Radiotherapy Treatment
Machines for Cancer
Radiotherapy Treatment Machines for Cancer

A. Purpose
   1. Selective irradiation of the 3D volume of a malignant cancer is the goal of radiation therapy.

B. Basic process
   1. Deliver a sufficiently fatal dose of radiation to the target volume while minimizing the damage to surrounding normal tissue.
After This Presentation You Will Know…

I. Spatially varying the intensity of an x-ray beam
II. IMRT
III. Planning
IV. Beam generation
V. Beam modification
VI. Dose measurement
VII. Treatment delivery
VIII. Results
Spatially Varying the Intensity of an X-ray Beam

A. Problem: Smart Tumor growth issue

1. Tumors typically entangle themselves around and near delicate tissues and grow into complex three-dimensional shapes so it is difficult to minimize the damage to the surrounding tissues while still administering a tumorcidal dose.

B. Solution: Intensity-modulated radiation therapy (IMRT)

1. Method of external beam radiation therapy that modulates the dose to conform to the size, shape, and location of the tumor.
IMRT

- Intensity Modulated Radio Therapy (IMRT)
  - External-beam radiotherapy
  - Planning
    - 4D-CT
  - Dose calculations are performed with treatment planning software
    - Analytical algorithm, AAA
- IMRT is administered using the Linear accelerator (LINAC) which employs 4 main processes:
  1. Beam generation
  2. Beam Modification
  3. Dose Measurement
  4. LINAC control
IMRT vs. VMAT

**IMRT(L) & VMAT(R)**

- Plan geometries [(a), (d)]
- Dose distributions in axial views [(b), (e)]
- Films in sagittal views [(c), (f)].
I. Analytical algorithms are used in calculating dose distribution in the planning stage

A. AAA- Anisotropic analytical algorithm

(AAA) 10.0.24.

1. Absolute point dose
   a) Measured with thermoluminescent dosimeters (TLDs)

2. Planar dose
   a) GafChromic® EBT2 film

Dose distributions in an axial view
Beam Generation: The LINAC

• The electrons are produced by the electron gun by thermionic emission from heated cathode to produce a beam that accelerates toward the anode.

• The electrostatic field between focuses the beam prior to entering the wave guide

• Steering coils control inlet direction
  • Deflects charged electrons perpendicular to magnetic field

• Once inside the accelerator wave guide the electromagnetic field of the radio frequency waves transfer energy to the electrons
  • Grouping the electrons
  • Traveling wave
Beam Modification

• Focusing coils & outlet steering coils to ensure correct direction and continual focus of the beam

• Achromatic bending system

• Further modification occurs in the treatment head, high energy electrons converted to photons or x-rays

• Multileaf collimator modifies beam to ensure the shape of the delivered beam matches that of the tumor
Dose Measurement

- Photons pass through ion chamber for dose measuring and beam quality monitoring.

- Dose measured and controlled simultaneously
  - 2 independent ionization chambers: 1. The primary dosimeter. 2. secondary ion-chamber.

- Dose measurement and administration are done simultaneously.
  - Further shaping of the beam with multi-leaf collimator
Dose Measurement continued

- Each part of the human body presents its own challenges that require solutions in order for the treatment to be plausible and provide necessary treatment with the minimal damage to the healthy surrounding tissues.
  - IMRT treatments in the body cavity
    - Gate the x-ray beam in synchrony with the movements due to breathing
      - Complicated by the inevitable anatomical and medical variances in human patients
    - In the head and pelvis
      - How much damage to spare a section, possibly a gland, while also delivering a sufficient amount.
Treatment Delivery

- LINAC control
  - One computer system controls both LINAC and the multi-leaf collimator.
  - Allows for synchrony between delivery dose and multi-leaf collimator.
- Direct effects due to delivery
  - Tumorcidal dose delivered and minimal exposure to surrounding tissues
  - Often patients experience epidermal scars
Results

• IMRT radiotherapy machines…..
  • Reasonably fast computation time
  • Effective delivery
  • Minimizes damage to surrounding sensitive tissues
  • Very successful form of treatment for cancers especially with the tumors that have a more difficult conformation complicated by sensitive surrounding tissues.
  • Accuracy of measurement and delivery is constantly being improved upon.
Conclusion

• We discussed…
  • Spatially varying the intensity of an x-ray beam
  • IMRT planning using AAA
  • The critical importance of the Linear Accelerator in IMRT treatments
  • Beam generation
  • Beam modification
  • Dose measurement
  • Treatment delivery
• Results


The End

I just have one tattoo—it's six dots on my chest, done by my oncologist.

I need them for aligning the laser sights on a flesh-searing relativistic particle cannon,

so it will only kill the parts of me that are holding me back.

But your barbed wire bicep tattoo is pretty hardcore, too!

No, it's OK.

I'll just go put a shirt on.