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**Appendices (Publications associated with the following project tasks)**

### A. Improved Dosimetric Models of the Head and Brain


### B. Development of Improved Skeletal Dosimetry Models


C. Development of Dosimetric Techniques for Nonuniform Activity Distributions


D. Pediatric Dosimetry Phantoms and Radionuclide S Values

H. G. Blanco, "Revisions and Radiation Transport in Mathematical Models of Adult and Pediatric Patients", Master's Thesis, University of Florida, Chapter 4 – Multiregion Kidney Model


E. Microdosimetry of Beta Emitters in Radioimmunotherapy


F. Mechanisms of Molecular Radiation Damage


Executive Summary

Research Accomplishments

Significant work in state-of-the-art computational techniques for internal dosimetry has been completed under DOE Grants DE-FG03-94ER61846 at Texas A&M University and DE-FG05-95ER62006 at the University of Florida. Since 1994, these grants have provided research support and/or thesis or dissertation topics for 9 PhD students and 17 MS students in the fields of nuclear engineering, health physics, medical physics, and more recently biomedical engineering. The project team has contributed to the publications of 1 book, 4 book chapters, 12 refereed journal articles, and 1 refereed symposium proceeding. An additional 7 journal articles have been recently submitted and are in review. The Principal Investigator has given 8 presentations at national and international research meetings on the project research, while the students involved in the project have collectively given 32 scientific presentations. Below is a brief summary of the major tasks of research; a complete compilation of key publications are given in the various appendices to this report.

Improved Dosimetric Models of the Head and Brain As initially reported in JNM in 1996, work has been completed on a detailed extension of the head and brain model originally published in MIRD Pamphlet No. 5-Revised. The new model includes substantial revisions to the head to include eyes, a defined neck, and much improved facial skeleton. The brain is now modeled using eight subregions: caudate nuclei, cerebellum, cerebral cortex, lateral ventricles, lentiform nuclei, thalamus, third ventricle, and white matter. These subregions will now permit detailed suborgan dosimetry in the support of new and developing radiopharmaceuticals used in neuroimaging studies. The model will formally appear in the March 1999 issue of JNM as MIRD Pamphlet No. 15. In addition, we have completed work on a pediatric series of similar head and brain models. An article on these pediatric models has been submitted recently to JNM (see appendix).

Development of Improved Skeletal Dosimetry Models Work has also been completed on a new comprehensive dosimetry model of the skeleton. The work is summarized in a series of 3 papers recently submitted to JNM (see appendix). The model includes two new 3D transport models for electrons within trabecular bone and cortical bone, respectively. In both the articles on trabecular bone dosimetry and cortical bone dosimetry, detailed summaries of previous models are presented. The 3rd paper in the series gives a detailed derivation of reference skeletal masses for some 22 skeletal sites in the adult. These new masses are derived for the latest recommendations of the ICRP as given in its Publication 70 and are used in the calculation of both regional and skeletal-averaged S values for a variety of beta- and electron-emitting radionuclides used in radionuclide therapies of the skeleton and other organ systems. Also within the 3rd paper, a comprehensive comparison is given of the new model, the skeletal model of MIRD Pamphlet No. 11, the skeletal model of MIRDose2 (ICRP 30), and the skeletal model of MIRDose3 (model of K. F. Eckerman). In this study, significant differences are noted in the various model approaches. In addition, various inconsistencies and undocumented modeling approaches are also noted. Our new model will be formally presented to the MIRD committee for its consideration at its March 1999 meeting. This work on skeletal dosimetry has additionally lead to a productive collaboration with Drs. Roger Howell and Dandamudi Rao at the University of Medicine and Dentistry of New Jersey. Finally, through DOE research support via the Health Physics Faculty Research Award, additional work on NMR microscopy of trabecular bone has been initiated at UF for future extensions of the Reference Man model to models more appropriate to older medical patient populations. Details of these additional studies are also included in the appropriate articles of the appendix.

Development of Dosimetric Techniques for Nonuniform Activity Distributions A new effort was initiated by the research team through the formation of a new Task Group on Nonuniform Dosimetry within the MIRD Committee lead by Dr. James Robertson. In this task group, it was decided that a new dosimetry tool for handling nonuniform activity distributions should be produced within the committee in response to criticisms in the literature that the MIRD schema was restricted only to whole-organ dosimetry calculations. With the MIRD committee's input, the UF research team developed a series of voxel S values for use with quantitative assessments of activity distributions via PET or SPECT. A full description of the voxel S value approach, along with a detailed summary of other approaches such as dose point kernel convolution and direct Monte Carlo simulation, is given in MIRD Pamphlet No. 17 which will appear in the January 1999 issue of JNM. The appendices to this pamphlet include voxel S values for P-32, Sr-89, Y-90, Tc-99m, and I-131 within 6-mm and 3-mm voxels. An additional set of voxel S values were generated for 100-μm voxels and I-131 for use with autoradiographic data. A full extension of the voxel S value methodology to many more radionuclides and image voxel dimensions is currently under consideration by the MIRD committee.
Pediatric Dosimetry Phantoms and Radionuclide S Values  The purpose of this particular task is to perform detailed simulations of electron transport within the Cristy and Eckerman pediatric phantom series so as to fully document electron absorbed fractions for various source and target organ combinations. These electron absorbed fractions are to be used to update the radionuclide S values originally published by the MIRD committee within MIRD Pamphlet No. 11. Over the course of the last three years, however, the committee has requested several substantial revisions to the Cristy and Eckerman phantom series. These changes include (1) addition of an esophagus, (3) adoption of the MIRD 15 head model and its pediatric versions, (3) addition of a prostate gland, (4) addition of a multiregion kidney model (to include the cortex, medulla, papillae, and pelvis regions), (5) inclusion of a mucosa and epithelial layers to all walled organs (for use as both a source and target region), and (6) a complete revision to the lower large intestines with the explicit delineation of the rectum (primarily for use in radiation dosimetry studies associated with radionuclide therapy of prostate cancer). At the present time, all six revisions have been completed to all pediatric phantoms and electron transport simulations will be completed by January 1999. Photon transport within the phantoms is scheduled for Spring/Summer of 1999 following the adoption of a final skeletal dosimetry model to be used in future MIRD publications. Additionally, the committee has requested us to perform electron transport studies within the 3-mo, 6-mo-, and 9-mo pregnant women phantoms as well. This work will be initiated within the coming year pending funding for this effort. At this same time, work has begun between the MIRD committee, former committee-chair David Weber, and Keith Eckerman at ORNL on a complete update of the MIRD Decay Scheme Monograph. With this work being completed in the coming year, the committee should then be in position to begin work on a final revision to MIRD Pamphlet No. 11.

Microdosimetry of Beta Emitters in Radioimmunotherapy  While at Texas A&M University, the research team developed a comprehensive method of predicting distributions of cellular dose within tumors resulting from uptake of beta-emitting radiolabeled antibodies within RIT. This work resulted in a series of three publications and presentations at 11th Symposium on Microdosimetry (see appendix). With the transition to UF, this task was refocused on the work associated with the production of voxel S values and the publication of MIRD Pamphlet No. 17.

Mechanisms of Molecular Radiation Damage  This final task involves continuing work to model radiation damage to biomolecules at the molecular levels. Early work in this task was published within two book chapters associated with a DOE-sponsored workshop in 1993. More recently, work on modeling radiation damage to the biomolecule glycylglycine was published in collaboration with Drs. James Turner and Robert Hamm at ORNL. Finally, we have recently initiated a collaboration with the UF Department of Radiation Oncology to implement the OREC/RADLIES computer models in a system to predict DNA molecular damage under conditions unique to radiotherapy of head and neck tumors. This research tool will allow radiation oncologists to quantify the effects of tumor hypoxia and use this information eventually within standard radiation treatment planning systems. We will pursue NIH funding of this work within the coming year. A paper describing our preliminary work in this area has been submitted to the International Journal of Radiation Oncology, Biology, and Physics.

Interactions with the MIRD Committee  The UF research team supported by these DOE grants has provided physics and simulating modeling support to a wide range of MIRD Committee Task Groups. The following is a list of task groups the Principal Investigator currently serves as either Task Group Leader or Task Group Member. DOE’s continued support of the efforts of the MIRD committee is gratefully acknowledged.

Leader, MIRD Task Group, Dosimetric Models of the Head and Brain, Appointed (1993-)
Leader, MIRD Task Group on Skeletal Dosimetry, Appointed (1993-)
Leader, MIRD Task Group on a Circulating Blood Model, Appointed (1993-)
Leader, MIRD Task Group on Absorbed Fractions for Photon and Electron Sources, Appointed (1993-)
Leader, MIRD Task Group on Tracheal Dosimetry, Appointed (1993-)
Member, MIRD Task Group on Stochastic Dosimetry in Radionuclide Therapy, Appointed (1998-)
Member, MIRD Task Group on High-Dose Radionuclide Therapy, Appointed (1994-)
Member, MIRD Task Group on Short Range Radiations, Appointed (1998-)
Member, MIRD Task Group on S-Value Tables, Appointed (1993-)
Member, MIRD Task Group on Small-Scale Dosimetry, Appointed (1993-)
Member, MIRD Task Group on Nonuniform Dosimetry, Appointed (1992-)

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Graduate Students Supported or Associated with the Project

Listing by Name, Date, Current Position, and Project Title

MHP - denotes Health Physics Program (Medical Option)
WMHP - denotes Health Physics Program (Waste Management Option)
PRHP - denotes Health Physics Program (Power Reactor Option)
MP - denotes Medical Physics Program
BME - denotes Biomedical Engineering

Current Students (PhD)

Bulent Aydogan, PhD (MP), Graduate Research Assistant
  Dissertation Topic:  Modeling Radiation Damage to DNA Plasmids
  Graduation Date:  December 1999

Derek Jokisch, PhD (MHP), Graduate Research Assistant
  Thesis Topic:  Development of an MRI-Based Dosimetry Model of Trabecular Bone
  Graduation Date:  August 1999

Brian Morabito, PhD (MP), Graduate Research Assistant
  Dissertation Topic:  Measurement of Radiation Damage to DNA Plasmids
  Graduation Date Date:  December 1999

Phillip Patton, PhD (MHP), Graduate Research Assistant
  Dissertation Topic:  NMR Microscopy of Trabecular Bone
  Graduation Date:  May 2000

Alumni (PhD)

Lionel Bouchet, PhD (Health Physics)
  Postdoctoral Research Assistant, University of Florida
  Dissertation:  Development of Improved Methods for Internal Dosimetry Calculations
  Graduation Date:  December 1998

Kory A. Kodimer, PhD (Health Physics)
  Researcher, Radiation Safety Engineering of Chandler, Arizona
  Dissertation:  Monte Carlo Calculations of Absorbed Fractions and S Values for Anthropomorphic Pediatric Phantoms
  Graduation:  August 1995

Eun-Hee Kim, PhD (Health Physics)
  Staff Physicist, Korean National Cancer Hospital
  Dissertation:  “Microdosimetric Cellular-Dose Calculations for Beta Emitters in Radioimmunotherapy”
  Graduation Date:  May 1995

John W. Poston, Jr., PhD (Health Physics)
  Senior Health Physicist, Idaho National Engineering Laboratory
  Dissertation:  “Improved Dosimetric Model of the Gastrointestinal Tract”
  Graduation Date:  December 1994

How Moom Lau, PhD (Health Physics)
  Nuclear Energy Unit, Puspati Complex, Selangor, Malaysia
  Dissertation:  “Mechanisms of Radiation Damage to Poly(U)”
  Graduation Date:  August 1994
Current Students (Master's)

Didier Rajon, MS (MHP), Graduate Research Assistant
Thesis Topic: Improved Computational Models for Bone Dosimetry
Graduation Date: August 1999

Kathryn Wilson, MS (MHP), Graduate Research Assistant
Thesis Topic: Biological Dosimetry Using Irradiated Plasmids
Graduation Date: August 2000

Jon Shepard, MS (MP), Graduate Research Assistant
Thesis Topic: Development of a Pediatric Tomographic Phantom
Graduation Date: August 2000

Alumni (Master's)

Phillip Patton, PhD (MHP), Doctoral Program at UF
Thesis Topic: Nuclear Magnetic Resonance Assessment of Chord Distributions for Trabecular Bone
Dosimetry: The Effects of Sample Freezing and Thawing
Graduation Date: August 1998

Pablo Blanco, MS (MHP), Returned to France
Thesis: Electron Transport within Revised Mathematical Models of Pediatric Patients
Graduation Date: August 1998

Derek Jokisch, MS (MHP), Doctoral Program at UF
Thesis: Nuclear Magnetic Resonance Imaging as a Tool for Studying Beta-Dosimetry in Trabecular Bone
and Red Marrow Regions
Graduation Date: August 1997

Talal A. Chohan, MS (MHP), Department of Health, State of Florida
Thesis: A Survey of Plain Film X-Ray Examination Parameters for Pediatric Patients
Graduation Date: December 1996

Ricardo Reyes, MS (MHP), Doctoral Program at UF
Master's Thesis: Estimates of Organ Doses for Pediatric Patients Undergoing Diagnostic X-Ray Procedures
Graduation Date: August 1996

Scottie W. Walker, MS (Health Physics)
Sandia National Laboratory
Thesis: “Experimental Verification of Monte Carlo Transport Calculations”
Graduation Date: May 1995

Robert A. Parry, MS (Health Physics)
Assistant Radiation Safety Officer, Ben Taub Hospital, Houston, Texas, Department of Radiological Sciences, Baylor College of Medicine.
Thesis: “S-values for Bone-Seeking Radionuclides”
Graduation Date: May 1995

Lionel G. Bouchet, MS (Nuclear Engineering)
Doctoral student, Health Physics Program, University of Florida
Graduation Date: December 1994

Donald Crady, MS (Health Physics)
Employment Unknown
Non-Thesis Project: "An Improved Dosimetric Model of the Brain"
Graduation Date: August 1994

Sebastian Calvo, MS (Health Physics)
Internal Dosimetrist at the Oak Ridge National Laboratory
Thesis: "Estimates of Electron Absorbed Fractions of Energy for the Upper Respiratory Tract"
Graduation Date: August 1994

Anne Zuzarte de Mendonca, MS (Nuclear Engineering)
Returned to France
Thesis: "Trabecular Bone Dosimetry Using a Monte Carlo Code"
Graduation Date: August 1993

Oscar H. Hernandez, MS (Health Physics)
Employment Unknown
Thesis: "A Linear Time-Varying Simulation Model of the Respiratory System"
Graduation Date: August 1993

Jody Spence, MS (Health Physics)
Assistant Radiation Safety Officer,
University of Texas Southwest Medical Center at Dallas
Thesis: "A Feasibility Study of a Gelatine-Based Tissue Substitute"
Graduation Date: May 1993

Miles C. Smith, MS (Health Physics)
Health Physicist, Benchmark Environmental Corporation
Thesis: "Nearest-Neighbor Distributions of Free Radicals Produced within Charged-Particle Tracks in Liquid Water"
Graduation Date: May 1990
Project Output

Books and Book Chapters


Refereed Journal Articles (Submitted or In Review)


Refereed Technical Journals (Published)


Symposium Proceedings (Refereed)


Scientific Meeting Presentations (made by the Principal Investigator)


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Scientific Meeting Presentations (made by Graduate Students)


