Modulated arc therapy for TBI

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Objectives

• Describe the two widely used TBI delivery techniques
• Describe how MLCs in an arcing gantry may be used to create a uniform craniocaudal profile for TBI
Modified Standing Technique

Concerns

• Patient fatigue
• Incompatible with pediatric cases that require anesthesia support
• Requires large vault

Photo credit: Khan, F The Physics of Radiation Therapy, 4th ed.
Bilateral Technique

Concerns
• Dose homogeneity
• Requires large vault

Changing What’s Possible
Photo credit: Khan, F The Physics of Radiation Therapy, 4th ed.
“Sweeping Beam” Technique

Concerns
- Dose homogeneity
  - Patient thickness
  - $1/r^2$ effect

Changing What’s Possible

Gravity-oriented compensator

Schematic diagram from Chui, CS et al. Total Body Irradiation with an arc and a gravity-oriented compensator, IJROBP, 39(5) 1997, pp1191-5
Effective treatment area of TBI field
Hanging wedge

Primary TBI machine is a Varian 600 C/D (ca. 1999) with no tertiary MLCs

Jaw setting: 40x25 cm
Tertiary MLCs move hanging wedge further from source.

Concern:
• Weight of wedge is now 35 lbs.
How can our sweeping-gantry technique be used on a machine with tertiary MLCs?

Reduce the field size...

.... Unacceptable.
Intensity modulated TBI with MLCs

MLC apertures indexed to position of translating bed

Whole body CT → Optimize dose via field width parameter → Import MLCs into TPS → Calculate dose on CT

Figure 3 from Hussain A., et al. *Total body irradiation dose optimization based on radiological depth*, J Appl Clin Med Phys, 13(3), 2012
The effective dose rate is lower at points located \textit{away} from the CRA due to inverse square fall-off and from a larger effective depth.

These points need a longer exposure period to match the dose along the central reference axis (CRA).
Problem: What MLC pattern will produce an acceptably flat profile in the craniocaudal dimension of the patient?
Model the problem

130° arc

Gantry source positions

Phantom dose points
130° arc

100 cm SAD

Isocentric plane

Project a relative output at each dose point

Changing What’s Possible
At this plane, the off-axis distance of each dose point is easily known.
Fill a 2D matrix with output at each point as a function of gantry angle.
Gantry angle vs. dose point position
Gantry angle vs. dose point position

Gantry not directed at these dose points

Effective output/MU (cGy)

Longitudinal position (cm)

Gantry angle (Varian Standard)

Collimation

Apply

Changing What’s Possible
130° arc  
Gantry source positions  
100 cm SAD  
Apply collimation  
Phantom dose points
40x40 cm² baseline is too non-uniform
Iteratively apply different models of MLC motion to optimize profile uniformity.
Iteratively apply different models of MLC motion to optimize profile uniformity.
Workflow in ECLIPSE

1. Register patient & Create phantom
2. Create arc fields & Import MLC file
3. Calculate with set MUs & Export fields
4. Patient specific QA on the fields
Benefits of MLC approach

• Safer
  – No risk of dropping heavy Tx device on patient
  – Interlocked

• Reliable
  – Less dependent on physical integrity of wedge

• Potential for further development
  – Patient specific profiles
Summary

• A simple model of rotational dose delivery was helpful in selecting a dynamic MLC pattern for TBI

• Rotational dose delivery is a feasible technique for TBI in a small vault