Prostate Brachytherapy Techniques & Applications

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35th ICRO PG Teaching Program
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Outline

• Epidemiology

• Evidence

• History

• Technique
Epidemiology

- Globocan- Prostate Cancer in India

<table>
<thead>
<tr>
<th>Year</th>
<th>Incidence</th>
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<tbody>
<tr>
<td>2018</td>
<td>25696</td>
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<tr>
<td>2025</td>
<td>32537</td>
</tr>
<tr>
<td>2030</td>
<td>38035</td>
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<tr>
<td>2035</td>
<td>43899</td>
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<tr>
<td>2040</td>
<td>50141</td>
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</table>
Clinical Scenario

• Aging population

• Elderly

• Advanced stages

• Emerging evidence for brachytherapy
Evidence

• The Prostate Testing for Cancer & Treatment (ProtecT)
  • Radiotherapy outcomes are similar to surgery
  • Improved toxicity & QoL
• Brachytherapy
  • Major cancer guidelines & societies worldwide
Low Dose Rate Brachytherapy (LDR-BT)

- Monotherapy for low-risk disease- established
- Prostate Cancer Results Study Group-10 Year outcomes
  - Freedom from Biochemical Failure (FFBF) - >86%
  - Distant Metastasis Rates - <10%
  - Prostate-cancer-specific mortality (PCSM) < 5%
  - Overall survival (OS) >85%
  - Grade 3–4 toxicities <4% (of patients)
LDR-BT monotherapy or boost for intermediate risk disease

- Prostate Cancer Results Study Group-10 Year outcomes
  - Freedom from Biochemical Failure (FFBF) - 65 – 90%
  - Monotherapy compared to EBRT + LDR-BT (RTOG 0232)
    - No difference in FFBF, OS, DM or PCSM
    - Fewer late events
LDR-BT boost for high risk disease

- Accepted modality of treatment
- RTOG 0019
- CALGB 99809
- ASCENDE-RT (Androgen Suppression Combined with Elective Nodal and Dose Escalated Radiation Therapy)
ASCENDE -RT

• $^{125}$I brachytherapy boost

• External Beam Radiation Therapy - 78 Gy

• Twice as likely to have experienced biochemical failure (at a median follow-up of 6.5 years).
## Treatment Related Morbidity

<table>
<thead>
<tr>
<th></th>
<th>Time (yrs.)</th>
<th>LDR-PB (%)</th>
<th>DE-EBRT (%)</th>
<th>P value</th>
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</thead>
<tbody>
<tr>
<td>Cumulative Incidence Gr. 3 GU events</td>
<td>5</td>
<td>18.4</td>
<td>5.2</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Prevalence of Gr. 3 GU morbidity</td>
<td>5</td>
<td>8.6</td>
<td>2.2</td>
<td>0.058</td>
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<tr>
<td>Cumulative Incidence Gr. 3 GI events</td>
<td>5</td>
<td>8.1</td>
<td>3.2</td>
<td>.124</td>
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<tr>
<td>Adequate Baseline Erections</td>
<td>5</td>
<td>45</td>
<td>37</td>
<td>.30</td>
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</tbody>
</table>
ASCENDE RT

- 6 year follow up

- Health related QOL
  - Similar

- Physical & Urinary Function Scales
  - Better in LDR Arm
HDR-BT

- Monotherapy
  - Low Risk & Intermediate Risk Disease

- High Risk - Clinical trials

- FFBF- > 85 % at 5 years.
- OS-> 95%
- PCSM<-4%
- LR<-4%
- DM<-4%
HDR Boost for Intermediate & High-Risk Disease

- 5 year- Better than EBRT alone
  - PCSM-99-100 %
  - OS-85-100 %
  - LR-0-8%
  - DM-0-12 %

- Toxicity –RTOG 0321
  - Gr 3-4 toxicity-2.6 %
  - Stricture Rates-0.7 %
Evolution of Modern Brachytherapy

- In 1911 – Pasteau
TECHNIQUE CHANGES: Open Brachytherapy Implant: 1960 to early 1980’s
Template Guided Implants
Late 1980’s onwards
Pre- Plan System (1990s)

• Dose -144 Gy (I 125)

• Seeds & Needles

• US Guidance

• Preplanned needle positions

• CT after 4 weeks for post-planning
Intra-operative Technique (2000’s)

- Computerized Image Capture in 3 D
- Computerized “Live” Planning
- Computer “Guided” Needle Implant
- Computerized delivery of Seeds/HDR Source
Techniques

- CT Based
- Real time US based
Patient Selection - For Monotherapy

Low-risk disease
• Gleason score <6,
• PSA <10 ng/ml,
• Clinical tumour classification T1, T2a)

Favourable intermediate-risk disease
• Gleason score 7,
• or PSA 10–20 ng/ml
• or clinical tumour classification of T2b, T2c
• Primary Gleason score 3 + 4,
• <50% positive biopsy cores,
• and only a single intermediate-risk feature.
For Brachytherapy Boost-High-risk disease

High-risk disease
• Gleason score 8–10
• PSA >20 ng/ml,
• Clinical tumour classification of T3a
For Brachytherapy Boost

Unfavourable intermediate-risk disease
- Gleason score 7
- PSA 10–20 ng/ml
- Clinical tumour classification of T2b, T2c
- Primary Gleason score 4+3
- > 50 % positive biopsy cores
- Multiple intermediate risk features
Absolute Contraindications

• Ataxia telangiectasia
• Pre-existing rectal fistula
• Medically Unsuitable
• Distant metastases
• Absence of rectum such that TRUS guidance is precluded
• Large TURP defects
Relative Contraindications

- Moderate-to-severe urinary symptoms (AUA Score < 20)
- Patient peak urinary flow rate < 10 cm³/s
- Postvoid residual volume before brachytherapy > 100 cm³
- Large prostate (> 60 cm³)
- Pubic Arch interference
Table 3 Properties of radionuclides and quality planning constraints

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>$t_{1/2}$ (days)</th>
<th>Average energy (keV)</th>
<th>Prostate (CTV)</th>
<th>Urethra</th>
<th>Rectum</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>D90</td>
<td>V100</td>
<td>V150</td>
</tr>
<tr>
<td>$^{125}I$</td>
<td>59.4</td>
<td>28.4</td>
<td>&gt;100% of dose</td>
<td>&gt;90–95%</td>
<td>&lt;50–60%</td>
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<tr>
<td>$^{103}Pd$</td>
<td>17.0</td>
<td>20.7</td>
<td></td>
<td></td>
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<tr>
<td>$^{131}Cs$</td>
<td>9.7</td>
<td>30.4</td>
<td></td>
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<tr>
<td>$^{192}Ir$</td>
<td>73.8</td>
<td>380</td>
<td>&gt;90–95% of dose</td>
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No normal tissue constraints from ABS owing to wide range of fractionation options.

ABS, American Brachytherapy Society; CTV, clinical target volume; EQD2, equivalent dose in 2 Gy fractions.

Zaorsky, N. G. et al. (2017) The evolution of brachytherapy for prostate cancer
Nat. Rev. Urol. doi:10.1038/nrurol.2017.76
LDR BT fractionation

ABS & GEC ESTRO

• Monotherapy with $^{125}$I – 145 Gy

• EBRT- 41.4 to 50.4 Gy at 1.8-2 Gy/#
• Before BT-Gap of 2-8 weeks
• LDR Boost-108-110 Gy
• Optimal implant-
  • D90 of 140 -180 Gy

• $^{103}$Pd is 125 Gy,

• $^{131}$Cs is 120 Gy
HDR-BT fractionation and sequencing

15 Gy in three fractions at 5 Gy per fraction
11–22 Gy in two fractions, at 5.5–11 Gy fractions,
12–15 Gy in a single fraction

EBRT- 36-54 Gy in 1.8-2 Gy
Gap-1-6 weeks
Real-time US-based planning

- Average total time from theater start to treatment delivery is approx. 1.5 – 2 hours
- 3D US based planning in treatment room
- Nonstop real-time procedure, all in one room, requires no couch shifts and minimizes implant shift
- Requires a shielded Operating Room or availability of anesthesia in the brachytherapy suite
Real-time prostate clinical workflow

- Patient into operating room
- Imaging with TRUS
- Pre-planning
- US guided needle insertion
- Treatment planning
- Treatment delivery in the OR
Acquiring Prostate Images

Template
Support
Stepper
System
Probe Rotational Mover
Acquiring Prostate Images

- Imaged volume
- Transverse Transducer
- Sagittal Transducer
- Bi-planar Ultrasound Probe
- Probe Rotation
3D Ultrasound: Image captured in approximately 10 seconds, with creation of a 3D model
Transverse Ultrasound Image
Prostate Mapping: Contouring live in 3D
Planning
Viewing the plan in 3D
Plan Evaluation - Central Slice
Plan Evaluation - Apex Slice
Conclusion

1. Prostate Brachytherapy is indicated for almost all stages of the disease
2. Brachytherapy Boost to be considered after EBRT for advanced stages
3. Newer Technology is user friendly & efficient
4. Patient selection is key to avoid severe toxicity