Before We Start....

HOW TO ACCESS AND REVIEW

• Go to https://proknowsystems.com/
• Sign in (if you don’t an account, create a free one)
• After you’re signed in, enter “Select Organization: AAMD”
• Top menu, select “Contouring Accuracy”
• Select structure
• To contour, click on “Contour and Score”
• For interactive population results, you need to have contoured and submitted at least one try (per structure), then you will have access to the “Population Results” tab

AAMD 2019 Contouring Workshop
Male Pelvis

Aaron Kusano, MD SM & Matthew Ladra, MD MPH
June 16, 2019
Disclosures

ProKnow Systems: Paid Consultant
Research supported by ProKnow Systems

The “Anatomy” of this Workshop

1. Review Pre-Meeting Contouring Results
2. Physician Lecture
3. Live Contouring Exercises & Instant Review of Results

Move on to next structure
### Dice Coefficient: Intuitive but Low-Sensitivity Measure of Accuracy


\[
\text{Dice Coefficient} = \frac{2 \times |X \cap Y|}{|X| + |Y|}
\]

- Demonstrates the amount of overlap
  - A perfect overlap = 1.00
  - No overlap = 0.00
- May not be sensitive enough for RT contouring
  - Large voxel error (e.g. 20 mm) is penalized the same as an insignificant error (e.g. 1 mm)

### StructSure Score: High-Sensitivity Measure of Accuracy

Penalty per Error Voxel = (Voxel Penalty/mm) * (Distance Error mm – 1 mm Forgiveness)

Accuracy Score = 100 x [# Reference Voxels – S Voxel Penalties] / # Reference Voxels
A Contour Accuracy Metrics for Radiation Oncology

There was significant inter-clinician variation in OAR contouring. The degree of variation is organ-dependent. We found substantial dose differences resulting strictly from contouring variation (differences ranging from $–289\%$ to $56\%$ for mean OAR dose; $–22\%$ to $35\%$ for maximum dose).

"Is a StructSure score predictive of DVH accuracy? Yes."

StructSure score of > 70 predicts dose error within 10%
Measuring Contour Accuracy is Important, but Disruptive

- In an ideal world,
  - we would have been measuring contouring accuracy starting in the 1990s when 3D planning became prevalent,
  - and even more so with the introduction of highly conformal plans (IMRT, VMAT, proton, etc.).

- This is not an ideal world.
  - However, better late than never.
  - The importance of high accuracy, high precision contouring is finally receiving its due ...

- But, what happens when we start measuring experienced, practicing professionals with a highly sensitive contouring metrics?

Outline

- Background
- Male Pelvis
- Organs
  - Penile Bulb
  - Prostate
  - Seminal Vesicles
Background

“A review of target delineation and image segmentation prior to planning deserves more standardization.”
Aggregate analysis of RO-ILS data indicates that more than a quarter of all reported events occurred in treatment planning.

Common Theme: events related to normal tissue definition
- Critical structures not contoured
- Normal tissues incorrectly or incompletely delineated

"The comprehensive identification and delineation of organs at risk (OARs) are vital to the quality of radiation therapy treatment planning and the safety of treatment delivery."
So..... Take a Deep Breath

https://www.rtog.org/CoreLab/ContouringAtlases/MaleRTOGNormalPelvisAtlas.aspx
### Other Resources...

**CLINICAL INVESTIGATION**

**PENILE BULB IMAGING**

KENT E. WALLNER, M.D., *‡ Gregory S. Merrick, M.D., § Mark L. Benson, M.D., § WAYNE M. BUTLER, Ph.D., ‡ JEFFREY MAKI, M.D., § and BRYAN G. TOLLENAAR, M.S. §

Departments of *Radiation Oncology and ‡Diagnostic Radiology, Department of Veterans Affairs, Puget Sound Health Care System, Seattle, WA; §Department of Radiation Oncology, University of Washington, Seattle, WA; §Schiller Cancer Center and §Department of Radiology, Wheeling Hospital, Wheeling, WV; §Division of Radiation Oncology and Biophysics, The George Washington University Medical Center, Washington, DC

**CLINICAL INVESTIGATION**

**RADIOGRAPHIC AND ANATOMIC BASIS FOR PROSTATE CONTOURING ERRORS AND METHODS TO IMPROVE PROSTATE CONTOURING ACCURACY**

PATRICK W. MCLAUGHLIN, M.D., ‡‡ CHERYL EVANS, M.S., ‡ MARY FENG, M.D., ‡ and VRINDA NARAYANA, PH.D., ‡‡

‡‡ Department of Radiation Oncology, University of Michigan, Ann Arbor, MI; and ‡‡Department of Radiation Oncology, Providence Cancer Center, Novi, MI
Contributing Factors Contour Variation

- Radiographic – Image quality and observer interpretation
- Anatomic – Variable positional anatomy from person to person
- Developmental – variable changes that can happen with BPH
Penile Bulb (pre-meeting contours)

Consensus

Click to activate mouse wheel slice navigation

Population Results

Histogram of Initial Dice Coefficient
N: 62 | Min: 0.00 | Max: 0.87 | Median: 0.58 | Mean: 0.33 | Std Dev: 0.19

Frequency

Initial Dice Coefficient
Penile Bulb (pre-meeting contours)

Population Results

Histogram of Initial Score

N: 62 | Min: 0.00 | Max: 96.70 | Median: 0.00 | Mean: 12.89 | Std Dev: 23.86

Expert Contour Volume = 2.7cc
**PENILE BULB**

- Penile bulb bounded by crura laterally, the corpora cavernosum/spongiosum anteriorly, and the levator ani posteriorly

https://en.wikipedia.org/wiki/Corpus_spongiosum_penis

---

**PENILE BULB**

- Crura attach to ischiopubic rami
- Between crura, the corpus spongiosum enlarges forming the penile bulb
- Penile bulb attaches superiorly to the inferior surface of the urogenital diaphragm

Fig. 2. Mid-bulbar CT and MR images. The asterisk indicates the penile bulb.

PENILE BULB

STARTING INFERIORLY BELOW THE ISCHIAL TUBEROSITIES
SCROLL SUPERIORLY PAYING ATTENTION TO MUSCLES
OBSERVE THE PLANES THAT BECOME APPARENT BETWEEN MUSCLES
DO NOT EXTEND INTO ANTERIORLY INTO PENIS

https://www.health.harvard.edu
Genitourinary Diaphragm (GUD)
Muscular layer separating the pelvic cavity from the perineal region
Also referred to as Urogenital Diaphragm

https://www.earthslab.com/anatomy/urogenital-diaphragm/
**Superior to the Penile Bulb**

Penile Bulb should have a visible fat plane where you can distinguish it from the crura.

Superior to this...

---

**Loss of fat plane (inferior GUD)**

There will be clear loss of fat plane.

Anterior to the rectum and and bounded by the pelvic bone, a triangle shape forms the inferior GUD.

---

Loss of fat plane (inferior GUD)

The center of the GUD will have a circular appearance where the external sphincter lies.

Still inferior to the to the prostate

Hourglass shape of the superior GUD

Just above the GUD, Apex of the prostate

Prostate (pre-meeting contours)
Prostate (pre-meeting contours)

Population Results

Histogram of Initial Dice Coefficient

N: 59 | Min: 0.02 | Max: 0.99 | Median: 0.91 | Mean: 0.89 | Std Dev: 0.12

Frequency

Initial Dice Coefficient

47

Prostate (pre-meeting contours)

Population Results

Histogram of Initial Score

N: 59 | Min: 0.00 | Max: 97.36 | Median: 99.21 | Mean: 92.04 | Std Dev: 20.99

Frequency

Initial Score

48
Prostate (pre-meeting contours)

Population Results

Histogram of Initial Volume (cc)

Expert Contour Volume = 79cc

PROSTATE

Retrospective data suggests prostate apex is at least 1cm above upper limit of penile bulb (Li et al. Chin J Cancer 2010)

• Also commonly mentioned: Apex starts 1.5cm above the penile bulb
PROSTATE – CT delineated volumes

• Most studies suggest that prostate contours created on CT datasets alone typically overestimate the true prostate volume
  • Gao et al. physician delineated prostate volume on average 30% larger than the "true" prostate volume
  • Included only 84% of the gold standard volume, on average
• Systematic delineation errors
  • Missing posterior portions of the prostate
  • Over-contouring anterior prostate
Common Prostate Contouring Errors

Creating a pedestal by continuing apex contour inferiorly through the GUD


Common Prostate Contouring Errors

Inferiorly contouring into the GUD anteriorly (bone as boundary) or posteriorly (rectum as boundary)

Common Prostate Contouring Errors

Contouring large projections of the SV as prostate. (Hard not to unless you’ve got MRI)

Common Prostate Contouring Errors

Contouring bladder fascia anteriorly and superiorly as prostate
Common Prostate Contouring Errors

Underestimating the superior extent of prostate that connects to bladder neck

PROSTATE APEX
Lowest portion of prostate
• Exact caudal extent of apical glandular elements challenging due to pelvic floor muscles
Prostate Apex Contouring Errors

- Majority of time overestimated
  - Tough to distinguish apex from adjacent muscle on CT
  - Parts of GUD can easily be mistaken for the prostate
  - Exclusively using rectum as posterior border of prostate
  - Assuming prostate has fixed relationship with bony anatomy
  - Wide variation in anterior fascial space/dorsal venous complex

PROSTATE – Anterior Border

Retropubic Space
- Fat and Venous Plexus
- Anterior Fibromuscular Stroma (AFMS)
  - Dark on T2
  - Contiguous with bladder neck
  - Contains no glandular tissue

Difficult on CT to locate anterior extent of AFMS as has similar density to adjacent venous plexus (not bad idea since some prostate cancers of transition zone may involve AFMS). OK when using only CT to include the venous plexus and any nonfatty tissue in the retropubic space
**PROSTATE – Lateral borders**

Prostate does not extend into or beyond the levator ani muscles
- Levator ani is the inferolateral border of the prostate
- Typically thicker anteriorly than posteriorly where it slings around the rectum
- On CT, best to assume thickness is same as near the rectum as anteriorly so as to ensure not missing prostate

**PROSTATE – Posterior Border**

When there is no clear fat plane demarcating the prostate from the rectum, can use anterior rectal wall as posterior border of prostate
PROSTATE- Base of Bladder

Base of prostate in direct continuity with bladder
- Can be difficult to distinguish without contrast
- Also true of prominent median lobes from BPH
- Without contrast, window/level to distinguish bladder
- T2 MRI helpful

Level of GUD
Base of Prostate
PROSTATE – What an MRI Adds

With MRI, better discrimination between the posterior border of the prostate and the anterior rectal wall when compared to CT scan.

Thickness of levator ani and capsule more obvious with MRI, thus employing MRI makes lateral border definition of prostate more accurate.

http://dx.doi.org/10.1590/S0100-39842009000300012

Seminal Vesicles (pre-meeting contours)
Seminal Vesicles (pre-meeting contours)

Population Results

Histogram of initial Dice Coefficient
N: 51 | Min: 0.00 | Max: 0.85 | Median: 0.78 | Mean: 0.74 | Std Dev: 0.16

Histogram of Initial Score
N: 51 | Min: 0.00 | Max: 90.79 | Median: 76.21 | Mean: 67.25 | Std Dev: 23.20
**Seminal Vesicles (pre-meeting contours)**

Population Results

![Histogram of Initial Volume (cc)](image)

- Histogram of Initial Volume (cc)
  - N: 51 | Min: 5.29 | Max: 43.75 | Median: 9.69 | Mean: 11.13 | Std Dev: 6.59

- Expert Contour Volume = 12cc

---

**SEMINAL VESICLES**

Paired glands positioned below and posterior to the urinary bladder, lateral to the vas deferens. Each vesicle consists of a single tube folded and coiled on itself.
SEMINAL VESICLES

Base of Prostate
Seminal Vesicles

Seminal Vesicles
Seminal Vesicles

95

Seminal Vesicles

96
SEMINAL VESICLES - MRI

Easier to distinguish the proximal seminal vesicles separation from the prostatic base, appearing on T2 like high intensity cluster of grapes.

MRI also helpful in assessing invasion of the seminal vesicles.

DOI: 10.1594/ecr2014/C-0889

ADDITIONAL SCENARIOS
Sagittal and Coronal Views Help Tremendously

Bladder Prostate Interface
“Just Keep the Rectal Dose as Low as You Can”

RECTAL SPACER
Thank you!