Prostate HDR Treatment Planning – Considering CT

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Disclosures

- None

Objectives

- Review prostate HDR techniques based on CT
- Discuss the challenges and pitfalls
- Review an example of a QA process/clinical workflow for CT

CT-based Planning: Seattle Technique (1990's)

HIGH DOSE-RATE AFTERLOADING [192]IRIDIUM PROSTATE BRACHYTHERAPY: FEASIBILITY REPORT

TIMOTHY P. MATE, M.D.,* JAMES E. GOTTESMAN, M.D.,* JOHN HATTON, CMD,* MICHAEL GRIBBLE, M.SC.* AND LYNN VAN HOLLEBEKE, R.N.*

*Seattle Prostate Institute, Swedish Hospital Medical Center, 1221 Madison Street, Seattle, WA 98104

- Feasibility study of multi-fraction HDR prostate brachytherapy
- From 1989-1995: 104 patients
- One implant, 3.0 Gy – 4.0 Gy x 4, with 50.4 Gy EB
- Described evolution of their CT-based technique

Int. J. Radiation Oncology Biol. Phys., Vol. 41, No. 3, pp. 525–533, 1998

Seattle Technique -- Implant

- Transperineal needles
- Transrectal U/S (TRUS) guidance
- 18-22 needles (evolving configuration)
- Template sutured to perineum
- Flexible cystoscopy to verify needle insertion (with legs down)

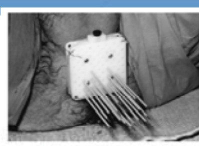


Fig. 4. Patient with completed implant. The use of plastic afterloading catheters allows for easy identification at time of postimplant CT.

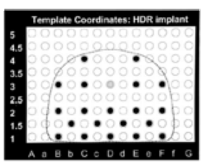


Fig. 3. Typically, 18 to 22 needles are used in our current implant configuration. Note that, in Rows #3 and #4, there are no midline

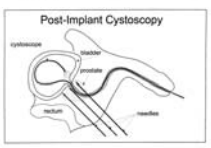


Fig. 5. Flexible cystoscopy helps ensure that the needle tips are

Seattle Technique -- Imaging

- Post-op CT, legs down
- Lateral Scout to verify needle positions just beneath bladder
- Contrast in bladder (define superior extent of prostate)
- Contrast in urethra
- Image base to apex, 5-mm cuts, perpendicular to the needle array to record needle position (tilted gantry)
- Prostate margin contoured (no mention of OAR volumes)

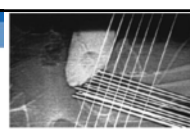
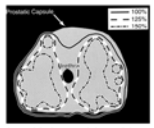


Fig. 6. A lateral scout view at the time of postimplant CT is first done to verify needle location. Note that the needle tips are positioned just under the bladder to be sure that the prostate base and prostoseminal vesicle junction are adequately implanted.

Fig. 7. A postimplant CT begins the treatment-planning process. Images are obtained at 5-mm increments from base to apex, on which the prostate margin is marked on each image. The plastic afterloading tubes show as air-filled chambers. Bladder contrast

Seattle Technique – Dosimetry

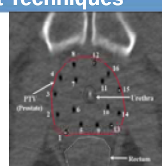
- CT-based optimization of HDR dwell times
- Peripherally weighted dose distribution (focus on areas of disease)
- V100 at least 90%
- Limit urethra to 120% isodose
- → compromise in coverage (areas of low tumor probability)
- B or R dose-volume constraints??

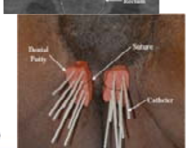


CT-based Planning: Current Techniques

- Other implementations similar
  - Commercially available templates
  - Fixed LDR-like needle grid
  - Needles fixed to the template by means of a locking screw
- Another CT-based technique (2000's)
  - "Freehand" implant technique pioneered by UCSF RO team
  - More flexibility in needle spacing
  - Custom made template with friction collars to hold catheters in place
  - One implant, 19 Gy x 2, with 45 Gy EB

JOURNAL OF APPLIED CLINICAL MEDICAL PHYSICS, VOLUME 8, NUMBER 4, FALL 2007





UCSF Technique – Freehand Implant

- Entry points marked on perineum to avoid urethra and ischium, on either side of median raphe
- 16 fr luer lock needles inserted under TRUS guidance (no template).
- Friction collars are placed ahead of time by OR.
- Obturators removed, luer locks trimmed off, aquaplast used to more evenly space the needles

Images courtesy of I-Chow J. Hsu

UCSF Technique – Custom Template

- 1 Tbsp. dental putty and activator rolled together
- Dental molding putty placed around needles/friction collars to keep needles in place (hardens in 3 minutes)
- Two putty "templates" (one per side)
- Cystoscopy after procedure determine if anterior four needles are "tenting" the bladder.

Images courtesy of I-Chow J. Hsu

Putty: Pickett B, Pouliot J. Prostate brachytherapy. In: Van Dyk J, ed. Modern technology of radiation oncology. Vol 2. Madison (WI): Medical Physics Publishing; 1999:387–421.

UCSF Technique -- Dosimetry

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- Non-contrast CT
- Dwell time optimization performed
- Manual dose shaping
- Planning Constraints (RTOG 0321):
  - PTV → V100% ≥ 90% (with urethral sparing this may be lower, V100% > 80%)
  - Bladder and Rectum = V75% < 1cc. (Per RTOG 0321)
  - Urethra (foley-defined)= V125% < 1cc;

RADIATION THERAPY ONCOLOGY GROUP
RTOG 0321
PHASE II TRIAL OF COMBINED HIGH DOSE RATE BRACHYTHERAPY AND EXTERNAL BEAM RADIOTHERAPY FOR ADENOCARCINOMA OF THE PROSTATE

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Objectives

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Challenges/Pitfalls: Catheter Movement

- Literature shows that catheters (needles) locked to the perineal template still exhibit interfraction displacements, possibly due to
  - changes in acute edema between the prostate and the perineal skin
  - changes in OARs, i.e., rectal filling
- Studies report interfraction displacements ranging from 3 mm to 20 mm

Brachytherapy 12 (2013) 260–266

Int. J. Radiation Oncology Biol. Phys., Vol. 80, No. 1, pp. 85–90, 2011

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Challenges/Pitfalls: Catheter Movement

- Not all catheters move by the same amount (e.g., anterior vs. posterior)
- Not all catheters have an equal effect on dose delivered (catheters with long vs. short total dwell time)
- The pattern of displacement is affected by many factors:
  - fractionation scheme
  - implant equipment, such as the type of catheters and templates used
  - how the displacements are measured
  - what corrective actions are done to address catheter migration
- → Catheter movement needs to be evaluated for a particular technique and corrective actions need to be developed

Brachytherapy 12 (2013) 260–266 Int. J. Radiation Oncology Biol. Phys., Vol. 80, No. 1, pp. 85–90, 2011

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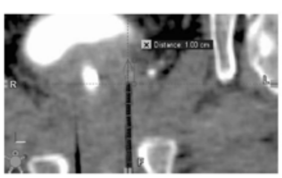
Henry Ford -- Correction Methods

- Process to restore catheters to their planned positions if ≥ 3mm (Tiong *et al*, preserve tumor control)
- 1 implant, 3-4 fx over 2 days
- Verify CT (vCT) prior to latter fractions
- Rigidly registered based on implanted fiducials and calcifications in prostate
- Determine amount to adjust each catheter manually (~20 min for 11-19 needles)
- MD makes adjustment→ treat (no rescan, no post dosimetry)

Online correction of catheter movement using CT in high-dose-rate prostate brachytherapy

Yimei Huang*, Brett Miller, Anthony Doemer, Dan Babij, Sanath Kumar, Rene Prontera, Teamour Nurushev, Indrin J. Chetty, Ibrahim Aref



Brachytherapy 12 (2013) 260–266

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Challenges/Pitfalls: Correction Methods

- Just one example of a correction method
- Other options using a vCT:
  - Recalculate dose on new scan using *shifted* catheter positions & re-optimize if necessary
  - Push catheters back in then rescan/replan
  - Other questions: Re-define volumes on new scan or just register old contours?
    - Prostate, OARs
    - CBCT vs CT as the verify scan
- Time-consuming solutions
- Another option: multi-fx → single-fraction (UCSF)

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CT-based Planning: WUSM/SCC (2014)

- January 2014: Initiated single fraction prostate HDR
  - 19 Gy x 1 monotherapy** or 15 Gy x 1 as boost
- Volume
  - 9 in 2014
  - 36 in 2015
  - 19 by 06/2016 (Mondays every week)
- Implemented the freehand technique pioneered by UCSF RO team

***Prada et al, (Spain) Brachytherapy. 2012;11(2):105-110*
***Prada et al. Radiotherapy and Oncology 119 (2016) 411–416*
***Hoskin et al. (UK) Radiotherapy and Oncology 110 (2014) 268–2712*

Prep for HDR Prostate at WUSM/SCC

- Reached out to our peers
  - Visits to other clinics (CT-based, U/S-based techniques)
  - On-site training from vendors (TPS and U/S system)
  - UCSF MD proctored our first treatment
- Discussed workflows & associated staffing needs, timelines
  - Involved teams (RO team, O/R scheduling and recovery, urology)
- Investigated, purchased, & commissioned equipment
  - U/S, stepper, needles, immobilization systems
- Dry-runs
  - Practice plans
  - Mock implants (Fruit, U/S phantom) with mock O/R table set up
  - Practice putty templates
- Generate documentation (procedures, checklists)

civco.com & bkultrasound.com

Decide on a Workflow

Pre- Implant | **Implant and Treatment** | **Post Treatment**

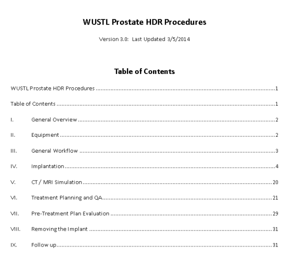
Volume Study → Implant in OR (~2 hr, AM) → Recovery (1-2 hr, AM) → Patient to Rad Onc → CT/MR Scan(s) → Planning & QA → Treatment → Implant Removal → Follow Up

Another challenge/pitfall: long timelines--even with one fraction!

-Implant in OR ~ 7:30-8:30 am
-Recovery ~ 10:30-11:30 am
-CT ~ 11:30-12:30 pm
-Treat in HDR suite ~ 2-4 pm

Documentation

- 39 page procedural document
- Patient informational packet (hospital)
- Recovery staff instructions
- Multiple checklists for therapists, dosimetrists, physicists…*developed over time and with more experience*



WUSTL Prostate HDR Procedures

Version 3.0: Last Updated 3/5/2014

Table of Contents

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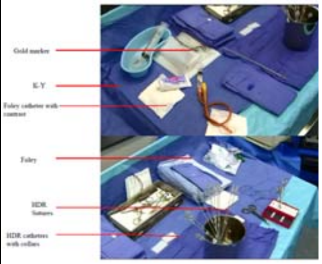
Equipment and OR Setup → Therapist Checklist



Effective date: 4/6/2015

HDR Prostate Supply Prep Checklist

We Bring to OR:

- ☐ Brachy Prostate Pack
- ☐ Prostate Cart
- ☐ Prolene Sutures x2
- ☐ Gold Seed Markers
- ☐ US manipulating arm
- ☐ US arm base
- ☐ US unit(w/prostate probe)
- ☐ Endocavity water standoff kit:
  - Tape for water channel
- ☐ Alcohol Gauze Jar
- ☐ 16 FR Sterile Leur lock Catheter needles
- ☐ 4 pillows
- ☐ Dental putty in separate containers:
  - 1 scoop putty base
  - 1 scoop putty activator
- ☐ Paint pen
- ☐ Sterile marker & ruler
- ☐ Red catheter numbers
- ☐ Aquaplast grids (3 x 4.5cm approx.)
- ☐ Striker stretcher ordered for OR by 4pm the day before.
- ☐ Patient's chart
  - Copy of brachy consent
  - Copy of procedure consent
  - HDR Prostate yellow Rx sheet
  - Radiation Oncology Admission History
  - Pathology
  - Volume Study Notes
- ☐ Sterilized friction cuffs
- ☐ Sterile gloves for putting on cuffs

OR will Supply:

- ☐ Sterile gloves for Dr.
- ☐ Sterile instrument pack
  - Scissors
  - Needle driver
  - Pickups
  - Towel clamps
- ☐ Sterile H2O/ Saline for probe cover
- ☐ OR table
- ☐ OR Fluoro (if needed)
- ☐ Foley Catheter
- ☐ Contrast
- ☐ Cystoscope w/180 degree rotation

Unologist: ____________

Number: ____________

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CT Simulation

- Care must be taken when transferring patient from stretcher to CT couch and back → minimal disturbance of implant.
- HoverMatt® single-use, air mattress for easier transfer
- Legs strapped to pillows, slightly apart
- HFS, arms on chest
- CT protocol (specific): One scan → two datasets: 2 mm thick slices of entire implant, 1 mm high res recon near distal end of implant to properly localize needle (catheter) tips
- Need to check needles go deep enough to cover prostate → adjustments can be made on CT couch as needed
- Physics is present in the sim with a checklist to guide the process…

www.hovermatt.com

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CT Simulation Checklist – Physics

BJH/WUSM/SCC HDR Prostate Medical Physics Consultation

Patient: Patient ID:
Radiation Oncologist: HAG Rx: 15 Gy or 19 Gy ? Implant Date:

Typical Needle Configuration

RT		LT	
1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16

**RT/LT = Patient's right and left

Actual Needle Configuration at Time of CT sim

RT	LT

Yes No
- ☐ ☐ Record needle positions on diagram above?
- ☐ ☐ O.R. needle marks in blue aligned w/ corresponding template? If no, needles may be loose.
- ☐ ☐ Needles tight within putty? If no, may have to glue needles *after* MD has verified needle placement.
- ☐ ☐ Exiting needle length at least 5 cm from template (min 3 cm)? If no, alert MD that these needles cannot be pushed in further, or may not be usable for treatment. Maybe needle(s) can be pulled out.
- ☐ ☐ Acquire CT using HDR Prostate Protocol with imaging extents set for 2mm and 1 mm recon?
- ☐ ☐ CT: is template flush against skin? If no, recommend building up putty thickness adjacent to skin.
- ☐ ☐ CT: is template thickness ≥ 3 cm (min 2cm)? If no, recommend building up putty thickness.
- ☐ ☐ CT: do needles reach prostate base? If no, recommend adjustment of needle depths.
- ☐ ☐ Adjustment performed by MD to push needles towards prostate base? Re-check exit needle length.
- ☐ ☐ If adjusted, are needles still tight within putty?
- ☐ ☐ Needles glued into place by Physics (if necessary)?
- ☐ ☐ Needles re-marked by Physics in red (if necessary)?

Catheter marks placed by RTTs in O/R after implant

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Treatment Quality Assurance – Physics

- Plan QA
  - On-screen/printout review of
    - Plan Parameters
    - Plan quality (RTOG 0321)
  - Independent calculation check of treatment time
  - Plan QA Checklist for Physics
- Pre-treatment QA
  - Similar to other HDR intersitital treatments

HDR Prostate Checklist	Checked?	Comments
Correct image set (Series?, # of images?)		
Plan Properties:		
Rx Dose (Mosaiq vs Plan)		
[illegible]		
Check all contours		
Channel:		
Channel numbering		
Digitization		
Correct machine assigned to applicators		
Catheter lengths		
Step size = 0.5 cm?		
Offset = 0.5 cm?		
Dwell Times:		
Distribution of dwell times reasonable?		
No 0.1s dwells		
No empty channels		
Isodoses		
Prostate DVH:		
V100 ≥ 90% (Min V100 = 85%)		
Urethra:		
V125 < 1cc		
V150 = 0%		
Bladder & Rectum:		
V75 < 1cc		
V100 = 0%		
Implant DVH:		
HI = (1- V150/V100) ≥ 0.5		
P-P Calc within 15%?		

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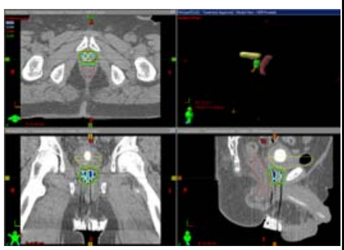
Conclusions on CT-based Prostate HDR

- Been around since early 90's
- WUSM: long history of CT-planned HDR interstitial brachytherapy → "easiest" modality to implement
- Variations in workflow (e.g., dose-fractionation, implant technique, equipment)
- Brief history of HDR prostate brachytherapy, please refer to the *ACR Appropriateness Criteria®: High-dose-rate brachytherapy for prostate cancer* (on-line)



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