Electron Beam Therapy - Reloaded

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Introduction: e vs. γ vs. p

- Depth dose and lateral profiles
  - Suitable for superficial tumors
  - Requires collimation close to skin
- Clinical e unchanged for decades and underutilized in cancer radiotherapy
- ~15% utilization

EAT – Electron Arc Therapy

- Electron beam delivered in partial arc
- Modifications to linac/cone and TPS
  - Shortened cone
  - Different PDDs
  - Cutout shape
- Patient-specific cast/shield and bolus
- Primarily for chest wall irradiation
- Univ. of Utah

Leavitt 1985 Electron ARC therapy: physical measurement and treatment planning techniques IJROBP 11
McNeely 1988 Electron arc therapy: chest wall irradiation of breast cancer patients IJROBP 14(6)
ECT – Electron Conformal Therapy

- One or a few electron beams
- Bolus electron conformal therapy
  - Tissue equivalent
  - Modulate electron energy
  - Keep PTV within 90% isodose volume
  - Minimize dose to distal/underlying critical structures and normal tissue

Perkins 2001 A custom three-dimensional electron bolus technique for optimization of postmastectomy irradiation IROBP61

MERT – Modulated Electron Radiotherapy

- Multiple electron beams
- Energy modulation
  - Bolus or energy selection
- Intensity modulation
  - Cutout
  - eMLC
  - pMLC
  - Scanning beam

Henzen et al 2014 Beamlet based direct aperture optimization for MERT using a photon MLC. Med Phys, 41
Henzen et al 2014 Monte Carlo based beam model using photon MLC for modulated electron radiotherapy. Med Phys, 41

DEAR – Dynamic Electron Arc Radiotherapy

- Electron radiation is delivered in ARC mode
- Electron applicator and cut-out are kept to provide lateral beam constriction
- Treatment couch is in simultaneous motion with gantry rotation to prevent collision. Beam always normal to skin and SSD = 100 cm
- Couch motion, gantry rotation, and dose rate are modulated to produce desirable dose distributions

DEAR design

- DEAR: 6, 9, 12 MeV.
- Photons: 6X, tangent, no wedge

Plan comparison: chest wall phantom
WARNING

This application SHALL NOT be used to treat living subjects under any circumstances.

This application is used for imaging and treatment technique development only under non clinical conditions.

DEAR delivery demo

Room View

Patient View

Gantry and couch motion

Position

Speed
**Beam hold**

- **Dose (MU)**
- **Couch VRT (cm)**
- **Couch LAT (cm)**

**Dose rate modulation**

- **stdev = 1.6 MU/min**
- **stdev = 0.2 MU/min**

**Dosimetry: 6e on cylindrical phantom**

- **Static (15x10 cm², G=0°)**
- **DEAR (3x10 cm², G=315-45°)**
Virtual scanning mode

- 6 MeV electron
- D=1cm cutout
- CR film
- 148 CP (7MU/CP)
- Beam hold (D->e)

Potential DEAR case

Need for fine energy resolution
Small field electron beam dosimetry

- Composite dose map
- 6 MeV
- 1x1 cm² kernel

Small field electron dosimetry

- 6 MeV
- 10x10 cm²
- PDD
Small field dosimetry

- 16 MeV
- 10x10 cm²
- PDD

DEAR Summary

Advantages
- Uniform dose distributions over large and curved targets while maintaining narrow penumbra
  - Treated area > cone size
- DEAR delivery
  - Fixed cone/cutout
- DEAR delivery has high accuracy
  - Expected and actual plans agree very well
  - Trajectory log file can be used as a QC tool
  - Dosimetry

Challenges
- Small field dosimetry
- Not ready in clinical operation
- Couch motion
- Coarse energy selection
- Bolus
- Planning tools
  - Forward and inverse optimization
- Dynamic delivery collimators
  - Motorized electron collimator (MELC)
  - Electron MLC (eMLC)
- QA Tools

Summary: e vs. γ

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<th>Electron</th>
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Prototype eMLC


Looking to the Future

Antolak

Commercial eMLC


http://euromechanics.com/e_emlc.html
https://www.youtube.com/watch?v=F0BBbHRrjBg