Current Best Practice in Interventional Cardiology

EDITED BY BERNHARD MEIER

WILEY-BLACKWELL

Current Best Practice in Interventional Cardiology

EDITED BY

Bernhard Meier, MD, FACC, FESC
Cardiology
Swiss Cardiovascular Center Bern
University Hospital Bern
Bern
Switzerland

WILEY-BLACKWELL
A John Wiley & Sons, Ltd., Publication

This edition first published 2010 © 2010 by Blackwell Publishing Ltd

Blackwell Publishing was acquired by John Wiley & Sons in February 2007. Blackwell's publishing program has been merged with Wiley's global Scientific, Technical and Medical business to form Wiley-Blackwell.

Registered office: John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

Editorial offices: 9600 Garsington Road, Oxford, OX4 2DQ, UK
The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK
111 River Street, Hoboken, NJ 07030-5774, USA

For details of our global editorial offices, for customer services and for information about how to apply for permission to reuse the copyright material in this book please see our website at www.wiley.com/wiley-blackwell

Library of Congress Cataloging-in-Publication Data
Current best practice in interventional cardiology / edited by Bernhard Meier.
p. ; cm.
Includes bibliographical references.
ISBN 978-1-4051-8255-3
1. Heart–Surgery. 2. Heart–Diseases–Treatment. 3. Heart–Interventional radiology.
I. Meier, Bernhard, M.D.
[DNLM: 1. Heart Diseases–surgery. 2. Cardiovascular Diseases–diagnosis. 3. Diagnostic Imaging–methods. 4. Vascular Diseases–surgery. WG 169 C97517 2009]
RD598.C84 2009
617.4'12–dc22

2009014017

ISBN 978-1-4051-8255-3

A catalogue record for this book is available from the British Library.

Set in 9/12pt Meridien by Aptara® Inc., New Delhi, India
Printed and bound in Malaysia by Vivar Printing Sdn Bhd

1 2010

Commissioning Editor: Thomas V. Hartman
Development Editor: Kate Newell
Production Editor: Cathryn Gates
Production Controller: Susan Shepherd

List of Contributors

Stephan Achenbach, MD, FACC, FESC
Department of Cardiology
University of Erlangen
Erlangen, Germany

Junya Ako, MD
Center for Research in Cardiovascular Interventions
Stanford University Medical Center
Stanford, CA, USA

Yaron Almagor, MD
Interventional Cardiology
Shaare Zedek Medical Center
Jerusalem, Israel

Haran Burri, MD
Cardiology Service
University Hospital of Geneva
Geneva, Switzerland

Paul Chiam, MBBS, MRCP, FACC
Department of Cardiology
National Heart Center
Singapore

Stéphane Cook, MD
Cardiology
Swiss Cardiovascular Center Bern
University Hospital Bern
Bern, Switzerland

Alain Cribier, MD
Department of Cardiology
Hospital Charles Nicolle
University of Rouen
Rouen, France

Pim J. de Feyter, MD
Department of Cardiology
Erasmus University
Rotterdam, The Netherlands

Etienne Delacrétaz, MD, FACC
Cardiology
Swiss Cardiovascular Center Bern
University Hospital Bern
Bern, Switzerland

Helene Eltchaninoff, MD
Department of Cardiology
Hospital Charles Nicolle
University of Rouen
Rouen, France

Peter J. Fitzgerald, MD, PhD
Division of Cardiology
Stanford University Medical Center
Stanford, CA, USA

Otto M. Hess, MD
Cardiology
Swiss Cardiovascular Center
University Hospital
Bern, Switzerland

David Hildick-Smith, MD
Sussex Cardiac Centre
Brighton and Sussex University Hospital NHS Trust
Brighton, UK

Yasuhiro Honda, MD
Division of Cardiology
Stanford University Medical Center
Stanford, CA, USA

Roger Hullin, MD
Départment de Médecine Interne
Centre Hospitalier Universitaire Vaudois
Lausanne, Switzerland

Sriram Iyer, MD, FACC
Department of Cardiac and Vascular Interventional Services
Lenox Hill Heart and Vascular Institute of New York
New York, NY, USA

Pierre-Frédéric Keller, MD
Division of Cardiology
University Hospital of Geneva
Geneva, Switzerland

Simon Koestner, MD
Cardiology
Cardiovascular Department
University Hospital Bern
Bern, Switzerland

David Meerkin, MBBS
Interventional Cardiology
Shaare Zedek Medical Center
Jerusalem, Israel

Bernhard Meier, MD, FACC, FESC
Cardiology
Swiss Cardiovascular Center Bern
University Hospital Bern
Bern, Switzerland

Marco Roffi, MD
Division of Cardiology
University Hospital of Geneva
Geneva, Switzerland

David Rosenmann, MD
Interventional Cardiology
Shaare Zedek Medical Center
Jerusalem, Israel

Gary Roubin, MD, PhD, FACC
Department of Cardiac and Vascular Interventional Services
Lenox Hill Heart and Vascular Institute of New York
New York, NY, USA

Jean-Paul Schmid, MD
Cardiology
Swiss Cardiovascular Center Bern
University Hospital Bern
Bern, Switzerland

Georgios Sianos, MD, PhD, FESC
1st Department of Cardiology
AHEPA University Hospital
Thessaloniki, Greece

Sven Streit, MD
Cardiology
Swiss Cardiovascular Center
University Hospital
Bern, Switzerland

Jean-François Surmely, MD
Cardiology
Clinique de la Source
Lausanne, Switzerland

Jiri Vitek, MD, PhD
Department of Cardiac and Vascular Interventional Services
Lenox Hill Heart and Vascular Institute of New York
New York, NY, USA

Masao Yamasaki, MD
Division of Cardiology
Stanford University Medical Center
Stanford, CA, USA

Preface

A comprehensive textbook on interventional cardiology requires 3 volumes or a DVD. What you hold in your hand is a glimpse at the current best practice of some selected aspects of interventional cardiology.

The book is targeted at a wide spectrum of readers ranging from the accomplished interventional cardiologist, desirous of looking over the fence or filling in some of the few remaining dark spots in his or her knowledge or armamentarium, to the nurse, technician, or physician assistant active in interventional cardiology. A cardiologist referring patients for catheter-based interventions might want to take a look at what is available, and a cardiovascular surgeon might want to find out what is offered to patients before or instead of summoning surgical help. Finally, industry representatives and device developers may use it to keep abreast of the state of the art, remaining shortcomings, and needs that may yet have to be identified.

Part I is the bread-and-butter section: percutaneous interventions for coronary artery disease. Acute coronary syndromes account for more than one-third of patients treated with percutaneous coronary intervention (PCI, introduced under the name PTCA 32 years ago). Stents are an integral part of the procedure, at least intentionally. Globally, 10% to 30% of lesions are still treated without a stent, but this is usually imposed by circumstances rather than the primary plan. Drug-eluting stents are about to supplant the traditional bare metal stents. Their advantage is small but relevant enough to render bare metal stents unattractive, irrespective of the fact that they have done a superb job so far. As for indications, the delineation between bypass surgery and PCI has been concretized by randomized trials. Selected double-vessel disease and triple-vessel disease including the left main have been cleared for PCI, albeit only in selected cases. A remaining bastion is chronic total occlusion. The books are still open about how important it is to recanalize it, what the best stepwise approach is, and how much time, radiation, and material should be invested before giving up in favor of medical treatment or bypass surgery. End-stage coronary artery disease carries a stigma almost like end-stage cancer. The respective treatments discussed here are correctly called palliative. So is revascularization, by the way.

In Part II, a variety of noncoronary interventions are discussed, a popular name for them being structural interventions. The most intriguing example is percutaneous replacement of the aortic valve. This is the current phoenix of interventional cardiology and rightfully so. In a very common disease, onerous open heart surgery can be replaced by a catheter intervention, in some cases even under local anesthesia. In contrast to PCI, which started to compete with surgery in the easy case, percutaneous aortic valve replacement is starting with the difficult one. The future looks bright, as percutaneous aortic valve replacement appears to work even in these patients. Closure of atrial shunts preceded PCI by a couple of years. Moreover, it has the potential to become more common than PCI, as every fourth person carries a patent foramen ovale. The medical community is carefully investigating the true value of these procedures, and the respective chapters help with that endeavor. Carotid angioplasty currently involves by default a stent and a protection device. In contrast to PCI the differences between surgery and the percutaneous procedure are small (no thoracotomy, no heart-lung machine). Hence a draw in outcome is not accepted; the percutaneous approach has to be better and safer. We are not there yet, but we hope to be on the right track. Alcohol ablation for hypertrophic cardiomyopathy looks back on more than a decade of clinical use. It has been adopted as a first approach for most patients with this rather rare clinical need.

Part III is dedicated to interventional approaches to left ventricular failure. Biventricular pacing appears to have gained an indelible place for chronic treatment, whereas percutaneous left ventricular assist devices usually serve for short periods of time as bridges to recovery or more definitive treatments. Stem cell therapy is discussed as a glow on the horizon, although it is not quite clear whether the sun is rising on it or has already set on it and we just do not know yet.

Part IV deals with cardiovascular imaging, putting magnetic resonance in the forefront as the recognized technique of the future. Computed tomography and intravascular imaging such as ultrasound and optical coherence tomography are also discussed.

Whether the book is read from cover to cover, used as a hard-copy thesaurus to thumb through when a question comes up, or—why not?—utilized as a picture book to browse through when some spare time is at hand, the authors truly hope that the contact with this book will be interesting, rewarding, and pleasurable.

Bernhard Meier

Current Best Practice in Interventional Cardiology

Contents

Part IV Cardiovascular Imaging

PART I
Coronary Artery Disease

CHAPTER 1
Acute Coronary Syndromes

Pierre-Frédéric Keller and Marco Roffi
Division of Cardiology, University Hospital of Geneva, Geneva, Switzerland

Chapter Overview

- Acute coronary syndromes (ACS) are the acute manifestation of atherosclerotic coronary artery disease. Based on different presentations and management, patients are classified into non–ST-segment elevation ACS (NSTE-ACS) and ST-segment elevation myocardial infarction (STEMI).
- In western countries, NSTE-ACS is more frequent than STEMI.
- Even if the short-term prognosis (30 days) for NSTE-ACS is more favorable than for STEMI, the long-term prognosis is similar or even worse.
- Early invasive strategy is the management of choice in patients with NSTE-ACS, particularly in high-risk subgroups.
- Primary percutaneous coronary intervention (PCI) is the treatment of choice for STEMI. Facilitated PCI is of no additional benefit.
- The reduction of door-to-balloon time in primary PCI is critical for improved outcomes in STEMI patients.
- If fibrinolytic therapy is administered in STEMI, then patients should be routinely transferred for immediate coronary angiography, and if needed, percutaneous revascularization.
- High-risk ACS patients (eg, elderly patients, those in cardiogenic shock) have the greatest benefit from PCI.
- Antithrombotic therapy in ACS is getting more and more complex. The wide spectrum of antiplatelet agents and anticoagulants requires a careful weighing of ischemic and bleeding risks in each individual patient.

ST-Segment Elevation Myocardial Infarction

The term acute coronary syndrome (ACS) has emerged as useful tool to describe the clinical correlate of acute myocardial ischemia. ST-segment elevation (STE) ACS includes patients with typical and prolonged chest pain and persistent STE on the ECG. In this setting, patients will almost invariably develop a myocardial infarction (MI), categorized as ST-segment elevation myocardial infarction (STEMI). The term non–ST-segment (NSTE) ACS refers to patients with signs or symptoms suggestive of myocardial ischemia in the absence of significant and persistent STE on ECG. According to whether the patient has at presentation, or will develop in the hours following admission, laboratory evidence of myocardial necrosis or not, the working diagnosis of NSTE-ACS will be further specified as NSTE-MI or unstable angina.

Recently, MI was redefined in a consensus document [1]. The 99th percentile of the upper reference limit (URL) of troponin was designated as the cut-off for the diagnosis. By arbitrary convention, a percutaneous coronary intervention (PCI)-related MI and coronary artery bypass grafting (CABG)-related MI were defined by an increase in cardiac enzymes more than three and five times the 99th percentile URL, respectively. The application of this definition will undoubtedly increase the number of

Current Best Practice in Interventional Cardiology. Edited by B Meier.

events detected in the ACS and the revascularization setting. The impact on public health as well as at the clinical trial level of the new MI definition cannot be fully foreseen.

The extent of cellular compromise in STEMI is proportional to the size of the territory supplied by the affected vessel and to the ischemic length of time. Therefore a quick and sustained restoration of normal blood flow in the infarct-related artery is crucial to salvage myocardium and improve survival.

Primary PCI Versus Thrombolytic Therapy

Primary percutaneous coronary intervention became increasingly popular in the early 1990s. Evidence favoring this strategy in comparison with thrombolytic therapy is substantiated by a meta-analysis of 23 randomized trials demonstrating that PCI more efficaciously reduced mortality, nonfatal reinfarction, and stroke (Fig. 1.1) [2]. The advantage of primary PCI over thrombolysis was independent of the type of thrombolytic agent used, and was also present for patients who were transferred from one institution to another for the performance of the procedure. Therefore, primary PCI is now considered the reperfusion therapy of choice by all the guidelines [3,4]. With respect to bleeding complications, a recent meta-analysis demonstrated that the incidence of major bleeding complications was lower in patients treated with primary PCI than in those undergoing thrombolytic therapy [2]. In particular intracranial hemorrhage, the most feared bleeding complication, was encountered in up to 1% of patients treated with fibrinolytic therapy and in only 0.05% of primary PCI patients. The algorithm for treatment of patients admitted for a STEMI is presented in Fig. 1.2 [5].

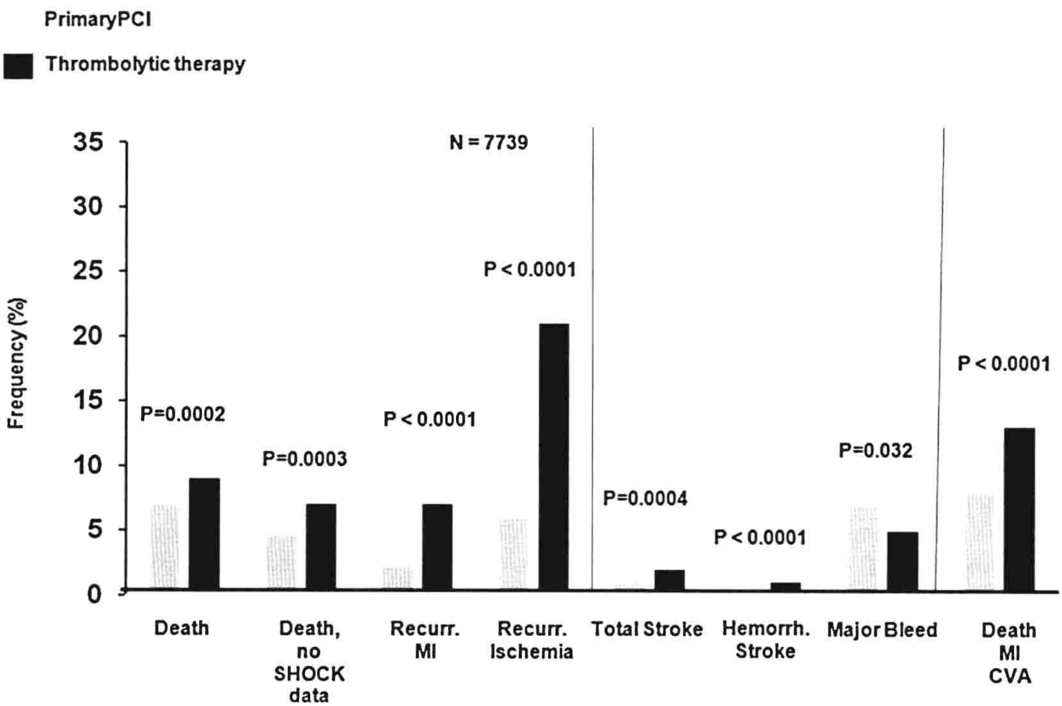

Figure 1.1 Short-term clinical outcomes of patients in 23 randomized trials of primary PCI versus thrombolysis. (Reproduced with permission from [2] Keeley EC, Boura JA, Grines CL. Primary angioplasty versus intravenous thrombolytic therapy for acute myocardial infarction: a quantitative review of 23 randomised trials. *Lancet.* 2003;361:13–20.)

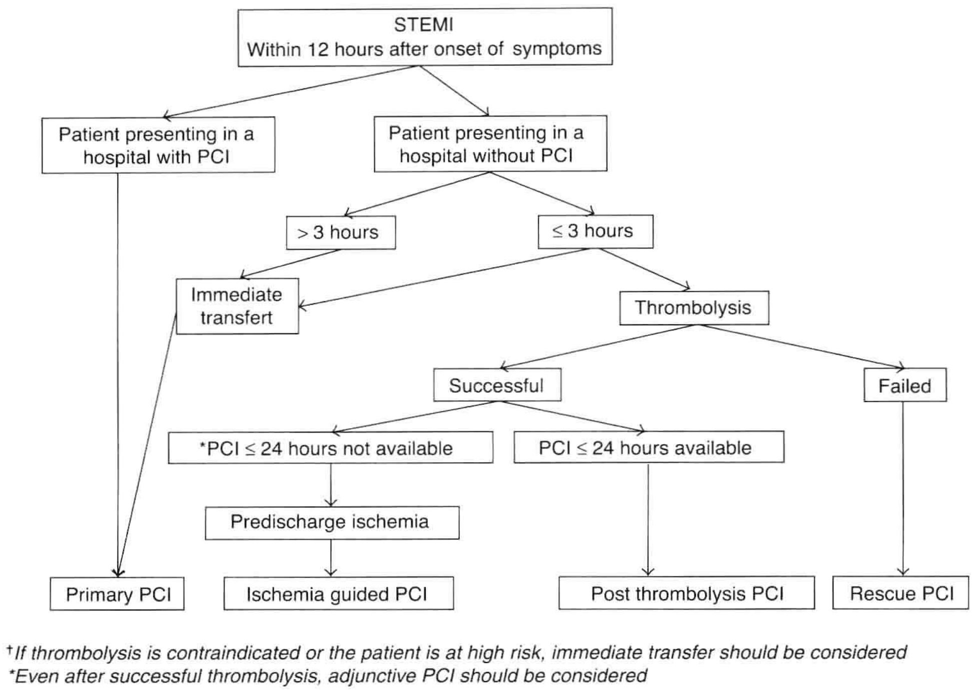

Figure 1.2 Algorithm for revascularization in STEMI patients with less than 12 hours from symptom onset according to the 2005 ESC guideline for PCI. (Reproduced with permission [5] from Silber S, Albertsson P, Aviles FF, et al. Guidelines for percutaneous coronary interventions. The Task Force for Percutaneous Coronary Interventions of the European Society of Cardiology. *Eur Heart J.* 2005;26:804–847.)

Advantages of Primary PCI

More than 90% of patients treated by primary PCI achieve normal flow (thrombosis in myocardial infarction [TIMI] grade flow 3) at the end of the intervention, while only 65% of patients treated by thrombolytic therapy benefit from this degree of reperfusion (Table 1.1) [6–8]. In addition, thrombolyis is characterized by a rapidly decreased efficacy after 2 hours of symptom onset (Fig. 1.3) [9]. There is a close relationship between the quality of coronary flow obtained after reperfusion therapy and mortality, and the prognosis of patients in whom flow normalization is not achieved is similar to that of patients with persistent vessel occlusion. The classification of TIMI myocardial blush grade allows an estimate of the tissue-level perfusion (Table 1.1). A critical link between lower TIMI myocardial blush grade, expression of a microcirculatory compromise, and mortality has been demonstrated in patients with normal epicardial flow following reperfusion therapy [10]. The improvement of clinical outcomes with primary PCI versus thrombolysis is also the consequence of a lower rate of reocclusion (0–6%). Accordingly, with thrombolytic therapy, reocclusion may occur in over 10% of cases even among patients presenting within the first 2 hours of symptom onset.

Mechanical complications of STEMI, such as acute mitral regurgitation and ventricular septal defect, were reduced by 86% by primary PCI compared with thrombolytic therapy in a meta-analysis of the GUSTO-1 and PAMI trials [11]. Free wall rupture was also significantly reduced by primary PCI [12]. Finally, primary PCI may allow earlier discharge (2–3 days following PCI versus 7 days following fibrinolytic therapy for uncomplicated courses).

Table 1.1 TIMI Classification of Coronary Flow and Perfusion

Flow Grade Classification

TIMI Flow Grade	Definition
0	No antegrade flow beyond the point of occlusion.
1	Faint antegrade coronary flow beyond the occlusion, although filling of the distal coronary bed is incomplete.
2	Delayed or sluggish antegrade flow with complete filling of the distal territory.
3	Normal flow that fills the distal coronary bed completely.

Perfusion Grade Classification

Perfusion Grade	Definition
0	Minimal or no myocardial blush is seen.
1	Dye stains the myocardium; this stain persists on the next injection.
2	Dye enters the myocardium but washes out slowly so that the dye is strongly persistent at the end of the injection.
3	There is normal entrance and exit of the dye in the myocardium so that the dye is mildly persistent at the end of the injection.

Adapted with permission from [7] Gibson CM, Schomig A. Coronary and myocardial angiography: angiographic assessment of both epicardial and myocardial perfusion. *Circulation.* 2004;109:3096–3105; and [8] Schömig A, Mehilli J, Antoniucci D, et al. Mechanical reperfusion in patients with acute myocardial infarction presenting more than 12 hours from symptom onset: a randomized controlled trial. *JAMA.* 2005;293:2865–2872.

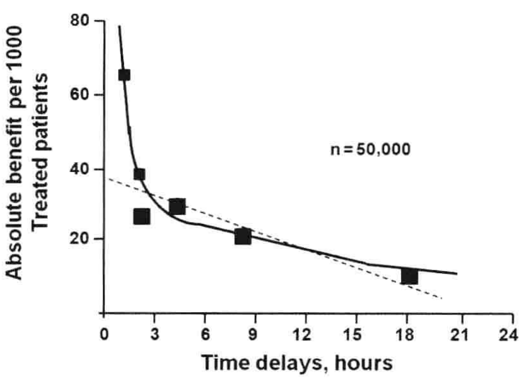

Figure 1.3 Time delays to thrombolysis in STEMI and the absolute reduction in 35-day mortality. (Reproduced with permission from [9] Boersma E, Maas AC, Deckers JW, Simoons ML. Early thrombolytic treatment in acute myocardial infarction: reappraisal of the golden hour. *Lancet.* 1996;348:771–775.)

Decreasing the Time to Reperfusion in Primary PCI

The survival benefit of reperfusion associated with thrombolytic therapy shrinks with increasing delay in the administration of the agent. For stable patients undergoing primary PCI, no association between symptom-onset-to-balloon time and mortality was observed in the U.S. NRMI registry [13]. In contrast, a significant increase in mortality was detected for patients with a door-to-balloon-time greater than 2 hours [14]. Therefore, the findings of primary PCI trials may be only applicable to hospitals with established primary PCI programs, experienced teams of operators, and a sufficient volume of interventions. Indeed, an analysis of the NRMI-2 registry demonstrated that hospitals with less than 12 primary PCIs per year have a higher rate of mortality than those with more than 33 primary PCIs per year [13]. Useful tools to decrease the door-to-balloon time are described in Table 1.2 [15].

Challenging Groups of Patients

Concomitant High-Grade Non-Culprit Lesions

The timing of revascularization of severe non-culprit lesion treatment in patients with multivessel