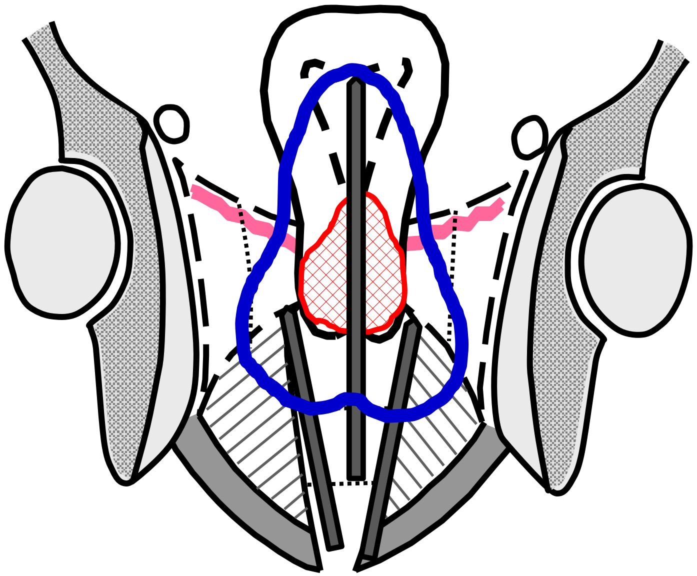
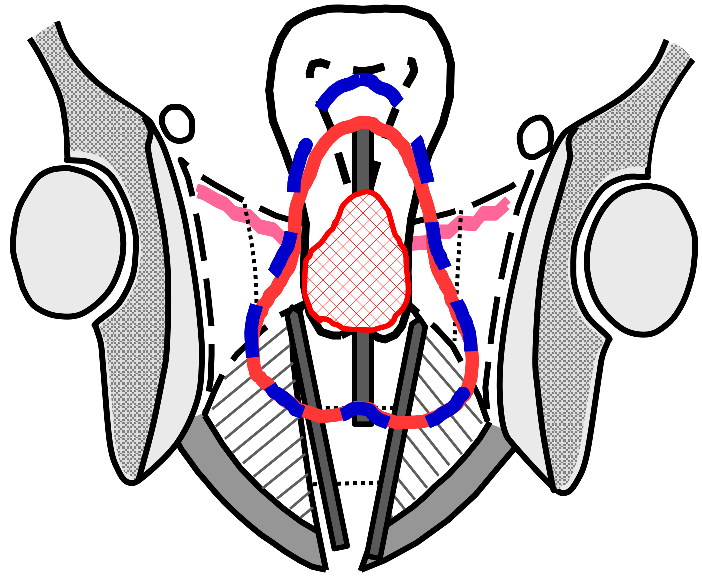
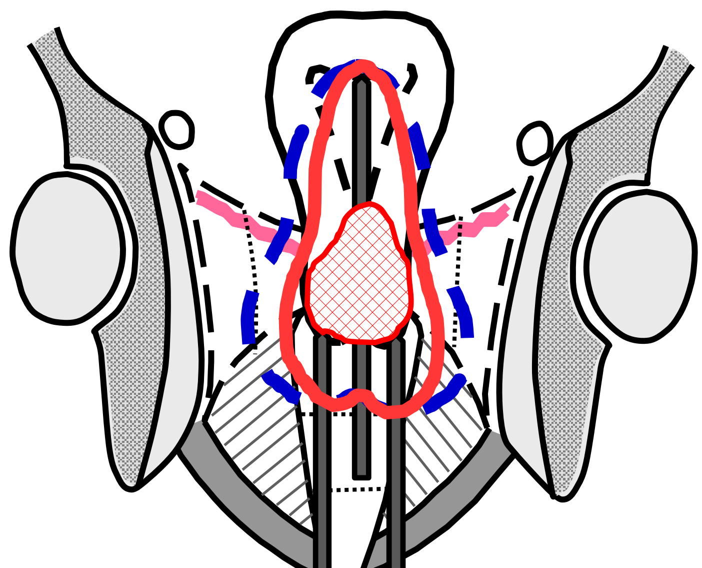


Ideal application
Longest tandem
Largest ovoids
Perfect pear

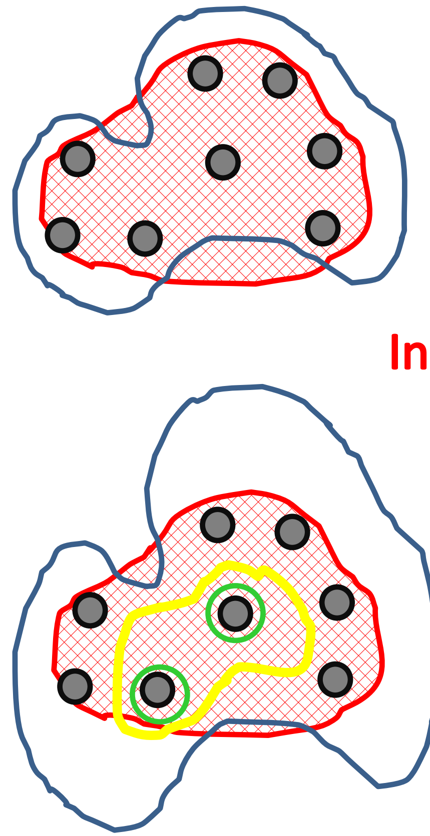


Poor application
Shorter tandem
Largest ovoids
Flattened pear

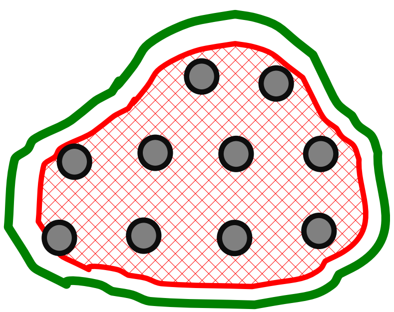


Poor application
Longest tandem
Smaller ovoids
Narrowed pear

Optimal geometry



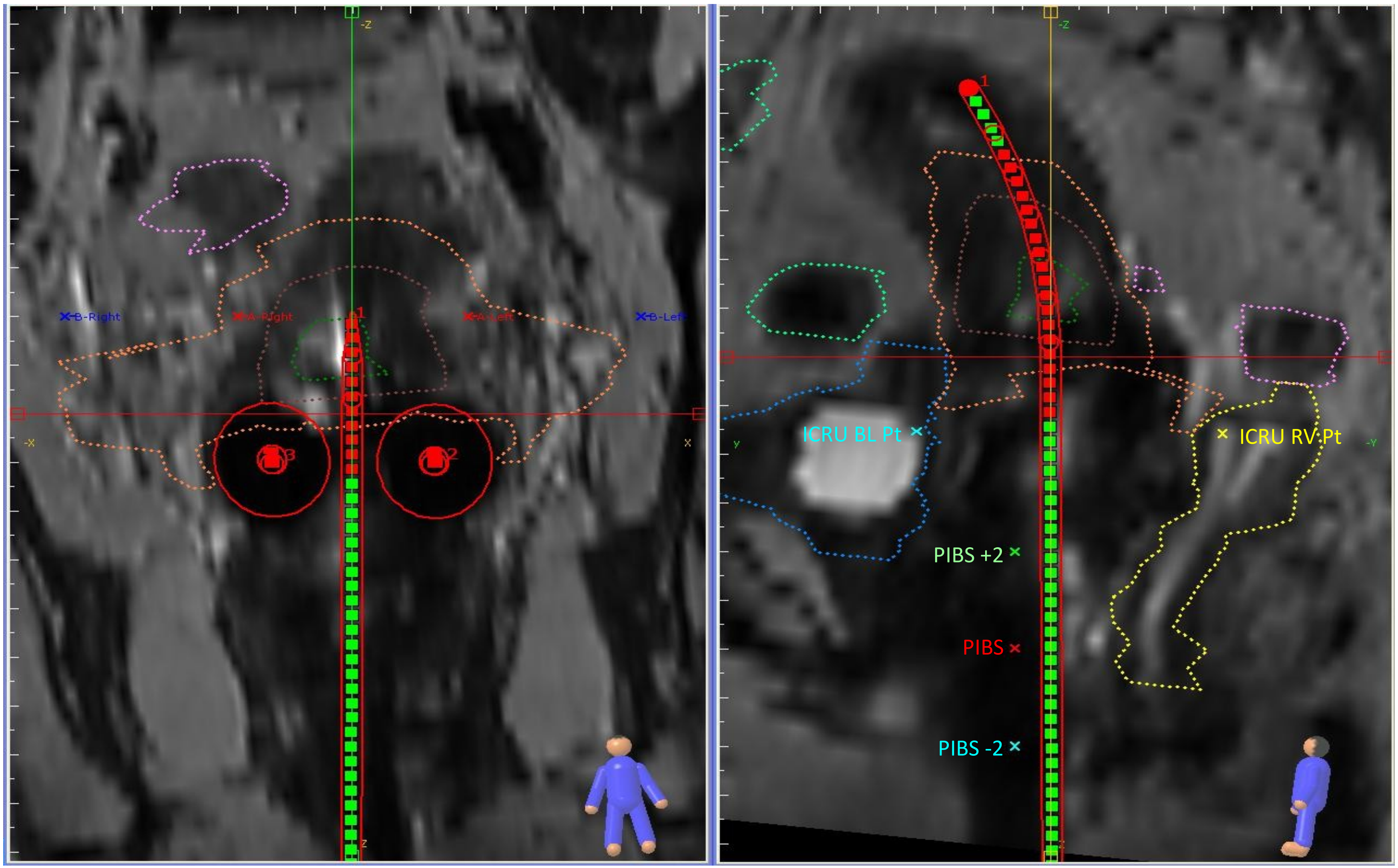
Inappropriate application
and resultant
dose distributions



Ideal application
and dose distribution


Physicist
Brachytherapy
Planning
Physician
Golden Rule
Good planning and optimization
cannot turn a poor insertion
into a great plan!

MRI images



B-Right
A-Right
A-Left
B-Left
ICRU BL Pt
ICRU RV Pt
PIBS +2
PIBS
PIBS -2

Steps of brachytherapy planning

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1
- Applicator reconstruction
  Manual, library based

2
- *Standard loading*
  - Based on known loading patterns from systems

3
- Normalization to a point
  - Planning aim vs Prescribed dose

4
- Plan *Optimization*
- *Methods*

LQ spreadsheet

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PHYSICAL - BIOLOGICAL DOCUMENTATION OF GYNAECOLOGICAL HDR BT

PATIENT , ID-number				tumour entity	
EXTERNAL BEAM THERAPY		TUMOUR	OAR	FIGO, TNM	
dose per fraction	1.8	D_{iso} [α/β=10Gy]	D_{iso} [α/β=3Gy]		
fractions without central shield	25	44.3	43.2		
fractions with central shield		0.0	0.0	GTV at diag.	cm^3
total dose	45.0	44.3	43.2		
				chemoth.	
Total volume (body contour) treated to 43 Gy [cm³]					
Total volume (body contour) treated to 57 Gy [cm³]					

BRACHYTHERAPY	F 1	F 2	F 3	F 4	F 5	F 6	TOTAL BT	TOTAL BT + EBT
							dose values in Gy	
date								
physicist								
MR / CT	MRI							
applicator(s): type, # needles								
applicator(s): dimensions								
Plan, remarks							*mean*	*stddev*
TRAK [cGy at 1m]							0.00	
TRAK intrauterine [%]								
TRAK vaginal [%]								
TRAK interstitial [%]								
Planning aim for D_{90} CT								
planning aim $EQD2_{10}$								44.3
dose to + A left								
A_{left} $EQD2_{10}$								74.0
dose to – A right								
A_{right} $EQD2_{10}$								74.0
dose to A mean								
A_{mean} $EQD2_{10}$								#VALUE!
GTV_{res} [cm³]								*0.0*
D_{98}								
D_{98} $EQD2_{10}$								44.3
CTV_{HR} [cm³]								*0.0*
D_{98}								
D_{98} $EQD2_{10}$							.0	44.3
D_{90}								
D_{90} $EQD2_{10}$							39.3	83.6
D_{50}								
D_{50} $EQD2_{10}$	0.0						0.0	44.3
CTV_{IR} [cm³]							*0.0*	*0.0*
D_{98}								
D_{98} $EQD2_{10}$	0.0	0.0				0.0	0.0	44.3
D_{90}		0.0						
D_{90} $EQD2_{10}$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.3
BLADDER [cm³]		0					*0.0*	*0.0*
Bladder reference point		0.0	0.0	0.0				
ICRU $EQD2_3$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.2
$D_{0.1cm^3}$		0.0	0.0	0.0				
$D_{0.1cm^3}$ $EQD2_3$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.2
D_{2cm^3}	6.4	6.4	6.4	0.0				
D_{2cm^3} $EQD2_3$	12.0	12.0	12.0	0.0	0.0	0.0	36.1	79.3
RECTUM [cm³]		0					*0.0*	*0.0*
Recto-vaginal reference point		0.0	0.0	0.0				
ICRU $EQD2_3$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.2
$D_{0.1cm^3}$		0.0	0.0	0.0				
$D_{0.1cm^3}$ $EQD2_3$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.2
D_{2cm^3}	5.6	5.6	5.6	0.0				
D_{2cm^3} $EQD2_3$	9.6	9.6	9.6	0.0	0.0	0.0	28.9	72.1
SIGMOID [cm³]		0					*0.0*	*0.0*

Summation of EBRT and Brachytherapy doses by EQD2

Reporting and auditing

Burdwan Medical College

Level 3: *Research-oriented reporting*
All that is reported in Level 1 and 2 plus

Absorbed-dose reporting for the tumor:
- $D_{98\,\%}$, $D_{90\,\%}$ for the CTV_{IR} even if not used for prescription
- $D_{90\,\%}$ for the GTV_{res}
- DVH parameters for the PTV
- $D_{50\,\%}$ for pathological lymph nodes
- DVH parameters for non-involved nodes (ext/int iliac, common iliac)

OAR volumes and points
- Additional bladder and rectum reference points
- OAR sub-volumes (*e.g.*, trigonum or bladder neck, sphincter muscles)
- Vagina (upper, middle, lower)
- Anal canal (sphincter)
- Vulva (labia, clitoris)
- Other volumes/sub-volumes of interest (*e.g.*, ureter)

Dose–volume reporting for OARs
- Dose–volume and DSH parameters for additional OARs and sub-volumes
- Vaginal dose profiles, dose–volume, and DSHs
- Length of treated vagina

Isodose surface volumes
- 85 Gy EQD2 volume
- 60 Gy EQD2 volume

ICRU 83 Section 8.8

BRACHYTHERAPY : EVOLUTION OPTIMIZATION

Optimization

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- Design a distribution of *source terms* such that the resultant dose distribution satisfies certain constraints and meets certain objectives *as well as possible*.

1. Forward Optimization (FO)

– **Dwell time** – adjust dwell times at each source position

– **Geometric** – based on implant geometry

– **Graphical** – local vs global; drag isodoses

2. Inverse Optimization (IO)

- *IPSA*
- *HIPO*

Brachy Optimization Types

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- **Forward – tedious but more robust.**

Generate plan | Define objectives | Optimize plan

- **Inverse – fast but less robust.**

Define objectives | Optimize plan | Generate plan

Optimization

Dwell time → Geometric → Graphical → Inverse

Inverse planning is only relevant when ***numerous applicators*** *(needles, catheters are used and the planning process by Forward Planning Optimization is* ***complex, laborious and time consuming****).*

Simulated Annealing

- Simulated annealing (SA) is a *probabilistic technique* for approximating the *global optimum* of a given cost function.
- Specifically, it is a *metaheuristic* to *approximate global optimization in a large search space* for an optimization problem. The technique used is *Stochastic Optimization*.
- For problems where *finding an approximate global optimum is more important than finding a precise local optimum in a fixed amount of time*, simulated annealing may be preferable.
- The name of the algorithm comes from *annealing in metallurgy* (a technique involving heating and controlled cooling of a material to alter its physical properties).

Inverse Planning Simulated Annealing

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- CT-based inverse planning.
- Produce an optimized plan in a very short time.
- Uses stochastic optimization only.
- Used for prostate (permanent implants, HDR), breast.

- Dose coverage of PTV (V100) lower.
- Dose homogeneity Index lower.
- Overloading of needle ends, higher active length, redundant dwell positions.
- DVH parameters often suboptimal.

Hybrid Inverse Planning Optimization

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- CT-based inverse planning.
- Produce an optimized plan in a very short time.
- Uses both stochastic and deterministic optimization.
- Used for prostate, breast, gynaecological implants.

- Dose coverage of PTV (V100) higher.
- Dose homogeneity Index higher.
- Overloading of needle ends, higher active length, redundant dwell positions.
- DVH parameters better and comparable to FO.

FO vs IPSA vs HIPO

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Strahlenther Onkol (2019) 195:991–1000
https://doi.org/10.1007/s00066-019-01513-x

ORIGINAL ARTICLE

Check for updates

Dosimetric comparison of inverse optimisation methods versus forward optimisation in HDR brachytherapy of breast, cervical and prostate cancer

Georgina Fröhlich[1,2] · Gyula Geszti[2] · Júlia Vízkeleti[1] · Péter Ágoston[1] · Csaba Polgár[1,3] · Tibor Major[1,3]

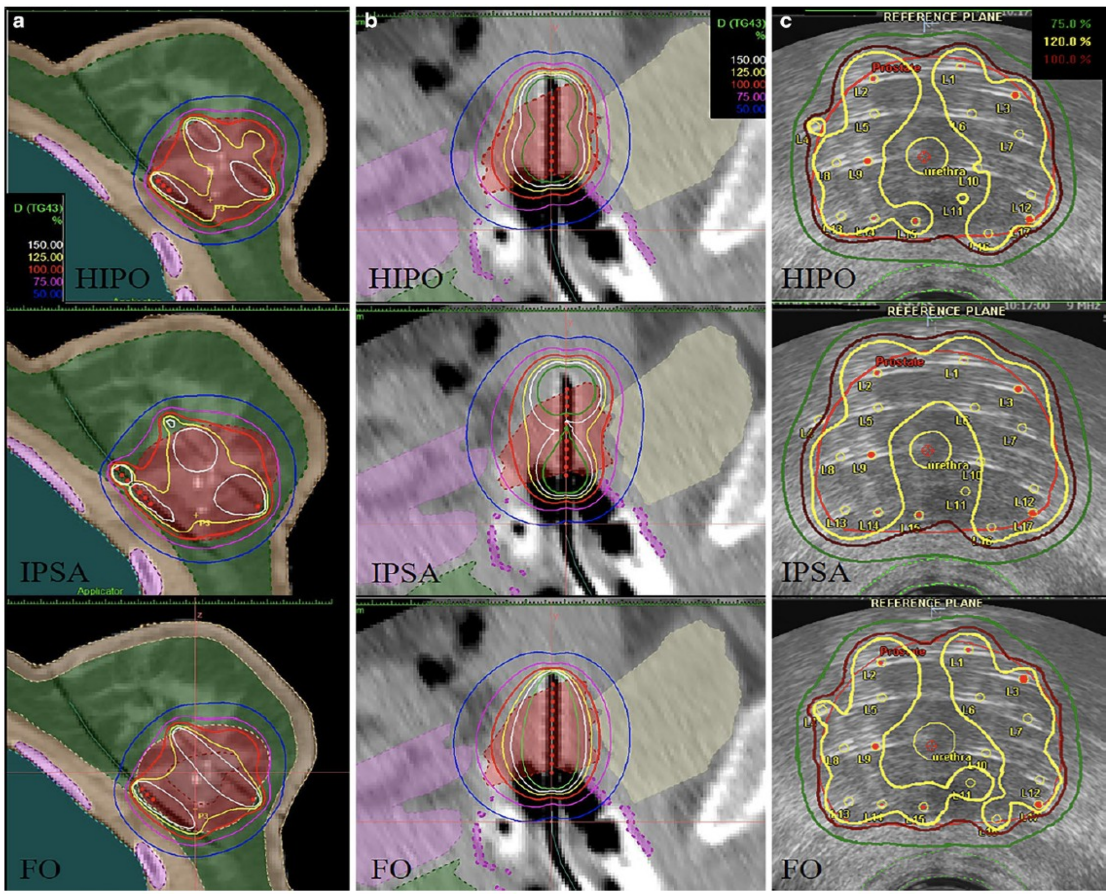

Fig. 1 Dose distributions using HIPO (hybrid inverse planning optimisation), IPSA (inverse planning simulated annealing) and forward optimisation (*FO*) in interstitial BT (brachytherapy) of breast (**a**), cervical (**b**) and prostate (**c**) cancer. *Red dots:* active dwell positions (volumes: *red:* PTV [planning target volume]; **a** *green:* non-target breast, *blue:* ipsilateral lung, *pink:* ribs; **b** *yellow:* bladder, *green:* rectum, *violet:* sigmoid, *pink:* vagina; **c** *yellow:* urethra, *green:* rectum)

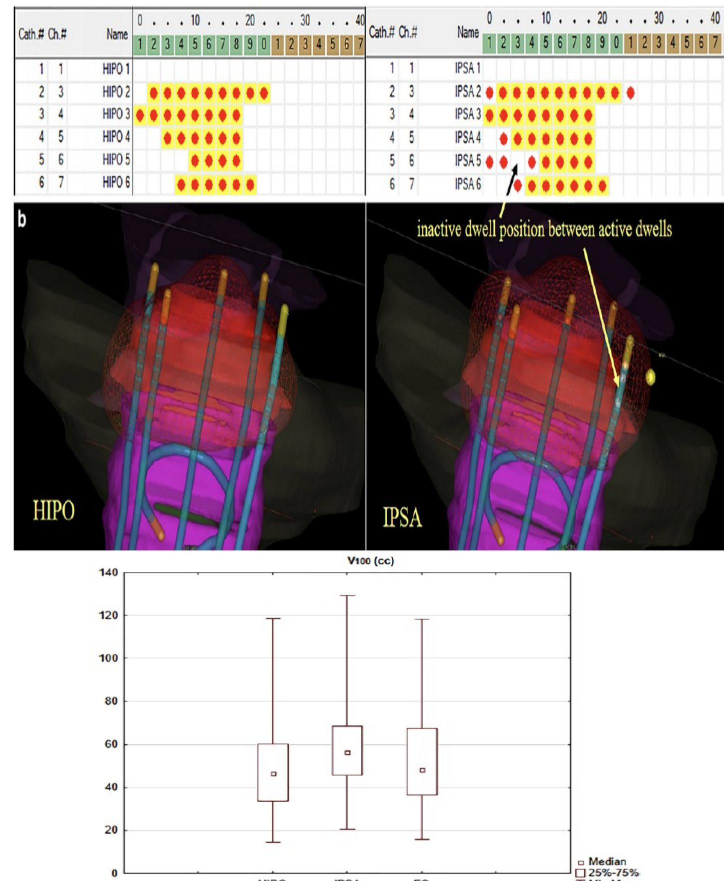

Fig. 2 The absolute volume irradiated by 100% of the prescribed dose (V_{100}) using HIPO (hybrid inverse planning optimisation), IPSA (inverse planning simulated annealing) and forward optimisation (*FO*) methods in interstitial cervical BT (brachytherapy) plans

PHYSICS CONTRIBUTION

IMAGE-GUIDED RADIOTHERAPY FOR CERVIX CANCER: HIGH-TECH EXTERNAL BEAM THERAPY VERSUS HIGH-TECH BRACHYTHERAPY

DIETMAR GEORG, PH.D., CHRISTIAN KIRISITS, PH.D., MARTIN HILLBRAND, M.SC., JOHANNES DIMOPOULOS, M.D., AND RICHARD PÖTTER, M.D., PH.D.

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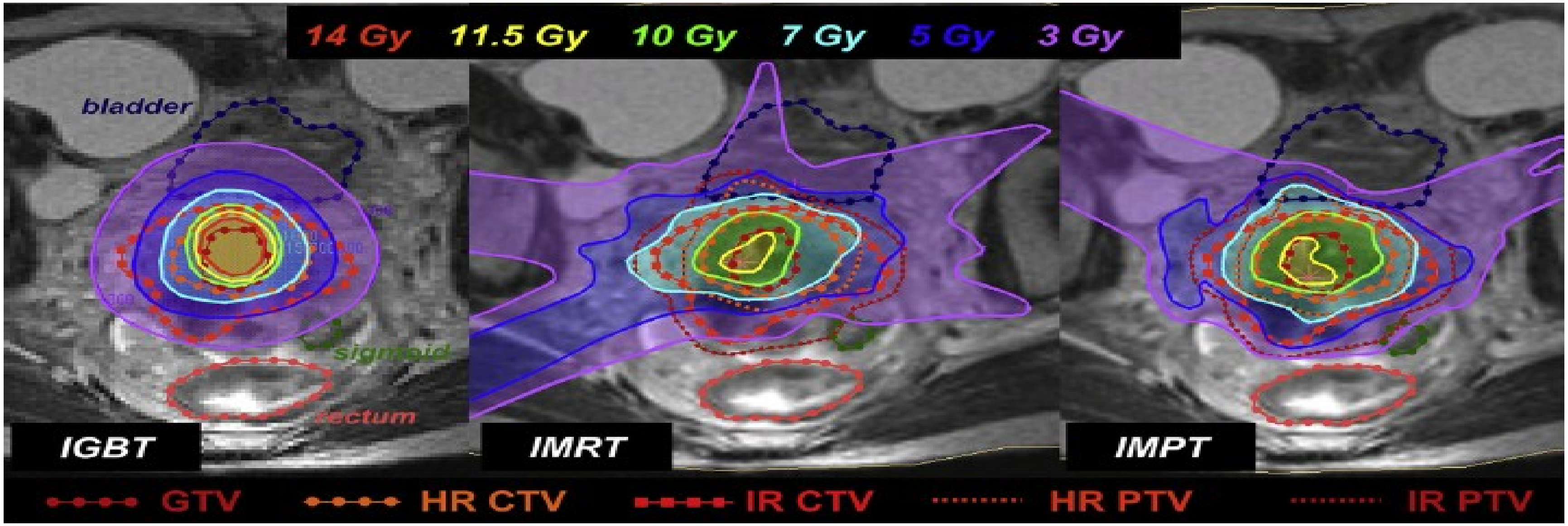
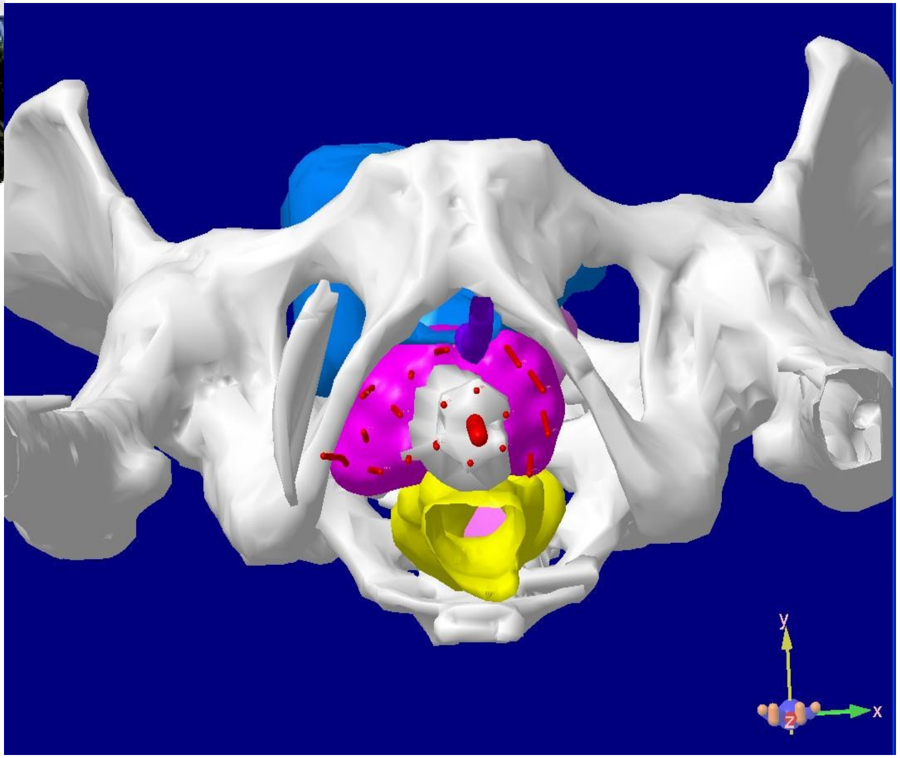


Conclusions

For image-guided cervix cancer treatments, both IMRT and IMPT seem to be inferior to BT.

Thank You



drabhishekbasu@yahoo.com