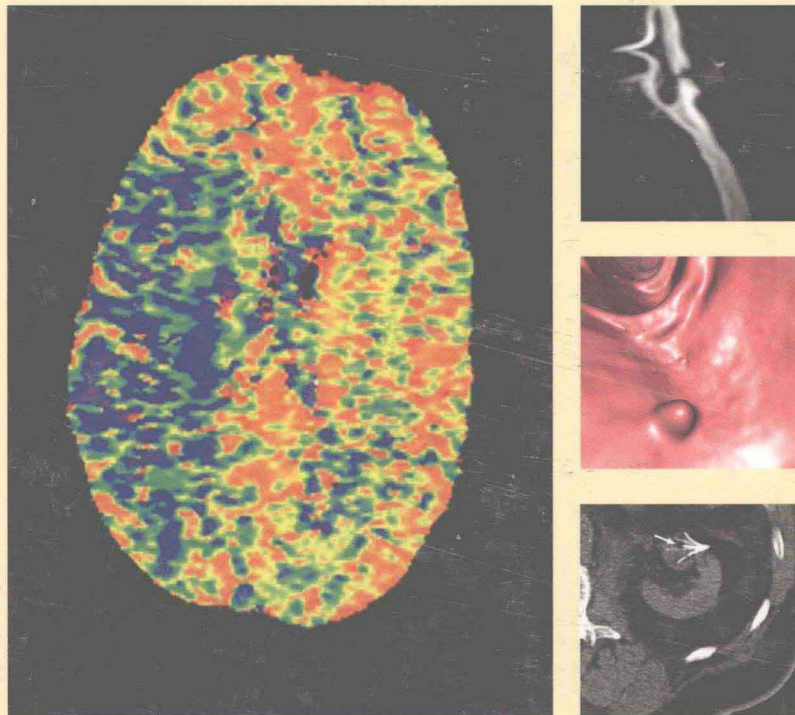


# CT AND MRI OF THE WHOLE BODY

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FIFTH EDITION

# CT and MRI of the Whole Body

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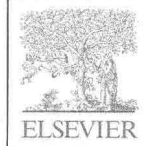
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## **CT and MRI of the Whole Body**



## D E D I C A T I O N

This book is dedicated to Elizabeth E. Haaga, daughter of John and Ellen Haaga, who was born on August 19, 1972, and died December 9, 1985. Beth had a disseminated neuroblastoma, which was diagnosed in 1984. She was treated with a bone marrow transplant and died from graft-versus-host disease and infection. As her parents, we loved her dearly and cherish the memory of her early years when she was well. After the onset of her illness, we came to know that her gentle and loving nature was accompanied by a remarkably strong character. She endured her pain and suffering without bitterness and never sought to hurt those who loved her. Indeed, most incredulously, she tried to lessen our emotional pain even while enduring her physical discomforts. Many authors have marveled at the qualities of children, and although Beth's short life and premature death have left us saddened beyond comprehension, her remarkable courage and sweetness have given us a lasting pride and respect. We remember her lovingly.

The book is also dedicated to my wonderful family: my wife and soul mate Ellen and our children, Matthew and Stacie Haaga, Timothy and Molly Haaga, and Rebecca Haaga. Although professional successes are important and rewarding, the joy and pride of a loving family far surpass such accomplishments. All my love to my current family (and any future additions).



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# Preface

This fifth edition of *CT and MRI of the Whole Body* is noteworthy for many reasons. Imaging technology has evolved remarkably since publication of the fourth edition, affording better equipment, images, and software to launch a revolution in disease diagnosis.

Advances in CT include improved spatial, contrast, and temporal resolution, which generates improved images of virtually all organ systems. The wide detector systems of MDCT and rapid image acquisition now permit imaging of the moving heart itself. Subsecond scan times combined with ECG gating allow evaluation of coronary arteries.

MRI improvements include more sophisticated pulsing sequences, subtraction methods, and better signal-to-noise ratios. Instruments with higher field strength improve spatial and temporal resolution and provide higher-quality spectroscopy. Faster image acquisition permits visualization of cardiac function, cine mode evaluation of chamber function, and quantitative methods for cardiac output. Better MRA studies of the cerebral and other vessels are possible.

Improved computer systems combined with more rapid processors and algorithms create three-dimensional images in virtually any plane. The easy and rapid availability of these multiplanar reconstructions facilitates the routine use of coronal and sagittal images for interpretations. Many authors have demonstrated that such images are more accurate than axial images for evaluation of certain organ systems and disease processes.

Equally important technologic developments are new detector systems and software and hardware methods for

better management of radiation dose and image quality. New detector systems developed and marketed by the vendors have efficiencies close to 99%, lessening the amount of unnecessary radiation exposure. Hardware and software equipment modulates the output of radiation depending on the patient's body size and the characteristics of the anatomic site being examined. Such advances combined with new scan protocols have optimized image quality and dosage so that unnecessary radiation exposure can be avoided.

In addition to MRI and CT imaging, PET scanning is discussed in some chapters in this edition, providing the reader with new correlative information. The new PET CT devices provide the unique combined perspective of high-quality anatomic imaging and physiologic molecular imaging. In the future it is likely that this approach will expand even further as new detector systems will be capable of managing multiple energy photons. It is likely that in the near future, all scanning devices will be such hybrid systems, and PET imaging will be combined with MRI scanners as well.

Finally, globalization of medical science (certainly less complicated than economic and political factors) opens the free exchange and dissemination of medical knowledge internationally. We are very pleased that many esteemed authors from around the world have contributed their support for this new comprehensive book. Our international authors from Europe, Asia, and South America have added unique scientific work to this edition.

JOHN R. HAAGA

# Preface to the First Edition

Since the introduction of computed tomography (CT) in 1974, there has been a remarkable revolution in the medical treatment of patients. The clinical use of CT has had a broad positive impact on patient management. Literally thousands of patients have been saved or their quality of life improved as a result of the expeditious and accurate diagnosis provided by CT. This improvement in diagnosis and management has occurred in all medical subspecialties, including neurological, pulmonary, cardiac, gastrointestinal, genitourinary, and neuromuscular medicine. Aside from the imaging advantages provided, the role of CT in planning and performing interventional procedures is now recognized. It is the most accurate method for guiding procedures to obtain cytological, histological, or bacteriological specimens and for performing a variety of therapeutic procedures.

The evolution and refinement of CT equipment have been as remarkable as the development of patient diagnosis. When we wrote our first book on CT, the scanning unit used was a 2-minute translate-rotate system. At the time of our second book the 18-second translate-rotate scanning unit was in general use. Currently standard units in radiological practice are third and fourth generation scanners with scan times of less than 5 seconds. All modern systems are more reliable than the earlier generations of equipment. The contrast and spatial resolution of these systems are in the range of 0.5% and less than 1 mm, respectively. The sophistication of the computer programs that aid in the diagnosis is also remarkable. There are now programs for three-dimensional reconstructions, quantitation of blood flow, determination of organ volume, longitudinal scans (Scoutview, Deltaview, Synerview, and Topogram), and even triangulation programs for performing percutaneous biopsy procedures.

CT units are now being installed in virtually every hospital of more than 200 beds throughout the United States. Most radiologists using these units are generalists who scan all portions of the anatomy. Because of the dissemination of this equipment and its use in general diagnosis, there exists a significant need for a general and complete textbook to cover all aspects of CT scanning. Our book is intended to partially supplement the knowledge of this group of physicians. We have attempted to completely

and succinctly cover all portions of CT scanning to provide a complete general reference text. In planning the book, we chose to include the contributions of a large number of talented academicians with expertise different from and more complete than our own in their selected areas. By including contributors from outside our own department, we have been able to produce an in-depth textbook that combines the academic strengths of numerous individuals and departments.

The book is divided into chapters according to the organ systems, except for some special chapters on abscesses and interventional procedures. In each of the chapters the authors have organized the material into broad categories, such as congenital, benign, or neoplastic disease. Each author has tried to cover the major disease processes in each of the general categories in which CT diagnosis is applicable. Specific technical details, including the method of scanning, contrast material, collimation, and slice thickness, are covered in each chapter. The interventional chapter extensively covers the various biopsy and therapeutic procedures in all the organ systems. Finally, the last chapter presents an up-to-the-minute coverage of current and recent developments in the CT literature and also provides extensive information about nuclear magnetic resonance (NMR) imaging. At this time we have had moderate experience with the NMR superconducting magnetic device produced by the Technicare Corporation and have formulated some initial opinions as to its role relative to CT and other imaging modalities. A concise discussion of the physics of NMR and a current clinical status report of the new modality are provided.

We would like to thank all those people who have worked so diligently and faithfully for the preparation of this book. First, we are very grateful to our many contributors. For photography work, we are deeply indebted to Mr. Joseph P. Molter. For secretarial and organizational skills, we are indebted especially to Mrs. Mary Ann Reid and Mrs. Rayna Lipscomb. The editorial skills of Ms. B. Hami were invaluable in preparing the manuscript. Our extremely competent technical staff included Mr. Joseph Agee, Ms. Ginger Haddad, Mrs. E. Martinelle, Mr. Mark Clampett, Mrs. Mary Kralik, and numerous others.

Finally, we are, of course, very appreciative of the support, patience, and encouragement of our wonderful families. In the Haaga family this includes Ellen, Elizabeth, Matthew, and Timothy, who provided the positive motivation and support for this book. Warm gratitude for unswerv-

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JOHN R. HAAGA  
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