
Glioma Imaging

Whitney B. Pope
Editor

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Physiologic, Metabolic, and
Molecular Approaches

Editor

Whitney B. Pope
David Geffen School of Medicine at UCLA
Los Angeles, CA
USA

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Preface

This book is intended to provide the most up-to-date synthesis of imaging with glioma biology and to highlight areas of unmet clinical need. Its focus is gliomas in adult patients. Gliomas are the most frequently occurring primary brain tumor. They range in grade from I to IV, with grade IV (glioblastoma) being not just the most malignant but also the most common. MRI is central to the clinical management of gliomas. Clinicians use MRI to generate differential diagnoses, improve neurosurgical planning, assess resection extent, and follow changes in tumor burden over the course of treatment. Though critically important, tracking tumor burden has historically presented significant challenges for MRI, particularly in distinguishing treatment effect from recurrent or residual disease. Addressing some of these difficulties, brain tumor treatment response has been formalized using Response Assessment in Neuro-Oncology (RANO) criteria based on measurements of enhancing tumor. Complementary to MRI, PET scans can refine characterization of tumor burden, adding value to standard imaging, especially when coupled with newer amino acid tracers that serve as markers for protein synthesis. This book explores the ever-expanding role of MR and PET in managing glioma patients, as reflected both in contemporary medical practice and in new applications being developed and validated for clinical use.

In many ways, the future is here. The molecular characterization of brain tumors has substantially advanced over the past decade and is now fundamental to the identification of many gliomas, as reflected in the updated 2016 World Health Organization (WHO) guidelines for brain tumor classification. Imaging techniques have advanced apace. Once used almost exclusively to characterize anatomic features of a tumor, newer approaches can now interrogate a wide range of tumor physiologic and metabolic characteristics. Additionally, entirely new fields such as “radiomics” and “imaging genomics” are emerging, and with them are enormous data sets that ultimately may be most effectively mined by artificial intelligence/machine learning-based paradigms. Yet a fundamental challenge remains: how can researchers and clinicians leverage these vast quantities of data into imaging-generated biomarkers that improve patient outcomes? Although traditionally it is the primary marker of disease burden, measurement of contrast enhancement retains its manifold limitations. Even with T2-weighted and FLAIR sequences, standard imaging can lack sufficient specificity and sensitivity for tumor in common clinical scenarios like pseudo-progression and pseudoresponse. Looking forward, this book examines path-breaking efforts to move beyond contrast

enhancement in addressing imaging needs of glioma patients—whether for predictive markers tailored to emerging treatments like immunotherapy or early response markers to hasten assessment of therapy effectiveness—that remain unmet.

The contributors for this volume are renowned leaders from around the world in fields encompassing clinical neuroradiology, neuro-oncology, and basic science imaging research. This work should be highly useful for general as well as subspecialized radiologists who interpret brain tumor imaging, as well as for neuro-oncologists, clinicians developing brain tumor trials who rely on imaging endpoints, neurosurgeons who resect gliomas, and also those researchers looking for perspective in understanding imaging-based global assessment of tumor status.

The book begins by outlining the current standard of care for high-grade gliomas and the role of MR imaging in providing that standard of care. It then details the biological underpinnings of blood-brain barrier breakdown, as bidimensional measurements of contrast enhancement remain the accepted quantitative measure of tumor burden. In subsequent chapters, the theoretical basis for important and widely available physiologic imaging techniques, including perfusion- and diffusion-weighted protocols and analysis, is examined in detail. A separate chapter is dedicated to major changes in the recent WHO reclassification of brain tumors—changes that are crucial to the daily practice of clinical neuroradiologists. Additional chapters explore the transformation of lower-grade tumors into more malignant ones, together with a raft of new technologies that advance our ability to image tumor physiology and metabolism, including CEST, amino acid PET, and spectroscopy. Informatics-based approaches that encompass “big data” and machine learning in the context of imaging genomics and radiomics are also addressed. Turning to treatment, the book reviews important recent advances in immunotherapy and its impact on brain tumor imaging interpretation. The book concludes with a review of multi-institutional efforts to standardize imaging protocol and interpretation—a matter of paramount importance for ongoing and future clinical trials.

In marrying “state of the practice” and “state of the science” assessments, this work is intended to help integrate emerging imaging technologies with clinical practice while also providing a more precise understanding of underlying tumor biology. This understanding, in turn, should facilitate individualized patient treatment, improve the application of imaging in clinical trials, and illustrate areas where new approaches can yield needed improvements in glioma characterization, all with the ultimate goal of lengthening and bettering the lives of brain tumor patients.

Los Angeles, CA, USA

Whitney B. Pope

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Contributors

Ovidiu C. Andronesi, PhD, MD Athinoula A. Martinos Center for Biomedical Imaging, Department of Radiology, Massachusetts General Hospital, Harvard Medical School, Boston, MA, USA

Ramon F. Barajas Jr., MD Departments of Radiology and Advanced Imaging Research Center, Knight Cancer Institute, Translational Research Program, Oregon Health and Science University, Portland, OR, USA

Tracy T. Batchelor, MD, MPH Department of Neurology, Brigham and Women's Hospital, Harvard Medical School, Boston, MA, USA
Center for Neuro-Oncology, Dana-Farber Cancer Institute, Boston, MA, USA

Ankush Bhatia, MD Department of Neurology and the Brain Tumor Center, Memorial Sloan Kettering Cancer Center, New York, NY, USA

Jerrold L. Boxerman, MD, PhD, FACR Department of Diagnostic Imaging, Rhode Island Hospital, Providence, RI, USA

Daniel P. Cahill, MD, PhD Department of Neurosurgery, Massachusetts General Hospital, Harvard Medical School, Boston, MA, USA

Michael Cardenas, MD Department of Radiation Oncology, University of California Davis, Sacramento, CA, USA

Peter D. Chang, MD Department of Radiology, University of California, Irvine, Irvine, CA, USA

Thomas L. Chenevert, PhD Department of Radiology, University of Michigan Medical School, Ann Arbor, MI, USA

Daniel S. Chow, MD Department of Radiology, University of California, Irvine, Irvine, CA, USA

Francesco Cicone, MD Department of Nuclear Medicine and Molecular Imaging, Lausanne University Hospital, Lausanne, Switzerland
Unit of Nuclear Medicine, Sant' Andrea Hospital, Sapienza University of Rome, Rome, Italy

Benjamin M. Ellingson, PhD UCLA Brain Tumor Imaging Laboratory, Center for Computer Vision and Imaging Biomarkers, Department of Radiological Sciences, David Geffen School of Medicine, University of California Los Angeles, Los Angeles, CA, USA

UCLA Neuro-Oncology Program, Department of Neurology, David Geffen School of Medicine, University of California Los Angeles, Los Angeles, CA, USA

UCLA Jonsson Comprehensive Cancer Center (JCCC), David Geffen School of Medicine, University of California Los Angeles, Los Angeles, CA, USA

Julie Ferris, BS/BA University of California, Irvine, Irvine, CA, USA

Craig J. Galban, PhD Department of Radiology, University of Michigan Medical School, Ann Arbor, MI, USA

Norbert Galldiks, MD Department of Neurology, University Hospital Cologne, Cologne, Germany

Institute of Neuroscience and Medicine (INM-3, -4), Research Center Juelich, Juelich, Germany

Center of Integrated Oncology (CIO), Universities of Aachen, Bonn, Cologne, and Duesseldorf, Cologne, Germany

Caterina Giannini, MD, PhD Department of Laboratory Medicine and Pathology, Mayo Clinic, Rochester, MN, USA

Elke Hattingen, PhD Neuroradiology, University Hospital Frankfurt, Frankfurt am Main, Germany

Raymond Y. Huang, MD, PhD Department of Radiology, Brigham and Women's Hospital, Boston, MA, USA

Derek R. Johnson, MD Department of Radiology, Mayo Clinic, Rochester, MN, USA

Timothy J. Kaufmann, MD Department of Radiology, Mayo Clinic, Rochester, MN, USA

Cymon N. Kersch, PhD Departments of Neurology, Blood-Brain Barrier Program, Oregon Health and Science University, Portland, OR, USA

Philipp Kickingeder, MD, MBA Department of Neuroradiology, Heidelberg University Hospital, Heidelberg, Germany

Karl-Josef Langen, MD Institute of Neuroscience and Medicine (INM-3, -4), Research Center Juelich, Juelich, Germany

Department of Nuclear Medicine, University of Aachen, Aachen, Germany
Juelich-Aachen Research Alliance (JARA) - Section JARA-Brain, Juelich, Germany

Peter S. LaViolette, PhD Medical College of Wisconsin, Milwaukee, WI, USA

Yan Li, PhD Department of Radiology and Biomedical Imaging, University of California San Francisco, San Francisco, CA, USA

Philipp Lohmann, PhD Institute of Neuroscience and Medicine (INM-3, -4), Research Center Juelich, Juelich, Germany

Janine M. Lupo, PhD University of California San Francisco, Department of Radiology and Biomedical Imaging, San Francisco, CA, USA

Michelle Miller-Thomas, MD Department of Neuroradiology, Washington University School of Medicine, St. Louis, MO, USA

Melanie A. Morrison, PhD Department of Radiology and Biomedical Imaging at UCSF, San Francisco, CA, USA

Centre for Clinical Brain Sciences, University of Edinburgh, Edinburgh, Scotland, UK

Department of Medicine, Imperial College London, London, UK

Daniel Paech, MD, MSc German Cancer Research Center (DKFZ), Division of Radiology, Heidelberg, Germany

Ji Eun Park, MD, PhD Department of Radiology and Research Institute of Radiology, University of Ulsan College of Medicine, Asan Medical Center, Seoul, South Korea

Alexander Radbruch, MD, JD German Cancer Research Center (DKFZ), Division of Radiology, Heidelberg, Germany

University Hospital Essen, Department of Diagnostic and Interventional Radiology and Neuroradiology, Essen, Germany

Sabrina M. Ronen, PhD Department of Radiology and Biomedical Imaging, University of California San Francisco, San Francisco, CA, USA

Brian D. Ross, PhD Department of Radiology, University of Michigan Medical School, Ann Arbor, MI, USA

University of Michigan School of Medicine, Departments of Radiology and Biological Chemistry, Center for Molecular Imaging, Ann Arbor, MI, USA

Marion Smits, MD, PhD Department of Radiology and Nuclear Medicine, Erasmus MC – University Medical Center Rotterdam, Rotterdam, The Netherlands

Christina Tsien, MD Department of Radiation Oncology, Washington University School of Medicine, St. Louis, MO, USA

Javier E. Villanueva-Meyer, MD University of California San Francisco, Department of Radiology and Biomedical Imaging, San Francisco, CA, USA

Pavithra Viswanath, PhD Department of Radiology and Biomedical Imaging, University of California San Francisco, San Francisco, CA, USA

Adam D. Waldman, FRCR, FRCP, PhD Centre for Clinical Brain Sciences, University of Edinburgh, Edinburgh, Scotland, UK

Department of Medicine, Imperial College London, London, UK

Elise Wang Department of Radiology, Memorial Sloan Kettering Cancer Center, New York, NY, USA

Patrick Y. Wen, MD Dana-Farber Cancer Institute, Boston, MA, USA

Robert J. Young, MD Department of Radiology and the Brain Tumor Center, Memorial Sloan Kettering Cancer Center, New York, NY, USA