Textbook of Interventional Neurology
Textbook of Interventional Neurology

Edited by
Adnan I. Qureshi
Zeenat Qureshi Stroke Research Center Minneapolis, MN
Associate Editor
Alexandros L. Georgiadis
Zeenat Qureshi Stroke Research Center Minneapolis, MN
## Contents

*List of contributors* vi

1. **History of interventional neurology** 1
   Adnan I. Qureshi

2. **Diagnostic cerebral angiography** 10
   Adnan I. Qureshi and Ameer E. Hassan

3. **Pathophysiological and pharmacological treatment of thromboembolic and ischemic complications associated with endovascular procedures** 30
   Ameer E. Hassan, Steve M. Cordina, Haitham H. Hussein, Deepak L. Bhatt and Adnan I. Qureshi

4. **Peri-procedural care** 58
   Alexandros L. Georgiadis, Mustapha A. Ezzeddine and Adnan I. Qureshi

5. **Acute ischemic stroke** 69
   Alexandros L. Georgiadis, Georgios Tsivgoulis, Andrei V. Alexandrov, Adnan I. Qureshi and José I. Suarez

6. **Cervical internal and common carotid artery stenosis** 95
   Adnan I. Qureshi and L. Nelson Hopkins

7. **Extracranial vertebral artery disease** 130
   Robert A. Taylor, Muhammad Zeeshan Memon and Adnan I. Qureshi

8. **Intracranial stenosis** 145
   Farhan Siddiq, Muhammad Z. Memon, Adnan I. Qureshi and Camilo R. Gomez

9. **Extracranial and intracranial arterial dissections** 166
   YihLin Nien, José Rafael Romero, Thanh N. Nguyen and Adnan I. Qureshi

10. **Traumatic vascular injury** 179
    Jefferson T. Miley, Qaisar A. Shah and Adnan I. Qureshi

11. **Intracranial aneurysms** 197
    Alexandros L. Georgiadis, Matthew D. Ford, David A. Steinman, Nauman Tariq and Adnan I. Qureshi

12. **Cerebral vasospasm** 230
    Adnan I. Qureshi, Mushtaq H. Qureshi, Jefferson T. Miley, Nauman Tariq and Giuseppe Lanzino

13. **Intracranial arteriovenous malformations** 255
    Dorothea Strozyk, Carlos E. Baccin, Johnny C. Pryor and Raul G. Nogueira

14. **Intracranial dural arteriovenous fistulas** 285
    Thanh N. Nguyen, Jean Raymond, Alexander M. Norbash and Daniel Roy

15. **Cerebral sinus thrombosis** 299
    Amit Singla and Randall C. Edgell

16. **Intracranial and head and neck tumors: embolization and chemotheraphy** 312
    Adnan I. Qureshi, Nauman Tariq, Rabia Qaiser, Herbert B. Newton and Stephen J. Haines

17. **Diagnostic and provocative testing** 357
    Haralabos Zacharatos, Ameer E. Hassan, M. Fareed K. Suri and Adnan I. Qureshi

18. **Spinal vascular and neoplastic lesions** 388
    Osman S. Kozak, Edgard Pereira and Adnan I. Qureshi

19. **Central retinal artery occlusion** 404
    Alberto Maud, Muhammad Zeeshan Memon, M. Fareed K. Suri and Adnan I. Qureshi

20. **Epistaxis** 419
    Alexandros L. Georgiadis, Steve M. Cordina, Haralabos Zacharatos and Adnan I. Qureshi

21. **Vertebroplasty and kyphoplasty** 428
    Stanley H. Kim, Anant I. Patel, Nancy Gruell, Kirk Conrad and Young J. Yu

22. **Clinical endovascular trials in stroke** 447
    Haitham M. Hussein and Adnan I. Qureshi

23. **Qualification requirements for performing neuro-interventional procedures** 466
    Adnan I. Qureshi, Alex Abou-Chebl and Tudor G. Jovin

---

**Index** 482

*Color plate section between pp. 246 and 247.*
Contributors

Alex Abou-Chebl MD
Director of Neurointerventional Services and
Assistant Professor of Neurology and Neurosurgery
University of Louisville
Louisville, KY
USA

Andrei V. Alexandrov MD
Director, Division of Cerebrovascular Disease
Director, Comprehensive Stroke Research Center and
Professor of Neurology,
University of Alabama Hospital
Birmingham, AL
USA

Carlos E. Baccin MD
Clinical Fellow
Department of Interventional Radiology
Hospital Beneficência Portuguesa
Sao Paulo
Brazil

Deepak L. Bhatt MD
Chief of Cardiology, VA Boston Healthcare System
Associate Professor of Medicine,
Harvard Medical School and
Director, Integrated Interventional Cardiovascular Program
Brigham and Women’s Hospital and
VA Boston Healthcare System
Boston, MA
USA

Kirk Conrad MD
Austin Radiological Association,
Austin, TX
USA

Steve M. Cordina MD
Endovascular Surgical Neuroradiology Fellow
Department of Neurology
University of Minnesota
Minneapolis, MN
USA

Randall C. Edgell MD
Assistant Professor of Neurology and Neurosurgery
Department of Neurology
St. Louis University
St. Louis, MO
USA

Mustapha A. Ezzeddine MD
Associate Professor of Neurology and Neurosurgery
Department of Neurology
Zeenat Qureshi Stroke Research Center
University of Minnesota
Minneapolis, MN
USA

Matthew D. Ford PhD
Postdoctoral Fellow
Biomedical Stimulation Laboratory
University of Toronto
Toronto, ON
Canada

Alexandros L. Georgiadis MD
Adjunct Assistant Professor of Neurology
Department of Neurology
Zeenat Qureshi Stroke Research Center
University of Minnesota
Minneapolis, MN
USA

Camilo R. Gomez MD, MBA
Director, Alabama Neurological Institute
Birmingham, AL
USA

Nancy Gruell RN
St. David’s Medical Center
Austin, TX
USA

Stephen J. Haines MD
Lyle A. French Chair, Professor and Head
Department of Neurosurgery
List of contributors

University of Minnesota
Minneapolis, MN
USA

Ameer E. Hassan DO
Endovascular Surgical Neuroradiology Fellow
Zeenat Qureshi Stroke Research Center
University of Minnesota
Minneapolis, MN
USA

L. Nelson Hopkins MD
Department of Neurosurgery
Kaleida Health
Buffalo, NY
USA

Haitham H. Hussein MD
Zeenat Qureshi Stroke Research Center
Resident of Neurology
University of Minnesota
Minneapolis, MN
USA

Tudor G. Jovin MD
Co-Director, UPMC Stroke Unit
Co-Director, UPMC Center for
Neuroendovascular Therapy
UPMC Stroke Institute
Pittsburgh, PA
USA

Stanley H. Kim MD
Director of Neurovascular Surgery
Neurosurgery, Endovascular and Spine Center
Austin, TX
USA

Osman Kozak MD
Associate Director Neuroradiological and
Neurocritical Care
Abington Memorial Hospital
Willow Grove, PA
USA

Giuseppe Lanzino MD
Professor of Neurosurgery
Mayo clinic
Rochester, MN
USA

Alberto Maud MD
Endovascular Surgical Neuroradiology
Assistant Professor
Department of Neurology
University of Minnesota
Minneapolis, MN
USA

Paul L. Foster School of Medicine
Texas Tech University Health Science Center
El Paso, TX
USA

Muhammad Z. Memon MD
Pre-residency Fellow
Department of Neurosurgery
Zeenat Qureshi Stroke Research Center
University of Minnesota
Minneapolis, MN
USA

Jefferson T. Miley MD
Vascular and Interventional Neurology
Neurosurgery, Endovascular & Spine Center
Austin, TX
USA

Herbert B. Newton MD
Professor of Neurology, Neurosurgery and Oncology
James Cancer Hospital
Columbus, OH
USA

Thanh N. Nguyen MD
Assistant Professor Neurology
Boston University Medical Center
Boston, MA
USA

YihLin Nien MD
Stroke Fellow
Boston University Medical Center
Natick, MA
USA

Raul G. Nogueira MD
Assistant Professor in Neurology and Radiology
Department of Interventional Neuroradiology
Massachusetts General Hospital
Boston, MA
USA

Alexander M. Norbash MD
Professor and Chair of Radiology
Boston University Medical Center
Boston, MA
USA

Anant I. Patel MD
Neurosurgeon
Endovascular and Spine Center
Austin, TX
USA
<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edgard Pereira MD</td>
<td>Director, Interventional Neuroradiology Service</td>
<td>JFK Medical Center, Atlantis, FL, USA</td>
</tr>
<tr>
<td>Johnny C. Pryor MD</td>
<td>Instructor in Neurosurgery</td>
<td>Harvard Medical School, Director of Interventional Neuroradiology and Endovascular Neurosurgery, Massachusetts General Hospital, Boston, MA, USA</td>
</tr>
<tr>
<td>Rabia Qaiser MD</td>
<td>Resident, Department of Neurosurgery</td>
<td>University of Minnesota, USA</td>
</tr>
<tr>
<td>Adnan I. Qureshi MD</td>
<td>Associate Head and Professor</td>
<td>Zeenat Qureshi Stroke Research Center, Department of Neurology, University of Minnesota, Minneapolis, MN, USA</td>
</tr>
<tr>
<td>Mushtaq H. Qureshi MD</td>
<td>Research Fellow</td>
<td>Zeenat Qureshi Stroke Research Center, University of Minnesota, Minneapolis, MN, USA</td>
</tr>
<tr>
<td>Jean Raymond MD</td>
<td>Interventional Neuroradiology Research Laboratory</td>
<td>Centre hospitalier de l'Université de Montréal-Hôpital Notre-Dame, Montreal, Quebec, Canada</td>
</tr>
<tr>
<td>José Rafael Romero MD</td>
<td>Assistant Professor, Neurology</td>
<td>Boston University Medical Center, Boston, MA, USA</td>
</tr>
<tr>
<td>Daniel Roy MD</td>
<td>Professor of Radiology</td>
<td>Centre hospitalier de l'Université de Montréal-Hôpital Notre-Dame, Montreal, Quebec, Canada</td>
</tr>
<tr>
<td>Qaisar A. Shah MD</td>
<td>Director, Neurointerventional and Neurocritical Care</td>
<td>Zeenat Qureshi Stroke Research Center, Department of Neurology, University of Minnesota, Minneapolis, MN, USA</td>
</tr>
<tr>
<td>Farhan Siddiq MD</td>
<td>Neurosurgery Resident</td>
<td>Zeenat Qureshi Stroke Research Center, SUNY Upstate University Hospital, Syracuse, NY, USA</td>
</tr>
<tr>
<td>Amit Singla MD</td>
<td>Neurosurgery Resident</td>
<td>SUNY Upstate University Hospital, SUNY Upstate University Hospital, Syracuse, NY, USA</td>
</tr>
<tr>
<td>David A. Steinman PhD</td>
<td>Professor of Mechanical and Biomedical Engineering</td>
<td>University of Toronto, Toronto, ON, USA</td>
</tr>
<tr>
<td>Dorothea Strozyk MD</td>
<td>Interventional Neuroradiology Fellow</td>
<td>New York Presbyterian Hospital, Columbia University College of Physicians and Surgeons, New York, NY, USA</td>
</tr>
<tr>
<td>Jose I. Suarez MD</td>
<td>Professor of Neurology</td>
<td>Baylor College of Medicine, Houston, TX, USA</td>
</tr>
<tr>
<td>M. Fareed K. Suri MD</td>
<td>Assistant Professor of Neurology</td>
<td>University of Minnesota, Minneapolis, MN, USA</td>
</tr>
<tr>
<td>Nauman Tariq MD</td>
<td>Clinical Research Fellow</td>
<td>Zeenat Qureshi Stroke Research Center, Sunnybrook Hospital, Sunnybrook, NY, USA</td>
</tr>
</tbody>
</table>

Montreal, Quebec, Canada
Robert A. Taylor MD
Assistant Professor
Zeenat Qureshi Stroke Research Center
Departments of Neurology, Neurosurgery and Radiology
University of Minnesota
Minneapolis, MN
USA

Georgios Tsigoulis MD
Lecturer of Neurology
Democritus University of Thrace
Alexandroupolis
Greece

Young J. Yu MD
Neurosurgeon
Mount Saint Mary’s Hospital
Niagara Falls
New York, NY USA

Haralabos Zacharatos MD
Neurology Resident
Zeenat Qureshi Stroke Research Center
Department of Neurology
University of Minnesota
Minneapolis, MN
USA