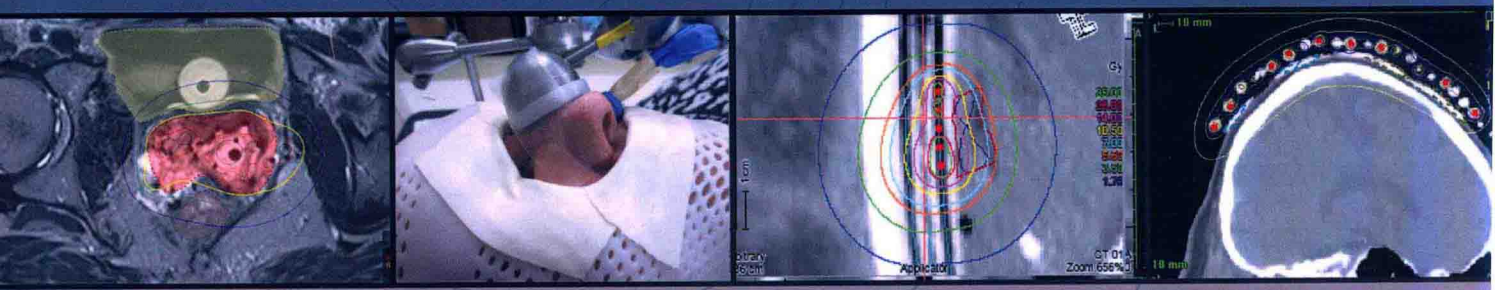
Second Edition

BRACHYTHERAPY

Applications and Techniques



Phillip M. Devlin

Robert A. Cormack • Caroline L. Holloway • Alexandra J. Stewart

Downloadable e-book Included

demosMEDICAL

Brachytherapy

Visit our website at www.demosmedical.com

ISBN: 9781620700822
e-book ISBN: 9781617052613

Acquisitions Editor: David D'Addona
Compositor: Newgen KnowledgeWorks

Medicine is an ever-changing science. Research and clinical experience are continually expanding our knowledge, in particular our understanding of proper treatment and drug therapy. The authors, editors, and publisher have made every effort to ensure that all information in this book is in accordance with the state of knowledge at the time of production of the book. Nevertheless, the authors, editors, and publisher are not responsible for errors or omissions or for any consequences from application of the information in this book and make no warranty, expressed or implied, with respect to the contents of the publication. Every reader should examine carefully the package inserts accompanying each drug and should carefully check whether the dosage schedules mentioned therein or the contraindications stated by the manufacturer differ from the statements made in this book. Such examination is particularly important with drugs that are either rarely used or have been newly released on the market.

Library of Congress Cataloging-in-Publication Data
Brachytherapy (Devlin)
Brachytherapy : applications and techniques / editor, Phillip M. Devlin, Robert A. Cormack, Caroline L. Holloway, Alexandra J. Stewart. — Second edition.
p. ; cm.
Includes bibliographical references and index.
ISBN 978-1-62070-082-2 — ISBN 978-1-61705-261-3 (ebook)
I. Devlin, Phillip M., editor. II. Cormack, Robert A., editor. III. Holloway, Caroline, L. editor. IV. Stewart, Alexandra J., editor. V. Title.
[DNLM: 1. Brachytherapy. WN 250.5.B7]
RC271.R27
616.99'406424—dc23 2015022760

Printed in the United States of America by Total Printing Systems.
15 16 17 18 / 5 4 3 2 1

Second Edition

BRACHYTHERAPY
Applications and Techniques

Phillip M. Devlin

Robert A. Cormack
Caroline L. Holloway
Alexandra J. Stewart

The print volume of *Brachytherapy: Applications and Techniques, Second Edition* includes free access to an e-book version. Log in to http://demosmedical.qbend.com/Brachytherapy and enter the below promo code.

NOTE: If the security coating has been removed, this book may not be exchanged or returned.

PEEL HERE

Marie Curie visits the Standard Chemical Company in Canonsburg, PA (1921) (photograph courtesy of the National Institute of Standards and Technology).

Brachytherapy

Applications and Techniques

Second Edition

Editor

Phillip M. Devlin, MD, FACR, FASTRO, FFRRCSI(Hon)
Chief, Division of Brachytherapy
Institute Physician
Dana-Farber Cancer Institute; and
Associate Professor of Radiation Oncology
Harvard Medical School
Boston, Massachusetts

Associate Editors

Robert A. Cormack, PhD
Associate Professor of Radiation Oncology
Department of Radiation Oncology
Dana-Farber Cancer Institute/Brigham and Women's Hospital
Boston, Massachusetts

Caroline L. Holloway, MD, FRCP(C)
Clinical Assistant Professor
Department of Radiation Oncology
University of British Columbia; and
Radiation Oncologist
British Columbia Cancer Agency
Vancouver Island Centre, Victoria, British Columbia, Canada

Alexandra J. Stewart, DM, MRCP, FRCR
Clinical Lead for Oncology
St Luke's Cancer Centre, Royal Surrey County Hospital; and
Honorary Senior Lecturer
University of Surrey
Guildford, England

demosMEDICAL
New York

In loving memory
Phil Devlin
1917–2009

Contributors

Michele Albert, MD, FRCPC
Department of Radiation Oncology
Harvard Medical School; and
Department of Radiation Oncology
Dana-Farber Cancer Institute/ Brigham and Women's Hospital
Boston, Massachusetts; and
Department of Radiation Oncology
Saint Anne's Hospital, Regional Cancer Center
Fall River, Massachusetts

Jesse N. Aronowitz, MD
Departments of Radiation Oncology and Urology
University of Massachusetts Medical School
Worcester, Massachusetts; and
Department of Radiation Oncology
Tufts University School of Medicine
Boston, Massachusetts

Douglas W. Arthur, MD
Department of Radiation Oncology
VCU-Massey Cancer Center
Virginia Commonwealth University
Richmond, Virginia

Nils D. Arvold, MD
Department of Radiation Oncology
Dana-Farber Cancer Institute/Brigham and Women's Hospital; and
Harvard Medical School
Boston, Massachusetts

Mandar S. Bhagwat, PhD
Department of Radiation Oncology
Dana-Farber Cancer Institute/Brigham and Women's Hospital
Boston, Massachusetts

Paul M. Busse, MD, PhD
Department of Radiation Oncology
Massachusetts General Hospital
Boston, Massachusetts

Ivan M. Buzurovic, PhD
Department of Radiation Oncology
Dana-Farber Cancer Institute/Brigham and Women's Hospital
Boston, Massachusetts

Chien Peter Chen, MD, PhD
Division of Radiation Oncology
Scripps Clinic, Scripps Radiation Therapy Center
San Diego, California

Gil'ad N. Cohen, MSc
Department of Medical Physics
Memorial Sloan-Kettering Cancer Center
New York, New York

Robert A. Cormack, PhD
Department of Radiation Oncology
Dana-Farber Cancer Institute/Brigham and Women's Hospital
Boston, Massachusetts

Antonio L. Damato, PhD
Department of Radiation Oncology
Dana-Farber Cancer Institute/Brigham and Women's Hospital
Boston, Massachusetts

David Jeffrey Demanes, MD, FACRO, FACR, FASTRO
Department of Radiation Oncology
Ronald Reagan UCLA Medical Center
Santa Monica, California

Phillip M. Devlin, MD, FACR, FASTRO, FFRRCSI(Hon)
Division of Brachytherapy
Dana-Farber Cancer Institute; and
Harvard Medical School
Boston, Massachusetts

Ron DiGiaimo, MBA, FACHE
Revenue Cycle, Inc.
Austin, Texas

Scott A. Friesen, MSc
Department of Radiation Oncology
Dana-Farber Cancer Institute/Brigham and Women's Hospital
Boston, Massachusetts

Jorgen L. Hansen, MSc
Department of Radiation Oncology
Dana-Farber Cancer Institute/Brigham and Women's Hospital
Boston, Massachusetts

Louis B. Harrison, MD, FASTRO
Department of Radiation Oncology
H. Lee Moffitt Cancer Center and Research Institute
Tampa, Florida

Lara Hathout, MD, FRCPC
Department of Radiation Oncology
Université Laval
Centre Hospitalier Universitaire de Québec-L'Hôtel-Dieu de Québec
Quebec City, Quebec, Canada

Kathryn D. Held, PhD
Department of Radiation Oncology
Harvard Medical School; and
Department of Radiation Oncology
Massachusetts General Hospital
Boston, Massachusetts

Caroline L. Holloway, MD, FRCP(C)
Department of Radiation Oncology
University of British Columbia; and
British Columbia Cancer Agency
Vancouver Island Centre
Victoria, British Columbia, Canada

Kenneth S. Hu, MD
Department of Radiation Oncology
Mt. Sinai Beth Israel Medical Center
New York, New York

Atif J. Khan, MD
Department of Radiation Oncology
Robert Wood Johnson Medical School & the Rutgers Cancer Institute of New Jersey
New Brunswick, New Jersey

Leonard H. Kim, MS, AMusD
Department of Radiation Oncology
Robert Wood Johnson Medical School & the Rutgers Cancer Institute of New Jersey
New Brunswick, New Jersey

Frédéric Lacroix, PhD
Department of Radiation Oncology
Université Laval
Centre Hospitalier Universitaire de Québec-L'Hôtel-Dieu de Québec
Quebec City, Quebec, Canada

Larissa J. Lee, MD
Department of Radiation Oncology
Dana-Farber Cancer Institute/Brigham and Women's Hospital; and
Harvard Medical School
Boston, Massachusetts

Professor Peter C. Levendag
Department of Radiation Oncology
Erasmus Medical Center–Daniel den Hoed Cancer Center
Rotterdam, the Netherlands

Anna O. Likhacheva, MD, MPH
Department of Radiation Oncology
Banner MD Anderson Cancer Center
Gilbert, Arizona; and
Department of Radiation Oncology
University of Texas MD Anderson Cancer Center
Houston, Texas

Ray Lin, MD
Division of Radiation Oncology
Scripps Clinic, Scripps Radiation Therapy Center
San Diego, California

J. Nicholas Lukens, MD
Department of Radiation Oncology
University of Pennsylvania School of Medicine
Philadelphia, Pennsylvania

André-Guy Martin, MD, MSc, FRCP(C)
Department of Radiation Oncology
Université Laval
Centre Hospitalier Universitaire de Québec-L'Hôtel-Dieu de Québec
Quebec City, Quebec, Canada

Keyur J. Mehta, MD
Department of Radiation Oncology
Montefiore Medical Center
Bronx, New York

Casilda Menchaca-Garcia, MBA
Revenue Cycle, Inc.
Austin, Texas

Subhakar Mutyala, MD
Department of Radiation Oncology
University of Arizona Cancer Center at Dignity Health
St. Joseph's Hospital and Medical Center
Phoenix, Arizona

Arthur Sun Myint, FRCP (Edin), FRCP (London), FFRCSI (Dublin), FRCR, FICS (Chicago)
University of Liverpool; and
International Contact Radiotherapy Network; and
GEC ESTRO (Rectal & Anal Brachytherapy)
Wirral, Merseyside, United Kingdom

Thomas Niedermayr, PhD
Radiation Oncology—Radiation Physics
Stanford University School of Medicine
Stanford, California

Paul L. Nguyen, MD
Dana-Farber Cancer Institute/Brigham and Women's Hospital; and
Department of Radiation Oncology
Harvard Medical School
Boston, Massachusetts

Desmond A. O'Farrell, MSc
Department of Radiation Oncology
Dana-Farber Cancer Institute/Brigham and Women's Hospital
Boston, Massachusetts

Peter F. Orio, III, DO
Department of Radiation Oncology
Dana-Farber/Brigham and Women's Hospital at Milford Regional Medical Center
Milford, Massachusetts; and
Dana-Farber/Brigham and Women's Hospital in Clinical affiliation with South Shore Hospital
Weymouth, Massachusetts

Chandrajit P. Raut, MD, MSc
Department of Surgery
Harvard Medical School; and
Division of Surgical Oncology
Brigham and Women's Hospital; and
Center for Sarcoma and Bone Oncology
Dana-Farber Cancer Institute
Boston, Massachusetts

Chirag Shah, MD
Department of Radiation Oncology
Summa Health System
Akron, Ohio

Simona F. Shaitelman, MD, EdM
Department of Radiation Oncology
University of Texas MD Anderson Cancer Center
Houston, Texas

Alexandra J. Stewart, DM, MRCP, FRCR
St Luke's Cancer Centre
Royal Surrey County Hospital; and
University of Surrey
Guildford, England

Abigail L. Stockham, MD
Department of Radiation Oncology
Mayo Clinic
Rochester, Minnesota; and
Brigham and Women's Hospital
Boston, Massachusetts

Emily Neubauer Sugar, MS
Department of Radiation Oncology
Dana-Farber Cancer Institute/Brigham and Women's Hospital
Boston, Massachusetts

Tamara Syverson, BSRT(T)
Revenue Cycle, Inc.
Austin, Texas

David N. Teguh, MD
Department of Radiation Oncology
Erasmus Medical Center–Daniel den Hoed Cancer Center
Rotterdam, the Netherlands

Nitika Thawani, MD
Scott & White Healthcare
Temple, Texas

Prabhakar Tripuraneni, MD, FACR, FASTRO
Division of Radiation Oncology
Scripps Clinic, Scripps Radiation Therapy Center
San Diego, California

Nikolaos Tselis, MD, PhD
Department of Radiation Oncology
Sana Klinikum Offenbach
Offenbach, Hessen, Germany

Frank A. Vicini, MD, FASTRO
Michigan Healthcare Associates/ 21st Century Oncology
Farmington Hills, Michigan

Akila N. Viswanathan, MD, MPH
Department of Radiation Oncology
Harvard Medical School
Boston, Massachusetts

Suzanne L. Wolden, MD
Department of Radiation Oncology
Memorial Sloan-Kettering Cancer Center
New York, New York

Foreword

It is a privilege to write this Foreword to the second edition of *Brachytherapy: Applications and Techniques*, edited by Dr. Phillip Devlin with the most able assistance of Drs. Alexandra Stewart, Robert Cormack, and Caroline Holloway.

In many ways brachytherapy can be considered the ultimate form of conformal radiation therapy as it is unparalleled in its ability to direct a large dose of radiation to the tumor while minimizing exposure to surrounding sensitive normal structures. Brachytherapy has a long and storied history in the treatment of neoplastic disease. The first successful applications of radioisotopes to treat cancer were reported shortly after the discovery of radium in 1898. Over the next century and more, the evolution of brachytherapy into a valued component of the radiotherapy of many malignancies became firmly established. Notwithstanding this remarkable legacy of success, there is a disturbing trend in the United States whereby the use of brachytherapy is in serious decline. The many profoundly negative consequences of decreasing brachytherapy utilization include greater cancer care expenditures, less patient choice, more treatment-related morbidity, and, most alarmingly, an increase in cancer-specific mortality.

Cancer patients deserve state-of-the-art evidence-based care including the delivery of high quality, high value brachytherapy. As education is essential to advance awareness of and proficiency in the full spectrum of brachytherapy applications, the appearance of the second edition of this highly regarded text is both a timely and most welcome event. The distinguished list of contributors to this work reads like a veritable "Who's Who" of international brachytherapy expertise making this an indispensable resource for students and practitioners of this complex and challenging modality. As with the first edition, Dr. Devlin and colleagues present a sophisticated yet highly readable text that is directed to the practicing clinician. The second edition of this book maintains the exceptionally high bar set by its predecessor in that it is painstakingly detailed, comprehensive, and thoroughly up-to-date. It fully describes the rapid evolution in the many techniques, technologies, and clinical data that underpin contemporary brachytherapy as an essential element in the multidisciplinary management of cancer. A particularly welcome feature is the clinical vignettes at the close of every chapter that bring seemingly remote concepts to life in real world practical applications.

Most notably, in my view, is that this book is infused with the infectious enthusiasm of Dr. Devlin himself. It has been one of the true pleasures of my professional career to witness the joy, passion, and energy he brings to the care of his patients, the education of his students and peers, and the advancement of our field. Reflective of his deep respect for the reader, he brings those same qualities to bear in crafting this remarkable work.

With the second edition of *Brachytherapy: Applications and Techniques*, Dr. Devlin and colleagues give us a text that instills a profound appreciation for the critical value of this essential modality. This book makes it clear that brachytherapy not only works, it is an irreplaceable component of contemporary cancer care.

David E. Wazer, MD, FACRO, FACR, FASTRO
Professor and Chairman
Department of Radiation Oncology
Alpert Medical School of Brown University
Providence, Rhode Island; and
Tufts University School of Medicine
Boston, Massachusetts

Preface to the Second Edition

It gives me great personal and professional satisfaction to present this second edition of *Brachytherapy: Applications and Techniques*. Brachytherapy, although underutilized, is at the very heart of cancer care; and, even in the era of advanced proton and IGRT treatment algorithms, it still is arguably the most conformal radiation therapy. Brachytherapy defines (mostly) the use of radioactive isotopes to provide a highly conformal, image-guided curative radiation doses to complex targets either deep or superficial. It takes advantage of the availability of many isotopes with different energies and half-lives so as to provide for a host of complex clinical scenarios where the therapeutic ratio (ultimately the good done for the harm avoided) is greatly aided by the steep dose falloff characteristics of these various isotopes. One hundred and seventeen years have passed since Marie Curie produced the first therapeutic isotope radium. This era quickly saw the first use of radium for therapeutic and anticancer therapies. At this writing, brachytherapy is a full and equal component of modern cancer care as well as the management of noncancerous proliferative diseases. Brachytherapy's early ascent as the first radiation therapy was eclipsed by the arrival of X-ray therapy. Over the years, radiation therapy has fully matured to include not only megavoltage radiations but also heavy particles such as protons. All radiation therapy has been greatly lifted by advanced image guidance for treatment planning and monitoring of its delivery. Radiation therapy has also grown hand in hand with improvements in surgical techniques as well as chemotherapy, immunotherapy, and molecular targeting therapy. Brachytherapy has grown just as external beam has. These following chapters will give a comprehensive update from our first edition 7 years ago, so that practitioners, residents, students, and other interested parties will have a sure guide along the way.

As I said in the first edition, the context for writing both editions is that of an extremely busy and comprehensive brachytherapy environment in a large Harvard teaching hospital in Boston. The Brigham and Women's Hospital and the Dana Farber Cancer Institute's multidisciplinary clinics have been a superb location and community in which not only to grow a large volume high-quality brachytherapy practice but also in which to explore and teach the full extent of brachytherapy's capability and power. The chapter authors and associate editors are drawn from my own group, the group that did fellowships with us, and leaders in the other great brachytherapy centers both in the United States and abroad. This also has provided unparalleled access to essentially every conceivable clinical scenario, from which our authors can best teach you.

Any medical resource such as this textbook must, at its very core, contain and draw from the excellence of its authorship in three interwoven areas—in the clinic, in education, and in research. To these must also be added organizational excellence so as to create a sustainable high-quality practice focused on patient safety. These chapters are the latest and finest distillation of the literature, techniques, and clinical examples with many updates on the latest developments in brachytherapy across the disease sites. Ultimately, the book, in order to continue to succeed, must clearly state why and how to do high-quality brachytherapy.

New in this edition to lead off is a lovely view of the history of brachytherapy by looking at the evolution of prostate brachytherapy by redounded world leader in brachytherapy history, Jesse Aronowitz from the University of Massachusetts. This chapter is a pure delight to read and comprehensively traces the story from Marie Curie to the modern day. His encyclopedic knowledge not just of the technical developments but also of the significance of these to the lives of the individuals involved is so enriching and inspiring.

Two supportive chapters follow on Radiobiologic Concepts for Brachytherapy and Technical Aspects of Brachytherapy. The former was again written with the deft hand of Associate Editor Dr. Alexandra J. Stewart, a former fellow and clinical lead for oncology of the Royal Surrey County Hospital in England, in conjunction with Robert Cormack and Harvard's Kathy Held. These three collaborated to give the necessary and sufficient components for practice and illustrated the points with worked clinical vignettes. The chapter is more streamlined than before for best access to what is needed. We all should leave a bookmark in this chapter as we continue to refine equivalent dose paradigms for various diseases, stages, and clinical needs (eg, recurrent disease).

The third chapter on the Technical Aspects of Brachytherapy, is an in-house production written in collaboration with essentially all our physicists in the brachytherapy space. Associate Editor Robert Cormack gently coordinated a wonderful review of what is really important and necessary for a safe and high-quality practice. Starting with the isotopes themselves, it courses over permanent and temporary, manual, and image guided and through low, high, and pulsed dose rates. The major areas of gynecologic and prostate are augmented with a careful look at custom surface devices. They cover dosimetry, heterogeneity, as well as issues of transit dose and backscatter. They lead us to look at the future with advanced planning algorithms and robotic brachytherapy, as well as advanced enhancements to optimize workflow including all meaningful quality end points. They explain electronically generated low-energy sources and importantly contrast it to the more common definition of isotope-based therapy.

Genitourinary brachytherapy is commonly practiced for both early and intermittent high-risk stages of disease with or without external beam radiation therapy, with very low dose rate or high dose rate (HDR) with a variety of techniques across centers. Our in-house dynamic team led by Paul Nguyen has produced a most useful update here.

They systematically approach the very low dose rate (VLDR) implants through epidemiology, relevant literature, guidelines, contraindications, from low-favorable-risk to intermediate- and high-risk groups. They systematically cover toxicities, radiation safety, ultrasound techniques, volume, geometry seed, and seed carrier choice. Common treatment planning and dosimetry techniques lead into dose evaluation, operation room (OR) procedures, and the subtleties of pre versus live in OR planning. They point to the future deployment of SAVE and HELP techniques. With a similar approach, they have updated HDR applications and techniques including fiducial markers and computer graphic dose optimization schemes.

The late breaking trial showing such significant biological control for the use of a seed boost in the locally advanced cases may well change the management of this stage of disease, in which there would likely be a resurgence of seed boost for this stage.

In a minor way, I also collaborated in this chapter to draw together the smaller experience with penile brachytherapy, for which I am so grateful for the assistance of Dr. Juanita Crook from the British Columbia Cancer Agency. A former American

Brachytherapy Society president, she is the undoubted global leader in drawing attention to the possibility of organ and functional preservation for penile cancer.

Gynecologic brachytherapy is such a bedrock of our specialty with much excellent literature that I was so happy that under the wonderful direction of my close colleagues and friends, Akila N. Viswanathan, Larissa L. Lee, and Antonio Damato have produced such a superb update to the first edition. The intervening years have yielded so much new, clinically significant data, that modern gynecologic brachytherapy is image based, not reference point based and is blessed with extremely strong internationally agreed on guidelines. This chapter covers the locally advanced cervix approaches including patient evaluation, choice for modality of care, and the subtleties of low, pulsed, and high dose rate therapy. In a similar manner, postoperative endometrial, medically inoperable and vaginal vault recurrences, and primary vaginal cancers are reviewed. Complications and follow-up care provide important practical guidance for what to expect and what to do.

The physics considerations by Antonio Damato comprehensively cover contouring, digitization, and the evolution of international guidelines. Treatment planning considerations lead us to the growing practice of expressing a common nomenclature for a host of doses and fractionation schemes with different external beam dose contributions, in terms of equivalent 2 Gy dose. This has already been proven to be incredibly useful to have better understanding of composite dose to the clinical targets as well as to the organs at risk for toxicity. Quality management for these complex cases and regulatory parameters is thoroughly discussed.

Breast brachytherapy has undergone much change and maturation in the last 7 years with new applicators and techniques as well as excellent prospective data and even more trials ongoing. To head up this revision, Atif Khan, a former fellow and dear friend and Simona Shaitelman gathered a star-studded writing group to include Frank Vicini and Doug Arthur, all four world leaders in brachytherapy and principal investigators on highly significant practice changing studies. This chapter succinctly covers the rationale, patient selection, and adroitly uses tables for easy comparisons of the already-reported as well as the ongoing trials. There is an excellent review of every applicator, from single through multilumen, to interstitial and noninvasive techniques. They discuss comparative benefits and risks, quality of life, cost of care, and considerations for the future of breast brachytherapy. Clinical vignettes top off this super revision.

Thoracic brachytherapy was also very worthy of an update in view of exciting new trials. Subhakar Mutyala until recently at Scott & White in Austin, TX, with his in-house group led the superb reworking of this chapter. For thematic simplicity, we chose to move esophagus brachytherapy to the gastrointestinal (GI) chapter. Great hope was placed on the ACASOG trial and robotic approaches for early-stage disease. The modern use of the planar and volume seeding technique is well reviewed. The locally advanced clinical scenario is comprehensively reviewed and includes the variety of isotopes as well as the context of the relationship to modern external beam techniques. The opportunity to advance the use of HDR afterloading, and intraoperative radiation therapy (IORT) in the context of dose escalation and the treatment of recurrent disease is very important for comprehensive practice. Here again the choices for dose rates, clinical planning, and review of the risk of significant complications are well reviewed. The surgical scenario is so important to understand along with its own inherent risk of complications so as to give a realistic view of what additional risk and benefit come with these brachytherapy techniques. Here again, Dr. Mutyala's team offers lucid practical clinical advice to guide practitioners. Importantly, also the role of endobronchial brachytherapy both in the definitive and palliative settings are carefully explored for technique and also for literature-based dose and fractionation scheme. I find this a super useful review of the actual pragmatics of these important procedures that is Dr. Mutyala's hallmark. Combination therapy including laser, stents, and photodynamic therapy (PDT) is finally explored in the important real-life contexts of tumor recurrence, reirradiation, replete with images, tables, and useful references.

The need for a good chapter on skin and superficial targets was one of the significant driving forces for this new edition. There are many unique aspects and even paradoxes here. The most practiced brachytherapy in the United States is done with the least amount of prospective literature and is done mainly by dermatologists not radiation oncologists! That being said, this superb team led by the MD Anderson's Anna Likhacheva and Harvard's Ivan Buzurovic has produced an honest, concise, and really useful chapter. Starting with some brief history, it courses over the most common histologies in the context of modern dermatologic practice to find a reasonable set of selection criteria including histology, physical location, cosmetic impact, and potential alternatives. They review a host of different techniques that links very well to the broad range of applications for cutaneous targets. This includes a solid review of the use of electronically generated low-energy radiation therapy sometimes called electronic brachytherapy—a phrase itself that generates controversy. While reviewing the retrospective papers and the few prospective papers, they include really useful, detailed commentary so as to guide what meaning can be taken. The sheer lack of a tradition of prospective data, as we see elsewhere in this book, is a call to start this process with patterns of care analysis, and so on. The chapter would have been sufficient, but the addition of the generalized work flow for surface application technique section by Ivan Buzurovic is comprehensive, hugely useful, and is full of process, advice, and explanation. Six clinical vignettes with image and dose conclude this stellar innovation to the book.

A veritable who's who of head and neck brachytherapy was assembled by Nick Lukens to give a world-class concise review of applications and techniques across the many anatomic disease sites within head and neck. Nick and Ken Hu (and I) had trained with Lou Harrison in the Memorial Sloan-Kettering Cancer Center (MSKCC) tradition. Bringing Peter Levendag and David Teguh helped us to better feature the European traditions in contrast to those of the United States. Paul Busse, my colleague here at Harvard, filled this international perspective out with "Boston's style." Most useful is the repetitive structure of the chapter that courses over the literature and reviews the interaction with surgery and external beam therapies in the primary, locally advanced, and recurrent settings. All dose rates, all manner of applicator and catheter techniques, and all characterizations of dose are in a matrix with this repetitive pattern. A delightful addition here is suggested important elements of each implant with regard to informed consent. The details with which each operative technique section is written are a pleasure to behold and will be most useful in our larger goal to maintain and preserve these operative skills for the next generation.

Our home team of Nils Arvold and his then central nervous system (CNS) fellow extraordinaire Abigail Stockham, have given us a most comprehensive and systematic review of brachytherapy of the CNS including the spinal cord. Each section organizes and provides detailed commentaries on what the meanings of the various studies are and where the particular data and applications belong either in ongoing new research or in ongoing clinical practice. The primary glioma section takes us through the radiobiological and physics considerations and fully reviews the level 1 data that were negative. Additional literature from Boston and San Francisco importantly teaches the strong need to balance the efficacy of a therapy with the various toxicities and need for reoperation. This section finishes by reaching to the future with modern molecular approaches and a potential new role for brachytherapy. Glioma recurrences, low-grade tumors, and atypical meningioma each gets an equally thorough exposure and with realistic evaluations of the gaps in data, as well as the complex use here of stereotactic radiosurgery and radiotherapy. The most active area of clinical research in CNS is in the deployment of Cs-131 in post-cavity resection for metastases. In addition to the excellent description of the growing literature and technique, there is a most thoughtful cost analysis review.

As we included in the first edition, the role of dural plaque and paraspinal seed therapy is nicely updated particularly demonstrating the greater potential here for both seed and catheter-based research with advanced and evolving image technology. Four of our own cases demonstrate clinical situations, indications, techniques, and dosimetric

outcomes across two atypical meningiomas and two metastases in four different brain sites.

There is no chapter that covers so comprehensively such a large and different set of organ sites as that of the Gastrointestinal Brachytherapy chapter. And, there is no better person for such a global task than Alex Stewart of the Royal Surrey Hospital in England. Alex completed two fellowship years among us, and although she now directs her hospital's cancer program, she has never really left us. She is the "energizer bunny" of my brachytherapy life and I have never met a harder worker. To increase the load, we moved esophagus from the thoracic chapter for greater usability and included Nitika Thawani here as she wrote much of that part. The international group hails from England, Greece, Canada, India (and Texas), as well as Burma. Their international perspective resounds throughout in the literature review and analysis, as well as in their comprehensive review of indications and techniques.

In the esophagus section, there is a deftly woven review of indications and techniques with trial data and guidelines. Discussed in the review is the potential confounding situation of a solid randomized trial being contrasted with an RTOG phase II study's excessive toxicity that disallowed a confirmatory phase III trial and that may have changed much about how esophagus brachytherapy is performed. Palliative care is similarly reviewed importantly in the context of many other existing and future therapeutic interventions to find its optimal role. Pancreas is thoughtfully reviewed for inclusiveness with a good perspective on the lack of data and variability of presentation and other treatment philosophies.

More importantly, bile duct adjuvant therapy with external beam radiotherapy (EBRT) is advocated in selected R1 resection settings with reasonable case series. Despite a solid literature to support it, this is one of the areas where I believe we should champion new study. The fact that so many partial hepatectomies leave positive margins, should, if for no better reason than quality assurance (QA), be challenged as the "definitive" therapy and more integrative alternative, possibly including brachytherapy in selected cases could be entertained anew.

From southeast Asia, we get the larger perspective on primary liver tumors. A broad array of liver-directed therapy is reviewed and includes seeds, catheters, all dose rates, stereotactic therapy, as well as radioembolization therapy. Metastatic liver disease mostly of colorectal origin and including breast and lung disease gets a super synopsis of the literature and of ongoing trials in the context of modern systemic chemotherapy.

Our rectal cancer section steps out of the box to redefine contact orthovoltage (formerly called "Papillon") as "brachytherapy"—a definition that used to belong purely to isotope-based energy sources. There are proponents and protagonists in many disease sites here. I am just thrilled that the conversation can also be played out in these pages. For the practitioner and patient, I would strongly advocate for inclusion to make sure all options are available as widely as possible. Another theme is the potential for extreme hypofractionation. The techniques and the case vignette are so elegantly presented by Sunny Myint, who is the undoubted world advocate. His contribution extends to causing an international cooperative study group to do prospective trial.

HDR rectal brachytherapy in the Montreal technique of Te Vuong is fully described with the various indications, techniques for preop, non-op, dose escalation, and palliative settings. Emerging literature may lead to the greater study of nonoperative approaches in which brachytherapy would play an important part.

Another "Papillon" technique is interstitial anal brachytherapy. Michele Albert, who was my very first brachytherapy fellow, and with whom I share this practice, locally inspires this final section of the chapter. Her excellent review of literature, applications, and techniques opens up the possibility that this organ sparing technique would be an increasing and really useful part of definitive care—yet another organ to preserve!

Five super vignettes for biliary, hepatic interstitial, hepatic radioembolization, rectal, and anal cases give most useful demonstrations of the great breadth and width of GI brachytherapy with so much more evidence-based work to do.