

# Image-Guided Spine Interventions

**Springer**

*New York*

*Berlin*

*Heidelberg*

*Hong Kong*

*London*

*Milan*

*Paris*

*Tokyo*

# Image-Guided Spine Interventions

Editor

**John M. Mathis, MD, MSc**

*Chairman, Department of Radiology, Lewis-Gale Medical Center, Salem, Virginia;  
Professor and Chairman, Department of Radiology, Virginia College of  
Osteopathic Medicine, Blacksburg, Virginia*

Associate Editors

**Blake A. Johnson, MD**

Associate Editor, Spine Radiology

**Peter S. Staats, MD**

Associate Editor, Pain Anesthesia

**F. Todd Wetzel, MD**

Associate Editor, Spine Orthopedics

With 189 Illustrations in 292 Parts, 39 in Full Color



**Springer**

John M. Mathis, MD, MSc  
Chairman  
Department of Radiology  
Lewis-Gale Medical Center  
Salem, VA 24153

*and*

Professor and Chairman  
Department of Radiology  
Virginia College of Osteopathic Medicine  
Blacksburg, VA 24060  
USA

Library of Congress Cataloging-in-Publication Data  
Mathis, John M.

Image-guided spine interventions / John M. Mathis.

p. cm.

Includes index.

ISBN 0-387-40320-5 (alk. paper)

1. Spine—imaging. 2. Spine—Surgery. 3. Surgery—Data processing. I. Title.

RD768.M388 2003

617.5'6—dc21

2003052966

ISBN 0-387-40320-5

Printed on acid-free paper.

© 2004 Springer-Verlag New York, Inc.

All rights reserved. This work may not be translated or copied in whole or in part without the written permission of the publisher (Springer-Verlag New York, Inc., 175 Fifth Avenue, New York, NY 10010, USA), except for brief excerpts in connection with reviews or scholarly analysis. Use in connection with any form of information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed is forbidden.

The use in this publication of trade names, trademarks, service marks, and similar terms, even if they are not identified as such, is not to be taken as an expression of opinion as to whether or not they are subject to proprietary rights.

While the advice and information in this book are believed to be true and accurate at the date of going to press, neither the authors nor the editors nor the publisher can accept any legal responsibility for any errors or omissions that may be made. The publisher makes no warranty, express or implied, with respect to the material contained herein.

Printed in the United States of America.

9 8 7 6 5 4 3 2 1

SPIN 10936368

[www.springer-ny.com](http://www.springer-ny.com)

Springer-Verlag New York Berlin Heidelberg  
A member of BertelsmannSpringer Science+Business Media GmbH

*To the women in my life who make all things possible:  
Krista, Jamie, Juanita, Jean, Ida, Mildred, and Vernice.*

# Preface

The field of interventional radiology is constantly undergoing change, and its procedures evolve over time. There is currently tremendous pressure on our specialty, as cardiology and vascular surgery appropriate existing vascular interventions. We need to be looking constantly for new procedures that will replace this loss. In the 1980s, the introduction of vascular access provided new procedures that included the placement of temporary venous catheters, ports, tunneled catheters, and dialysis maintenance. As a result of vascular access the number of procedures performed in some interventional labs doubled. The same revolution is occurring again with the advent of image-guided spine intervention. Five percent of the American population at any one time has back pain. This huge patient population is seeking help for this disabling and persistent problem.

*Image-Guided Spine Interventions* describes the varied and numerous procedures that are available to the image-guided interventionist, who may provide these therapies for the spine. This book embraces clinical evaluation, pharmacological requirements, procedural recommendations, and a spectrum of procedures that will be of interest to the image-guided spine interventionist. It covers a broad range of material that is presented by experts in each field, including discography, intradiscal electrothermal therapy (IDET), percutaneous discectomy, vertebroplasty and ballon kyphoplasty, epidural steroid injections, selective nerve root blocks and autonomic nerve blockade, diagnostic epidurography and therapeutic epidurolysis, sacroiliac and facet joint injections, implanted drug delivery systems, and epidural blood and fibrin patches for CSF leaks. Some of the techniques described, such as ozone therapy are expected to evolve further in the next decade. This book will be useful to all physicians who deal with back pain, including pain anesthesiologists, spine neurosurgeons, orthopedists, and radiologists.

As a previous president of the American Society of Spine Radiology and as a physician who has worked to develop image-guided spine intervention in academic and clinical practice, my entire practice is now

devoted to providing these interventions. My clinical practice has more than doubled because of the introduction of these spine procedures. This is the next huge opportunity for the image-guided interventional community. I sincerely hope this work will be useful in helping you establish and grow a minimally invasive spine interventional practice. It has been a rewarding area for me.

John M. Mathis, MD, MSc

# Contents

Preface vii

Contributors xi

- 1 Spine Anatomy 1  
*John M. Mathis, Ali Shaibani, and Ajay K. Wakhloo*
- 2 Materials Used in Image-Guided Spine Interventions 27  
*John M. Mathis*
- 3 Patient Evaluation and Criteria for Procedure Selection 37  
*Paul J. Christo and Peter S. Staats*
- 4 The Surgeon's Perspective: Image-Guided Therapy  
and Its Relationship to Conventional Surgical Management 53  
*F. Todd Wetzel and Frank M. Phillips*
- 5 Image-Guided Percutaneous Spine Biopsy 69  
*A. Orlando Ortiz and Gregg H. Zoarski*
- 6 Discography 94  
*Kurt P. Schellhas*
- 7 Intradiscal Electrothermal Annuloplasty 121  
*Timothy S. Eckel*
- 8 Automated Percutaneous Lumbar Discectomy in the  
Treatment of Herniated Discs 137  
*Gary Onik and Wendell A. Gibby*
- 9 Epidural Steroid Injections and Selective Nerve Blocks 149  
*Blake A. Johnson*
- 10 Diagnostic Epidurography and Therapeutic Epidurolysis 171  
*K. Dean Willis*



11	Facet Joint Injections	203
	<i>Timothy S. Eckel</i>	
12	Autonomic Nerve Blockade	219
	<i>Wade Wong and John M. Mathis</i>	
13	Sacroiliac Joint Injection	234
	<i>M.J.B. Stallmeyer and Gregg H. Zoarski</i>	
14	Percutaneous Vertebroplasty	245
	<i>John M. Mathis</i>	
15	Implanted Drug Delivery Systems	273
	<i>John C. Oakley</i>	
16	Endovascular Therapy of the Spine	292
	<i>Ali Shaibani and Ajay K. Wakhloo</i>	
17	Epidural Blood and Fibrin Patches	322
	<i>Lisa Watanabe</i>	
18	Balloon Kyphoplasty	334
	<i>John M. Mathis, Wayne J. Olan, and Stephen M. Belkoff</i>	
19	Intradiscal Oxygen-Ozone in the Treatment of Herniated Lumbar Disc	349
	<i>Mario Muto, Cosma Andreula, and Marco Leonardi</i>	
	Index	359

# Contributors

*Cosma Andreula, MD*

Department of Neuroradiology, A.O. Policlinico-Anthea Hospital,  
Bari 70124, Italy

*Stephen M. Belkoff, PhD*

Department of Orthopaedic Surgery, The Johns Hopkins University,  
Baltimore, MD 21224, USA

*Paul J. Christo, MD*

Department of Anesthesiology and Critical Care Medicine, The Johns  
Hopkins University School of Medicine, Baltimore, MD 21205, USA

*Timothy S. Eckel, MS, MD*

Division of Neuroradiology, Annapolis Radiology Associates,  
Annapolis, MD 21401, USA

*Wendell A. Gibby, MD*

Department of Radiology, Riverwoods Advanced Diagnostic  
Imaging Center, Provo, UT 84604, USA

*Blake A. Johnson, MD*

Department of Radiology, University of Minnesota Medical School,  
Minneapolis, MN 55455; Director of CNS Imaging, Center for  
Diagnostic Imaging, St. Louis Park, MN 55416, USA

*Marco Leonardi, MD*

Servizio di Neuroradiologia, Ospedale Bellaria, Bologna 40139, Italy

*John M. Mathis, MD, MSc*

Department of Radiology, Lewis-Gale Medical Center, Salem,  
VA 24153; Department of Radiology, Virginia College of Osteopathic  
Medicine, Blacksburg, VA 24060, USA

*Mario Muto, MD*

Department of Neurological Science, Operative Unit of  
Neuroradiology, Cardarelli Hospital, Naples 80122, Italy

*John C. Oakley, MD*

Yellowstone Neurosurgical Associates, Northern Rockies Pain and  
Palliative Rehabilitation Center, Billings, MT 59101, USA

*Wayne J. Olan, MD*

Department of Radiology, Suburban Hospital, Bethesda, MD 20814,  
USA

*Gary Onik, MD*

Department of Surgical Imaging, Celebration of Health/Florida  
Hospital, Celebration, FL 34747, USA

*A. Orlando Ortiz, MD, MBA*

Department of Radiology, Winthrop-University Hospital, Mineola,  
NY 11501, USA

*Frank M. Phillips, MD*

Spine Center, University of Chicago, Chicago, IL 60640, USA

*Kurt P. Schellhas, MD*

Department of Radiology, University of Minnesota Medical School,  
Minneapolis, MN 55455; Neuroimaging and Spinal Intervention,  
Center for Diagnostic Imaging, St. Louis Park, MN 55416, USA

*Ali Shaibani, MD*

Department of Radiology, Northwestern University Medical School,  
Chicago, IL 60611, USA

*Peter S. Staats, MD*

Department of Anesthesiology and Critical Care Medicine, The Johns  
Hopkins University School of Medicine, Baltimore, MD 21205, USA

*M.J.B. Stallmeyer, MD, PhD*

Interventional and Diagnostic Neuroradiology, Department of  
Radiology, University of Maryland School of Medicine, Baltimore,  
MD 21093, USA

*Ajay K. Wakhloo, MD, PhD*

Department of Radiology, University of Miami School of Medicine,  
Miami, FL 33136, USA

*Lisa Watanabe, MD*

Department of Radiology, Long Beach Memorial Medical Center,  
Long Beach, CA 90806, USA

*F. Todd Wetzel, MD*

Department of Orthopaedics, University of Chicago Spine Center,  
Chicago, IL 60640, USA

*K. Dean Willis, MD*

Alabama Pain Center, Huntsville, AL 35801, USA

*Wade Wong, DO, FACR*

Department of Radiology, University of California, San Diego,  
La Jolla, CA 92118, USA

*Gregg H. Zoarski, MD*

Departments of Radiology and Neurosurgery, University of  
Maryland, Baltimore, MD 21201, USA