TREATMENT PLANNING: CLINICAL ELECTRONS
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PURPOSE

The purpose of this lecture is to provide the medical physicist with (1) an overview of important concepts in electron beam treatment planning, (2) key references to expand upon their knowledge, and (3) a series of questions designed to review that knowledge.

REVIEW TOPICS

1. Physics Principles Impacting Electron Dose Distributions
   a. Principles of energy loss and multiple Coulomb scattering (MCS)
   b. Application of energy loss and scattering to %DD curve
   c. Principle of side-scatter equilibrium (SSE)
   d. Application of SSE to field-size dependence of output

2. Properties of Electron Dose Distributions in Water
   a. Central-axis depth dose
   b. Off-axis dose profiles
   c. Dose output

3. Impact of Patient Heterogeneity on Dose Distribution
   a. Oblique and irregular surfaces
   b. Internal inhomogeneities

4. Principles of Electron Beam Treatment Planning
   a. Selection of beam energy
   b. Selection of beam direction
   c. Collimating techniques
   d. Bolus techniques
   e. Field abutment techniques
   f. Techniques for circular anatomy
   g. Recommendations for treatment planning

FOR MORE INFORMATION

See SAMS session (TH-A-500-1, 2013) titled “Electron Radiotherapy: Past, Present, and Future” in the AAPM virtual library. A similar session from 2012 is also in the virtual library.
SUGGESTED READING MATERIAL

Background in Electron Beam Physics and Dosimetry

Electron Beam Dose Calibration

Clinical Electron Beam Dosimetry

Effect of Tissue Heterogeneity
Electron Pencil-Beam and New Dose Algorithms


Electron Beam Treatment and Treatment Planning

General


Electron Bolus and Conformal Therapy


Collimation


Specialized Electron Beam Therapy Techniques

Extremities

Electron Arc Therapy

Total Skin Electron Therapy

Intraoperative Electron Therapy

Craniospinal Irradiation

Total Scalp Irradiation
REVIEW QUESTIONS

1. What is the principle of side-scatter equilibrium? Explain how this principle affects the field-size dependence of depth dose and output. Explain how it can cause output to falloff faster than inverse square.

2. Discuss the energy dependence of the following depth dose quantities – $D_s$, $R_{90}$, $R_p$, and $D_x$.

3. Explain the field size dependence of depth dose, i.e. how it affects $D_s$, $R_{90}$, $R_p$, and $D_x$.

4. Discuss how penumbra depends on depth and air gap as a function of energy.

5. What is the square root method for depth dose?

6. What influence does air gap have on output and depth dose?

7. How does angled incidence affect depth dose and penumbra?

8. How does a sharp surface discontinuity affect the underlying dose distribution, i.e. where does the volumes of increased/decreased dose lie? Discuss the resulting clinical impact for the nose and ear.

9. Explain why abutted chest wall fields sometimes give significant lung dose, i.e., how the penetration of the dose distribution increased in lung tissue.

10. Discuss the influence of hard bone (e.g. mandible) on the underlying dose distribution. Is backscatter dose from bone clinically significant? Why is there an increased dose in bone, and is it clinically significant?

11. What is the relationship between lead thickness (mm) required to stop incident electrons and electron energy, $E_{p,0}$ (MeV)? List three clinical reasons for skin collimation and give a clinical example for each.

12. How does increased dose from electron backscatter depend on energy ($E_z$) at the tissue-lead interface? How can the patient be protected from backscattered dose from internal collimation?

13. Discuss the dose distribution behind a 1-cm diameter lead block, and how does it vary with energy and air gap? How can this type of block be used to treat retinoblastoma?

14. Define electron bolus. List three clinical reasons for electron bolus and give a clinical example for each.

15. Give two methods for verification of the intended use of electron bolus.

16. Explain the three different classifications of abutting electron fields and a clinical example of each. How is dose inhomogeneity resulting from field abutment minimized during the course of treatment?

17. In treatment of whole limb with electrons, six to eight fields (with falloff) spaced as evenly as possible around the limb’s axis can be used. How does the depth dose change relative to that of a single beam? Why is arc therapy with a narrow field (e.g. 5-cm wide at isocenter) a poor option?

18. In electron arc therapy of the chest wall, explain how and why the depth dose changes relative to that of the unarced beam. Why is the width of the secondary electron insert narrower in the portion used to irradiate the superior part of the chest wall than the inferior part? Write the equation relating the field width, $W$, for treating a cross-sectional anatomy with a mean radius of curvature, $\rho$, to that of the central axis width, $W_0$, treating a cross-sectional anatomy with a mean radius of curvature $\rho_0$. Why is skin collimation required for electron arc therapy of the chest wall?

19. For total skin therapy using the Stanford technique, explain (1) why each patient is treated with two beams at gantry angles 90° ± $\theta$, (2) why the light field edges from the two fields are separated by a large gap, and (3) why a 1-cm thick scatter plate directly in front of the patient improves dose homogeneity.

20. Describe the CT lookup tables and beam data input necessary to commission a pencil beam dose algorithm. What comparisons with dose measurements would you make to verify proper data input prior to clinical use? What are the strengths of the Hogstrom pencil beam model in its clinical application? Under what circumstances will the algorithm have dose inaccuracies greater than 5%?