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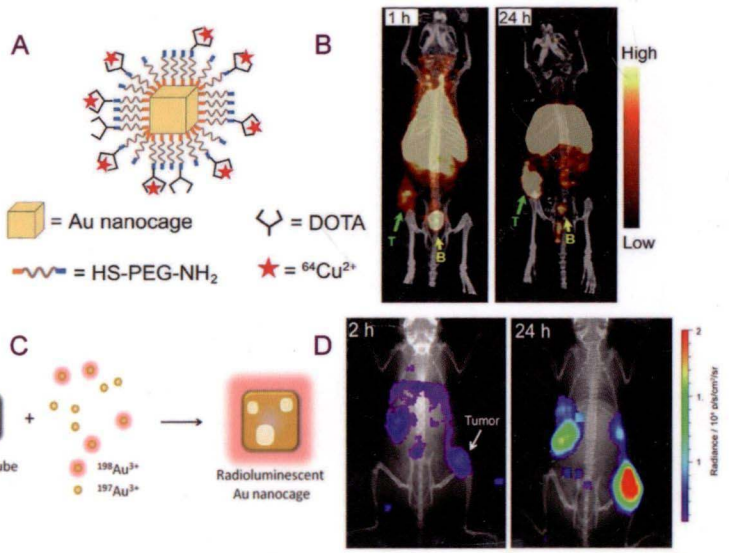

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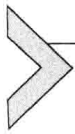

VOLUME ONE HUNDRED AND TWENTY FOUR

ADVANCES IN CANCER RESEARCH

Emerging Applications of Molecular Imaging to Oncology

Edited by

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Emerging Applications of Molecular Imaging to Oncology

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PREFACE

As molecular pathways in cancer succumb one by one to increasingly sensitive methods of detection, we can begin to isolate the key drivers of malignancy—with implications for management. Cancer researchers are continually uncovering molecular subsets of what were until recently considered single pathologic entities. Because it is inherently noninvasive, sensitive, and quantitative, molecular imaging enables measurement of biochemistry within tissue and lends itself well to identification of disease subsets and, by extension, precision medicine.

In this volume of *Advances in Cancer Research*, we start by discussing quantitative radiology, and how to extract optimum value out of existing, primarily anatomic clinical imaging studies. We focus on new technologies (nanomedicine, fluorescence-guided surgery, Cerenkov imaging, and smart MR agents) as well as on new targets for detecting cancer directly or for studying the biology of its supporting microenvironment (chemokine receptor 4, hypoxia, pH, and the extracellular matrix). We also address emerging clinical applications, including molecular-genetic imaging, immune cell tracking, assessment of immune therapies, and aspects of tumor metabolism.

A goal of this volume is to communicate the excitement in molecular imaging research as the imaging technologies continue to evolve and adapt to new discoveries in cancer pathogenesis in ways that will enable more precise management of patients suffering from this protean disease.

MARTIN G. POMPER
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CONTENTS

CHAPTER ONE

Quantitative Radiology: Applications to Oncology

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Contents

Abstract

Oncologists, clinician-scientists, and basic scientists collect computed tomography, magnetic resonance, and positron emission tomography images in the process of caring for patients, managing clinical trials, and investigating cancer biology. As we have developed more sophisticated means for noninvasively delineating and characterizing neoplasms, these image data have come to play a central role in oncology. In parallel, the increasing complexity and volume of these data have necessitated the development of quantitative methods for assessing tumor burden, and by proxy, disease-free survival.

1. INTRODUCTION

Oncologists, clinician-scientists, and basic scientists collect a plethora of data in the process of caring for patients, managing clinical trials, and investigating cancer biology. As we have developed more sophisticated

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means for noninvasively delineating and interrogating neoplasms, the resulting image data have come to play a central role in oncology. To understand the current impact and long-term promise of radiology with respect to oncology, it may help to characterize the nature of the information sought as we diagnose and treat cancer patients.

The ultimate goal of patient care in oncology is to maximize disease-free survival (DFS)—or, barring that, progression-free survival (PFS)—while minimizing the morbidity of treatment (i.e., to maximize quality-adjusted life years). Ignoring intercurrent illnesses and treatment morbidity for the sake of this discussion, we take PFS to be a function of tumor burden, which can be decomposed into two independent factors: the number of tumor cells and the malignant potential of each cell. For many years, the former—extent—was determined via exploratory surgery and summarized as tumor stage, and the latter—grade—was determined by pathologists from what was hoped to be a biologically representative sample obtained during this operation. Advances in radiology first became evident with respect to staging, for the simple reason that it is much easier to generate images that show macroscopic groups of cells than it is to generate images that show how these cells are likely to behave. Only in the last decade has radiology begun to offer information regarding tumor biology, and such information still pales in comparison with that obtained from histopathology and genetic analysis.

In parallel with the increasing complexity of image data, there has been steady progress in the quantification of these data. Although clinical radiology reports are unfortunately replete with verbiage such as "large mass in the right frontal lobe," researchers have begun to deliver on the promise of computer-based methods for quantification of tumor extent and have also developed quantitative or semiquantitative methods for characterizing tumor biology. The premise underlying such efforts is that quantitative—rather than qualitative—indications of tumor extent and biology render more precise prediction of DFS, thereby promising superior patient care and assessment of therapy. Herein I explore the arc of radiology's contributions to oncology, both in terms of the information provided and efforts to quantify this information, with the expectation that such exploration will shed light on future developments in oncology research and practice.

2. RADIOLOGICAL CHARACTERIZATION OF TUMORS

The advent of computed tomography (CT) revolutionized the staging of solid tumors; since then, the quality and range of information provided to