Prostate HDR Treatment Planning – Considering CT

Jacqueline E. Zoberi, Ph.D.
Washington University School of Medicine
Siteman Cancer Center
Saint Louis, MO

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
• 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

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)

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)
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

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
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 J-Chow J. Hsu

UCSF Technique – Dosimetry

- Non-contrast CT
- Dwell time optimization performed
- Manual dose shaping
- Planning Constraints (RTOG 0321):
  - PTV \( \rightarrow \) \( V_{100\%} \geq 90\% \) (with urethral sparing this may be lower, \( V_{100\%} > 80\% \))
  - Bladder and Rectum = \( V_{75\%} < 1cc \) (Per RTOG 0321)
  - Urethra (foley-defined) = \( V_{125\%} < 1cc \)

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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

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

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)
**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) 268–271**
Prep for HDR Prostate at WUSM/SCC

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

Decide on a Workflow

Pre-Implant
  - Volume Study
  - Implant in OR (~2 hr. AM)
  - Recovery (~1-2 hr. AM)

Implant and Treatment
  - Patient to Rad Onc
  - CT/MR Scan(s)
  - Planning & QA
  - Treatment
  - Implant Removal

Post Treatment
  - Follow Up

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

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
CT Simulation

- Care must be taken when transferring patient from stretcher to CT couch and back to 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): Two scans → two datasets. 2 mm thick slices of entire implant, 1 mm high res scan 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...

CT Simulation Checklist – Physics

Catheter marks placed by RTTs in OR after implant
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 interstitial treatments

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)