INVERSE PLANNING IN BRACHYTHERAPY

Prof G K Rath

Professor and Head of Radiotherapy &

Chief, Dr. BRA IRCH,

All India Institute of Medical Sciences, New Delhi

BRACHYTHERAPY

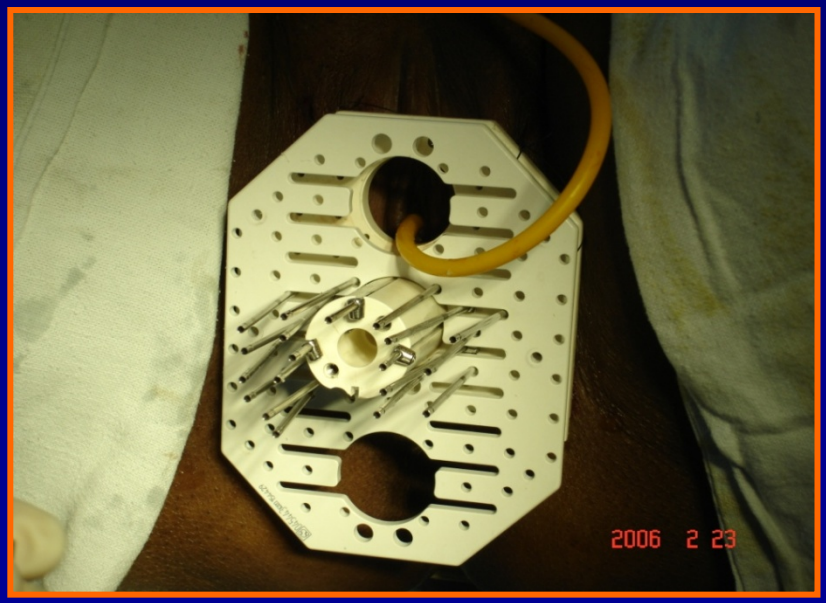
Ca Buccal mucosa

Ca Tongue

Ca Esophagus-ILRT

Soft Tissue Sarcoma

INTERSTITIAL BRACHYTHERAPY IN CA CERVIX



Ca Cervix- Perineal Template Brachytherapy

ADVANTAGE OF BRACHYTHERAPY

- Earliest form of conformal therapy
- Delivers dose to tumor from within the tumor
- Sharp dose fall off
- Avoids uncertainties of organ motion
- Acute morbidity less
- Short treatment time
- Dose escalation possible

BRACHYTHERAPY PLANNING

The success depend on

- Good placement of catheters
- Good treatment planning

Brachytherapy plan is based on different imaging modalities like:

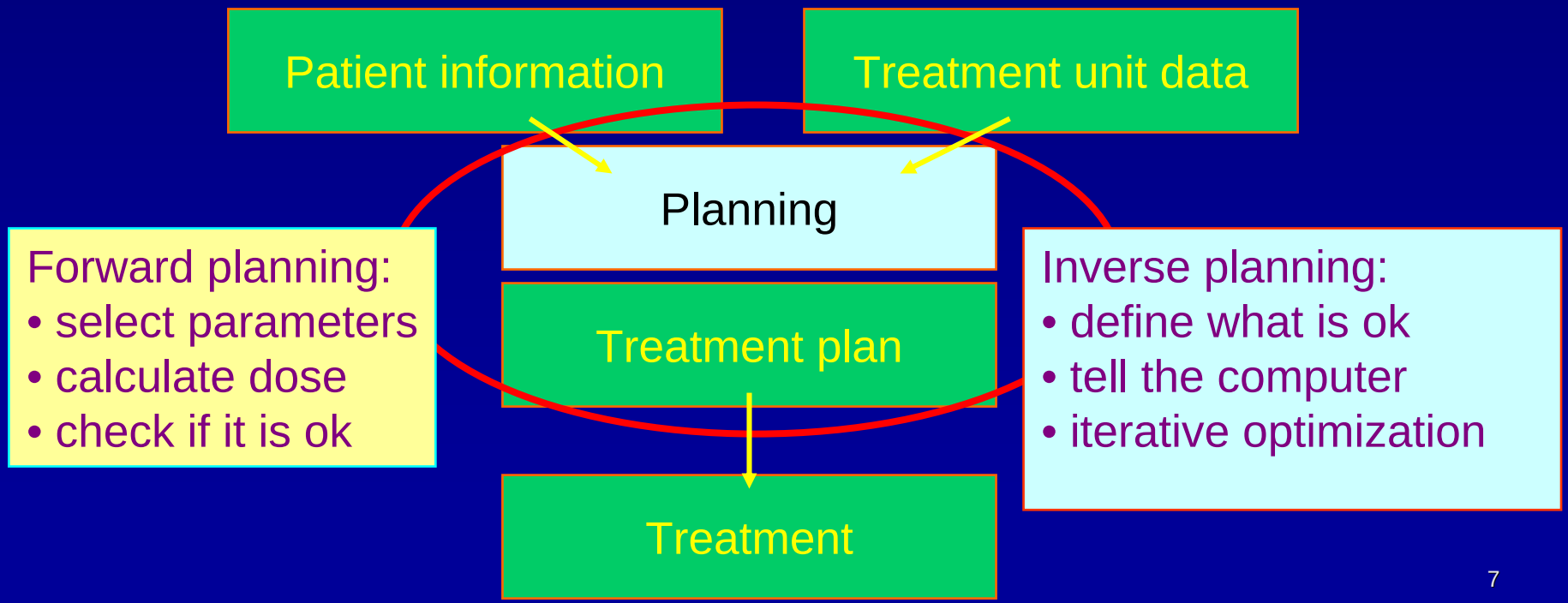
- X-Ray based -ca cervix
- CT based - interstitial
- MR based-cervix
- PET based

BRACHYTHERAPY PLAN OPTIMIZATION

- Point Dose Optimization
- Geometric Optimization
- Inverse Planning Optimization

CONCEPT OF INVERSE PLANNING

Forward versus Inverse Planning



INVERSE PLANNING IN BRACHYTHERAPY

- Inverse planning is an anatomy-based dose distribution optimization approach - similar to IMRT in teletherapy
- requires 3D-imaging (CT, MRI, Ultrasound, etc.) and the segmentation
- contouring of Volumes of Interest (VOI).

PIONEERS OF IPSA

- Etienne Lessard
- I Chow Joe Hsu
- Jean Pouliot

UCSF, USA.

IPSA

- Allows optimization in seconds
- Offers better dose coverage to the target than other optimizations
- Provides significantly better protection to organs at risk
- Allows planning of all anatomical sites
- Minimizes the impact of misplaced catheters
- Provides superior dose distributions not possible before

INVERSE PLANNING PROCESS

- CT scan - 3D, large volume, small slices
- Outlining of ALL relevant structures (targets and critical organs)
- DICOM transfer of CT data sets and structures to planning system
- Definition of dose constraints
- Computer optimization
- Verification

INDICATIONS OF IPSA

Useful where there are multiple optimization points

All Brachytherapy applications particularly

- Interstitial Brachytherapy in cancer cervix

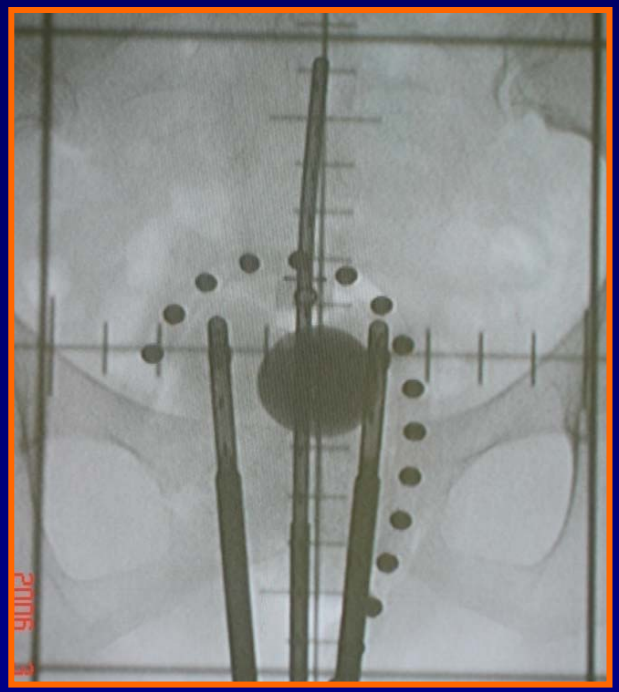
APPLICATIONS OF IPSA

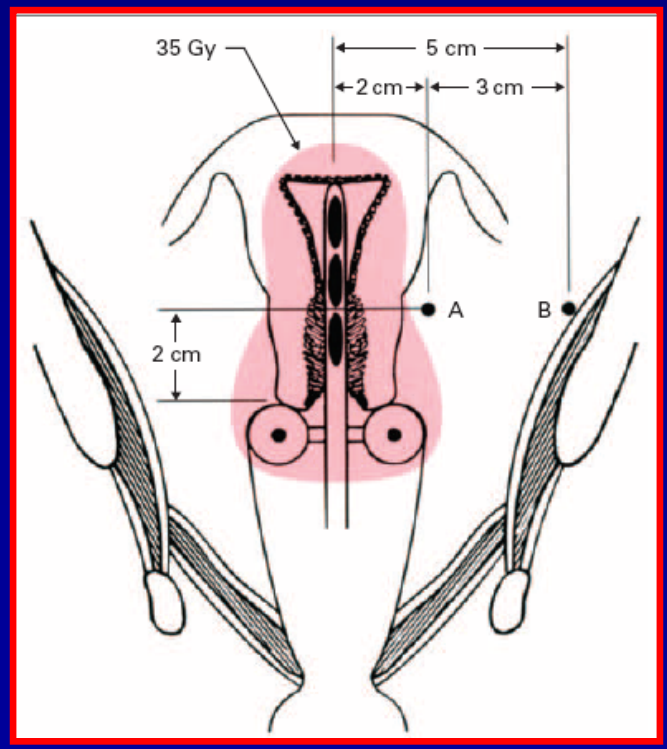
- Gynecological sites
- Rectum
- Prostate
- Nasopharynx
- Base of tongue
- Breast

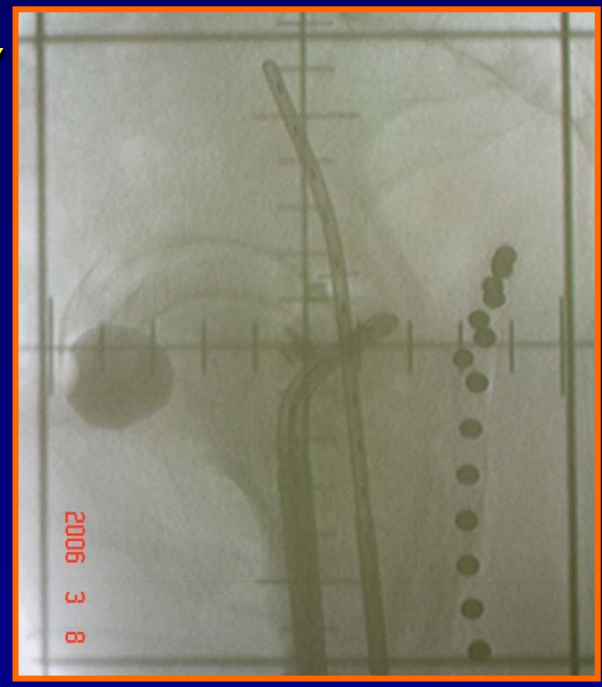
RATIONALE OF USING IPSA

- Tandem Ovoid I/C system, Fletcher Suit applicator used since long –Pear shaped high dose region centered on Cervix
- Allows very high dose to cervix sparing bladder and rectum
- Even large cervical tumors can be treated
- When tumor goes beyond Cx particularly stages **IIB & IIIB** -above system is inadequate
- Interstitial Brachytherapy indicated (with or without image guidance) because **dose distribution needed beyond pear shape**
- Variety of template systems (Syed-Neblett,Mupit) developed with or without image guidance

BRACHYTHERAPY
ICRT cervix







RATIONALE OF USING IPSA

- Wide variety of dose distributions can be generated by positioning needles acc to extent of tumor extension to the parametria & adjusting the dwell time and dwell positions
- Currently available optimization schemes (geometric and dose point) fail to use anatomical informations- result in approximation of shape of anatomy
- Reducing CTV to geometric representations disregarding anatomical relationships can result in overdose to OAR
- Dose has to be as conformal to relevant anatomy as possible
- Currently available TPS –not anatomy based

RATIONALE OF USING IPSA

- ICRU 38 dictates dose distribution based on visualization of applicator & bony landmarks rather than coverage of tumor and avoidance of normal structure
- ICRU points may not accurately estimate dose to bladder and rectum
- Target coverage and dose to OAR has been questioned (Ling 87,Kapp 92,Barillot 94,Fellner 01)
- In IPSA- anatomy based optimization algorithm developed to rapidly produce conformal dose coverage to target vol while minimizing dose to OAR in the delivery of HDR Brachy

RADIATION ONCOLOGISTS,MEDICAL PHYSICISTS,DOSIMETRISTS CAN NOW FORGET CATHTERS AND FOCUS ATTENTION ON ANATOMY

What is IPSA

- An Inverse Planning System
- Developed by UCSF
- An automated planning tool based on objective satisfaction approach (Inverse Planning) & solved by a stochastic optimization engine (Simulated Annealing)
- IPSA determines the active dwell positions &times (the dose plan) that best fulfills the dose objectives
- IPSA is flexible to allow planning of all anatomical sites & techniques (Interstitial,Intracavitary and surface)

Inverse Planning Simulated Annealing

Inverse Planning (IP)

An optimization Technique where the user enters the desired dose objectives and the computer seeks a solution

Simulated Annealing (SA).

An optimization engine that "heats up and cools down" dwell time positions so as to provide an optimal solution

IPSA CLINICAL APPLICATIONS

Int. J. Radiation Oncology Biol. Phys., Vol. 54, No. 4, pp. 1243–1251, 2002

0360-3016/02/$–see front matter

ELSEVIER

PII S0360-3016(02)03802-6

PHYSICS CONTRIBUTION

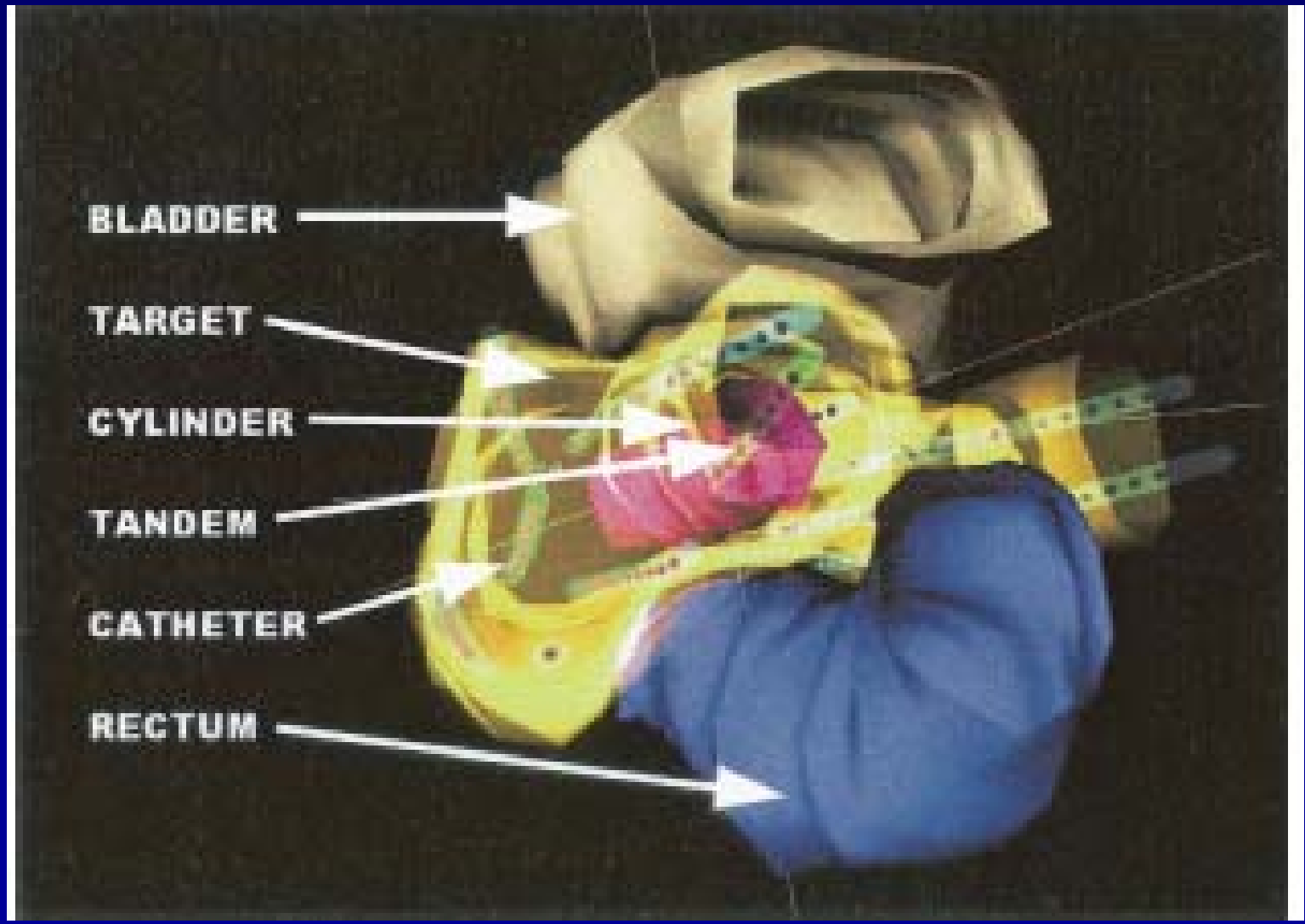
INVERSE PLANNING FOR INTERSTITIAL GYNECOLOGIC TEMPLATE BRACHYTHERAPY: TRULY ANATOMY-BASED PLANNING

ETIENNE LESSARD, M.SC., I-CHOW HSU, M.D., AND JEAN POULIOT, PH.D.

Department of Radiation Oncology, University of California San Francisco, San Francisco, CA

- Inverse planning showed improved protection to OAR
- Planning time significantly reduced
- Improves physicians control over treatment
- Better coverage than manual plan

IPSA – FOR INTERSTITIAL BRACHYTHERAPY



Int. J. Radiation Oncology Biol. Phys., Vol. 63, No. 4, pp. 1270–1274, 2005

0360-3016/05/$–see front matter

doi:10.1016/j.ijrobp.2005.07.972

PHYSICS CONTRIBUTION

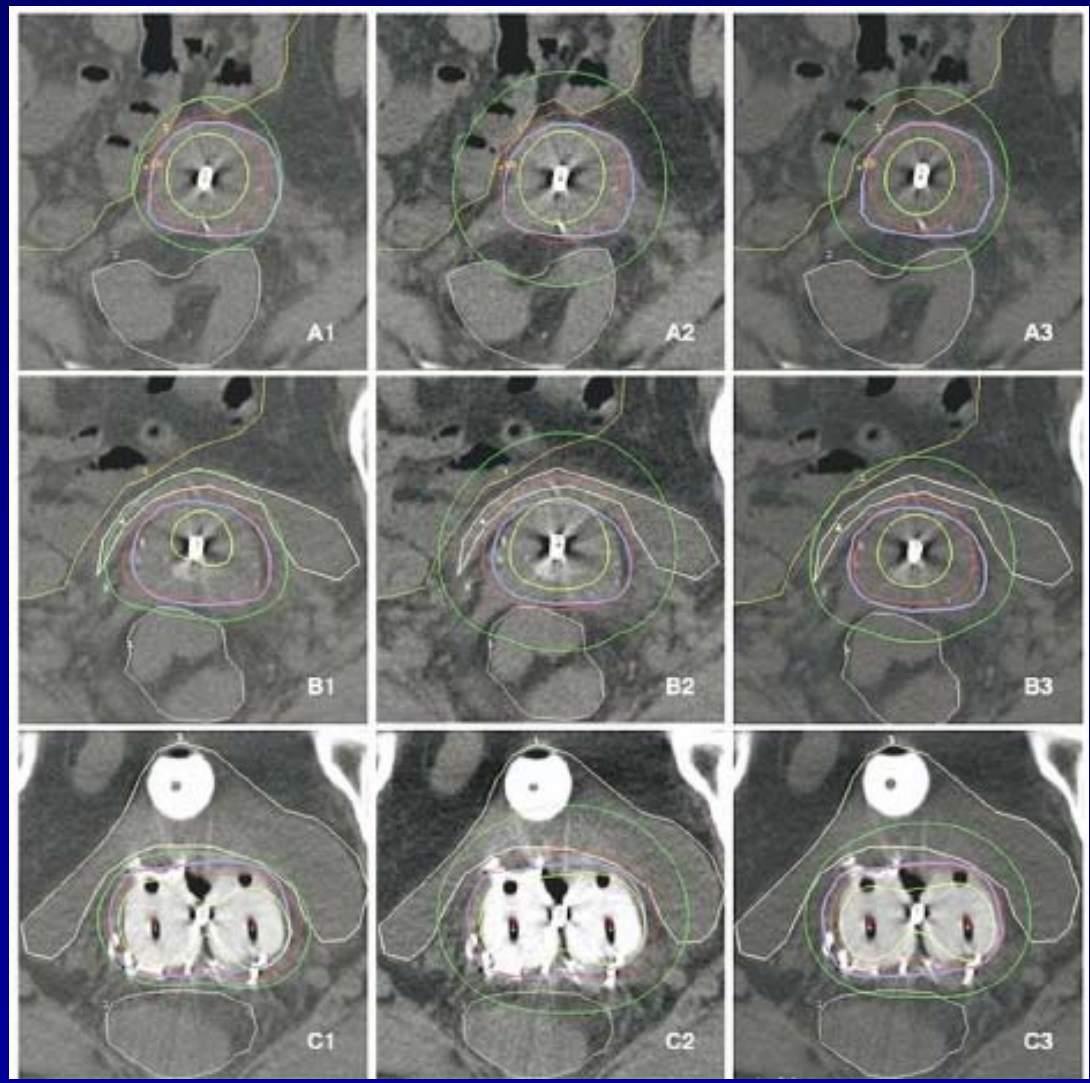
3D INVERSE TREATMENT PLANNING FOR THE TANDEM AND OVOID APPLICATOR IN CERVICAL CANCER

KELLY D. DEWITT, M.D.,* I. CHOW JOE HSU, M.D.,* JOYCELYN SPEIGHT, M.D., PH.D.,* VIVIAN K. WEINBERG, PH.D.,† ETIENNE LESSARD, PH.D.,* AND JEAN POULIOT, PH.D.*

*Department of Radiation Oncology and †Biostatistics Core, University of California, San Francisco, San Francisco, CA

COMPARISION OF THREE PRESCRIPTION TECHNIQUES

Panel A is at the level of the mid ovoids,
Panel B is at the level cervical os,
Panel C is at the level of point A.
Method 1 is IPSA
Method 2 is pointA
Method 3 is bladder sparing (2 cc of bladder limited to 80% of dose).
The yellow line is the 150% isodose line, the red line is the 100% isodose line, and the green is the 50% isodose line.



AIIMS EXPERIENCE

S694 I. J. Radiation Oncology ● Biology ● Physics Volume 69, Number 3, Supplement, 2007

2880 **Comparison of Inverse Planning Optimization with Classical Optimization Methods in HDR Interstitial Template Brachytherapy Planning for Cervical Carcinoma**

G. K. Rath, V. Subramani, D. N. Sharma, K. S. Jothy Basu, N. Gopishankar, A. Bahl, T. Ganesh

All India Institute of Medical Sciences, New Delhi, India

Purpose/Objective(s): To evaluate the dosimetric superiority of inverse planning optimization with classical optimization using various dosimetric indices in interstitial brachytherapy (IBT) planning for cervical carcinoma.

Materials/Methods:

- N= 10
- TRUS guided IBT.
- CT based planning performed in PLATO system for Microselectron HDR.
- For each patient 5 plans were made.
- Dose - 10 Gy.

AIIMS EXPERIENCE

Table 1: Comparison of inverse optimization with classical optimization methods in HDR Brachytherapy

Target	Conv_plan	DPO	GO	PIO	IPSA
V_{95}	113.1 ± 33.2	140.6 ± 92.0	132.1 ± 77.30	133.6 ± 69.3	151.1 ± 97.7
COIN	0.49 ± 0.2	0.65 ± 0.2	0.59 ± 0.13	0.79 ± 0.07	0.91 ± 0.1
DNR	66.3 ± 7.4	41.4 ± 28.0	40.2 ± 33.8	52.7 ± 22.6	44.9 ± 22.7
HI	0.33 ± 0.07	0.37 ± 0.26	0.59 ± 0.34	0.53 ± 0.12	0.69 ± 0.1
EI	45.3 ± 23.8	21.2 ± 6.3	18.8 ± 8.4	15.2 ± 9.6	28.9 ± 3.7
Bladder					
D_{5cc}	6.29 ± 1.7	6.8 ± 2.8	6.9 ± 3.5	6.1 ± 1.8	4.3 ± 2.4
V_{50}	1.5 ± 1.1	2.4 ± 0.3	2.41 ± 2.9	1.9 ± 1.6	1.12 ± 1.5
V_{75}	0.32 ± 0.3	0.77 ± 1.2	0.84 ± 1.3	0.08 ± 0.1	0.05 ± 0.01
Rectum					
D_{5cc}	7.4 ± 2.7	7.4 ± 1.1	7.2 ± 0.8	6.6 ± 0.3	4.9 ± 2.8
V_{50}	1.6 ± 1.2	1.5 ± 0.2	4.7 ± 5.5	1.1 ± 0.2	1.3 ± 0.2
V_{75}	0.68 ± 0.6	0.46 ± 0.3	0.43 ± 0.2	0.25 ± 0.3	0.15 ± 0.1

Volumes (V_{95}, V_{50}, V_{75}) are in cm^3, D_{5cc} in Gy and DNR and EI in %

Rath et al IJROBP 2007

AIIMS EXPERIENCE

Conclusions:

- The inverse optimization resulted in improved dose conformity and homogeneity compared to classical optimization methods.

- The IPSA optimization showed better target dose conformity and reduced dose to OAR.

- The dosimetric gain achieved by IPSA may reflect in patient treatment outcome significantly.

CONCLUSION

Inverse planning in brachytherapy

- Similar to IMRT planning in teletherapy
- Anatomy based planning
- Reduces dose to OAR
- Increases the Target volume coverage
- Takes less planning time
- Further studies in different sites needed

THANK YOU