Image-Guided Prostate Brachytherapy: A US/MR-Based HDR Workflow

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Conflict of Interest

- Nothing to disclose

- I do not endorse any products, manufacturers, vendors, or suppliers mentioned in this talk.
Objectives

✓ Overview of our center’s experience performing intraoperative prostate HDR brachytherapy using US and MR image guidance

✓ Describe of the prostate HDR treatment workflow including:
  o Image acquisition
  o Contouring
  o Pre-planning
  o Needle insertion
  o Needle reconstruction
  o Dose optimization and evaluation
  o Treatment preparation and treatment

✓ Discuss challenges encountered as well as practical tips and tricks for ensuring a smooth procedure
UNMC HDR Prostate Brachytherapy Program
UNMC HDR Prostate Brachytherapy Program

• Treatment types:
  o **Boost**
    ▪ 110+ patients
    ▪ Primarily US guided (with some MR guidance)
    ▪ 1 x 15 Gy HDR followed by 25 x 1.8 Gy EBRT
    ▪ SpaceOAR and fiducials implanted after HDR
  o **Focal Salvage**
    ▪ 5 patients
    ▪ US/MR guided
    ▪ 2 x 13 Gy, 2 wks apart

• Logistics:
  o Treat ~1-2 patients per week
  o Sometimes treat 2 patients per day
HDR Boost Treatment Workflow

- Prep equipment
- Prep patient
- Preplan
- Needle insertion

- Final plan
- Prepare for Tx
- Treat
- Teardown, clean, document
Prep equipment in treatment room:

- Stepper
- Sterile supplies (template)
- Ultrasound
- Afterloader
- Oncentra Prostate Computer

Prep equipment
Prep patient
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Teardown, clean document
Prep equipment in treatment room:

- Prepare US brachy balloon:
  - Fill inside with US gel
  - Slide balloon to US probe and tape end down to secure in place
  - Fill with saline using syringe
  - Remove all air bubbles!
**Prep equipment in treatment room:**

- Sterile OR nurse/tech will assemble template & prep all sterile items

- Insert needle and test locking mechanism

- Measure distance to ensure template height has not changed
Prep Patient:

- Patient put under general anesthesia
- Anesthesia administers paralytic (Rocuronium)
- Patient placed in dorsal lithotomy position (ensure legs are level)
- Foley catheter placed
- Suction rectum (if needed)
- Use Ioban to tape genitals away from perineum
- Prep perineum with Iodine
- Time out
- Attach stepper and US to couch, insert probe
- Insert template into stepper holder arm
- Place sterile drapes
Optimize US placement and image quality:

- Center the prostate laterally in the template/grid (urethra aligned with column “D”)

- Adjust the probe height or inflate the brachy balloon so that the bottom template/grid row is a few mm above to the posterior edge of the prostate
  - Don’t overdo it though! Else, the rectum may be squashed against the prostate and/or the prostate will be pushed anteriorly into the pubic arch

- Ensure there are no ultrasound artifacts

- Ensure the whole prostate from base to apex (plus some margin) is well visualized
Pre-plan: Acquire 3D US image → Contour → Insert virtual needles → Optimize plan
Pre-plan: **Acquire 3D US image** → Contour → Insert virtual needles → Optimize plan

- Acquire 3D US image:

Video courtesy of Elekta https://www.youtube.com/watch?v=zSuWCw2Z3c4
Pre-plan: **Acquire 3D US image** → Contour → Insert virtual needles → Optimize plan

**Challenge: Artifacts**
- Air bubble in brachy balloon
- Gas/stool in rectum
- Bad contact between the probe and rectum

**Recommendation:**
- Fix the issue and re-image to ensure accurate visualization
Pre-plan: Acquire 3D US image → **Contour** → Insert virtual needles → Optimize plan

- CTV = whole prostate on US, seminal vesicle(s) include if disease is present
- PTV = prostate + 0-3 mm asymmetric margin
- No formal US/MR image registration, but pull up diagnostic Ax T2 MR side-by-side → compare length/width/height and volume
- Rad Onc relays areas of disease seen on MR to physics team to ensure full coverage in those regions

**3D US in TPS**

**Ax T2 MRI**

compare side-by-side

**PTV** = prostate + 1-3 asymmetric margin
Pre-plan: Acquire 3D US image → Contour → **Insert virtual needles** → Optimize plan

Needle placement guidelines:

1. Use ~10-20 needles, “less is more”

2. Follow approximate peripheral loading

3. Try to space out needles from each other

4. Avoid radially overlapping needles if possible (prevents shadowing of anterior needles by artifacts of posterior needles)

Pre-plan: Acquire 3D US image → Contour → **Insert virtual needles** → Optimize plan

Needle placement guidelines:

5. Use template loading pattern for guidelines
Needle placement guidelines:

6. Do not place needles through urethra (blocked in Oncentra)

**Pre-plan:** Acquire 3D US image → Contour → **Insert virtual needles** → Optimize plan

Only 1 row blocked due to urethra being narrow and straight

5 rows blocked due to urethra bending laterally! (may have to disable blocking)
Pre-plan: Acquire 3D US image → Contour → **Insert virtual needles** → Optimize plan

Needle placement guidelines:

7. Ensure the lowest template row in the prostate is a few mm above the posterior edge
Pre-plan: Acquire 3D US image → Contour → Insert virtual needles → Optimize plan

Rx = 15 Gy x 1
Needle insertion pushed prostate slightly superior

Video courtesy of Elekta https://www.youtube.com/watch?v=2SuWCwZ3c4
Insert Stabilization Needles:

- Stabilization needles help keep the prostate from being pushed superiorly as the treatment needles are inserted
- Choose 2 unused grid locations near middle of prostate
Challenge: Needles aren’t going in the desired direction

Possible solution: Use diddler (similar to crochet needle) between template and patient to bend needles
**Challenge:** Pubic Arch Interference

**Possible solutions:**
- Angle patient’s legs farther back towards chest (>90°)
- Change angle of US probe/template
- Reduce filling of the brachy balloon
- Use diddler to try to bend needle underneath pubic arch
- Adapt plan and choose new needle locations
**Final-plan:** Acquire 3D US image → Contour → Reconstruct needles → Optimize plan
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PrePlan CTV Contour for guidance
Final-plan: Acquire 3D US image → Contour → **Reconstruct needles** → Optimize plan
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**Challenge:**
Artifacts or US image quality makes reconstructing needles difficult. Sometimes needles can be nearly invisible.

**Solution:**
Go back to live imaging, re-insert obturator, & wiggle it until you can see it. Use live reconstruction.

**Measure Freelenlength:**

- Measure needle freelenlength with ruler
- Enter measured freelenlength into TPS
- Ensure measured value is relatively close to the tracked freelenlength
- **Tip:** We perform the measurement in parallel with the final planning (contouring and needle reconstruction) to save time.
Information needed to accurately localize the dwell positions:

1. Measured needle freelength
2. Location of the needle tip
3. Distance from the needle tip to the first dwell position
4. Catheter index length

Teardown, clean document

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Treat

Final-plan: Acquire 3D US image → Contour → Reconstruct needles → Optimize plan

Dose Objective Guidelines: ABS, RTOG 0321, RTOG 0924, & other institutions

Prepare for treatment:

- Perform 2nd check calculation
- Prepare documentation
- Send plan to afterloader control computer
- Physics 2nd check
- Connect needles & transfer tubes to afterloader
- Check cable run
- Pre-tx survey, safety checks, post signs, etc

Images courtesy of Sunnybrook Health Science Centre https://sunnybrook.ca/content/?page=60442
HDR Focal Salvage Workflow

- Patients with locally recurrent prostate cancer after previous radiation treatments
- Focal HDR brachytherapy to the PI-RADS lesion
HDR Focal Salvage Workflow

1. Radiologist marks PI-RADS lesion
   - AX T2 TSE MR, 2 mm slices, acquired within 1 wk of tx

2. Rad Onc contours focal GTV
   - Needle insertion: ~5-12 needles

3. Acquire 3D ultrasound
   - Rx = 2 x 13 Gy (2 wks apart)
   - Use salvage dose objectives

4. Register MR/US & contour
   - PTV = GTV + 5 mm, retract from OARs

References:
Summary

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Images cited throughout