

## PREFACE

The book *Molecular Imaging and Therapy* focuses on selected topics of the clinical uses of molecular imaging and targeted molecular radiotherapy techniques with an emphasis on oncological disease processes. This book is primarily designed for clinicians and students/trainees in fields that interpret or utilize molecular imaging techniques to diagnose and/or treat their patients, though scientists and clinicians in other fields will hopefully find use as well.

Chapter 1 reviews molecular imaging of Parkinson's disease. Diagnosis of Parkinson's disease by clinical examination alone is limited because there are other disease conditions such as essential tremors, multiple systemic atrophy, and progressive supranuclear palsy that may present with similar symptoms. Imaging has played an important role in early diagnosis and management of the disease. Molecular imaging is essential for early detection and enabling clear distinction between other similar disease entities that may mimic Parkinson's disease.

Chapter 2 reviews molecular imaging of head and neck cancers. FDG PET/CT and PET/MRI are essential tools in the evaluation of head and neck cancers (HNC) and can detect the primary site of malignancy in patients with cervical lymph node metastases from an unknown origin and guide treatment. Compared to traditional imaging, 18F-FDG PET/CT has higher sensitivity in detecting distant metastases and potential second primary malignancy. 18F-FDG PET/CT also helps in evaluating recurrent or persistent disease that can be treated with salvage therapy with a high negative predictive value. 18F-FDG PET/CT is also integrated in radiotherapy planning for accurate target delineation. Hypoxia imaging in head and neck cancers has also been evaluated with novel molecular imaging agents. Sentinel lymph node biopsy with SPECT/CT and gamma probe guides early-stage HNC surgeries.

Chapter 3 reviews nuclear imaging and therapy of thyroid disorders. This chapter reviews the basics of molecular imaging in thyroid disease and special considerations in radioiodine therapy of benign diseases such as Graves' disease, autonomously functioning nodules, and toxic multinodular goiter. It also discusses the use of radioiodine therapy in the setting of differentiated thyroid carcinomas. A brief discussion of peptide receptor radionuclide therapy in medullary thyroid cancer is also included.

Chapter 4 reviews molecular imaging of lung and pleural tumors. PET/CT and PET/MRI imaging play an imminent role in thoracic oncology such as pulmonary nodule evaluation, initial disease staging, therapy planning, response evaluation, and post treatment monitoring for disease recurrence. The purpose of this chapter is to give an overview of the various clinical uses, advantages, pitfalls, and advancements in molecular imaging and therapy of lung and pleural tumors.

Chapter 5 reviews molecular imaging of mediastinal tumors. PET/CT imaging plays a crucial role in the diagnosis, characterization, and management of mediastinal tumors. The mediastinal tumors discussed are categorized into anterior mediastinal tumors, including thymic tumors, teratoma/Germ cell tumors, lymphomas, and neurogenic tumors in the posterior mediastinum. Molecular imaging with PET when combined with CT or MRI can provide valuable

information on tumor metabolism, staging, therapy planning, response assessment, and post-treatment monitoring for disease recurrence. The purpose of this chapter is to provide a clear review of the role, advantages, pitfalls, and advancements of molecular imaging in each mediastinal tumor.

Chapter 6 reviews molecular imaging of breast cancer. Breast cancer is one of the most common types of malignancy, with an increasing incidence worldwide. FDG PET has an established role in the staging of locally advanced breast cancers, along with its use in response assessment after systemic therapy. Non-FDG molecular imaging agents also have a potential role in breast cancer imaging. These include agents that target hormonal and tyrosine kinase receptors, tumor microenvironment, and fibroblast activation protein inhibitors. Gamma camera-based modalities such as breast-specific gamma imaging, sentinel lymph node imaging, and skeletal scintigraphy also play a significant role in the management of subsets of patients with breast malignancy.

Chapter 7 reviews molecular imaging of hepatobiliary cancers. The role of molecular imaging in hepatobiliary tumors is evolving and the development of new molecular imaging agents has renewed the interest in molecular imaging applications in hepatobiliary malignancies. In addition to providing information for tumor staging, treatment planning, response assessment, and detection of disease recurrence, molecular imaging provides additional information on the biological and molecular behavior of the tumor to assess disease prognosis and outcome. Molecular imaging agents targeting different metabolic pathways (glucose and lipid metabolism) and receptors (somatostatin and fibroblast activation protein inhibitors) have been evaluated in hepatocellular carcinoma, cholangiocarcinoma, liver metastasis and neuroendocrine tumors. The current role of molecular imaging in hepatobiliary tumors and its advantages and disadvantages over conventional imaging modalities, along with a brief overview of newer PET molecular imaging agents is provided in this chapter.

Chapter 8 reviews molecular imaging of neuroendocrine tumors. Neuroendocrine tumors are a diverse group of neoplastic entities with variable degrees of neuroendocrine differentiation that are imaged and, in some cases, treated with molecular imaging and targeted molecular radiotherapy techniques. This chapter provides an overview of molecular imaging and therapy of neuroendocrine tumors with radiopharmaceuticals including  $^{111}\text{In}$ -octreotide,  $^{123}\text{I}$ -mIBG,  $^{131}\text{I}$ -mIBG,  $^{68}\text{Ga}$ - or  $^{64}\text{Cu}$ -DOTATATE,  $^{177}\text{Lu}$  DOTATATE, and  $^{18}\text{F}$ -FDG. The biodistribution of these radiopharmaceuticals is reviewed along with dosing and, for therapies, the inclusion and exclusion criteria.

Chapter 9 reviews the utility FDG PET/CT in non-prostate male genitourinary pathology. FDG PET/CT can be a useful modality in the evaluation and staging of cancers of the male GU (genitourinary) tract. Similar to its application with the more common malignancies, FDG PET/CT can provide helpful information when evaluating for sites of disease such as recurrent, nodal, and/or metastatic disease in the setting of these GU cancers. This chapter reviews the utility of PET/CT in the evaluation of non-prostate male GU pathologies such as the penis and testicles. Some very rare tumors as well as infectious and/or inflammatory conditions that can affect the GU system are also described.

Chapter 10 reviews molecular targeted radionuclide therapy for prostate cancer. According to the American Cancer Society, prostate cancer affects 1 in 8 men. This chapter reviews the molecular targeted radionuclide therapy for prostate

cancer, including pretherapy imaging and evaluation, considerations during the course of therapy, and follow-up. Dosimetry and alpha-particle therapies are also discussed.

Chapter 11 reviews molecular imaging of pediatric lymphoma, sarcomas, and other solid tumors. Pediatric tumors are rare, but often rapidly progressive malignancies which require early diagnosis, accurate staging, and appropriate treatment. Molecular imaging techniques with PET/CT and single photon emission computed tomography (SPECT) with CT (SPECT/CT) can often localize and accurately stage pediatric malignancies before morphological changes are evident with anatomical imaging techniques. In post-therapy patients, PET/CT and SPECT/CT may more accurately identify or exclude residual/recurrent malignancy. PET/CT with  $^{18}\text{F}$ -FDG usually shows increased tumor uptake in pediatric lymphoma and many other extra-cranial solid tumors. Amino acid based molecular imaging agents can be used in brain tumors and somatostatin receptor (SSTR) peptide molecular imaging agents can be used for tumors of neuroendocrine origin.

Chapter 12 reviews molecular imaging of infection. Molecular imaging of infection has been part of diagnostic imaging since the early days of radiopharmaceuticals. This chapter discusses the properties of diagnostic radiopharmaceuticals  $^{67}\text{Ga}$ -citrate,  $^{111}\text{In}$ - and  $^{99\text{m}}\text{Tc}$ -labeled leukocytes and  $^{18}\text{F}$ -FDG, along with when they are best deployed. Molecular imaging of infection is best performed with  $^{18}\text{F}$  FDG for the majority of indications. This chapter explores the currently available means of diagnosis and best practices.

I am profoundly grateful to all of the contributing authors who have provided their exceptional talent and countless hours to help produce this outstanding textbook. The wide range of important clinical topics will serve as a strong foundation in common and novel molecular imaging and targeted molecular radiotherapy techniques for clinicians, scientists, and students of many fields as they work to improve the care of their patients.

I hope this book serves as a resource for all who wish to learn about and apply molecular imaging and therapy techniques in their clinical and research practices and to simulate continued exploration and innovation in this vitally important and growing field.

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