Clinical PET

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Clinical PET
Principles and Applications

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Cover illustrations: (Background, Figure 9-1, see p. 148) Selected coronal whole-body PET images show a subcutaneous extravasation of FDG solution. (Foreground and back cover, Figure 10-3, see p. 168) Four cases of occipital lobe epilepsy.

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This book is dedicated to Thomas T. Haynie, MD,
doctor-teacher-friend.

Foreword

Nuclear medicine contributes significantly to the initial diagnosis of disease, assessment of response to therapy, and exploration of the natural history of disease, and is beginning to have an expanded role in therapy. The techniques enable appraisal of anatomy and physiology. An area of the field of nuclear medicine with many applications and great potential is positron emission tomography (PET), which has evolved from a research tool to active clinical use in less than 30 years. The progression from the first experimental animal studies of ^{14}C-labeled deoxyglucose used to measure functional brain activity by means of postmortem autoradiography in the early 1970s to the application of ^{18}F-fluorodeoxyglucose (FDG)-PET on a routine clinical basis has been exhilarating. For many diseases and physiologic evaluations, PET has shown itself to be superior to other imaging techniques. This is especially true for such functions as the differentiation of recurrent tumor from radiation necrosis (brain tumors), and staging and following the effects of therapy for Hodgkin and non-Hodgkin lymphomas, head and neck tumors, breast cancer, melanoma, ovarian neoplasms, and others. In benign areas, PET helps in the assessment of tissue viability (myocardial infarction and stroke), infection, and inflammation.

Positron emission tomography imaging offers the opportunity and challenge of taking advantage of metabolic activity as well as anatomy. Cancer cells have a generally increased uptake of glucose. Hence, the ever-expanding role of ^{18}F-FDG PET in nuclear oncology. This metabolic difference is useful in evaluating whether pulmonary lesions are benign or malignant. The sensitivity and specificity of PET in Hodgkin and non-Hodgkin lymphomas continues to be expanded. Use of radioactive nitrogen, radiolabeled purines, pyrimidines, and amino acids offer diverse opportunities to apply PET to metabolic, anatomic, and functional oncologic clinical studies. Altered metabolic pathways imaged in real time can aid in predicting therapeutic efficiency. Functional studies may permit measurement of therapeutic response before anatomic changes are noted. An even more exciting potential is the possibility of using PET to detect early epithelial or tissue changes at

the molecular level that may presage clinical cancer. Here early detection may provide opportunities for prevention or earlier therapeutic intervention.

PET interpretation requires knowledge of physics, pharmacy, anatomy, physiology, disease process, and artifacts. This book presents the current science, technology, and, where applicable, the art necessary to synthesize the complexities of PET. The diagnostic competence and acumen of the nuclear medicine physician/radiologist will be tested to make proper interpretations today and be prepared to move to incorporate new knowledge and techniques tomorrow. Future PET techniques and radiopharmaceuticals will emerge and be implemented. Expanded and exciting avenues are here now, and a universe of PET and related techniques are on the horizon.

Dr. Kim and his colleagues have provided us with a beacon and a path for this journey.

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Preface

Positron emission tomography (PET) has been around long enough that it is hard to think of it as being anything special. It has been a valuable research tool in academic institutions since the 1970s, but its move into clinical practice in community hospitals has just begun.

Those who are now working with PET, or have made the decision to do so, understand just how different a perspective on disease this modality provides. In most patients for whom it is indicated, PET provides earlier and more sensitive detection. It is special, but not in ways that are immediately evident. It requires a shift in the diagnostic paradigm, and adjustments in patient management, to capture the advantages of early diagnosis.

Questions remain on how and when payment will be made for PET studies, but as with so much else in medicine, once patients and referring physicians know what PET can do for them, it will not be refused. Given time, it will eventually be documented that PET saves money overall by eliminating unnecessary and futile interventions in patients with advanced disease. That's the power of imaging the body's biochemistry.

The momentum toward the use of PET is expected to grow with the advent of molecular imaging. The sequencing of the genome and proteomes is establishing the fundamental molecular basis of how cells function. Molecules can now be designed to stop the disease or to prevent it from occurring. Imaging of gene expression could eventually provide the basis for developing therapeutic strategies individualized to a patient's genetic characteristics. Biology and genetics were merged with medicine to produce the new field of molecular medicine, and that created the need for an imaging technology that looks at the biology of a disease. As drug company research and molecular imaging converge, imaging probes will be used to select patients for treatment with specific drugs.

The main impact of PET in community practice now, and likely for several years to come, is in oncology. Whole-body PET in cancer patients enables clinicians to identify malignant diseases in their early stages, differentiate benign from malignant tumors, examine the entire

body for metastases, and determine the effectiveness of cancer therapeutics.

It has been predicted that PET would undergo spectacular growth in the 21st century as molecular medicine becomes central to the analysis of disease. The burgeoning world of PET is reflected in recent scientific meetings including Radiological Society of North America (RSNA) and Society of Nuclear Medicine (SNM).

This book provides comprehensive information on the basic principles and clinical applications of PET. Emphasis is placed on the familiarization of normal distribution, artifacts, and pitfalls of common agents such as fluorodeoxyglucose (FDG) in conjunction with computed tomography (CT), magnetic resonance imaging (MRI), or ultrasound (US) to establish the clinical effectiveness of PET. Practical understanding of updated PET scanners, cyclotron, image process, and quantification is also stressed. This book is therefore divided into two parts: the first part discusses the basic principles of PET, such as instrumentation, image process, fusion, radiopharmaceuticals, radiosynthesis, safety and economics. The second part discusses the clinical applications of the technique in neurology, cardiology, infection, and oncology.

We hope this book meets the growing needs of diagnostic radiologists, nuclear physicians, and clinicians for understanding the basic principles and clinical applications of PET.

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