Nuances of Proton Therapy Planning and Delivery

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Overview of today discussion

- Proton Therapy Planning Basics
- Target definitions and the variable PTV
- Beam delivery methods and what they can offer
Planning Strategies 101

- Cover the target with appropriate margins
- Spare the critical structures
- Plan with fields that deliver the most "robust" plan
What is “Robust” in Proton therapy ??
Tools to do our job

- **Photons**
  - Energy
  - Wedging
  - Weighting
  - IMRT

- **Protons**
  - Range
  - Modulation
  - Compensators
  - IMPT
Equivalent Path Lengths

- In Photons
  - Convert HU to Relative Electron/Physical Density

- In Proton
  - Convert HU to Relative Stopping Power Ratios
The Physics of Protons

Depth Dose Curves for Different Treatment Types

- High Energy X-Rays
- 200 MeV Protons

- Healthy Tissue
- Tumor

Relative Dose vs. Depth in Tissue (cm)
The Physics of Protons

Spread Out Bragg Peak (SOBP)
Range and Modulation

Isovalues (%)
- 100.0
- 95.0
- 70.0
- 50.0
No Compensator

Proton Beam

Aperture

Target Area

Inhomogeneity (Air Pocket)
Theoretical to Actual
What we need for distal conformity
Ray Trace the Proton
Limiting Resolution of Drill Bit
Single Compensator
Manufactured Device
Comp Attached to Snout
Dose delivered as planned
Problem: Patient Motion
Not the desired compensation nor planned dose distribution
Compensator needs to include uncertainties for Set-up / Motion
Smearing

Ensure that required range is present at a particular point AND all points within it's smearing radius
Equivalence to Motion
Original vs Smear Compensator
Compensators
Patient Specific Apertures
Penumbra at Various Air Gaps
Other Techniques: Patch Fields

Definition – distal edge of one field meets the lateral border of the other field

- 50% meets the 50% to make up a 100%
- Consists of a through field and a patch onto the through field
Illustration: Total isodose distribution using 3 patch pairs

Patch 1- LAO THRU + LPO PATCH
Patch 2- RAO THRU + RPO PATCH
Patch 3- POP THRU LATS + LT and RT POST PATCHES
ICRU Definitions

- CTV
- GTV
- ITV
- PTV = ITV + SM

Patient
ICRU Definitions

Patient

ITV

PTV = ITV + SM
Adding the Uncertainty Process
The More I Think
The More Confused I Get
What about those tails??
Uniform Modulation
Use of multiple fields daily
Spot Scanning
Spot Scanning -> IMPT
Thank You for your attention!!