

## **The ECG**

### **A Two-Step Approach to Diagnosis**

---

**Springer**

*Berlin*

*Heidelberg*

*New York*

*Hong Kong*

*London*

*Milan*

*Paris*

*Tokyo*

MARC GERTSCH

---

# The ECG

## A Two-Step Approach to Diagnosis

Foreword by Christopher Cannon

With 1154 Figures and 54 Tables



Springer

Professor Dr. MARC GERTSCH  
Department of Cardiology  
Swiss Cardiovascular Center Bern  
University Clinic Inselspital  
CH-3010 Bern  
Switzerland

ISBN 3-540-00869-1-3

Library of Congress Cataloging-in-Publication Data

Gertsch, Marc, 1936-

The ECG : a two-step approach to diagnosis / Marc Gertsch.

p. ; cm.

Includes bibliographical references.

ISBN 3-540-00869-1 (hard cover : alk. paper)

1. Electrocardiography. I. Title.

[DNLM: 1. Electrocardiography--methods. 2. Arrhythmia--diagnosis. 3. Heart Diseases--diagnosis. WG G384e 2004]

RC683.5.E5G477 2004

616.1'207547--dc21

2003054780

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in other ways, and storage in data banks. Duplication of this publication or parts thereof is only permitted under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer-Verlag. Violations are liable for prosecution under the German Copyright Law.

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

<http://www.springer.de>

© Springer-Verlag Berlin Heidelberg 2004  
Printed in Germany

The use of registered names, trademarks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

Product liability: The publishers cannot guarantee the accuracy of any information about the application of operative techniques and medications contained in this book. In every individual case the user must check such information by consulting the relevant literature.

Production Editor: Frank Krabbes, Heidelberg  
Typesetting: wiskom e.K., Friedrichshafen  
Cover design: D & P, Heidelberg

Printed on acid free paper

SPIN: 10911129

14/3109 - 5 4 3 2 1 0

I dedicate the book to my wife Ursula  
and to our children Gustav, Natacha, Sonja and Anatol



## Foreword

On this, the 100<sup>th</sup> anniversary of the electrocardiogram (ECG), it is a delight to welcome a new and comprehensive book on ECGs and arrhythmias. Professor Gertsch has compiled a wonderful book that covers all aspects of electrocardiography but with a very practical and clinically useful approach. In reading this book, I have been struck by its very straightforward layout and setup of each chapter, divided into sections for busy readers and advanced readers. This allows the reader to skim through the highlights of a particular section and, if he or she is more interested, can delve more deeply into that topic. The book has a very clear outline format so that one can follow the various issues on a topic. For example, in the ECG section, the various components of the ECG are divided into subsections and the various normal variants that can be seen are listed as subsections within each part of the chapter. The illustrations, figures, and tables in the book are very helpful. Within each chapter to explain vectors or mechanisms of arrhythmia are illustrations in color. Cataloged at the back of each chapter are example ECGs of all the topics discussed in each chapter.

This makes this book very useful for all levels of physicians and health-care professionals interested in ECGs, ranging from medical students who are first being exposed to electrocardiograms, to senior cardiologists who wish to find more detailed information about particular abnormalities. For all these reasons, I feel this book will be a welcome addition to the medical literature and should be very useful to cardiologists, electrophysiologists, internists, primary care physicians, nurses, medical residents, exercise physiologists and technicians, and all other health-care professionals caring for cardiac patients. Congratulations to Professor Gertsch on creating this important new book.

Christopher Cannon  
Associate Professor of Medicine  
Cardiovascular Division  
Department of Medicine  
Brigham and Women's Hospital  
Harvard Medical School  
Boston MA 02115  
USA



## Preface

Twenty-five years ago a publisher invited me to write an ECG book. I refused because I had no time, having a 120 percent job. This was a good decision. In the decades which followed I have learned much more about the ECG and about teaching. And so I have eventually created this book at the end of my professional life, taking a 50 percent time out for three years.

Being involved in non-invasive and invasive cardiology, I had the constant opportunity to compare the ECG patterns with hard facts, such as echocardiographic and angiographic findings, to name only the most important ones. I became acquainted with the significance of arrhythmias during the implantation of many pace-makers and attending intensive care and emergency stations.

In this book I have tried to differentiate between basically important and frequent ECG patterns and arrhythmias on one hand, and less important and rarer – but interesting – findings on the other. This has been achieved by dividing most chapters into a section *At a Glance* and a section *The Full Picture*. Moreover, I have taken up many suggestions by my colleagues, thus providing an extensive presentation of the normal ECG and its (normal) variants, and a large chapter about exercise ECGs. Other ideas were cooked in my own kitchen, such as the chapters ‘Differential Diagnosis of Pathologic Q Waves’ and ‘Special Waves, Signs and Phenomena’, as well as a list of the etiologies of electrolyte imbalances, and of pericarditis. With clinical data and the inclusion of about 50 case reports (also called ‘short stories’), the clinical significance of ‘the ECG’ is highlighted and the reading experience thus enhanced.

The book is intended for cardiologists, internists and general practitioners, for the specialist team in intensive care units and for especially gifted and interested students.

Marc Gertsch

## Introduction by Bernhard Meier

A single author book in any field of cardiology has become an exquisite rarity. It takes a super specialist to comprehensively review the large topic of electrocardiography in a fashion appropriate to cardiologists, internists, general practitioners, and medical students. Marc Gertsch meets that requirement as only few can. He is a professor of cardiology at the University of Bern, Switzerland, and he has devoted his professional life largely to the dwindling art of ECG interpretation. Keeping up a regular practise of clinical and invasive cardiology alongside has enabled him to correlate ECGs and real life at all times. At the dusk of his career he has sat down to convey his profound knowledge of electrocardiography to all those in the medical profession who use this key tool of the trade. Only few medical professionals have no interface whatsoever with electrocardiography. To all others who deal with the electrocardiograms occasionally or regularly, this book offers a unique opportunity to catch-up, to keep abreast, or even to excel in this domain.

The book is unique in its style as it is unique in its depth of practical information on carefully selected sub-headings of the topic. The illustrations remain faithful to the saying that a picture is worth a thousand words. Yet, wherever needed, text and tables are interspersed and the clinical, physiological or etiological background of depicted electrocardiographic changes are elucidated, for example in a comprehensive list of etiologies of electrolyte imbalances.

The examples of electrocardiograms are carefully selected out of a gargantuan gamut of real life ECGs accumulated in a large tertiary center over years. They are crisply reproduced, succinctly explained, and very often rendered absolutely fascinating by the added history of the patient concerned.

The witty two-layer structure of the book allows the matter-of-fact reader to take home whatever is needed (and a little more) in virtually no time, while the wizard finds tasty tidbits, passion, and joy in digging into the deeper level.

This book is the next best thing to hovering over real ECGs, fresh from the machine, together with a master of the art such as the author Marc Gertsch.

Bernhard Meier, MD  
Professor and Chairman of Cardiology  
Swiss Cardiovascular Center Bern  
University Hospital  
CH-3010 Bern, Switzerland

# Acknowledgements

I am grateful to:

- many colleagues in and outside of the hospital and my boss, Professor Bernhard Meier (Head of the Department of Cardiology, University Clinics, CH-Inselspital Bern), for continuous psychological support. Thanks also to Bernhard Meier for compiling an introduction for the book
- Professor Hein JJ Wellens (Utrecht/Netherlands), also for psychological support
- my colleagues Reto Candinas, Thomas Crohn, Andres Jaussi, Paul Dubach, Marc Zimmermann, Verena Eigenmann, Martin Kägi, Benjamin Fässler, Guy de Sépibus, Felix Frey, Kerstin Wustmann, Christian Schüpfer, Christoph Noti, Beat Meyer, Etienne Delacrétaz, Jürg Fuhrer, Therese Sifeddine and the nurses of the intensive care and emergency units for providing ECGs
- Etienne Delacrétaz MD, for substantial and invaluable help in the chapter ‘The WPW Syndrome’
- Paul Dubach MD, for having a glance at the chapter ‘Exercise ECG’
- the ‘Katharina Huber-Steiner Foundation’ and Paul Mohacsi MD, for a grant of 7000 dollars.
- Pascal Meier MD, for valuable technical assistance
- Matthias Meier, student of architecture, for scanning about 50 percent of the ECGs
- Willi Hess, scientific illustrator, who put all my ideas into more than 50 splendid figures, with admirable endurance (and did more than this)
- Christoph Obrecht lic. biol., for most valuable assistance in many respects, including meticulous reading of the manuscript, asking uncomfortable questions, improving the English, scanning the other 50 percent of the ECGs, secretarial assistance, and repairing computers and other machines. Without his assistance I would not have been able to finish the book
- Benjamin Fässler, MD, and Christoph Obrecht for correcting the final manuscript, thus eliminating the last (?) errors
- Sandra Fabiani, Dr Thomas Mager, and Andrew Spencer of Springer-Verlag (Heidelberg/Berlin), with whom cooperation was extremely satisfying and pleasant
- Professor Christopher Paul Cannon (Brigham and Women’s Hospital, Boston, USA) for writing the foreword.

August 2, 2003. Marc Gertsch



# Contents

Foreword .....	vii
Preface .....	ix
Introduction by Bernhard Meier .....	x
Acknowledgements .....	xi
Abbreviations .....	xxxiii

## Section I Theoretical Basics and Practical Approach

Introduction and Concept of the Book .....	1
Introduction .....	1
The Value of ‘the ECG’ Today .....	1
Limitations of the Pattern ECG .....	1
Conclusions .....	2
Concept of the Book .....	2

### Chapter 1

Theoretical Basics .....	3
1 Anatomy of the Impulse Formation and Impulse Conduction Systems .....	3
2 Normal Impulse Conduction .....	3
3 Action Potential of a Single Cell of Working Myocardium and its Relation to Ion Flows .....	4
4 Atrial Depolarization and Repolarization .....	5
5 Ventricular Depolarization and Repolarization .....	6
5.1 Vectors and Vectorcardiogram .....	6
5.2 Simplified QRS Vectors .....	6
6 Lead Systems .....	7
7 ‘Magnifying Glass’ and ‘Proximity’ Effects .....	7
8 Refractory Period .....	9
9 Nomenclature of the ECG .....	9
References .....	11

### Chapter 2

Practical Approach .....	13
1 The Practical Approach .....	14
1.1 Definitive ECG diagnosis .....	15

2	Practical approach	16
2.1	Analysis of rhythm	16
2.2	Detailed analysis of morphology	17
	References	18

## Section II Pattern ECG

### Chapter 3

	<b>The Normal ECG and its (Normal) Variants</b>	19
1	Components of the Normal ECG	19
1.1	Sinus Rhythm	19
1.1.1	Atrial Vectors in Sinus Rhythm	20
1.2	PQ Interval	21
1.3	QRS complex	21
1.3.1	QRS Axis in the Frontal Plane ( $\bar{A}QRS_F$ )	21
1.3.2	QRS Axis in the Horizontal Plane	22
1.3.3	Two Special QRS Patterns	22
1.3.4	Other Normal Variants of the QRS Complex	22
1.4	ST Segment	23
1.4.1	Common Pattern of ST elevation: ST elevation in $V_2/V_3$	23
1.4.2	Rare Pattern of ST Elevation: Early Repolarization	24
1.5	T Wave and U Wave	24
1.5.1	T Wave	24
1.5.2	U Wave	25
1.6	QT Interval	25
1.7	Arrhythmias	25
1.8	Day-to-Day and Circadian Variation	26
	General Conclusion	27
	References	27

### Chapter 4

	<b>Atrial Enlargement and Other Abnormalities of the p Wave</b>	45
1	Left Atrial Enlargement (p Mitrale)	45
2	Right Atrial Enlargement (p Pulmonale)	45
3	Biatrial Enlargement (p Biatiale)	45
4	Acute Left Atrial Overload	46
5	Acute Right Atrial Overload	46
6	Other Abnormalities of the p Wave	46
7	Etiology, Prevalence and Clinical Significance of Left Atrial Enlargement	46
8	Etiology, Prevalence and Clinical Significance of Right Atrial Enlargement	47
9	Vectors in Left Atrial Enlargement	47
10	Vectors in Right Atrial Enlargement	47
11	Special Alterations of the p Wave	47

11.1	So-called ‘p Pulmonale Vasculare’	47
11.2	p Pseudo-Pulmonale	48
11.3	Imitation of p Pulmonale	48
11.4	p Biatritale/Biatritial Enlargement	48
11.5	Other Uncommon p Configurations in Sinus Rhythm	48
11.5.1	Negative p Wave in Lead I	48
11.5.2	Ebstein’s Anomaly	48
11.5.3	Atrial Infarction	48
11.5.4	Tricuspid Atresia	48
	References	48

## Chapter 5

	<b>Left Ventricular Hypertrophy</b>	53
1	ECG Indices for LVH	53
2	Diagnosis of LVH in Intraventricular Conduction Disturbances	54
3	Etiology and Prevalence	54
4	Validation of the QRS Voltage Criteria	55
5	Detection of LVH in Ventricular Conduction Disturbances	55
5.1	Right Bundle-Branch Block	56
5.2	Left Bundle-Branch Block	57
5.3	Left Anterior Fascicular Block	57
5.4	Other Ventricular Conduction Disturbances	58
6	Detection of LVH in Special Conditions	58
6.1	Hypertrophic Obstructive Cardiomyopathy	58
6.2	Asymmetrical Apical LVH	59
6.3	Systolic and Diastolic Overload	59
6.4	LVH Associated with Marked LV Dilatation	59
7	Factors Impairing the ECG Diagnosis of LVH	59
7.1	Gender and Race	59
7.2	Age	59
7.3	Body Habitus and Body Weight	59
7.4	Other Pathologic Conditions	59
7.5	Variability of the Frontal and Horizontal QRS Vector	60
8	Conclusions	60
9	Pathophysiology and Effects of LVH on the ECG	60
10	Prognosis of LVH	60
	References	60

## Chapter 6

	<b>Right Ventricular Hypertrophy</b>	75
1	ECG Conditions for RVH	75
1.1	RVH without RV Conduction Disturbance	75
1.2	RVH with iRBBB (QRS Duration Normal)	75

1.3	RVH with RBBB (QRS Duration > 0.12 sec)	76
2	Etiology and Prevalence	76
3	Vectors in RVH	76
4	RVH in the ECG	77
4.1	Single R Wave, QR Complex or RS Complex in Lead $V_1$	77
4.2	Incomplete Right Bundle-Branch Block	77
4.3	Complete Right Bundle-Branch Block	77
4.4	$S_I/S_{II}/S_{III}$ Type	77
4.5	Rare Type of RVH	78
4.6	P Wave Alterations	78
5	Differential Diagnosis of Possible Signs of RVH	78
5.1	Frontal QRS Right-Axis Deviation	78
5.2	qR Type in Lead $V_1$	78
5.3	Tall R Wave and RS Complex in Lead $V_1$	78
5.4	Incomplete Right Bundle-Branch Block	79
5.5	Complete Right Bundle-Branch Block	79
5.6	$S_I/S_{II}/S_{III}$ Type	79
6	Systolic and Diastolic Overload	79
7	Effect of Systolic Pressure in the Right Ventricle and Pulmonary Artery on the ECG	79
	References	79

## Chapter 7

	<b>Biventricular Hypertrophy</b>	89
1	Usual ECG Signs for BVH	90
2	Other ECG Signs for BVH	90
2.1	Shallow $S_{V_1}$ , Deep $S_{V_2}$	90
2.2	Katz-Wachtel Sign	90
2.3	Special QRS Pattern in Right Bundle-Branch Block	90
	References	90

## Chapter 8

	<b>Pulmonary Embolism</b>	95
1	ECG Alterations	95
1.1	Alterations of QRS	95
1.2	Alterations of Repolarization	95
1.3	Rhythm Disturbances	95
1.4	Alterations of the P Wave	95
2	Value of ECG in Suspected Acute PE	96
2.1	Differentiation of AMI from Acute PE	96
2.2	Analysis of Heart Rhythm and Conduction Disturbances	96
2.3	ECG Signs of Acute RV Overload	96
2.4	Control of Clinical Evolution	97
2.5	Subacute and Chronic repetitive PE	97

3	Prevalence of ECG Signs Suggesting PE .....	97
4	ECG Signs and Grade of Acute PE .....	98
5	Practical Procedures in Suspected Acute PE .....	98
6	ECG in Subacute PE .....	99
7	Historical Perspective .....	99
	References .....	100

## Chapter 9

	<b>Fascicular Blocks .....</b>	<b>105</b>
	Etiology and Prevalence .....	105
1	Left Anterior Fascicular Block .....	105
2	Left Posterior Fascicular Block .....	105
3	Intraventricular Conduction System Anatomy .....	106
4	Etiology of Fascicular Blocks .....	106
	4.1 Etiology of LAFB .....	106
	4.2 Etiology of LPFB .....	107
5	Left Anterior Fascicular Block .....	107
	5.1 Vectors and the ECG .....	107
	5.2 Variants .....	108
	5.3 Prognosis .....	109
6	Left Posterior Fascicular Block .....	109
	6.1 Vectors and the ECG .....	109
	6.2 Special Remarks: $\bar{A}QRS_F$ , ECG Patterns and Etiology .....	109
	6.3 Prognosis .....	110
7	Very Rare Patterns of Fascicular Blocks .....	111
	7.1 LAFB plus LPFB .....	111
	7.2 Left Septal Fascicular Blocks .....	111
	7.3 Right Fascicular Blocks .....	111
	References .....	111

## Chapter 10

	<b>Bundle-Branch Blocks (Complete and Incomplete) .....</b>	<b>117</b>
1	Complete Right Bundle-Branch Block .....	117
2	Incomplete Right Bundle-Branch Block .....	118
3	Complete Left Bundle-Branch Block .....	118
4	Incomplete Left Bundle-Branch Block .....	118
5	Etiology and Prevalence .....	118
6	Complete Right Bundle-Branch Block .....	119
	6.1 QRS Vectors .....	119
	6.2 Repolarization Vectors .....	120
	6.3 Determination of Frontal QRS Axis in RBBB .....	120
	6.4 Myocardial Infarction in RBBB .....	120
	6.5 Right Ventricular Hypertrophy in RBBB .....	120

7	Incomplete Right Bundle-Branch Block .....	120
8	Complete Left Bundle-Branch Block .....	121
	8.1 QRS Vectors .....	121
	8.2 Repolarization Vectors .....	122
	8.3 Determination of Frontal QRS Axis in LBBB .....	122
	8.4 Myocardial Infarction in LBBB .....	122
	8.5 Left Ventricular Hypertrophy in LBBB .....	122
	8.6 Incomplete Left Bundle-Branch Block .....	122
9	Special Aspects of Bundle-Branch Blocks .....	122
	9.1 Rate-Dependent Bundle-Branch Block .....	122
	9.2 Alternating, Intermittent and Reversible BBB .....	122
	9.3 Difference of QRS and QT Duration in RBBB and LBBB .....	123
10	Prognosis .....	123
	References .....	123

## Chapter 11

	<b>Bilateral Bifascicular (Bundle-Branch) Blocks .....</b>	<b>131</b>
1	RBBB + LAFB .....	131
2	RBBB + LPFB .....	132
3	Prognosis .....	132
4	Etiology .....	132
5	Differential Diagnosis of RBBB + LAFB .....	133
6	Differential Diagnosis of RBBB + LPFB .....	133
7	Differential Diagnosis of RBBB + LAFB + LPFB <i>Without</i> Complete AV Block .....	133
8	Prognosis .....	134
9	Indications for Pacemaker Implantation .....	134
	References .....	134

## Chapter 12

	<b>Atrioventricular Block and Atrioventricular Dissociation .....</b>	<b>145</b>
1	Anatomic Localization of AV Block .....	145
2	Degrees of AV Block .....	145
	2.1 AV block 1° .....	145
	2.2 AV block 2° .....	146
	2.2.1 AV block 2° Type Wenckebach .....	146
	2.2.2 AV block 2° Type Mobitz .....	146
	2.2.3 AV block 2° Type Advanced .....	146
2.3	Complete AV Block .....	146
2.4	Types of Complete AV Block .....	146
	2.4.1 Infra-His Complete AV Block .....	146
	2.4.2 Supra-His Complete AV Block .....	147

3	AV Dissociation .....	147
3.1	Three Types of AV Dissociation .....	147
3.1.1	AV Dissociation with Accrochage .....	147
3.1.2	Isorhythmic AV Dissociation .....	148
3.1.3	AV Dissociation with Interference .....	148
4	Nomenclature and its Implications .....	148
4.1	Differences Between Complete AV Block and AV Dissociation .....	148
4.2	Pathophysiology and the ECG .....	148
4.3	Clinical Significance .....	149
5	Atrioventricular Block .....	149
5.1	AV Block 1° .....	149
5.1.1	Hemodynamics in AV Block 1° .....	149
5.2	AV block 2° .....	149
5.2.1	AV Block 2° Type Wenckebach .....	150
5.2.2	AV Block 2° Type Mobitz .....	150
5.2.3	AV Block 2° Type Advanced (High Degree) .....	151
5.3	AV Block 3° .....	151
5.3.1	Simultaneous Supra-His AV Block and Bundle-Branch Block .....	152
5.3.2	AV Blocked Atrial Premature Beats .....	152
5.3.3	Development of Complete AV Block .....	152
5.3.4	Etiology and Clinical Significance of Complete AV Block .....	153
5.3.5	His Bundle Derivations .....	154
5.3.6	ECG and Anatomical Lesions .....	154
5.3.7	Therapeutic Conclusions .....	154
6	Special AV Dissociation .....	154
6.1	Special Conditions in AV Dissociation .....	154
6.1.1	AV Dissociation in a Postextrasystolic Beat .....	154
6.1.2	Ventriculophasic Sinus Arrhythmia .....	155
6.1.3	AV Dissociation in Ventricular Tachycardia .....	155
	References .....	155

## Chapter 13

	<b>Myocardial Infarction</b> .....	167
	Etiology .....	167
1	ST Vectors, Q Vectors and T Vectors .....	167
2	Stages of Myocardial Infarction .....	168
2.1	Acute Stage .....	168
2.2	Subacute Stage .....	168
2.3	Old (Chronic) Stage .....	168
3	Localization of Q-Wave Infarction .....	169
3.1	Anteroseptal Infarction .....	169
3.2	Extensive Anterior (Anterolateral) Infarction .....	169
3.3	Lateral Infarction (Isolated MI of the Lateral Wall) .....	169

3.4	Inferior Infarction .....	169
3.5	Posterior ('True' Posterior) Infarction .....	169
3.6	Right Ventricular Infarction .....	171
4	Differential Diagnosis of 'Classical' Infarction Patterns (Pathologic Q waves, ST Elevation, Abnormal T Waves) .....	172
5	Complex Infarction Patterns .....	173
6	Special Infarction Patterns .....	174
	Conclusion .....	174
7	Etiology and Prevalence .....	175
7.1	Arteriosclerotic Coronary Artery Disease (Common) .....	175
7.2	Congenital Coronary Artery Disease (Rare) .....	175
7.3	Other Conditions of Coronary Artery Disease (Rare) .....	175
8	Nomenclature of Infarction Stages .....	176
8.1	Electropathophysiologic Evolution .....	176
8.2	International Terminology .....	177
8.3	Histopathologic Evolution .....	177
8.4	Clinical Findings and Practical Experience .....	177
9	Combination of Infarction Patterns .....	177
9.1	Infarction of Adjacent Areas .....	177
9.2	Infarction of Separate or Opposite Localization .....	178
10	Complex Infarction Patterns .....	178
10.1	Infarction Associated with Right Bundle-Branch Block .....	178
10.2	Infarction Associated with Left Bundle-Branch Block .....	179
10.2.1	Infarction in Pacemaker Patients .....	180
10.3	Infarction in Left Anterior Fascicular Block .....	180
10.4	Infarction in Left Posterior Fascicular Block .....	181
10.5	Infarction in Bilateral Block .....	181
10.5.1	Infarction in RBBB + LAFB .....	181
10.5.2	Infarction in RBBB + LPFB .....	181
11	Special Infarction Patterns .....	181
11.1	The So-Called Non-Q-Wave Infarction .....	181
11.2	Infarction with ST depression $\geq 3$ mm .....	182
11.3	Infarction with 'Nonsignificant' Q Waves at Usual Localization .....	182
11.4	Infarction with 'Nonsignificant' Q Waves at Unusual Localization .....	183
11.5	Infarction with RSR' Type in Precordial (and Inferior) Leads .....	183
11.6	Infarction with Pure or Predominant Reduction of R Wave Amplitude .....	183
11.7	Atrial Infarction .....	183
12	Differential Diagnosis of 'Classical' Q-wave Infarction Patterns .....	184
13	Localization of Infarction and Localization of Coronary Occlusion .....	184
14	Estimation of Infarct Size .....	184
15	Electropathophysiology .....	185
15.1	Acute Stage .....	185

15.2	Subacute Stage	185
15.3	Old (Chronic) Stage	185
16	Complications of Acute MI	186
16.1	Arrhythmias and Conduction Defects	186
16.2	Nonarrhythmic Complications	186
	References	186

## Chapter 14

	Differential Diagnosis of Pathologic Q waves	265
	Definition of Normal Q Wave	265
	Definition of (Formally) Pathologic Q Wave	265
1	Myocardial Infarction	265
1.1	New Q Waves	265
1.2	ST Elevation	266
1.3	Negative T Waves	266
2	Normal Variants	266
2.1	Frontal Plane	266
2.2	Horizontal Plane	266
3	Left Ventricular Hypertrophy	266
4	False Lead Poling	266
5	Left Bundle-Branch Block	266
6	Pre-Excitation (Wolff-Parkinson-White Syndrome)	267
7	Hypertrophic Obstructive Cardiomyopathy	267
8	Congenital Corrected Transposition of the Great Arteries	267
9	Situs Inversus	267
10	Q Waves after Pneumectomy	268
11	Q Waves in Pneumothorax	268
12	Q Waves after Pericardectomy	268
13	Q waves in Amyloidosis of the Heart	268
14	Pseudo-Q Wave due to Retrograde Atrial Activation	268
15	A Rarity: Q Waves in Muscular Dystrophy Steinert	268
16	QR Complex in Lead V <sub>1</sub>	268
17	Q Wave in Lead V <sub>1</sub> in Right Atrial Dilatation	268
	References	269

## Chapter 15

	Acute and Chronic Pericarditis	283
	Etiology	283
1	Acute Pericarditis	283
2	Chronic Pericarditis	284
3	Etiology and Prevalence	284
4	PQ Depression	284
5	ST Elevation and ST Vector	284

6	Differential Diagnosis of Acute Pericarditis versus Acute MI	284
6.1	ST Elevation	285
6.1.1	Amplitude of ST Elevation	285
6.1.2	Configuration of ST Elevation	285
6.1.3	ST Elevation in Frontal ECG Leads and Frontal ST Vector	285
6.1.4	ST Elevation in Horizontal Leads	285
6.2	Pathologic Q Wave	286
6.3	PQ Depression	286
6.4	T-Wave Negativity	286
7	General Differential Diagnosis of ST Elevation	286
8	Arrhythmias	288
9	Chronic Pericarditis	288
10	Cardiac Tamponade	288
11	Clinical Findings in Acute Pericarditis	288
	References	288

## Chapter 16

	<b>Electrolyte Imbalances and Disturbances</b>	299
1	Hyperkalemia (Hyperpotassemia)	299
2	Hypokalemia (Hypopotassemia)	299
3	Hypercalcemia	299
4	Hypocalcemia	300
5	Therapy of Potassium Imbalance	300
5.1	Severe Hyperkalemia	300
5.2	Severe Hypokalemia	300
6	Hyperkalemia (Hyperpotassemia)	300
6.1	Differential Diagnosis of Tall and Peaked T waves	301
6.2	Prevalence, Clinical Findings and Etiology of Hyperkalemia	301
6.3	Therapy of Severe Hyperkalemia	302
7	Hypokalemia (Hypopotassemia)	302
7.1	Pathophysiology of Hyperkalemia and Hypokalemia	303
8	Hypercalcemia	303
9	Hypocalcemia (Isolated or Associated with Hyperkalemia)	303
10	Hypomagnesemia	303
11	Hypermagnesemia	303
12	Sodium Imbalance	304
13	New Classification of Antiarrhythmic Drugs	304
	References	304
	Appendix 1 Etiology	305

## Chapter 17

<b>Alterations of Repolarization</b> .....	323
1 ST Segment .....	323
1.1 ST Elevation .....	323
1.2 ST Depression .....	323
2 T Wave .....	324
2.1 T Negativity .....	324
2.2 T Positivity .....	324
3 Special Remarks .....	325
3.1 Atypical Behavior of Repolarization in Acute Myocardial Infarction and Acute Pericarditis ...	325
3.2 Patterns with Prolonged or Shortened QT Duration .....	325
3.3 Giant Negative T Waves .....	325
References .....	326

## Section III Arrhythmias

### Chapter 18

<b>Atrial Premature Beats</b> .....	329
1 Prevalence and Clinical Findings .....	330
2 Therapy .....	330
References .....	331

### Chapter 19

<b>Atrial Tachycardia</b> .....	337
1 ‘Salvos’ of Atrial Premature Beats .....	337
2 ‘Benign’ Atrial Tachycardia .....	337
3 Atrial Tachycardia of Medium Duration and High Rate .....	337
4 ‘Incessant’ Atrial Tachycardia .....	337
5 Atrial Tachycardia with Atrioventricular Block 2° .....	337
6 Multifocal Ectopic Atrial Tachycardia (Chaotic Atrial Mechanism) .....	337
7 Ectopic (Focal) Atrial Tachycardia .....	338
8 Atrial Reentry Tachycardia .....	338
9 Repetitive Paroxysmal Atrial Tachycardia .....	338
10 Paroxysmal Atrial Tachycardia with AV Block .....	338
11 Left Atrial Tachycardia .....	339
12 Multifocal Atrial Tachycardia (Chaotic Atrial Tachycardia) .....	339
13 Accelerated Atrial Rhythm .....	339
14 Closing Remarks .....	339
References .....	339

## Chapter 20

<b>Atrial Flutter</b>	347
1 Morphologic Types of Atrial Flutter	347
1.1 Common Type (Type 1)	347
1.2 Uncommon Type (Type 2)	347
2 Nomenclature	348
3 Etiology	349
4 Clinical Significance	349
5 Pathophysiology and Therapeutic Consequences	350
References	350

## Chapter 21

<b>Atrial Fibrillation</b>	363
Etiology and Prevalence	363
1 Hemodynamics	363
2 Clinical Significance	364
3 Therapy	364
4 Etiology and Prevalence	364
5 Aberration in Atrial Fibrillation	365
5.1 Ashman Beats	365
5.2 Atrial Fibrillation in Pre-excitation (Wolff-Parkinson-White Syndrome)	365
6 Regular Ventricular Action in AF	365
7 Interatrial Dissociation in AF	366
8 Differential Diagnosis	366
9 Electrophysiology	366
10 Clinical Significance	367
11 Therapy and Prevention	367
11.1 Electric and Drug Conversion	367
11.2 Implantable Defibrillator	367
11.3 Maze Procedure and Catheter Ablation	367
11.4 Pacemaker	367
11.5 Prevention of Recurrent AF	367
11.6 New-Onset Atrial Fibrillation	367
11.7 Rate Control	368
11.8 Prevention of Thromboembolism	368
11.9 Drug Rate Control versus Electroconversion	368
11.10 Final Remarks	369
References	369

## Chapter 22

<b>Sick Sinus Syndrome (and Carotid Sinus Syndrome)</b>	379
1 Characteristics	379
1.1 Sinus Bradycardia	379

1.2	Sinus Standstill/Arrest	379
1.3	Exit Block or Sinoatrial Block	379
1.4	Bradycardia–Tachycardia Variant	379
1.5	AV Node and Bundle Branches	380
2	Clinical Significance	380
3	Prognosis and Complications	380
4	Therapy	380
5	Prevalence and Etiology	380
6	Pseudo versus True Sick Sinus Syndrome	381
6.1	Influence of Drugs	381
6.2	Abnormal Vagal Reaction After Invasive Procedures	381
6.3	Excessive Sinus Bradycardia in Athletes	381
6.4	Atrial Premature Beats with AV Block	381
6.5	‘Laboratory’ Sick Sinus Syndrome	382
6.6	Sinus Nodal Re-entry Tachycardia	382
7	Hypersensitive Carotid Sinus Syndrome	382
7.1	Cardioinhibitory Type	382
7.2	Vasodepressor Type	382
8	Symptoms and Complications	382
9	Electrophysiologic Testing	382
10	Therapy	382
	References	383

## Chapter 23

	<b>Atrioventricular Junctional Tachycardias</b>	391
1	Conduction in Sinus Rhythm	391
	Conduction in AVNRT	391
3	Common Form of AVNRT	392
4	Rare Form of AVNRT	392
5	Differential Diagnosis	393
5.1	Atrial Flutter	393
5.2	AV Reentry Tachycardia in the WPW Syndrome	393
5.3	Aberration	393
6	Symptoms of AVNRT (Common Form)	393
7	Clinical Significance of AVNRT (Common Form)	393
8	Etiology and Prevalence	394
9	Special Types of AV Junctional Tachycardias	394
9.1	Accelerated AV Junctional Rhythm	394
9.2	Automatic Junctional Tachycardia (AJT)	394
9.3	Permanent Junctional Reciprocating Tachycardia (PJRT)	394
10	Prognosis	395
11	Therapy of AVNRT (Common Form)	395

12	Therapy of the Other Types of AV Junctional Tachycardias .....	395
	References .....	395

## Chapter 24

	<b>The Wolff-Parkinson-White Syndrome .....</b>	<b>405</b>
1	Pre-Excitation Pattern (WPW Pattern) .....	405
1.1	Nomenclature .....	405
1.2	ECG Patterns in Pre-Excitation .....	406
1.3	Differential Diagnosis of the WPW Pattern .....	406
1.3.1	Myocardial Infarction .....	406
1.3.2	Left Ventricular Hypertrophy .....	406
1.3.3	Pseudo-Delta Wave .....	406
2	Tachycardias in the WPW Syndrome .....	406
2.1	Reentry Tachycardias .....	406
2.2	Atrial Fibrillation and Atrial Flutter in the WPW Syndrome .....	407
2.3	Therapy .....	408
2.4	Therapeutic Pitfalls .....	408
3	Etiology .....	408
4	Anatomy and Localization of Accessory Pathways .....	409
4.1	Algorithms .....	409
5	Degree of Pre-Excitation, Latent Pre-Excitation and Concealed Accessory Pathway .....	410
6	Repolarization Abnormalities .....	411
7	Differential Diagnosis .....	411
8	Tachyarrhythmias Associated with the Wolff-Parkinson-White Syndrome .....	411
8.1	Atrioventricular Reentry Tachycardia .....	412
8.2	Other Tachycardias Associated with an Accessory Pathway .....	413
8.2.1	Special Condition: Atrial Fibrillation .....	413
8.3	Ventricular Fibrillation and Sudden Death .....	413
9	Other Accessory Connections .....	413
9.1	Mahaim Fibre and Mahaim Tachycardias .....	413
9.2	Lown-Ganong-Levine Syndrome .....	414
10	Therapy of the WPW Syndrome .....	414
10.1	Acute Termination of Tachycardia .....	414
10.2	Chronic Therapy for Prevention .....	415
10.3	Treatment of Patients with an Asymptomatic WPW Pattern .....	415
	References .....	416

## Chapter 25

	<b>Ventricular Premature Beats .....</b>	<b>435</b>
1	Definition and Nomenclature .....	435
1.1	Coupling Interval .....	435
1.2	Compensatory Pause .....	435
1.3	Morphology and Origin .....	435

1.4	Special Types	436
1.4.1	R-on-T Phenomenon	436
1.4.2	Interponated VPBs	436
1.4.3	Fusion Beat	436
1.4.4	Concealed Bigeminy	436
2	Differential Diagnosis	436
3	Mechanism	436
4	Prognosis	436
5	Therapy	437
	References	437

## Chapter 26

	Ventricular Tachycardia	445
1	Definition and Characteristics of Ventricular Tachycardia	445
2	Types of Ventricular Tachycardia	445
2.1	Monomorphic VT	445
2.1.1	Etiology of Monomorphic VT	446
2.2	Polymorphic VT of Type ‘Torsade de Pointes’	446
2.2.1	Etiology of Torsade de Pointes VT	446
2.3	Polymorphic VT (without ‘Torsade de Pointes’)	446
3	A Special Condition: Accelerated Idioventricular Rhythm	446
4	Differential Diagnosis of ‘Wide QRS’ Tachycardias: VT <i>versus</i> SVT with Aberration	446
4.1	Types of SVT with Aberration (SVT with Wide QRS)	447
4.1.1	SVTab with Bundle-Branch Block	447
4.1.2	SVTab in Wolff-Parkinson-White Syndrome	447
4.1.3	SVT with other Aberrations	447
4.2	Criteria for Differentiation Between VT and SVTab	447
4.3	Criteria for Differentiation Between VT and Artifacts	447
5	Therapy	447
6	Pathophysiology	448
6.1	Reentry	448
6.2	Enhanced Automaticity	448
6.3	Triggered Activity	449
6.4	Electrotonus	449
6.5	Onset of VT	449
7	Types of Ventricular Tachycardia	449
7.1	Monomorphic VT	449
7.2	VT of the Type Torsade de Pointes	449
7.3	Polymorphic VT Without Torsade de Pointes	450
7.4	Special Types of VT	450
7.4.1	Parasystolic VT	450
7.4.2	Bidirectional VT	450

7.4.3	Double Tachycardia	450
7.4.4	Accelerated Idioventricular Rhythm	450
8	Differential Diagnosis of Regular Monomorphic ‘Wide QRS Complex’ Tachycardias: VT <i>versus</i> SVT with Aberration	451
8.1	General Remarks	451
8.1.1	Age and Prevalence	451
8.1.2	Underlying Cardiac Disease	451
9	Electrocardiographic Findings in Monomorphic VT	451
9.1	General Findings	451
9.1.1	AV Dissociation	451
9.1.2	Fusion Beats and (Ventricular) Capture Beats	451
9.1.3.	VA Block 2°	451
9.1.4	Rate	451
9.1.5	Regularity	452
9.1.6	Comparison of ‘Wide QRS’ Tachycardia ECG with a <i>Previous</i> ECG Without Tachycardia	452
9.2	QRS Criteria	452
9.2.1	QRS Duration	452
9.2.2	Frontal QRS Axis	452
9.2.3	Morphologic QRS Criteria	452
10	Misdiagnoses of Wide QRS Tachycardias	454
10.1	VT Misdiagnosed as SVTab	454
10.2	Differentiation Between Wide Complex Tachycardias (especially VT) and Artifacts	454
11	Final General (and Therapeutic) Considerations	455
	References	456

## Section IV Special Topics

### Chapter 27

	Exercise ECG	479
	Information from the Exercise Test	479
1	Indications and Contraindications	479
1.1	Indications	479
1.2	Contraindications	480
2	Limitations	480
3	Methods	480
3.1	Exercise Limited by Symptoms	481
3.2	Heart Rate	481
3.3	Blood Pressure	481
3.4	Double Product	481
3.5	Workload and Exercise Capacity	482
3.6	Duration of Exercise	482
3.7	Stepwise Exercise versus the Ramp Protocol	482
3.8	Criteria for Interruption of the Test	482

4	Procedure .....	482
4.1	Exercise Preparation .....	482
4.2	Exercise Procedure .....	483
5	Validation .....	483
5.1	Ischemic Response .....	483
5.1.1	ST Segment .....	483
5.1.2	T Wave .....	484
5.1.3	Q Wave .....	484
5.2	Arrhythmias and Conduction Disturbances .....	484
5.3	Pitfalls .....	485
6	Complications .....	485
6.1	Severe Cardiac Complications .....	485
6.2	Severe Noncardiac Complications .....	486
6.3	Common Nonsevere Complications .....	486
6.4	Rare Nonsevere Complications .....	486
7	Specificity and Sensitivity .....	486
8	Exercise in Pre-existing Bundle-Branch Block and Left Anterior Fascicular Block .....	487
9	New Bundle-Branch Block During Exercise .....	487
10	Ventricular Premature Beats During Exercise .....	487
11	Alterations of QRS During Exercise, Without Intraventricular Conduction Disturbances .....	487
12	Right Precordial Leads in the Exercise Test .....	487
13	Exercise Test After Aortocoronary Revascularization .....	488
14	Exercise ECG After PTCA .....	488
15	Exercise Training in Cardiac Rehabilitation After MI and Revascularization .....	488
16	Exercise Training in Heart Failure .....	488
17	Prognostic Impact of the Exercise Test .....	488
	References .....	489

## Chapter 28

	Pacemaker ECG .....	505
1	Single-chamber Pacemaker .....	505
2	Dual-chamber Pacemaker .....	506
3	Electric Complications and Failures .....	506
3.1	Undersensing and Oversensing .....	506
3.2	Lead Fracture and Lead Insulation Damage .....	507
4	Pacemaker Codes .....	507
5	Morphologic Features .....	508
6	Pacemaker-Mediated Arrhythmia .....	508
7	Pacemaker Malfunction .....	509
7.1	Battery Depletion .....	509
7.2	Electrode Problems .....	509
7.3	Oversensing and Undersensing .....	509

8	Pacemaker Syndrome .....	509
8.1	Prevalence .....	509
8.2	Condition .....	509
8.3	Pathophysiologic Mechanisms .....	510
9	Indications for Pacing .....	510
9.1	Pacing in Hypertrophic Obstructive Cardiomyopathy .....	510
9.2	Pacing in Heart Failure .....	511
10	Prognosis of AV Sequential (Physiologic) Pacing vs Single-Chamber Ventricular Pacing .....	511
10.1	Conclusions .....	512
	References .....	512

## Chapter 29

	<b>Congenital and Acquired (Valvular) Heart Diseases .....</b>	<b>525</b>
1	Congenital Heart Diseases .....	525
1.1	Atrial Septal Defect of the Ostium Secundum Type .....	525
1.1.1	Differential Diagnosis .....	525
1.2	Atrial Septal Defect of the Ostium Primum Type .....	526
1.3	Valvular Pulmonary Stenosis .....	526
1.4	Tetralogy of Fallot .....	526
1.5	Ventricular Septal Defect .....	526
2	Acquired Valvular Diseases .....	526
3	Congenital Heart Diseases .....	526
3.1	Ductus Arteriosus Botalli .....	526
3.2	Eisenmenger Syndrome .....	526
3.3	Transposition of the Great Arteries .....	527
3.4	Situs Inversus .....	527
3.5	Ebstein's Anomaly .....	527
3.6	Complex Congenital Cardiac Diseases .....	527
3.7	Mitral Valve Prolapse (Barlow's Disease) .....	527
3.8	Hypertrophic Obstructive Cardiomyopathy (HOCM) .....	527
4	Acquired Valvular Heart Diseases .....	527
4.1	Valvular Aortic Stenosis .....	527
4.2	Valvular Aortic Incompetence .....	527
4.3	Mitral Stenosis .....	527
4.4	Mitral Incompetence .....	528
	References .....	528

## Chapter 30

	<b>Digitalis Intoxication .....</b>	<b>535</b>
1	Extracardiac Symptoms .....	535
2	Electrophysiology and Pharmacokinetics .....	536
3	Acute Digitalis Intoxication and its Therapy .....	536
	References .....	537

## Chapter 31

<b>Special ECG Waves, Signs and Phenomena</b> .....	541
1 Ashman Phenomenon .....	541
2 Brugada Sign or Syndrome .....	541
3 Cabrera Sign .....	542
4 Chatterjee Phenomenon .....	542
5 Delta Wave .....	542
6 Dressler Beat .....	543
7 Early Repolarization .....	543
8 Epsilon Wave .....	543
9 McGee Index .....	543
10 McGinn White Pattern ( $S_I/Q_{III}$ Type) .....	543
11 Katz-Wachtel Sign .....	543
12 Nadir Sign .....	543
13 Osborn Wave .....	543
14 Pardee Q Wave .....	543
15 R-on-T Phenomenon .....	544
16 Shallow s Sign .....	545
17 Stork Leg Sign .....	545
Final Comment .....	545
References .....	545

## Chapter 32

<b>Rare ECGs</b> .....	561
Multifocal or Chaotic Atrial Rhythm .....	561
Absent Pericardium .....	562
Right Ventricular Dysplasia (Arrhythmogenic Right Ventricular Cardiomyopathy) .....	562
Severe Hypertrophic Cardiomyopathy .....	563
Strange R Wave in Lead $V_2$ in a Patient with Severe Hypertrophic Cardiomyopathy .....	564
Strange R Wave in Lead $V_1$ in a Patient without Right Ventricular Hypertrophy or Posterior Infarction .....	565
What is the Rhythm? .....	565
After Left Pneumectomy .....	568
After Right Pneumectomy .....	568
Pneumothorax .....	569
Electrical Alternans .....	570
Common and Rare False Poling of the Limb Leads (Lead Displacement) in Frontal QRS Left Axis and in Frontal QRS Vertical Axis .....	570
Situs Inversus .....	573
Epileptic Attack of the ECG Machine .....	575
Parasystole .....	575
Left Pleural Effusion .....	576
So-Called Postsyncope Bradycardia Syndrome .....	576

‘Dying Heart’ .....	578
Two p Waves: Highly Specific for a Transplanted Heart .....	579
Pseudo-p Waves in Precordial Leads $V_3/V_4$ .....	580
‘Double Ventricular Repolarization’ .....	581
T Wave without QRS Complex .....	581
Double Ventricular Response to a Single Atrial Impulse. Another Artifact? .....	582
Another Rare ECG .....	583
References .....	584
Subject Index .....	585
ECG Index .....	607

## Abbreviations

The following abbreviations are used regularly throughout the text.

AAI pacing	Atrial inhibited atrial pacing
ACE	Angiotensin-converting enzyme
acPE	Acute pulmonary embolism
AF	Atrial fibrillation
AJT	Automatic junctional tachycardia
AMI	Acute myocardial infarction
AP or acP	Action potential
APB	Atrial premature beat
ÅQRS <sub>F</sub>	Mean QRS axis in the frontal plane
ASD	Atrial septal defect
AV	Atrioventricular
AVNRT	Atrioventricular nodal reentrant tachycardia
BVH	Biventricular hypertrophy
CABG	Aortocoronary bypass grafting
CAD	Coronary artery disease
CHD	Coronary heart disease
CK = CPK	Creatine kinase
CK-MB	Myocardial-bound creatine kinase
COPD	Chronic obstructive pulmonary disease
Coro	Coronary angiogram/coronary angiography. (In most cases 'Coro' also includes left ventricular angiography/-gram)
CPK	Creatine phosphokinase
CPR	Cardiopulmonary resuscitation
CT	Computerized tomography
CX	Circumflexa (circumflex branch of the left coronary artery)
DC	Direct current
DD	Differential diagnosis
DDD	Double chamber double inhibited (pacing)
ECG	Electrocardiogram
Echo	Echocardiogram/echocardiography (in most cases color Doppler is integrated)
EF	Ejection fraction (in most cases of the left ventricle)
EPI/EPS	Electrophysiologic investigation/study
HOCM	Hypertrophic obstructive cardiomyopathy

Htx	Xeno-transplantation of the heart
ICD	Implantable cardioverter defibrillator
INR	International normalized ratio (for oral anticoagulation)
LA	Left atrium/left atrial
LAD	Left anterior descending coronary artery = left anterior descending branch of the LCA
LAD	Left axis deviation ( $\angle QRS_F < -30^\circ$ )
LAFB	Left anterior fascicular block (= left anterior 'hemiblock')
LBBB	(Complete) left bundle branch block
LCA	Left coronary artery
LPFB	Left posterior fascicular block (= left posterior 'hemiblock')
LV	Left ventricle/left ventricular
LVH	Left ventricular hypertrophy
MET	Metabolic equivalents
MET	Maximal exercise test
MI	Myocardial infarction
MRI	magnetic resonance imaging
NSAID	Nonsteroidal anti-inflammatory agent
PA	Pulmonary artery
PE	Pulmonary embolism
PET	Positron emission tomography
PJRT	Permanent junctional reciprocating tachycardia
PTCA	Percutaneous coronary transluminal angioplasty
RA	Right atrium/right atrial
RBBB	(Complete) right bundle branch block
RCA	Right coronary artery
RV	Right ventricle/right ventricular
RVD	Right ventricular dysplasia
RVOT	Right ventricular outflow tract
SA	Sinoatrial
SACT	Sinoatrial conduction time
SN	Sinus node
SNRT	Sinus node recovery time
SPECT	Single proton emission computed tomography
SR	Sinus rhythm
SVPB	Supraventricular premature beat
SVT	Supraventricular tachycardia
SVTab	Supraventricular tachycardia with aberration
VPB	Ventricular premature beat
VSD	Ventricular septal defect
VT	Ventricular tachycardia
VVI	One-chamber ventricular (pacemaker)
VVI(R)	Ventricular inhibited ventricular pacing with rate responsiveness
WPW syndrome	Wolff-Parkinson-White syndrome

The ECG

A Two-Step Approach to Diagnosis

Gertsch, M.

2004, XXXIV, 616 p., Hardcover

ISBN: 978-3-540-00869-9