Sarcoma and Radiation Therapy

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Objective:
Helping you make informed decisions

• Introduction
• Process
• Radiation primer
  – Science & technology
  – Applications
  – Side effects
• Questions and answers
Sarcoma: Introduction

• 2017 in USA
  – 12,390 new diagnoses (adults & children)
  – 4,990 deaths
  – 164 subtypes

• Can occur in any part of body
  – Connective tissue sarcoma
  – Skeletal sarcoma

• Surgery is predominantly the primary treatment

• Radiation - adjuvant, salvage or palliative role
Management of Rare Tumors

• Multidisciplinary group of experts
• In sarcoma, fragmented by site
  – Orthopedic
  – General surgeons
  – H&N surgeons
• Also age
  – Pediatrics
• Geographic location
  – Access to sub-specialty care
• Diagnosis after “Whoops” surgery

Difficult to generalize management
Key Principles

Tumor Board & Multi-Disciplinary decision-making

- Pathology & appropriate imaging
- Planned oncologic surgical resection
- Adjuvant/palliative systemic Tx for certain types
- Radiotherapy
  - Timing
  - Modality
Aphorisms

• “Half treatment with surgery and half treatment with radiation never add up to one successful treatment.”

William (Bill) T Moss
1919-2015
Radiation Decisions

• Tumor >5 cm, or high grade, or contaminated margins

• Like Real Estate
  – Location, location
  – Size
  – Timing
Post-operative XRT
30-33 treatments

Pre-operative XRT
25 treatments

Smaller volume
Process of Radiotherapy: Preparation
Consent
Nurse Teach
CT Simulation
CT Simulation
Contouring
Dosimetry
Physics
External Beam Radiotherapy

Photons:
• Megavoltage bundles of energy
• Generated in linear accelerator (Linac)
• Deep penetration,
  • Skin sparing
• Reliable dosimetry
  • Sharper beam edges
  • Accuracy and precision
• Image guidance
Dosimetry: Measurement of absorbed dose (Gray)

- Maximum absorbed dose below the skin
- Attenuation with depth
  - Corrections for air
- Opposed beam provides homogeneous dose distribution
- A layer of tissue equivalent bolus allows dose build up to provide full dose at skin
Shielding: Beam’s Eye View

- Multileaf Collimation (MLC)
- Head of the linac
- Blocks the beam
- Shapes the field edges
- 3-D Conformal RT
3-D Conformal beam arrangement

Each beam has homogeneous intensity
Intensity Modulation Radiation Therapy (IMRT)

Intensity modulated by MLCs to shape the dose distribution
3-D Conformal Head & Neck
Stereotactic Body Radiation Therapy (SBRT)

Volumetric modulated arc therapy (VMAT)
Dose Volume Histograms
Particle therapy

- Electrons
  - Dosimetry
  - Applications
    - Skin cancer
    - IORT

Electron Beam Dose Distribution

100% Dose
0%
Depth
ELECTRON THERAPY SET-UP
Intraoperative Radiation Treatment (IORT)
Particle therapy

- Protons
  - Dosimetry
  - Applications
Cyclotron & Beam Transport Line
Gantry
Treatment Rooms

The Gantry Room
RADIATION TOXICITY
TOXICITY:
DAMAGE EXPRESSED DURING MITOSIS

Acute toxicity
During treatment
Dose, volume & drug related
Reversible damage to tissues with rapid cell renewal
Cell division necessary to maintain function
  E.g., skin erythema, mucositis, esophagitis

Delayed acute toxicity
  Occurs 6 weeks - 6 months after RT
  Acute reaction of slow turnover tissues
  E.g., radiation pneumonitis, L’Hermitte’s
Acute skin reaction

4 days post XRT (66 Gy)

10 days post XRT

4 weeks post XRT
Late reactions

Related to \textit{fraction size, volume}

Manifest 6-18 months after RT

Irreversible damage
  – parenchymal cells with slow turnover
  – connective tissue & vasculature

E.g., fibrosis, spinal cord myelitis, malignancy
Late skin toxicity
20 years post
Neutron RT for osteosarcoma

• Fibrosis
• Altered pigmentation
• Telangectasia
• Delayed healing from minor injury
Persistent damage after severe acute reactions

Related to total dose, dose rate

Concurrent chemotherapy

Co-morbidities, infection, trauma

- Destruction of Basement Membrane Zone

E.g., Chronic skin ulcers, GI & bladder
TISSUE TOLERANCE

• TD5/5
  – Total dose, given in standard fraction sizes, that produces a 5% risk of damage to a specified organ at 5 years
  – Dose constraints
  – “Organs At Risk” delineated during RT planning

• Relationship between dose & volume recorded on histogram
  – Risk of damage quantified
**THERAPEUTIC RATIO:**
DOSE-RESPONSE RELATIONSHIP OF TUMOR CONTROL & NORMAL TISSUE COMPLICATIONS
REPAIR

• All organized tissues mount repair to injury
• RT response similar to other trauma, e.g., surgery

BUT

• XRT delivers a repetitive injury
• All cellular and extracellular components within tissue affected by free radicals
  – DNA damage
  – Complex molecules, lipids, proteins etc sublethal damage
Prevention

- Limit volumes, doses,
- Avoid trauma, infection
- Radioprotection
- Oxygenation
SURVIVAL

• More people are surviving
• Radiation contributes to survival
• With increasing survival, late, permanent toxicities
Conclusion

• Good evidence on what works, what does not
• Good technology
  – helps reduce dose to normal tissue
  – therapeutic dose to target
  – estimates risk
• Individualized planning
• Cognizant not just of benefits, but potential harm