Patient Safety Focused QA

LDR Brachytherapy
Vrinda Narayana
LDR Brachytherapy?

- D < 2 Gy/h
- Old
  - Ra-226; Cs-137; Ir-192
    - Gynecological; interstitial
- New
  - Pd-103; I-125; Cs-131
    - Prostate implants
    - Eye plaques
    - Brain tumors
Prostate Brachytherapy

Pre-implant planning

0-3 weeks

Implant

0-4 weeks

Post Evaluation
Volume Study

Pre-implant planning

US
Pre plan

- Variseed - plan
Implant

Pre-implant planning

0-3 weeks

Implant

US

US

Fluoro

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Post evaluation

Pre-implant planning

US

0-3 weeks

Implant

US

Fluoro

0-4 weeks

Post Evaluation

↓

US

CT

MR

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High quality implant
Patient Safety focus

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AAPM Task groups

- TG 56 - 1997
  - Code of practice for brachytherapy
- TG 64 – 1999
  - Permanent prostate seed implant brachytherapy
- TG 128 – 2008
  - QA for prostate brachytherapy US systems
- TG 137 – 2009
  - Dose Prescription and Reporting
High Quality Post Evaluation

- Volume; Time
- Source Strength
- Prostate
  - $V_{200}$, $V_{150}$, $V_{100}$, $V_{90}$
  - $D_{100}$, $D_{90}$, $D_{80}$
  - $D_{90} \geq PD$?
- Rectal wall
  - $D_{2cc}$
- Urethra
  - $D_{1cc}$

Stock, et. al. 1998
Potters et. al. 2001

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VA incident

- 2002 - 2009
  - 92 medical events
    - 57 patients: prostate < 80% of PD
    - 35 patients: rectum >100 Gy (misplaced seeds)
  - No post-implant dosimetry
  - Inadequate supervision of AU
  - No corrective action on poor quality implants
Medical Event

- Wrong dose
  - Prescribed dose difference 20% or greater
  - Dose $> 0.05$ Sv
  - Dose to tissue $>0.5$ Sv to organ, tissue, skin

- Wrong individual

- Wrong isotope

- Leaking source

- Migrated source
Medical events FY 2010

- Implant 2005; reported 2010
  - Seeds too deep in sigmoid colon
  - Underdose prostate
  - Inadequate prostate visualization
  - 7 additional violations on inspection

- Implant (5)
  - 100 % of seeds outside prostate
  - Inadequate visualization of prostate
Medical events FY 2010

- Implant 2005-2007
- High dose to urethra
Quality Management and Radiation Safety

- Imaging QA
- Tx Planning system
- Checklists
- Seed Assay
- Tx Plan check
- Implant QA
- Radiation Survey
- Post-implant evaluation
Imaging QA

- US – TG128
  - Precise Volume and Area
  - Needle-Grid Alignment
- C-arm
- CT
- MR

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Treatment planning

- Acceptance and Commissioning
- Repeat at upgrades
Treatment Planning checks

- Prescription Dose
- Source strength
- Target expansions
- Needle positions
- Seed positions
- IDL
- Dose Parameters
Seed Assay

- NIST traceable Well Chamber
- 10% seed assay
  - Within $\pm$ 3%
  - $>\pm5\%$ contact manufacturer
- Autoradiograph
Checklists

- Wrong individual
  - ID by 2 means
  - Time out
- Wrong Isotope
  - One isotope
  - One source strength (mCi vs U)
- Wrong prescription
  - Primary
  - Boost
- Wrong source strength
- Leaking source
  - Wipe test
  - Gentle handling (Mick applicator jams)
Wrong Dose - Complex

- High gradients

PD
1.2 PD
0.8 PD
Case Study

- Prescription
  - I 125
  - 100 Gy to the prostate
- CT
  - day of implant
- D90 – 79 Gy
- Is this a Medical Event??
Swelling

- 1997 Narayana et. Al.
- 1.5 swelling

Before implant CT

< 24 h CT

> 1 m CT
Timing of evaluation

- **Optimal time**
  - 10±2 d  Cs-131
  - 16±2 d  Pd-103
  - 42±2 d  I-125

- **Recommended time**
  - 10±2 d  Cs-131
  - 16±2 d  Pd-103
  - 1 month ± 1 week  I-125
Case Study

- Prescription
  - I 125
  - 100 Gy to the prostate
- CT
  - 1 month
- D100 – 121Gy
- Is this a Medical Event??
Narayana et. al 2005

- 6 prostate implant cases
- Contouring workshop
  - 6 expert Radiation Oncologists
- Contouring stations
  - 59 participants – all claimed to contour prostate at their institutions
    - Physicians
    - Dosimetrist (few)
    - Physicist (few)
Contouring errors

- D90
- V100

Physician 1
Physician 2
Physician 3

Physician 4
Physician 5
Physician 6

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Changes in volume

- 6 MD experts with training
- 59 observers with no training
V100

- 6 MD experts with training
- 59 observers with no training
6 MD experts
With training

59 observers
No training

Study

0 1 2 3 4 5 6
McLaughlin et. al. 2006

- Day 1 vs Day 14 dosimetry
- MR based
- Rapid strands
MR anatomy

- Seminal vesicles
- External Sphincter
- Prostate apex
- Prostate
- GUD
- Penile Bulb
- Crura of Corpus Cavernosa
- Levator Ani muscle

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Case Study

- Prescription
  - I 125
  - 100 Gy to the prostate
- MR
  - 3 weeks post
- D90 – 79 Gy
- Is this a Medical Event??
Where is it cold?

- Apex or base?
- Low or high risk?
Pitfall of CT contouring

- Superior
- MR base
- Anterior CT base
- CT apex
- Anterior
- MR
- Rectum

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Imaging Modality

- Registration
Full Dataset
Region of Interest

CT

MR
Prostate inside bladder
Bladder neck inside the prostate
Medical Event?

- Specific to prostate implants
- Activity vs. Dose based
- U implanted difference $\pm 20\%$ prescription
- U calculation error causing $\pm 20\%$ prescription
- U in a ring 3cm outside target $>20\%$ of total U
- Source $>3$cm from target
Patient Specific QA
Prostate implants

- Checklists
- Adequate Training
- Documented Procedures
- Simple Processes