Therapeutic Applications of Monte Carlo Calculations in Nuclear Medicine

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Philadelphia, PA: Institute of Physics, 2002, 364 pages, $100

Related Fields of Medicine. Nuclear medicine and radiation oncology involving radioimmunotherapy (RIT) and other internal emitter therapies.

Format. Hardcover book.

Audience. For the dose estimation methods: medical physicists, health physicists, and radiation oncologists involved in RIT and similar topics. For the quantitative nuclear imaging sections: nuclear medicine physicians and diagnostic radiologists.

Purpose. Review of Monte Carlo (MC) methods in internal emitter radiotherapies.

Content. This book contains 15 chapters, by 24 authors, on MC-based strategies and background material for patient-specific therapeutic absorbed dose estimations or "treatment plans." A consumer's list of available MC software systems is given. Some reports on nonmalignant disease treatments such as irradiation of arterial walls and the synovium are provided. Quantitative imaging methods (primarily using SPECT) and a report on some of the available nuclear medicine treatment planning systems are also included. Point source kernels, built via MC, are described. Chapters are provided on radiobiology and cellular-scale dose estimation. Reviews of the MIRD methodology and the standard MIRD phantoms are also part of the text.

Highlights. The 2 initial chapters, describing general MC methods and their application to nuclear medical dose estimation, are important. Chapter 6 is useful for its review of various MC computer codes available and the limitations of each. Because the book is essentially limited to spatial MC applications, chapter 5 provides a necessary summary of the geometric phantoms used in dose estimation. Kassis' description of radiobiology and choice of radionuclide is excellent and contains interesting novel information on cellular bystander effects. Like politics, dose estimation is a local phenomenon, so there is the requisite segment (by Roeske and Humm) on microdosimetry. Although relating this material to the organ-sized analyses in other chapters is difficult, it is important to see the effect of cellular internalization of α- and Auger emitters. Also included is an extended discussion of imaging methods, with emphasis on SPECT and PET. The analysis done at Lund University (Ljungberg and Strand) is particularly interesting for the determination of scatter and attenuation effects in ^{131}I photon detection. One caveat: Two-dimensional imaging gets rather short shrift in this chapter, and the CT-assisted matrix inversion planar technique of City of Hope National Medical Center (Duarte, CA) is incorrectly described.

Limitations. Although the text is well written and free of typographic errors, several annoying figure layout and quality problems occur. All color plates are grouped contiguously in the last chapter. This grouping is disruptive to that segment as well as to the logical flow of the earlier chapters that refer to those figures. Some black-and-white drawings are difficult to read, such as the bone structure display in chapter 13. Alternative figures are not provided, so that cord lengths used in the Eckerman and Bouchet analyses of bone doses are not shown in the text. A more profound sin of omission deserves mention. Spatial analyses are conceptually only half of any nuclear medicine dose estimation problem. It would have been appropriate if at least 1 chapter had been devoted to MC in the time domain. A cursory discussion in chapter 2 of MC in the calculation of $\tilde{A}$ in the MIRD schema (dose $= S \times \tilde{A}$) does not do justice to this subject. In the overall analytic picture, even if all geometric (S) problems were solvable via MC or some other mathematic analysis, we would have remaining questions regarding uncertainties in the total number of decays in each organ, tissue, or voxel. Kinetic modeling with MC methods, using data from the necessarily limited number of imaging and sampling times, could have been provided in the text. Unless these $\tilde{A}$ uncertainties are estimated (and reduced), the reader planning treatment will still have a difficult stochastic problem. A consideration of area under the curve could possibly have widened the readership of the text to include medical oncologists and pharmacologists involved with chemotherapy. This is an important overlap that RIT practitioners share with medical oncology.

Related Reading. Other MC volumes include Morin's *Monte Carlo Simulation in the Radiological Sciences* (CRC Press; 1988). There is a companion book to the text reviewed here: Ljungberg, Strand, and King's *Monte Carlo Calculations in Nuclear Medicine: Applications in Diagnostic Imaging* (IOP Publishing; 1998). Absorbed dose methods for internal emitters are covered in *AAPM Report Number 71: A Primer for Radioimmunotherapy and Radionuclide Therapy* (Medical Physics Publishing; 2001), by Macey et al. Specific articles may be located from these resources and the Internet.

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