INVERSE PLANNING IN BRACHYTHERAPY

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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

Patient information

Treatment unit data

Planning

Treatment plan

Treatment

Forward planning:
• select parameters
• calculate dose
• check if it is ok

Inverse planning:
• define what is ok
• tell the computer
• iterative optimization
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 IIIB & 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
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
PHYSICS CONTRIBUTION

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

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

<table>
<thead>
<tr>
<th>Target</th>
<th>Conv_plan</th>
<th>DPO</th>
<th>GO</th>
<th>PIO</th>
<th>IPSA</th>
</tr>
</thead>
<tbody>
<tr>
<td>V95</td>
<td>113.1 ± 33.2</td>
<td>140.6 ± 92.0</td>
<td>132.1 ± 77.30</td>
<td>133.6 ± 69.3</td>
<td>151.1 ± 97.7</td>
</tr>
<tr>
<td>COIN</td>
<td>0.49 ± 0.2</td>
<td>0.65 ± 0.2</td>
<td>0.59 ± 0.13</td>
<td>0.79 ± 0.07</td>
<td>0.91 ± 0.1</td>
</tr>
<tr>
<td>DNR</td>
<td>66.3 ± 7.4</td>
<td>41.4 ± 28.0</td>
<td>40.2 ± 33.8</td>
<td>52.7 ± 22.6</td>
<td>44.9 ± 22.7</td>
</tr>
<tr>
<td>HI</td>
<td>0.33 ± 0.07</td>
<td>0.37 ± 0.26</td>
<td>0.59 ± 0.34</td>
<td>0.53 ± 0.12</td>
<td>0.69 ± 0.1</td>
</tr>
<tr>
<td>EI</td>
<td>45.3 ± 23.8</td>
<td>21.2 ± 6.3</td>
<td>18.8 ± 8.4</td>
<td>15.2 ± 9.6</td>
<td>28.9 ± 3.7</td>
</tr>
<tr>
<td>Bladder</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D50%</td>
<td>6.29 ± 1.7</td>
<td>6.8 ± 2.8</td>
<td>6.9 ± 3.5</td>
<td>6.1 ± 1.8</td>
<td>4.3 ± 2.4</td>
</tr>
<tr>
<td>V50</td>
<td>1.5 ± 1.1</td>
<td>2.4 ± 0.3</td>
<td>2.41 ± 2.9</td>
<td>1.9 ± 1.6</td>
<td>1.12 ± 1.5</td>
</tr>
<tr>
<td>V75</td>
<td>0.32 ± 0.3</td>
<td>0.77 ± 1.2</td>
<td>0.84 ± 1.3</td>
<td>0.08 ± 0.1</td>
<td>0.05 ± 0.01</td>
</tr>
<tr>
<td>Rectum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D50%</td>
<td>7.4 ± 2.7</td>
<td>7.4 ± 1.1</td>
<td>7.2 ± 0.8</td>
<td>6.6 ± 0.3</td>
<td>4.9 ± 2.8</td>
</tr>
<tr>
<td>V50</td>
<td>1.6 ± 1.2</td>
<td>1.5 ± 0.2</td>
<td>4.7 ± 5.5</td>
<td>1.1 ± 0.2</td>
<td>1.3 ± 0.2</td>
</tr>
<tr>
<td>V75</td>
<td>0.68 ± 0.6</td>
<td>0.46 ± 0.3</td>
<td>0.43 ± 0.2</td>
<td>0.25 ± 0.3</td>
<td>0.15 ± 0.1</td>
</tr>
</tbody>
</table>

Volumes (V95, V50, V75) are in cm³, D50% in Gy and DNR and EI in %
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.
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