Rate – Interval Conversion Table

Rate (BPM)	Cycle length (ms)	Rate (BPM)	Cycle length (ms)
20	3000	215	279
25	2400	220	273
30	2000	225	267
35	1714	230	261
40	1500	235	255
45	1333	240	250
50	1200	245	245
55	1091	250	240
60	1000	255	235
65	923	260	231
70	857	265	226
75	800	270	222
80	750	275	218
85	706	280	214
90	667	285	211
95	632	290	207
100	600	295	203
105	571	300	200
110	545	305	197
115	522	310	194
120	500	315	190
125	480	320	188
130	462	325	185
135	444	330	182
140	429	335	179
145	414	340	176
150	400	345	174
155	387	350	171
160	375	355	169
165	364	360	167
170	353	365	164
175	343	370	162
180	333	375	160
185	324	380	158
190	316	385	156
195	308	390	154
200	300	395	152
205	293	400	150
210	286		

$$\text{Rate (BPM or min}^{-1}) = \frac{60{,}000}{\text{Cycle length (ms)}}$$

$$\text{Cycle length (ms)} = \frac{60{,}000}{\text{Rate (BPM or min}^{-1})}$$

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W. Fischer · Ph. Ritter

Cardiac Pacing in Clinical Practice

With a Foreword by D. Hayes

With 324 Figures in 547 Parts, 8 Tables, and Glossary

Springer

Dr. med. Wilhelm Fischer
Innere Abteilung, Krankenhaus Peißenberg
Hauptstraße 55–57, D-82380 Peißenberg

Dr. med. Philippe Ritter
Dept. de Stimulation Cardiaque d'Électrophysiologie
Centre Chirurgical Val d'Or, F-92210 Saint Cloud

Translator: Rodolphe Ruffy

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Dedicated to our families

Foreword

Pacemaker technology has evolved rapidly over the nearly 40 year history of the device. On several occasions over the past decade, I have heard individuals involved in some aspect of cardiac pacing, state that pacemaker technology had reached the end of it's developmental stage and no further improvements should be anticipated. Conversely, I've also heard many far-sighted individuals discuss potential pacemaker features and applications that seemed far-fetched. The latter group have been vindicated as pacemaker technology continues to advance. In such a dynamic field, it is crucial that state-of-the-art information exists and that it is provided in an understandable format.

In the course of our medical library acquisitions, many of us have purchased a medical textbook based upon the title that promises „state-of-the-art" information, only to be disappointed when the text fails to adequately deliver the expected information. Anyone who reads „*Cardiac Pacing in Clinical Practice*", whether cover-to-cover or used as a reference for management of clinical pacing problems, will find that the text fulfills all expectations. Drs. Ritter and Fischer have provided a comprehensive, understandable, state-of-the-art guide to clinical management of the pacemaker patient that can be appreciated by both physician and allied professional.

Preparation of such a comprehensive text by only two authors is an arduous task. However, the benefits of limited authorship is evident as one reads this book. There is a consistent style throughout in both text and graphics. This avoids redundancy and facilitates comprehension. In addition, the consistent writing style allows the authors to build on complexity from the beginning to end of each chapter. For example, the description of pacemaker system implantation encompasses the most basic portions, such as attaching the lead to the pulse generator, as well as less commonly encountered aspects such as pacemaker implantation in the cardiac transplant patient.

The extensive clinical experience of the authors is clearly evident. Every chapter is complete and up-to-date, from the description of the newer combipolar pacing configuration to new indications for pacing, and the extensive glossary and index makes it easy to seek answers to specific clinical questions. Readers who are involved in the day-to-day care of the pacemaker patient will find several chapters particularly helpful. The extensive discussion of pacing modes and their application allows a logical approach to individualizing pacemaker pre-

scriptions. An exhaustive guide to patient follow-up and programming is provided. Thorough knowledge and understanding of this text should allow providers to avoid complications in their practice. However, in the event that a patient with a complication is referred for treatment, practical management guidelines for everything from hematoma formation to Accufix™ lead management is included.

It is highly likely that this text will prove to be an enduring source of information in the field of cardiac pacing, providing an inclusive guide with an international perspective. Those of us dedicated to providing expert care in the arena of cardiac pacing, are hopeful that many countries will eventually develop and apply standards of care for the paced patient. Ritter and Fischer provide a work that could serve as a basis for such standards.

David L. Hayes, MD

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This book is the result of an intensive collaboration between scientists, engineers, and physicians from separate institutions, cities, countries, and continents.

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Philippe Ritter
St. Cloud

Wilhelm Fischer
Peissenberg

Contents

Abbreviations[1]

A	A wave (in atrial electrogram); activation of the atrium
AC	Alternating current
Ah	Ampere-hour
AH	Interval between the atrial electrogram (A wave) and activation of the His bundle (His electrogram)
AICD	Automatic implantable cardioverter/defibrillator
AMC	Automatic mode conversion
AV	Atrioventricular
AVD	AV delay; AV interval
BBB	Bundle branch block
BOL	Begin of life
BOS	Begin of service
BPEG	British pacing and electrophysiology group
BPM	Beats per minute
BTS	Bradycardia-tachycardia syndrome
CPU	Central processing unit
CPX	Cardiopulmonary stress testing
CSM	Carotid sinus massage
CSNRT	Corrected sinus node recovery time
CVTL	Conditional ventricular tracking limit
CWS	Chest wall stimulation
DAB	Diagonal atrial bipolar
DC	Direct current
ECG	Electrocardiogram
ELT	Endless loop tachycardia
EMI	Electromagnetic interference
EOL	End of life
EOS	End of service
EP	Evoked potential
ER	Evoked response
ERI	Elective replacement indicator
ERT	Elective replacement time
ES	Extrasystole
H	Signal of His bundle (His electrogram)
HOCM	Hypertrophic obstructive cardiomyopathy
HV	Interval between the His bundle (His electrogram) and the ventricular electrogram
Hz	Hertz
IC	Integrated circuit
ICD	Implantable cardioverter/defibrillator
ICHD	Intersociety Commission for Heart Disease Resources
IEC	International Electricotechnical Commission
INR	International normalized ratio
IPG	Implantable pulse generator
IS-1	International standard no. 1
ISO	International Standards Organization
I.U.	International unit
i.v.	Intravenous
kΩ	Kiloohm
kV	Kilovolt
LAH	Left anterior hemiblock
LBBB	Left bundle-branch block
LPH	Left posterior hemiblock
mA	Milliampere
min^{-1}	Per minute: unit for rate
ms	Millisecond
MRI	Nuclear magnetic resonance imager
MSNRT	Maximal sinus node recovery time
MSR	Maximal sensor rate
MSRI	Minimal sensor rate interval (according to MSR)
mT	Millitesla

1 For abbreviations of the International Pacemaker Code, see foldout table at back of book. ECG uses the signals P–U in accordance with Einthoven; these abbreviations are not listed here. The symbols A, P, V, R are used in the terminology of cardiac pacing to distinguish the following: *A* atrial stimulus; *P* atrial spontaneous event; *V* ventricular stimulus; *R* ventricular spontaneous event

mV	Millivolt
MV	Minute ventilation
μA	Microampere
μJ	Microjoule
μT	Microtesla
NASPE	North American Society of Pacing and Electrophysiology
NBG code	NASPE/BPEG generic pacemaker code
O_2	Oxygen
Ω	Ohm
PAC	Premature atrial contraction
PMT	Pacemaker mediated tachycardia
PPM	Pulses per minute
PSA	Pacer system analyzer
PTT	Partial thromboplastin time
PVARP	Postventricular atrial refractory period
PVB	Premature ventricular beat
PVC	Premature ventricular contraction
RAM	Random access memory
RBBB	Right bundle-branch block
ROM	Read only memory
RRT	Recommended replacement time
SACT	Sinoatrial conduction time
SNRT	Sinus node recovery time
SR	Sinus rhythm
SSS	Sick sinus syndrome
SVT	Supraventricular tachycardia
TARP	Total atrial refractory period
UR	Upper rate
URI	Upper rate interval
V	Volt
VA	Ventriculo-atrial
VES	Ventricular extrasystole
VS-1	Voluntary standard No. 1
WPW syndrome	Wolff-Parkinson-White syndrome