Post Procedure Evaluation

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Objectives

• Why evaluate implants after the procedure?
• Know the two types of post procedural evaluation and the goals of each.
• Know the characteristics of modern treatment planning.
• There is a hierarchy of evaluation tools.
• Believe in the importance of goal setting, self evaluation, change and re-evaluation.
Why Evaluate After the Procedure?

• What is being evaluated?
  – implant quality

• Why?
Why Evaluate After the Procedure?

• Individual implant assessment
• Programmatic improvements
• External incentives
  – Standard of Care (ABS, ACR, AAPM)
  – Regulatory (CFR, State regulations)
  – Fiscal (CMS)
  – Legal
Individual Implant Assessment: Inadequate Target Dose

- Therapeutic intervention
  - Adjuvant therapies
    - Re-implantation
    - External beam radiation
    - Chemotherapy / hormonal manipulation
    - Surgical intervention
  - Salvage therapy: follows recurrence
- Increased vigilance
  - Follow up and diagnostics (imaging and biochemical evaluation)
Individual Implant Assessment: Excessive dose to normal tissues

• Therapeutic intervention:
  – Almost always salvage rather than adjuvant (cross your fingers)
  – Hyperbaric oxygen to promote healing
  – Surgical intervention

• Increased vigilance
  – Patient awareness
  – Follow-up visits
  – Diagnostic procedures
Programmatic Improvement

• Technique evaluation
  – Planning
  – Delivery
    • OR methods (Example: patient alignment)
    • Brachytherapist

• Equipment evaluation
  – Delivery systems
    • Example: Loose seeds / Mick applicator
    • Example: Loose / stranded seeds
  – Broken on maladjusted equipment
Tips for Group Analysis

• Perform early and often
  – Usable data from small sets
  – Quick results energizes efforts

• Limit number of evaluation criteria
  – Too much data can be confusing
  – Fix one item at a time
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Post Implant Evaluation

- Patient follow up
- Group analysis
  - Program review
    - Technique assessment
    - Equipment assessment

If needed

Post Planning
Post Implant Dosimetry

Post implant evaluation cannot be performed without post implant dosimetry. Sometimes this requires a new image set which shows source locations, targets and critical structures. You cannot evaluate what you have done without seeing what you have done. Any hope of developing a grand unification theory depends upon this.

—A. Einstein, 1921, Nobel Prize acceptance speech
Films for Record
Films for record
Paired-Film Isodose Curves
Modern Treatment Planning
Plan Evaluation Paradigm

Create Post Plan (Isodose Lines, DVH, Quantifiers)

Adequate Target Coverage?

No

Appropriate Adjuvant Treatment?

No

Adjuvant Treatments:
Reimplantation
External Beam
Surgery
Chemotherapy
Hormonal Deprivation
Cryotherapy
Hyperthermia
Photo Therapies

Yes

Increased Watchfulness
Patient Counseling
Frequent Follow Up

Yes

Expected Complications?

No

Normal Follow Up

Yes

File Post Plan for Programmatic Review
Meaningful Post Planning

• Tomographic Image Based
• “Modern” Treatment Planning
  – 2-mm or smaller grid size
  – 3-dimensional calculation
  – Structure based analysis
  – Seed sorting
  – DVH based analysis
Tomographic Imaging Based Evaluation
Treatment Plan Evaluation: The Dose Evaluation Hierarchy

- Isodose Displays
- DVH
- Quantifiers

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Post Implant Isodose Distribution

Doses are in cGy
Dose Volume / Dose Surface Histograms

Dose Volume (Calculated Volume, Prostate) / Dose Surface (Urethra, Rectum) Histogram
(Based upon 2408 sample points)
Urethral Dose Trace

- Total evaluated urethra length: 27.1 mm
- Urethra > 250 Gy: 0.0 mm
Neurovascular Bundle Dose Traces

The graph shows dose traces for different distances. The x-axis represents distance in millimeters (mm), while the y-axis represents dose in cGy. The graph includes annotations for total evaluated lengths and dosages for different regions. The key points on the x-axis are marked as 6, 9, 12, 15, 18, 21, and 24 mm, with corresponding dose peaks and troughs. The image also includes text indicating the lengths evaluated: total evaluated ln b length: 35.4 mm; ln b > 250 Gy: 19.0 mm; mnb > 250 Gy: 32.0 mm; and Ln b 9 mm length: 44.1 mm.
Implant Quantifiers

CI
mPD
TVR₁
C₈₀
DHI₁
DHI₂
DWHM
LDR
TCP
NTCP
mPD
MPD
CI
Basal Dose Rate
UI
DNR
D₉₀
TCP
LDR
Reference Dose
A bevy of quantifiers

- Structure-based, DVH-derived
  - V quantifiers
  - D quantifiers
- Coverage
- Uniformity
- Complication probabilities, dose delivered to critical structures
Coverage Quantifiers

- Volume ($V_{100}$, $V_{90}$, $V_{80}$)
  - Structure (target) based
  - $V_N$ is the percentage of the target covered by $N\%$ of the reference (prescription) dose
  - Prostate example: For an iodine implant in which 145 Gy was prescribed, a $V_{90}$ of 92% means that 92% of the gland received 130 Gy ($0.9 \times 145\text{ Gy}$) or better
Coverage Quantifiers

• Dose ($D_{90}$)
  – Structure (target) based
  – $D_N$ is the minimum dose received by N% of the target
  – Prostate example: a $D_{90}$ of 140 Gy means that 90% of the gland received 140 Gy or better
  – Note: largely in an effort to compare Palladium and Iodine results some authors have taken to normalizing the D quantifiers to the reference dose. This can get quite confusing…
Implant Targets

• “It is a far, far better thing to have a firm anchor in nonsense than to put out on the troubled sea of thought.”

  – John Kenneth Galbraith
Prostate Example: Implant Quantifiers (TG-64 / ABS)

- Conformity / Coverage
  - $V_{100}$
  - $V_{90}$
  - $V_{80}$
  - $D_{90}$

- Uniformity
  - $V_{150}$

- Critical Structures
  - Urethra
    - Line plot
  - Rectum
    - Dose surface histogram
More Prostate: Revised ABS recommendations (Nag, et al., IJROBP, 2002)

- “Morbidity is intimately related to the dose to normal tissues”
- **Urethra**
  - Line plot (0.5 cm intervals)
  - DVH (urethra)
  - Prostate $V_{100}$, $V_{150}$, $V_{200}$
- **Rectum**
  - DVH (rectum)
- **Potency**
  - Neurovascular bundles
  - Bulb of penis
Total Activity (mCi U/1.27) by US Prostate Volume (cc)

Bice, et al., IJROBP, 1998
Publishing Data

If you present clinical implant results and you don’t bother to quantify and describe the dosimetric characteristics of the patient data set, you are a bobohead. This is like making a cake without flour, strudel without apples or love without a woman. Don’t do it, God will play dice with you.

—A. Einstein, Nobel Prize acceptance speech, Stockholm, 1921
Conclusions

- Post procedure evaluation is used to
  - Assess individual implant quality
  - Characterize group traits in order to make improvements in
    - Planning and delivery methods
    - Functionality of equipment
- Post implant dosimetry sometimes requires a new image set and treatment “plan”
Conclusions

• Modern treatment planning is performed from image sets that depict source and anatomical data together
• Post treatment dosimetry relies on
  – Isodose distributions
  – DVH / DSH
  – Quantifiers
• Establish goals and evaluate your ability to consistently meet them
Questions?