
Imaging in Clinical Oncology

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Editors

Imaging in Clinical Oncology

Second Edition

 Springer

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*This book is dedicated to all cancer patients and their families.
We are grateful to our teachers and thankful to our staff.*

Foreword

Biomedical imaging techniques play an essential and ever more increasing role in clinical oncology. Today, imaging is used in all phases of cancer management, including screening, image-guided biopsy, planning and guidance of treatment, assessment of therapy response, detection of recurrence, and even in palliative care patients, for whom minimally invasive interventional radiological techniques provide a valuable alternative to surgery.

During the last decade, the impact of imaging in cancer care has greatly expanded. Clinical oncologists rely increasingly on imaging information to make decisions about a patient. Specialists in oncological imaging have become trusted and highly valued members of the teams involved in tumor board reviews. It is now generally accepted that confrontation of the clinical, radiological, and pathological data is essential to establish a final diagnosis, to develop the management plan of a cancer patient, and to obtain follow-up of such a patient under treatment. The growing impact of imaging has been driven by technological improvements, which have provided new insights into the pathophysiology and behavior of tumors, by combining morphological, functional, and molecular techniques. There is no doubt that imaging constitutes a cornerstone in oncological research and patient management.

Traditionally, the role of imaging in cancer management has been mainly focused on screening and disease management, i.e., diagnosis and staging, treatment monitoring and follow-up. But, as the expression goes, there is much more than meets the eye. The term “*radiomics*” has been coined to describe the process of extracting quantitative features from medical imaging data of tumor phenotypes, by applying advanced data-mining and characterization algorithms. Such methods can potentially disclose tumor characteristics that are not seen, or at least not recognized, by the naked eye. The term “*radiogenomics*” refers to the correlation between imaging features and the underlying gene-expression patterns. Thanks to ongoing technological advances, imaging has gained a foothold in presymptomatic risk assessment (discovering a genetic predisposition to a certain disease through molecular diagnostics). Targeted imaging of receptors on tumor cells and the study of gene therapy expression are being introduced into clinical medicine. A completely different, but no less important, direction in imaging research is the rapid evolution of image-guided and targeted minimally invasive procedures, as an alternative to open surgery. Such imaging-guided therapy holds great promise to reduce complications and collateral effects of cancer treatment and eventually to improve patient outcome.

Screening examinations are performed in asymptomatic individuals for early detection of cancer, at a stage where it is easier to treat and potentially cure the disease. Early diagnosis of cancer through screening, based on imaging, offers the best hope to reduce the human and financial burden of cancer management and is a major contributor to a reduction in mortality for certain cancers. Different imaging techniques can be applied to screen for different types of cancer. Traditional examples of imaging-based screening include detection of breast cancer with mammography or of lung cancer with CT scans of the thorax. *Computer-aided detection/diagnosis* (CAD) has been successfully applied to improve lesion detection, for example in discovering breast cancer in digital mammography examinations. *Artificial intelligence* (AI) methods can extract volumetric and contrast enhancement features from imaging data sets in different types of cancer. There is hope that the development of specific imaging biomarkers to identify the presence of cancer will open the door to molecular diagnostics, thus heralding a new era in screening.

Once a cancer has been detected, the information derived from clinical imaging studies becomes essential to establish a certain *diagnosis*. Though pathology remains the gold standard (“the issue is tissue”), imaging studies are an essential part of the diagnostic work-up of the patient. Moreover, image-guided biopsy offers a good way to obtain tissue samples in a safe and minimally invasive way.

Staging is needed to gain information about how advanced the cancer is. Accurate staging is the cornerstone to determine treatment options and predict the prognosis. Staging involves looking at the primary tumor, the lymph nodes, and distant metastases in other organs. This is the so-called TNM classification system (tumor—nodes—metastasis). Imaging techniques allow us to perform a focused, noninvasive exploration of those organs in the human body where we know that cancer cells will thrive.

In recent years, treatment of cancer has made a giant leap forward. Thus, since more patients survive, it becomes ever more important to *assess the response to treatment*. Imaging can inform us whether there is a change in the tumor burden. The most commonly used imaging response assessment tool for solid tumors is the Response Evaluation Criteria in Solid Tumors (RECIST). RECIST recognizes four categories of response: complete response (i.e., complete disappearance of the target lesions); partial response (i.e., a 30% decrease in the sum of the target lesions); progressive disease (i.e., a 20% increase in the sum of the target lesions); and stable disease (i.e., smaller changes that don’t quite meet any of the above criteria). The RECIST guidelines rely on comparison of the baseline scan with the images after treatment (i.e., surgery, radiation, chemotherapy). Unfortunately, the concept of using relatively crude measurements to monitor the tumor (e.g., longest diameter of a mass, or approximate appraisal of the tumor volume) is inadequate; such visual comparisons can only indicate a delayed response to therapy and hold no information about the metabolism, vascularization, cell density, or other parameters of the tumor. This has led researchers to develop *quantitative imaging biomarkers* to accurately monitor changes in tumor volume and structure, angiogenesis and vascularization (perfusion imaging),

biochemical composition (MR spectroscopy), cell proliferation (diffusion weighted imaging), microscopic environment (diffusion tensor imaging), and metabolism (PET, SPECT). The inherent limitations of traditional imaging methods have led to the development of *hybrid imaging* techniques, such as PET-CT or PET-MR, which combine the metabolic sensitivity of nuclear medicine with the spatial and temporal resolution of radiological methods, such as CT or MRI.

Monitoring and *follow-up* refer to the process of following a patient after successful eradication of a tumor. Imaging studies are performed at regular intervals to monitor therapy response and screen the patient for detection of tumor relapse. The great advantage of imaging is that it can provide essential information without tissue destruction, in a noninvasive (or minimally invasive) way, over wide ranges of time. The biggest challenge here is to standardize imaging methodology, so that the technical parameters between baseline and follow-up studies are kept identical, to allow accurate comparisons.

The growing importance of imaging in cancer management has created new opportunities for the radiologist, but also new challenges. In order to function in a multidisciplinary cancer environment, the radiologist must understand and speak the language of the clinicians, and needs to acquire more clinical background knowledge in the field of oncology. At the same time, the imaging specialist should also have a profound understanding of tumor pathophysiology and how different characteristics of a tumor are reflected in morphological, structural, metabolic, and functional imaging studies. Together with oncologists, pathologists, surgeons, radiation therapists, and many other specialists, radiologists and nuclear medicine physicians are an essential part of the tumor board, to assist in the multidisciplinary decision-making on patients with cancer.

On a personal note, I am indebted to the editors of this book, my Greek friends Athanasios D. Gouliamos, John Andreou, and Paris A. Kosmidis, for giving me the opportunity to write this foreword. It is a great honor and a privilege to be invited; I'm very happy to oblige and to write this modest contribution. The editors have pooled their combined experience, wisdom, and skill to create a kaleidoscopic overview of the role of imaging in clinical oncology. They have managed to successfully aggregate an "all-star" team of distinguished authors, to cover a wide range of biomedical imaging techniques, in a variety of tumor types, including all phases of cancer management. The individual chapters in this book are well written and superbly illustrated; this greatly facilitates the task of the reader to comprehend this complex subject matter. Careful attention is given to the concepts that are crucial in understanding modern "multimodality," "multiparametric," and "hybrid" imaging techniques. Integration of different kinds of imaging technology helps the reader to better understand the pathophysiology of tumors and provides complementary information for improved staging and therapy planning. The information in this book is presented in a logical and straightforward manner, thus offering an enjoyable learning experience. I am convinced that *Imaging in Clinical Oncology* will become a standard textbook, useful not only to imaging specialists (including radiologists, nuclear medicine

physicians, and radiation therapists) but also to all clinicians with an interest in oncology. Close multidisciplinary collaboration, within a well-trained and experienced team, is the cornerstone in the management and care of oncological patients; and, as this book eloquently illustrates, imaging holds the key to success in the screening, detection, staging, treatment monitoring, and follow-up of patients with cancer.

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Preface

This new edition features many exciting changes since the first edition, published in 2013. Four new chapters are included while some of the original chapters have additional contributors. One of the new chapters covers the role of radiogenomics in oncologic imaging. Three new chapters elucidate multiple myeloma. Chapters on lymphomas have been extensively revised by the same authors who participated in the book *PET/CT in Lymphomas: A Case-Based Atlas*, published in 2015.

The new edition of *Imaging in Clinical Oncology* is divided in 20 parts. The first part covers a general approach to molecular imaging in oncology, imaging criteria for treatment response evaluation, imaging in radiation therapy, interventional radiology in oncology, imaging principles in pediatric oncology, and the role of radiogenomics in oncologic imaging. In the following 19 parts, the main types of cancers are addressed in different chapters and organized by organ systems (bone and soft tissue tumors, CNS tumors, head and neck tumors, lung cancer, breast cancer, gynecologic cancer, gastrointestinal cancer, neuroendocrine tumors, urogenital cancer, lymphomas, multiple myeloma, and melanoma).

The aim of this book is to promote the understanding between radiologists and clinical oncologists, presenting all the currently available imaging modalities and covering a broad spectrum of oncologic diseases from most organ systems. In each chapter the clinical oncologist begins with a brief introduction of each type of tumor. All relevant conventional and advanced imaging techniques and technologies of ultrasound, MRI, CT, and PET are then addressed by radiologists and nuclear medicine experts in their respective fields. Finally, the clinical oncologist provides a critical analysis of the treatment implications, usefulness, sequence, and combination of the imaging studies presented. Quantitative imaging data combined with laboratory biomarkers can help the clinical oncologist to recognize at the earliest possible time whether the applied treatment is ineffective so that therapy can be modified.

Incorporation of new data has not changed our initial aim to keep the content of this book as compact as possible. It is hoped that practitioners and

residents in radiology, nuclear medicine, clinical oncology, hematology, radiotherapy, and other specialties involved in cancer management will find this a true companion in their daily practice.

Athens, Greece

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