Hypofractionated Radiation Therapy and SBRT in Prostate Cancer

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Department of Radiation Oncology
Albert Einstein College of Medicine
Montefiore Medical Center

SBRT, 2013
Slide em Português!

BOM DIA!
• Conflitos de Interesse:
  – Varian Speakers Bureau
Let’s agree on the nomenclature first?

- **Conventional RT**: 1.8–2.0 Gy X 38-45 fx / 7-9 weeks = 75.6–85 Gy
  - Exploits differences in radiation responses of normal tissue and the tumor tissue to effect eradication of tumor without unduly damaging normal tissue
  - Protracted treatment program

- **Hypofractionated RT**: 2.5–3.0 Gy X 20-28 fx / 5-6 wks = 60-70 Gy
  - Exploits new technologies to increase dose to target without increasing normal tissue toxicity
  - “Pathway” to Stereotactic Radiosurgery?

- **Stereotactic Body RT**: 6-10 Gy X 4-6 fx / 2 wks = 35-50 Gy
  - Exploits differences in dose distribution to destroy effectively the tumor while sparing normal tissue
  - Single fraction to maximum 5-6 fraction therapeutic regimens
Radiobiology: Linear Quadratic Model

Prostate cancer is distinct in its radiobiologic response to therapy in comparison to other cancers

Expression of linear quadratic survival curve: \( S = e^{-\alpha D - \beta D^2} \)

- \( S \): fraction of cells surviving a dose \( D \)
- \( \alpha \): constant on non-repairable DNA breaks
- \( \beta \): constant on repairable DNA breaks

\( D = \alpha / \beta \) Ratio: magnitude determines how normal tissue or tumor will respond to the effects of radiation
Is Dose Escalation important in Prostate Cancer?

- PSA control is significantly affected by the dose fractionation employed
- Improved 10 year biochemical failure and 8 year freedom from failure
- Biochemical PFS with Dose Escalation:
  - Low risk: 80-90%
  - Intermediate risk: 70-85%
  - High Risk: 30-60%

PROG 9509 (Zietman et al., JCO 2010)
MDACC RCT (Kuban et al., IJROBP 2008)
Is Hypofractionated RT the best way to Dose Escalate in Prostate Cancer?

- Prostate cancers are also slow growing tumors with long doubling times and low mitotic rate/low proliferative index.

- **Low $\alpha/\beta$ ratio:** approximately 1.85 (range 1-4)

- Prostate cancers will be more sensitive to larger fraction sizes

- Prolonged fractionation will not change the therapeutic advantage between tumor control and late sequellae

- **Aim at larger doses per fraction:** Nothing is to be gained by using larger numbers of smaller fractions
The early clinical proof: HDR Brachytherapy

Grills et al, J. Urology 2004

• In 1999 HDR brachytherapy as mono-therapy was started at William Beaumont Hospital

• Study: HDR alone vs. LDR permanent seeds
  • 149 mostly low risk patients
    – 65 patients: HDR $^{192}$Ir
    – 84 patients: LDR using $^{103}$Pd
  • HDR: single after-loading implant 38 Gy = 9.5 Gy X 4 fractions BID minimum of 6 hours apart.

• HRD BED = 266 Gy
  – $\alpha/\beta$ of 1.5
  – 81 Gy standard fractionation with EBRT, BED = 178
Grills et al.

Results

• Biochemical control: 98%

• Decreased rates of acute urinary frequency, urgency, dysuria and rectal pain compared to LDR.

• Chronic urinary frequency, urgency and grade 2 rectal toxicities also decreased with HDR.

• Dramatic decrease (66%) in the rate of sexual impotency with HDR.
Hypofractionated RT in Prostate Cancer: Logistics, Economics and Practice

• The long duration of therapy is inconvenient to those who live far from RT centers or are unable to travel

• It is the most frequently patient-cited disadvantage of CFRT and a major cause of patient non-adherence

• Considering the travel time, long distance patients may have to travel to the cancer center, and the expense of parking, the shorter course of HFRT may save each man an average of $1,900 in out-of-pocket expenses

• Resource allocation could be improved with HFRT: staffing accounts for approximately 50% of radiation therapy costs
Hypofractionated RT in Prostate Cancer: Financial Considerations (T1c, G6, PSA<10)

<table>
<thead>
<tr>
<th>PROCEDURE</th>
<th>COST RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watchful waiting (over a 5 year period)</td>
<td>$5,500 - $8,000</td>
</tr>
<tr>
<td>Brachytherapy (Seed Implants)</td>
<td>$11,500 - $18,000</td>
</tr>
<tr>
<td>Radical Prostatectomy (Open)</td>
<td>$15,000 - $22,000</td>
</tr>
<tr>
<td>Stereotactic Body Radiation Therapy</td>
<td>$18,500 - $25,000</td>
</tr>
<tr>
<td>Radical Prostatectomy (Robotic)</td>
<td>$25,000 - $30,000</td>
</tr>
<tr>
<td>IMRT/IGRT (42-48 fractions)</td>
<td>$35,000 - $45,000</td>
</tr>
<tr>
<td>Proton Therapy (Complex - IMPT)</td>
<td>$65,000 - $110,000</td>
</tr>
</tbody>
</table>

RTOG 0938: “In addition to the potential for significant therapeutic gain, if a Hypofractionated regimen is found to produce comparable findings it would result in substantial health care cost savings and would also be more convenient for patients”
The Golden Standard:
Long-term Survival and Toxicity in Patients Treated With High-Dose Intensity Modulated Radiation Therapy for Localized Prostate Cancer. Spratt, Pei, Yamada, Kollmeier, Cox, and Zelefsky. MSKCC, 2013

- 1022 patients, 1997-2008, NCCN risk criteria
- 86.4 Gy using a 5-7 field IMRT technique
- 59% neoadjuvant and concurrent androgen deprivation
- Median F/U: 5.5 years (range 1-14 years).
- No prostate cancer-related deaths were observed in the low-risk group
- 74% retained sexual function at time of last follow-up.

<table>
<thead>
<tr>
<th>Toxicity</th>
<th>Grade 2+</th>
<th>Grade 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>GI</td>
<td>4.4%</td>
<td>0.7%</td>
</tr>
<tr>
<td>GU</td>
<td>21.1%</td>
<td>2.2%</td>
</tr>
</tbody>
</table>

Results:

Long-term Survival and Toxicity in Patients Treated With High-Dose Intensity Modulated Radiation Therapy for Localized Prostate Cancer. Spratt, Pei, Yamada, Kollmeier, Cox, and Zelefsky. MSKCC, 2013

<table>
<thead>
<tr>
<th>NCCN Risk</th>
<th>7yr BRFS</th>
<th>7yr DMFS</th>
<th>7yr PCSM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Risk</td>
<td>98.8%</td>
<td>99.4%</td>
<td>0%</td>
</tr>
<tr>
<td>Intermediate Risk</td>
<td>85.6%</td>
<td>94.1%</td>
<td>3.3%</td>
</tr>
<tr>
<td>High Risk</td>
<td>67.9%</td>
<td>82.0%</td>
<td>8.1%</td>
</tr>
</tbody>
</table>

- MV analysis predictive for DM: T stage (P<.001), Gleason score (P<.001), and >50% of initial biopsy positive core (P<.001)
- MV analysis predictive for PCSM: Gleason score (P<.004), percentage of biopsy core positivity (P<.003), and T-stage (P<.033)
“Conventional” High Dose IMRT” as the gold standard: Observations

- Minimize toxicity and not negate therapeutic gains
- Masterful technique: immobilization, daily set up reproduction
- Expert treatment planning: contouring, strict adherence to dose constraints
- Do not use the fastest plan and the fastest delivery!

- The long-term results of other dose escalation / intensification approaches like supplemental brachytherapy and hypofractionated stereotactic radiosurgery will need to be evaluated very carefully

- Do they achieve better tumor control with equal and less toxicity outcomes than conventionally fractionated high-dose IMRT?
“Moderate” Hypofractionated Prostate RT Studies

• Most used fraction sizes of 2-4Gy repeated daily for 15-30 fractions.

• Paved the way for SBRT studies.

• Careful with interpretation of failure:
  – ASTRO definition: 3 consecutive PSA rises – defines local control well
  – Phoenix definition: nadir + 2 ng/mL- a better predictor of distant metastasis, cancer-specific survival, and OS
HYPOFRACTIONATED INTENSITY-MODULATED RADIOTHERAPY (70 GY AT 2.5 GY PER FRACTION) FOR LOCALIZED PROSTATE CANCER: CLEVELAND CLINIC EXPERIENCE

Patrick A. Kupelian, M.D.,* Twyla R. Willoughby, M.S.,# Chandana A. Reddy, M.S.,† Eric A. Klein, M.D.,‡ and Arul Mahadevan, M.D.†

*Department of Radiation Oncology, M.D. Anderson Cancer Center Orlando, Orlando, FL; †Department of Radiation Oncology and ‡Glickman Urologic Institute, Cleveland Clinic Foundation, Cleveland, OH

- PTV: Prostate with 8 mm margins reduced to 4 mm posteriorly
- Median follow-up: 45 months (maximum 86)

<table>
<thead>
<tr>
<th>Risk Level</th>
<th>5-Year ASTRO Biochemical Relapse Free Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low risk</td>
<td>95%</td>
</tr>
<tr>
<td>Intermediate</td>
<td>85%</td>
</tr>
<tr>
<td>High risk</td>
<td>68%</td>
</tr>
<tr>
<td>Overall</td>
<td>82%</td>
</tr>
<tr>
<td></td>
<td>Acute Rectal</td>
</tr>
<tr>
<td>----------</td>
<td>--------------</td>
</tr>
<tr>
<td>0</td>
<td>51%</td>
</tr>
<tr>
<td>1</td>
<td>40%</td>
</tr>
<tr>
<td>2</td>
<td>9%</td>
</tr>
<tr>
<td>3</td>
<td>0%</td>
</tr>
<tr>
<td>4</td>
<td>0%</td>
</tr>
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</table>

RTOG Toxicity Scores

<table>
<thead>
<tr>
<th></th>
<th>Acute Urinary</th>
<th>Late Urinary</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>33%</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>48%</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>18%</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>1%</td>
<td>3</td>
</tr>
</tbody>
</table>

*Department of Radiation Oncology, M.D. Anderson Cancer Center Orlando, Orlando, FL; †Department of Radiation Oncology and Glickman Urologic Institute, Cleveland Clinic Foundation, Cleveland, OH
92 patients, T1c–2cNXM0, 2001-2004, median PSA 7.06
29 patients low-risk, 56 intermediate-risk, and 7 high-risk disease
Median follow-up 38 months

60 Gy/ 20 fx / 4 weeks, IGRT with fiducial markers.

ASTRO Biochemical Control = 76% at 3 years
Severe acute toxicity (Grade 3–4): 1 patient
Severe late toxicity (Grade 3): 0
• Hypofractionated RT: 55 Gy / 20 fx / 4 weeks
• Conventional RT: 64 Gy / 32 fx / 6.5 weeks
• Median FU 60 months
• GI and GU toxicity equal in both groups

<table>
<thead>
<tr>
<th>Biochemical Relapse-Free Survival @ 90 months (ASTRO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypofractionated</td>
</tr>
<tr>
<td>Conventional</td>
</tr>
</tbody>
</table>

Yeoh et al. IJROBP, 2006
Kuban et al., MD Anderson


• Phase III RCT: RT regimens based on maintaining equivalent acute toxicities while delivering a higher BED to the prostate

• 204 men randomized between:
  – CFRT (BED at $\alpha/\beta$ of 3 = 121): 75.6 Gy / 42 fx
  – HFRT (BED at $\alpha/\beta$ of 3 = 130): 72 Gy / 30 fx

• 5-year Phoenix FFBF rates:
  – CFRT: 92%
  – HFRT: 96%

• GI and GU toxicity rates: same
A word of caution!

Pollack et al. Five Year Results of a Randomized External Beam Radiotherapy Hypofractionation Trial for Prostate Cancer. IJROBP 2011

- RCT radio biologically designed to have
  - Equivalent acute toxicity between the HFRT (BED at $\alpha/\beta$ of 3 = 133) and CFRT (BED at $\alpha/\beta$ of 3 = 127)
  - Improved tumor control in the HFRT arm

- No statistically significant differences between the treatment arms in terms of BF or any failure
- GU toxicities were statistically higher in the HFRT arm (18.3% vs. 8.3%, $p = 0.028$)
- HFRT schedule had a significantly higher rate of GI toxicity during weeks 2 through 4
- Biological doses to the prostate (including the urethra) >80 Gy

- Initial assumption of iso-effectiveness of the trial design appears to be incorrect.
Results of Hypofractionation Prostate Studies: FFBF

Nicholas G. Zaorsky, Nitin Ohri, Timothy N. Showalter, Adam P. Dicker, Robert B. Den
Cancer Treatment Reviews, 2013
GU Toxicity of Hypofractionation Prostate Studies (RTOG 2+)

Nicholas G. Zaorsky, Nitin Ohri, Timothy N. Showalter, Adam P. Dicker, Robert B. Den
Cancer Treatment Reviews, 2013
GI Toxicity of Hypofractionation Prostate Studies (RTOG 2+)

Nicholas G. Zaorsky, Nitin Ohri, Timothy N. Showalter, Adam P. Dicker, Robert B. Den
Cancer Treatment Reviews, 2013
SBRT: Definition

- Fractional dose >5Gy
- Number of fractions <5
- Safe delivery is of utmost importance due to high fractional dose and small number of fractions. Each beam counts heavily.
- With RapidArc® technique, there are 1-3 arcs per treatment, so each arc counts heavily.
The Early SBRT Studies:  
*Madsen et al, 2007 (Virginia Mason Trial)*

- Phase I/II trial: 40 patients, median FU 41 months

- **SBRT with implanted fiducials: 33.5 Gy in Five Fractions**
  - *Calculated BED*: $33.5\text{Gy}/5\text{fx} = 78\text{Gy}$ in $2\text{Gy}$ fractions
  - $\alpha/\beta = 1.5\text{Gy}$

- ASTRO criteria FFR: 70% at 48 months
- No late Grade 3 GI / GU toxicity reported
- 6 patients developed impotence (26 reported potency pre-RT)

- Issues:
  - Small trial with limited follow up period (41 months)
  - BED calculations aimed low and alpha/beta high
Stanford SBRT Series
King et al., IJROPB, 82: 877–882, 2012

- Prospective single arm, 67 patients, 2003-09
- Stage <T2b, Gleason score 3+3=6 or 3=4=7, PSA <10
- Median FU 33 months

- Technique: SBRT with 5 mm prostate expansion except for 3 mm posteriorly using Cyberknife®

- PTV Dose: 36.25 Gy = 7.25 X 5 fractions (EQD2 = 91 Gy)
  - Daily for the first 22 patients, twice a week after
  - Normalized to 90% isodose line
  - Prescription dose covered 95% of volume

- DVH Rectum: V50% <50%, V80% <20%, V90% <10%, and V100% <5% (EQD2 = 74 Gy)
- DVH Bladder: V50% <40% and V100% <10% (EQD2 = 74 Gy)
- DVH femoral head V40% <5%
Stanford SBRT Series: Results

King et al., IJROPB, 82: 877–882, 2012

• PSA response after completion of SBRT shows a gradual decline

• Median PSA @ FU: 0.50 ± 0.72 ng/mL

• Relapse defined as PSA nadir +2 or biopsy proven recurrence

• 4 year BRFS = 94%

• 2 patients relapsed (biopsy proven) @ 2.8 and 3.2 years
# Stanford SBRT Series: Toxicity

*King et al., IJROPB, 82: 877–882, 2012*

<table>
<thead>
<tr>
<th>RTOG Toxicity</th>
<th>QD</th>
<th>QOD</th>
<th>P value</th>
<th>All patients</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GU TOXICITY</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade 0</td>
<td>37% (6/16)</td>
<td>80% (33/41)</td>
<td>0.003</td>
<td>68% (39/57)</td>
</tr>
<tr>
<td>Grade 1</td>
<td>50% (8/16)</td>
<td>12% (5/51)</td>
<td>0.004</td>
<td>23% (13/57)</td>
</tr>
<tr>
<td>Grade 2</td>
<td>6% (1/16)</td>
<td>5% (2/41)</td>
<td>1</td>
<td>5% (3/57)</td>
</tr>
<tr>
<td>Grade 3</td>
<td>6% (1/16)</td>
<td>2% (1/41)</td>
<td>0.48</td>
<td>3.5% (2/57)</td>
</tr>
<tr>
<td>Grade 4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>GI TOXICITY</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade 0</td>
<td>56% (9/16)</td>
<td>95% (39/41)</td>
<td>0.001</td>
<td>84% (48/57)</td>
</tr>
<tr>
<td>Grade 1</td>
<td>37% (6/16)</td>
<td>5% (2/41)</td>
<td>0.0004</td>
<td>14% (8/57)</td>
</tr>
<tr>
<td>Grade 2</td>
<td>6% (1/16)</td>
<td>0</td>
<td>0.28</td>
<td>2% (1/57)</td>
</tr>
<tr>
<td>Grade 3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Grade 4</td>
<td>0</td>
<td>0</td>
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</tr>
</tbody>
</table>
The Unknown....?????

- Optimal dosing for prostate hypofractionation
- Effects of dose escalation combined with hypofractionation
- Results and long term side effects of ultra-hypofractionation
RTOG 0938
A Randomized Phase II Trial of Hypofractionated Radiotherapy for Favorable Risk Prostate Cancer

- Accruing 174 patients with adenocarcinoma of the prostate biopsied within 1 year of randomization
- Gleason scores 2-6; Clinical stage T1-2a
- PSA < 10 ng/mL (should not be obtained within 10 days of biopsy)

- Arm 1: 36.25 Gy = 7.25 Gy X 5 fractions over 2.5 weeks (15-17 days)
- Arm 2: 51.6 Gy = 4.3 Gy X 12 daily fractions over 2.5 weeks (16-18 days)

- Stratify by treatment technique (machine)
  - All linear accelerator based treatment (excluding Cyberknife)
  - Cyberknife
  - Protons
RTOG 0938
Radiation Therapy Considerations

• Requires IMRT with inverse treatment planning or protons

• 3D-CRT dose delivery techniques are not allowed

• IGRT with radio-opaque fiducial markers or electromagnetic transponders implanted in the prostate must be used

• Maximum accrual from each center will be limited to 10% of the total protocol accrual.

• PI and Co-Chairs will perform a rapid review of the treatment plan for the first 5 cases from each institution prior to the institution delivering protocol treatment
RTOG 0938 RT Considerations
Total Prescribed Dose

- Arm 1: 5 fractions of 7.25 Gy = 36.25 Gy
  - Delivered twice a week over approximately 15-17 days
  - A minimum of 72 hours and a maximum of 96 hours should separate each treatment
  - No more than 2 fractions will be delivered per week

- Arm 2: 12 fractions of 4.3 Gy = 51.6 Gy
  - Delivered daily 5 days a week
  - Total duration of treatment: 16-18 days

- Dose Coverage:
  - Prescription dose should cover a minimum of 95% of the PTV
  - Minimum Dose within the PTV to a point that is 0.03 cc in size must be ≥ 95% of the prescribed dose.
RTOG 0938 RT Considerations
Proton Specific Doses

• For protons, the RBE is defined as 1.1
• Gy = Gy (RBE)/1.1

• Arm 1 (5 fractions): 7.25 Gy converts to 6.59 Gy physical proton dose
• Arm 2 (12 fractions): 4.3 Gy converts to 3.91 Gy physical proton dose

• Adjustments must be made during the treatment planning process to take into account the uncertainties along the beam direction, i.e. the range uncertainties, to ensure both distal and proximal coverage (distal and proximal margins).
Our Prostate SBRT Protocol

A Phase I Dose Escalation Study Using Ultra Hypofractionated, Image-Guided, Intensity-Modulated Radiotherapy in Prostate Cancer

• Participating Institutions:
  – Memorial Sloan-Kettering Cancer Center
  – Montefiore Medical Center, Einstein

• Objectives:
  – Primary: to assess toxicity of ultra hypofractionated prostate SBRT
  – Secondary objectives:
    • PSA relapse free survival
    • PSA kinetics
    • Pathologic response via repeat biopsy
    • Impact on sexual function

• Low and intermediate risk prostate cancer patients are eligible
Our Prostate SBRT Protocol

• Three different dose tiers:
  – 6.5Gy x 5 fxn every other day = 32.5Gy
  – 7.0Gy x 5 fxn every other day = 35.0Gy
  – 7.5Gy x 5 fxn every other day = 37.5Gy

• 30 patients for the first dose tier: no toxicity
• Second dose tier under way

• If there are more than 4 dose limiting toxicity events in any one cohort, trial will be terminated

• All patients will have fiducials placed and improved localization will allow for decreased size of PTV
Our Prostate SBRT Protocol

Simulation

- Fiducial markers placed at least one week prior to simulation
- Patient supine on Aquaplast® immobilization
- Oral contrast
- Full bladder, Foley catheter
- CT Simulation
Our Prostate SBRT Protocol

Target Volume Definition

• GTV: prostate gland

• CTV: prostate and seminal vesicles

• PTV expansion:
  – 5 mm in all dimensions except
  – 3 mm posteriorly toward rectum

• Normal tissues:
  – Outer and inner rectal wall (1 cm above & below PTV)
  – Outer and inner bladder wall (1 cm above & below PTV)
  – Large bowel
  – Small bowel
  – Bilateral femoral heads
Importance of Motion! 4D Localization
Our Prostate SBRT Protocol

Treatment Planning Parameters

**PTV**: 95% of PTV will receive ≥ 90% of prescription dose

\[ D_{95\%} \geq 90\% \]

**Normal Tissue Constraints**

<table>
<thead>
<tr>
<th>Structure</th>
<th>D(_{\text{max}}) (cGy)</th>
<th>D(_{\text{1cc}}) (cGy)</th>
<th>D(_{53%}) (cGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectal wall</td>
<td>&lt; 4175</td>
<td>&lt; 3850</td>
<td>&lt; 2400</td>
</tr>
<tr>
<td>Urethra</td>
<td>&lt; 4250</td>
<td>&lt; 4000</td>
<td></td>
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<tr>
<td>Bladder wall</td>
<td>&lt; 4250</td>
<td>&lt; 4200</td>
<td>&lt; 2400</td>
</tr>
<tr>
<td>Large bowel</td>
<td>&lt; 2900</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small bowel</td>
<td>&lt; 2500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Femoral heads</td>
<td>&lt; 3100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Prostate RapidArc vs. IMRT
Prostate RapidArc vs. IMRT

50% isodose curve
Prostate RapidArc vs. IMRT DVH

RapidArc has higher low dose volume than IMRT on femoral heads due to 360 gantry rotation.

IMRT: Triangle line
RapidArc: Square line

- IMRT Rectum
- RapidArc Rectum
- IMRT Rt Femoral
- RapidArc Rt Femoral
- IMRT bladder
- RapidArc bladder
Conclusions (???)

• Hypofractionation for prostate cancer is radio biologically sound and technically feasible

• SBRT for prostate cancer as presented is based on sound radiation biology, and is technically feasible and safe

• Long follow up is needed to confirm BRFS and low late toxicity rate

• Low and intermediate risk prostate cancer patients should be enrolled into well designed SBRT clinical trials
The Montefiore Einstein Radiation Oncology Prostate Team

Madhur Garg, MD (Program Leader)
William Bodner, MD
Chandan Guha, MD, PhD
Ravindra Yaparpalvi, MS (Physics)
Dinesh Myampathii, PhD (Physics)
Hilda Haynes, ARN (Protocol Coordinator)
Joanna Mikhail, NP (Program Coordinator)
Shankar Vishwanathan, PhD (Statistics)
Thank you!