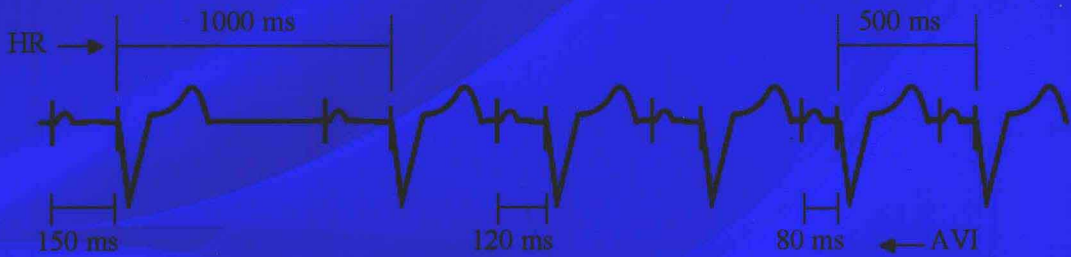


编著 蔡伯林

起搏器

心电图图谱

Pacemaker ECG and Atlas



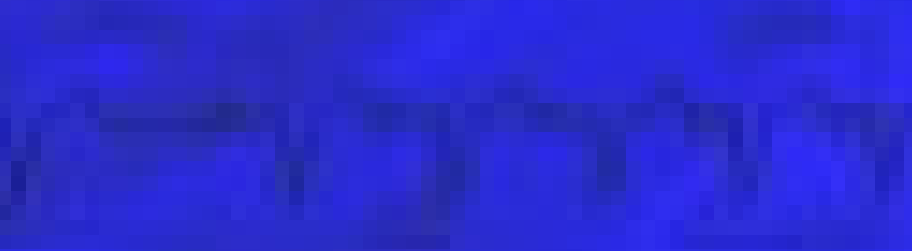
人民军医出版社

PEOPLE'S MILITARY MEDICAL PRESS

起搏器

心电图图谱

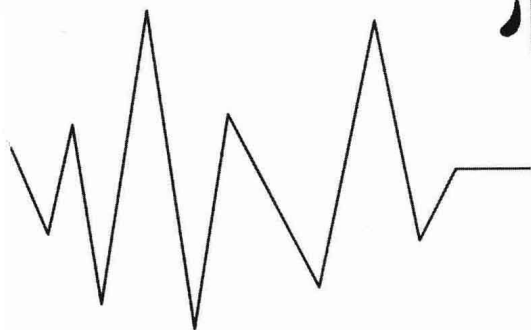
心电图显示起搏器起搏心律，起搏器起搏信号（P波）位于QRS波群之前。



人民卫生出版社
人民卫生出版社

起搏器

心电图图谱



Pacemaker ECG and Atlas

编著 蔡伯林



人民军医出版社

PEOPLE'S MILITARY MEDICAL PRESS

北京

图书在版编目 (CIP) 数据

起搏器心电图图谱 / 蔡伯林编著. —北京: 人民军医出版社, 2012.6
ISBN 978-7-5091-5191-4

I. ①起… II. ①蔡 III. ①心脏起搏器—心电图—图谱 IV. ①R540.4-64

中国版本图书馆 CIP 数据核字 (2012) 第 054793 号

策划编辑: 于 哲 秦速励 文字编辑: 曹 李 责任审读: 张之生

出版人: 石 虹

出版发行: 人民军医出版社 经销: 新华书店

通信地址: 北京市 100036 信箱 188 分箱 邮编: 100036

质量反馈电话: (010) 51927290; (010) 51927283

邮购电话: (010) 51927252

策划编辑电话: (010) 51927300—8052

网址: www.pmmp.com.cn

印刷: 潮河印业有限公司 装订: 京兰装订有限公司

开本: 787mm×1092mm 1/16

印张: 11.5 字数: 410 千字

版、印次: 2012 年 6 月第 1 版第 1 次印刷

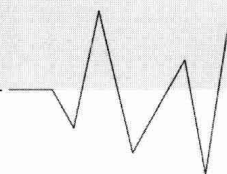
印数: 0001—2300

定价: 55.00 元

版权所有 侵权必究

购买本社图书, 凡有缺、倒、脱页者, 本社负责调换

内容提要



本书以图谱形式，从起搏器原理讲起，介绍了起搏器心电图方面的知识。全书共 15 章，内容包括起搏类型、起搏指征、起搏模式、起搏器系统与硬件、起搏器心电图及其心电图诠释等。全书为中英文对照，重点讲解了起搏器心电图的分析和判断，书末附有起搏器心电图练习，层次清晰、语言简洁，适于临床心血管医师、研究生、心电图专业人员参考阅读。

作者简介

蔡伯林 (BoLin Cai) 男

1973年起浙江医科大学附属第一医院内科医生(1973—, Physician, Internal Medicine, 1st Hospital, Zhejiang Medical University);

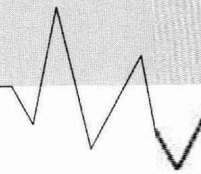
1983年浙江医科大学(现浙江大学医学院) 心内科硕士研究生毕业, 获硕士学位, 之后任附属第一医院心内科主治医师 (1983, Master Degree in Medicine/Cardiology, Attending/Cardiologist, Zhejiang Medical University) ;

1990年上海第二医科大学(瑞金医院) 心内科博士研究生毕业, 获博士学位(1990, MD, Internal Medicine/Cardiology; Shanghai 2nd Medical University) ;

1991年至1993年美国纽约哥伦比亚大学内外科医师学院心脏科博士后; 之后即任职于该医学中心, 一直从事包括起搏及心内电图之临床心电生理学诊断及有关心血管病研究工作 (1991—1993, Postdoctoral Fellowship, Cardiologic Division/Medicine, Columbia University the College of Physicians & Surgeons in the City of New York. Career in cardiac diagnosis of clinical electrophysiology including pacemaker and intracardiac electrogram, and related research in cardiovascular diseases thereafter) .



FOREWORD



Selection of pacemaker mode and proper interpretations of pacemaker electrocardiogram (ECG) are very important and essential in medical practice. A short practical and yet comprehensive book with basic electrophysiological principles, pacemaker design, and interpretation of pacemaker ECG are urgently needed.

Dr. Bolin Cai came to Columbia University Medical Center and began his research in cardiology in 1991. Besides doing research, he has accumulated an extensive experience in Holter monitor scanning and interpretation. Dr. Cai wrote this book “Electrophysiology and Interpretation of Pacemaker ECG”, dedicated not only to people who wish to learn or review quickly the basics of pacemaker ECG, but also to people who wish to acquire the ability to interpret the complex strips of pacemaker ECG. The latter is further aided by providing the exercise sessions of sample interpretations to the readers. Furthermore, the book emphasizes the simplicity rather than the complexity of pacemaker ECG. This is achieved by giving the readers only those essential concepts that are needed to make interpretations.

This book allows health care professionals including physicians, nurses, physician assistants, and paramedics, who are interested in learning basics and interpretations of pacemaker ECG including its normal and abnormal functions. Readers are expected to grasp the necessary skills to become a proficient interpreter of pacemaker ECG.

Kung-Ming, Jan, M.D., Ph.D.
Associate Professor
Division of Cardiology
College of Physicians & Surgeons
Columbia University
New York, NY



前言

起搏器应用国内亦日甚广泛，故，起搏器心电学知识务为专业人员之重要的从业基础。起搏器安装易，认识功能障碍善后难，精通起搏器心电生理更难。临床猝于起搏者每每发生，诸见于术后，而非术中。若能精通识别异常起搏之心电图并能正确处置，方能得心应手。所谓精通，非广读深研不可就，加之现成读本乏陈可据，相关资料多见外文书刊，为此，本书英中相并，可望助益。

临床医生仅是起搏器使用者，设计制造乃属电生物物理工程师们，但要分析起搏心电图，使用者亦不得不对基本原理有所理解，其中起搏时相周期最为要领。工程师们之原著理论多沉长，往往一图描述数页，仍难得其要，令人倦怠，倒不如看图识字更能一目了然。故本书以图解为主，释以文字，力求明了。最后附以图例分析，以达实践之目的。

起搏器日趋新型，功能更形复杂，可基本原理不变，学以基础，即能举一反三，反复实践，必然长进。

此书非寻常厚著，也未面面俱到，深入浅出不承，误论必有之，祈唯鉴不吝。

哥伦比亚大学医学院心脏学医师，詹孔明 (Kong-Ming Jan) 教授繁忙中校阅此书，并作重要修改，在此诚挚顿首。

蔡伯林

于哥伦比亚大学医学院

Email: blcai55_88@yahoo.com

目 录

Chapter 1 Basic Principles of Pacing

第 1 章 起搏基本原理	1
一、What's the pacemaker	
什么是起搏器	1
二、What are the working principles of a pacemaker	
何为起搏器做功原理	2
三、Conduction anatomy	
传导系统解剖	3

Chapter 2 Pacing Type

第 2 章 起搏类型	4
一、Temporary pacing	
临时起搏	4
二、Permanent pacing	
永久起搏	5
三、Unipolar pacing	
单极性起搏	5
四、Bipolar pacing	
双极性起搏	5
五、Single chamber pacing	
单腔起搏	6
六、Dual chamber pacing	
双腔起搏	6
七、Biventricular pacing	
双心室起搏	6
八、Implantable cardioverter-defibrillator (ICD)	
可植入性心脏复律除颤器 (ICD)	7



Chapter 3 Indications for Cardiac Pacing

第 3 章 起搏指征 8

一、Indications for temporary transvenous cardiac pacing

 临时起搏指征 8

二、Indications for a permanent pacemaker

 永久起搏指征 9

Chapter 4 Selection of the Appropriate Pacing Mode

第 4 章 合理选择起搏模式 11

一、Sinus node dysfunction with bradycardia

 窦房结功能不全心动过缓 12

二、AV block, bi- or tri-fascicular block

 房室阻滞, 双分支或三分支阻滞 12

三、Atrial fibrillation or flutter: VVI or VVI.R

 心房颤动或心房扑动: VVI 或 VVI.R 起搏 12

四、Carotid sinus syndrome: DDI, or DDD, or VVI

 颈动脉窦综合征: DDI, DDD 或 VVI 起搏器 12

五、Malignant vaso-vagal syndrome: DDI, or DDD

 恶性血管迷走神经综合征: DDI 或 DDD 起搏 12

Chapter 5 Pacemaker System or Pacing Hardware

第 5 章 起搏器系统与硬件 14

一、Pulse generator

 脉冲发生器 15

二、Lead

 导线 (电极) 15

三、Channel

 频道 18

四、Programmer

 程序设置器 18

Chapter 6 Stimulation, Strength and Capture Management

第 6 章 刺激、强度与起搏 19

一、Pacing stimulus

 起搏刺激 19

二、Pulse

 脉冲 19



三、 Stimulation threshold	
刺激阈值.....	20
四、 Strength-duration curve	
强度-时间曲线.....	20
 Chapter 7 Functional Concepts of Pacing	
第 7 章 起搏功能概念	22
一、 Concepts of nomenclatures	
术语概念.....	22
二、 Functional concepts	
功能概念.....	24
 Chapter 8 Pacemaker Codes and Modes	
第 8 章 起搏器编码与模式.....	30
一、 Mode	
模式	30
二、 Mode examples of code combination	
编码组合模例	31
 Chapter 9 Time Cycles of Pacing Modes	
第 9 章 起搏模式时相周期.....	36
一、 Abbreviations for native and paced events and portions of the timing cycle (Figure 9-1 and 9-2)	
固有事件、起搏事件和时相周期名词缩写 (图 9-1, 图 9-2)	36
二、 Single chamber timing cycles and mode examples	
单腔起搏时相周期与模例.....	38
三、 Timing cycles of dual chamber pacemakers	
双腔起搏器时相周期	48
 Chapter 10 Pacing Modes and ECG	
第 10 章 起搏模式与心电图.....	76
一、 ECG of RV pacing	
右心室起搏心电图	76
二、 ECG of LV pacing (Figure 10-2)	
左心室起搏心电图 (图 10-2)	78
三、 The causes of a dominant R wave in V1	
致 V1 导联 R 波的原因	78



四、Automatic gain control (AGC)	
自动增益控制 (AGC)	79
五、Sinus atrial activities	
窦房活动.....	79
六、The examples of pacing mode	
起搏模例.....	80
 Chapter 11 Pacemaker Malfunction (PKMF) and ECG Recognition	
第 11 章 起搏器故障与心电图识别.....	92
一、Failure to output	
输出不能.....	93
二、Failure to capture	
夺获 (起搏) 不能	94
三、Oversensing	
超感知	96
四、Undersensing	
感知低下.....	97
五、Inappropriate pacing rates	
起搏频率不当	100
 Chapter 12 Interpretation of Pacemaker EKG	
第 12 章 起搏器心电图诠释.....	114
一、Pacemaker timing measurement	
起搏器心率测量	115
二、Single chamber pacemaker EKGs	
单腔起搏器心电图	115
三、Dual chamber pacemaker EKGs	
双腔起搏器心电图	118
 Chapter 13 Pacemaker Syndrome	
第 13 章 起搏器综合征.....	122
一、Definition	
定义	122
二、Pathophysiology of pacemaker syndrome	
起搏器综合征病理生理学.....	122
三、Patients at risk for pacemaker syndrome	
起搏器综合征易发因素.....	128



四、Diagnosis	
诊断	128
五、Prevention of pacemaker syndrome	
起搏器综合征预防	129
六、Treatment of pacemaker syndrome	
起搏器综合征的治疗	129
 Chapter 14 Biventricular (bi-V) Pacing	
第 14 章 双心室起搏	131
一、Cardiac resynchronization or multi-site pacing	
心脏再同步化与多部位起搏	131
二、Leads and electrodes for bi-V pacing	
导线(极)与电极	132
三、Types of bi-V pacemakers (Figure 14-3)	
双心室起搏类型(图 14-3)	132
四、The mean QRS axis in the frontal plane during bi-V pacing	
双心室起搏平面心电图平均 QRS 电轴	134
五、ECG evaluation of bi-V pacing——diagnosis of capture	
双心室起搏心电图分析——确定起搏	134
六、Examples of bi-V pacing ECG	
双心室起搏心电图例	138
 Chapter 15 Pacemaker ECG Practice	
第 15 章 起搏器心电图练习	141
 References	
参考文献	169

Chapter 1 Basic Principles of Pacing

第 1 章 起搏基本原理

The aim of this chapter is to give sufficient background and information about cardiac pacemakers to allow interpretation of ECGs and telemetry strips of normal pacemaker behavior; to understand the indications and utility of a cardiac pacemaker; to be familiar with the coding system by which pacemaker modes are determined; to know what a paced ECG looks like and to be familiar with the different types of emergency pacing.

本章旨在描述起搏器基本知识，以便解释起搏心电图、远程心电图，了解起搏器的应用与适应证，熟悉起搏器编码系统及其起搏模式，认识各种包括紧急起搏的起搏器心电图。

一、What's the pacemaker 什么是起搏器

A pacemaker refers a medical artificial device which delivers electrical impulses through electrodes to stimulate the heart in order to regulate its rate and rhythm. It is primarily used to treat severe bradycardia resulted from abnormal sinoatrial node function or impaired or absent conduction through the atrioventricular node. Modern artificial pacemakers are programmable externally and selectable modes for the individual patient. A pacemaker and defibrillator can be assembled together in a single implantable device for both pacing and defibrillation. Some employ multiple electrodes to stimulate different positions in the heart to improve synchronization of the cardiac chambers.

何谓起搏器？即是一种人工医学装置，通过电极释放脉冲刺激心脏以调节心率和节律。主要用来治疗因窦房结和房室结功能异常所致的严重心动过缓。当代起搏器可为每个病人做体外程序设计和选择起搏模式。起搏器和除颤器可组装一起，既可起搏又可除颤。有些



且用多电极刺激心脏不同部位以达心脏同步功能。

二、What are the working principles of a pacemaker 何为起搏器做功原理

It is a process that a pacemaker delivers stimulus to depolarize a chamber or inhibits stimulation according to the indications controlled by its sensor. A single chamber pacemaker may deliver stimulation in a fixed rate. While, a pacing chamber, sensor sensing and pacing response constitute the working principle of a dual chamber pacemaker.

这是一个全过程，即起搏器根据其感知器指令释放刺激除极心腔，或抑制刺激。单腔起搏器可能按固定频率释放刺激，而双腔起搏器的做功原理由起搏心腔、感知器感知，以及起搏应答所组成。

1. Pacing chambers 起搏腔室

Where does a pacemaker pace? A pacemaker may pace either atrium or ventricle, or both. If a pacemaker paces only one chamber, it is called single chamber pacing, which is asynchronous pacing. If a pacemaker paces both the atrium and ventricle sequentially, it is considered dual-chamber pacing. It is AV synchronous pacing that has physiologically superior as the atrial contraction is restored.

起搏器起搏何部位？可起搏心房、心室，或同时二者。若只起搏一心腔，谓之单腔起搏，此系非同步起搏。若顺序起搏心房与心室，谓之双腔起搏，系同步起搏，因还原心房收缩，故甚具生理性。

2. Sensor sensing 感知器感知

How can a pacemaker know when the heart needs pacing? A sensor in a pacemaker is able to sense an intrinsic cardiac activity and respond suitably, either resulting in pacing or withhold in synchrony with the intrinsic heart rhythm.

起搏器何知需要起搏？感知器能感知心脏固有活动，做出起搏或者保持与固有心律同步的恰当反应。

3. Pacing response 起搏回应

How does a pacemaker have response to the sensing? Basically, a pacemaker responds to sensing in two ways by which it initiates impulses.

起搏器对感知如何回应？基本上，起搏器对感知以两种方式产生脉冲反应。

(1) Triggering, a pacemaker paces whenever an intrinsic or paced activity is sensed. This is most commonly seen in a dual chamber pacing, in which the sensing of a sinus or paced P wave triggers the ventricular lead to pace.

触发反应，只要一自然或者起搏活动被感知，起搏器便起搏。触发最常见于双腔起搏，



当一窦性或者一起搏 P 波被感知时，便触发心室起搏。

(2) Inhibition, a pacemaker is inhibited to deliver pacing stimulus whenever an intrinsic beat is sensed by the sensor. Inhibition is seen in both single and dual chamber pacemakers.

抑制反应，只要一自然搏动被感知，起搏器便停止起搏。此既见于单腔，也见于双腔起搏器。

三、Conduction anatomy 传导系统解剖

To understand the principles and concepts involved in cardiac pacing more thoroughly, a brief review of the anatomy and physiology of the specialized conduction system is necessary. An electrical impulse generated in the sinoatrial (SA) node depolarizes the atria to contract. The impulse then congregates upon the atrioventricular (AV) node with a short period of delay and continues spreading of the bundle branches and Purkinje's fibers to depolarize the ventricles (Figure 1-1). The SA node, AV node and the His-Purkinje system are involved as the relevant anatomy for cardiac pacing. A single chamber pacemaker of atrium or ventricle can actually be considered to replace the SA or AV node respectively. While the AV sequential pacing, or dual chamber pacemaker, is likely to be an AV bridge for the conduction.

以便较能透彻理解起搏原理，有必要复习传导系统之解剖生理功能。缘于窦房结之脉冲除极心房使之收缩，然后冲动沿房室结下传并稍延搁，经束支、His 束及浦肯野纤维除极心室（图 1-1）。窦房结、房室结、His-浦肯野系统诚然参与心脏起搏全过程。心房或心室单腔起搏器，实可认作窦房结或房室结之替代；而房室顺序起搏，或双腔起搏器，犹承房室桥梁之功能。

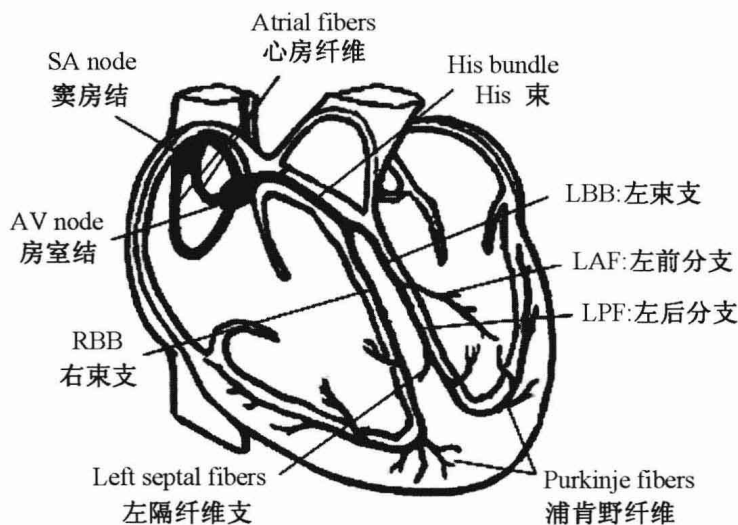


Figure1-1 Anatomy of the heart conduction system

图 1-1 心脏传导系统解剖

Chapter 2 Pacing Type

第2章 起搏类型

Pacemakers can be described for their different types according to the duration of pacing, the chamber paced, the chamber sensed, and the response of the pacemaker to the sensed impulse as well as polarities. Some of the more common types of pacemakers are listed here.

根据起搏持续时间、起搏和感知腔室，以及对感知事件和极性的反应，起搏器可分不同类型。现列举常见类型。

一、Temporary pacing

临时起搏

Temporary pacing can be performed as transcutaneous pacing or transvenous pacing. The former is also called external pacing, which is recommended for the initial stabilization of hemodynamically significant bradycardia of all types. The procedure is performed by placing two pacing pads on the patient's chest, either in the anterior/lateral position or the anterior/posterior position. The rescuer selects the pacing rate, and gradually increases the pacing current (in mA) until electrical capture (characterized by a wide QRS complex with a tall, broad T wave on the ECG) is achieved, with a corresponding pulse. An external pacing is an emergency procedure that acts as a bridge until transvenous pacing or other therapies can be applied.

临时起搏可经皮或静脉实施，前者又称体外起搏，用于初步稳定心动过缓时的血流动力学异常。置起搏电极板于患者前/侧或前/后胸壁，确定好起搏频率、递增电压，直至起搏心脏（QRS-T 宽大），并获相应频率。体外起搏系紧急措施，经静脉起搏或者其他有效治疗前起过渡作用。