

英文影印版

Weil and Tang

CPR 心脏骤停的复苏

Resuscitation of the Arrested Heart



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CPR: Resuscitation of the Arrested Heart

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CPR

Resuscitation of the Arrested Heart

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*To Mother Gretl Weil, the most wonderful person I have ever known.
And to my loving daughters, Susan and Carol, who follow in her footsteps.*
MHW

*To my parents, Zhenduo and Peijuan Tang, for their love and for showing me the joy of medicine.
To my wife Shijie and children, Kaiji and Katherine, for their support, faith, and love.*
WT

*And most of all to our co-workers and trainees from all over the world who have shared our
commitment and excitement as we pursued the science of critical care medicine.*
MHW and WT

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*The History of CPR; Mechanical Interventions;
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FOREWORD

Within our society there are four major causes of sudden and unexpected death. The four causes are war and trauma predominantly the result of automobile accidents, murders, and sudden cardiac deaths. For the first three of the four causes, our society has allocated tremendous resources, public attention, and effort to prevent such loss of productive life. Perhaps few resources are spent to prevent the fourth, sudden cardiac death, because it is the only cause intrinsic to the victim rather than to the action of others. Neither our society nor its political leaders seem to understand the magnitude of this problem. In no way is sudden cardiac death currently a day-to-day concern in our society.

With regard to loss of life during war, it is clear that our society currently goes to tremendous extremes of technology, commitment, and scrutiny to provide the military weaponry that will minimize the loss of life by its personnel. Entire government agencies attempt to prevent the loss of life by terrorism and other war-like acts. With regard to the loss of life and its prevention, including gun control, through murder, there is almost no political campaign that does not have crime and murder as a focus. There is certainly no major newspaper in this country that does not publish yearly or more often data about murder frequency, its geographic localization, the progress or failure of our society in this regard, the involved local law enforcement agencies, and the political structures needed to stem the number of such unfortunate events.

With regard to death from automobile accidents, which occurs to some 50,000 Americans a year, enormous efforts are made to stem this loss of life. Many related aspects of modern automobiles have been strengthened and tested, and money has been invested in improving safety. Speed limits are enforced to prevent death and injury. What is more, our newspapers are filled with daily and weekly examples of the unfortunate aspects of these all-too-frequent deaths.

For a moment, let us focus on the addition of seat belts and air bags to automobiles. Intensive public scrutiny and public interest combined with scientific experimentation and data proved the value of seat belts and air bags. This interest resulted in a change in automobile requirements that improved public safety and reduced mortality and morbidity significantly. But even the most optimistic experts note that it is only 2000 lives per year that are saved in the United States by the use of air bags. I believe it is useful to look at the economics of air bags only to make the point that when the public believes that sudden and unexpected deaths can be prevented, enormous resources are provided toward that goal. It has been estimated that the additional cost to the manufacturer and to the customer who buys an automobile for placement of air bags is \$200. In the United States, 10 million cars are sold each year, and this means that approximately \$2 billion each year is added to the purchase price. This \$2 billion is spent year in and year out on air bags. It is not a one-time expense. For each car, the air-bag system may last 5 to 10 years. If inclusion of air bags results in a savings of 2000 lives per year, the cost per life saved from the purchase of air bags is \$1 million per life saved. Certainly, there are other benefits to air bags aside from prevention of death in terms of minimizing disability and injury and their expense to society. Those numbers are difficult to estimate, but they can unquestionably be weighed against those of individuals whose lives are saved by suffer severe injuries. The expense in rehabilitation of such individuals will be very significant.

If the public were convinced that the problem of sudden cardiac death could be alleviated significantly by the broad distribution of cheap, automatic, reliable,

easy-to-use defibrillators, then (for a single year expenditure of \$2 billion) approximately 1 million defibrillators could be purchased and distributed in the United States (one defibrillator for approximately every 300 people). The distribution of these defibrillators would be initially in high density areas where certainly well more than 300 people might be served by a single device. If such money were expended on defibrillators for 1 year, during the second year \$2 billion could be spent on related training and instruction! In the third year, we could spend \$2 billion on improving the EMS system and the protocols for enhancing late resuscitation care as well as post-resuscitation care of victims. This book illuminates a host of directions for such improvements, as well as a hypothesis in need of direct clinical testing.

To estimate the potential value of such an effort follows. There are 360,000 lives lost to sudden death per year in the United States (1000 per day). I would estimate the current overall survival rate as 5%. With an increase in survival rate related to the aforementioned efforts from 5% to 15% (a 10% improvement), we could anticipate 36,000 lives per year saved in the United States. The cost would be approximately \$60,000 per life saved in the first 3 years, declining almost certainly to \$5000 to \$10,000 per life saved in subsequent years. Some significant cost increase might come from more persons surviving with severe brain injury, perhaps bringing the cost to about \$60,000 per life saved.

The question from a skeptic might be, "How certain are we that such expenditures of funds would in fact result in a significant improvement in survival from cardiac arrest?" One convincing piece of data is that accumulated from the experience with automatic implantable defibrillators. At this point in time, it can be stated without any equivocation that in victims of sudden cardiac death, out of the hospital, who have survived because of prompt resuscitative efforts, implantation of an automatic defibrillator ensures freedom from sudden death. It is well known that survivors of sudden cardiac death are victims once more of arrhythmic sudden cardiac death at a frequency that certainly approaches 50% in 2 years without such a device. Victims of sudden cardiac death who survive the episode may have a better initiating arrhythmia, such as ventricular tachycardia, than the victims of sudden cardiac death who do not survive with ventricular fibrillation. If every person who suffered sudden cardiac death was defibrillated promptly, we would likely see a 50% to 60% survival rate. From 50% to 60% is a reasonable conservative estimate of the numbers of victims of sudden cardiac death who have a cardiac cause.

Many of the victims of sudden cardiac death are not observed at the beginning of the episode and, therefore, have a much reduced chance of survival. Beginning with 360,000 deaths a year, and assuming 60% are cardiac-related and 20% of these are observed with a time frame in which rapid defibrillation would lead to survival, we have an improvement in survival from sudden cardiac death of at least 10%. Ten percent again would be 36,000 lives per year saved the first year and then every year. This number is many more than those Americans lost in war, even in this century, and is equal to the prevention of twice the number of murder-related deaths in the United States per year (17,000).

As indicated in Dr. Weil and Tang's Preface, improvement in survival from sudden cardiac death will occur not only by rapid defibrillation but also by strengthening every component of the "chain of survival." Dr. Max Harry Weil is one of the most distinguished, lifelong contributors to the fields of critical care medicine and cardiopulmonary resuscitation. He could easily be described as the founder of the field of critical care medicine. He has been a major and consistent contributor and force toward bringing clinical and laboratory research data to important conclusions with regard to the strategy for cardiopulmonary resuscitation and the strengthening of the chain of survival. Although other monographs in the field have emphasized strictly the research aspects or strictly the clinical approach and protocol approach to CPR, to my knowledge, this is the first modern volume to provide both a laboratory-based research and clinical-based

approach to the critical issues in this field. Dr. Wanchun Tang is one of Dr. Weil's colleagues who has also been a consistent force and contributor to the field. His efforts are clearly joined successfully with those of Dr. Weil in the production of this volume.

The coauthors and contributors to this work represent a broad group of investigators, scholars, and leaders in this field. They have written about the specialized areas in their contributions. The authors and coauthors are also heterogenous in terms of their broad backgrounds in cardipulmonary resuscitation, primary training, and emergency cardiac care. The heterogeneity of authorship and perspective complements the notion that this volume will be of value to readers who are sophisticated physician-investigators, practitioners, emergency physicians, nursing and technical staff, and potential members of the lay or medically associated communities who bear responsibility in the areas of resuscitation and emergency cardiac care.

I truly believe that volumes such as this one will aid in focusing the attention of our society and field leaders on the need for greater research and support and investment in measures to ultimately reduce the death toll.

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PREFACE

This volume addresses cardiopulmonary resuscitation, primarily of the adult victim. Accordingly, it has its major focus on “sudden death.” The magnitude of the clinical problem of sudden death is now well-documented and referred to throughout. Relatively uncommon in adults by comparison is asphyxial cardiac arrest, including aspiration, drowning, and hypoxic accidents. This is in contrast to findings for infants, children, and young adults in whom cardiac arrest is more likely to be from a primary respiratory or neurologic cause, or from an end-stage of a fatal illness, injury, or electrocution.

The disappointing outcome of cardiopulmonary resuscitation after sudden death reflects not only the constraints in implementation but, in our opinion, the still primitive knowledge of the pathophysiology of cardiac arrest and the implication for resuscitation. Surprisingly, there is a paucity of research and research support. Such a fact, in part, reflects the lack of incentive to support such research. The perception of many, in both the professional and lay communities, is that CPR is a “settled issue” that requires little or no additional research. Clinical practices evolved as prescribed in the *Standards and Guidelines of the American Heart Association*. These were first published in 1974 with relatively precise algorithms for interventions. Although the American Heart Association has always cautioned otherwise, this perception of a settled issue continues.

Like science more generally, medical science usually advances at an escalating pace only when there is focus on unresolved challenges of large magnitudes. The disappointing statistics that have disclosed little or no improvement in outcome in the more than 35 years since modern CPR was introduced notwithstanding, the science has progressed but little in the absence of such a focus by the profession, by the public, and by the government. The challenge is unequivocal—we identify the need for both better science and improved strategy for implementation. To illustrate the potential benefits, an improvement in outcome of CPR from the current approximately 5% national survival rate to as little as 20% would rescue more than two times the number of annual fatalities from automobile accidents and approximately ten times the number of annual fatalities from HIV infections.

Sudden death is unique. Time constraints are extreme. If resuscitative interventions are not begun within as little as 5 to 7 minutes, there is little likelihood of successful resuscitation and functional survival. To this extent, the American Heart Association’s concept of *the chain of survival* addresses such problems very well. It pinpoints the essential roles of lay bystanders. Professional providers, in most instances, simply cannot respond within the critical time window. The time constraints also pinpoint the potential importance of automated external defibrillation.

This textbook is for physicians, nurses, and emergency medical technicians at all levels who are the clinicians who provide cardiac resuscitation professionally and who teach CPR to others. It is also intended for nonprofessionals who have joined the campaign for more widely implemented “bystander CPR.” The first chapter reviews the fascinating history of resuscitation beginning with the pre-Christian era. It reviews the stepwise development of methods now employed or proposed and the technologic and biomedical advances that have brought us to the present. The second chapter projects the magnitude of the problem including cause and incidence. The next eight chapters address practices pertinent to basic and advanced cardiac life support. Newer therapies, many of which are still experimental, are described. In the following five chapters, the methods by which

the efficacy of CPR interventions may be assessed in real time, issues pertaining to postresuscitation management, cerebral outcome, and pediatric resuscitation are discussed. The following five chapters address the Emergency Medical System (EMS) and, specifically, the issues confronted by policy makers, medical directors, administrators, and professional providers, such as risks of infectious diseases, training, cost, outcome, and ethical and legal considerations. As yet largely unresolved options for more effective implementation are cited. In the final chapter, the editors summarize what we view as important, but as yet largely unresolved, issues that should be addressed if we are to advance scientific and clinical understanding of cardiac arrest and resuscitation. The editors hope that it may serve as a path to accelerated progress in this field.

We recognize that a diversity of viewpoints is expressed in this text. Such differences emerge in chapters related to the importance of mechanical ventilation during basic life support. The position taken by Drs. Klain and Bircher, in their excellent chapter, is traditional with respect to initial focus on the airway and ventilation. This viewpoint contrasts with the viewpoint adopted by the American Heart Association, which presents a large emphasis on early defibrillation and precordial compression. This is anticipated in our final chapter on *Looking to the Future*. Our purpose is best achieved if we express these differences—even if it inevitably leaves our readers with some insecurity but with anticipation that continuing research will provide an even better understanding.

We express our sincere appreciation to the experts who contributed so richly to this book. We are grateful to Dr. Myron Weisfeldt, an innovative leader both in the science and in the implementation of CPR. Dr. Weisfeldt has done much to call attention to the need for bystander-initiated CPR, the need for major improvement in the delivery system, and the unique potential of automated external defibrillators. During his tenure as the President of the American Heart Association, he invigorated volunteers who are professional medical, nursing, and paramedic providers, lay supporters, and biomedical engineers, and in some instances those who represent the CPR-related industry.

We have addressed subjects that literally deal with life and death, death without warning, and death that occurs in out-of-hospital victims without terminal illnesses. It is very challenging to study victims under these conditions. The restraints are practical, ethical, and legal. In the absence of secure data on patients, a large part of current knowledge and practices are based on experimental studies in animals. Although we appreciate that the guidelines and recommendations of the American Heart Association may be the best reference to standards of practice, these, nevertheless, represent consensus often without secure evidence based on controlled studies. It is peer consensus that fills the void in the absence of scientific proof. We are confident, however, that it will be advances in science and, specifically, better objective data on victims that will account for improved outcomes. We pinpoint the need for such data throughout this volume.

We stipulated for ourselves and our contributors full independence of authorship. The individual viewpoints of the experts were in each instance respected. Accordingly, the content of this volume is not constrained by a peer consensus. In many instances, the conclusions are based on data that came to light after the last consensus conference of the American Heart Association, which produced the Guidelines of 1992. We would, therefore, alert the reader that, in some instances, the content differs significantly and understandably from published guidelines.

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To Dr. Martin von Planta, one of our outstandingly productive former research fellows, and to Dr. Jay Falk, our colleague and collaborator for many years at the University of Health Sciences in Chicago, we express special thanks. They participated in the initial planning and recruitment of expert contributors. They also gave generously of themselves in contributing to this volume. We also acknowledge the loyalty and support of our present and former faculty members and fellows of the Institute of Critical Care Medicine who contributed approximately half the content of this book.

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NOTICE

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THE PUBLISHER

CONTENTS

1. THE HISTORY OF CPR 1
*Yoshihide Nakagawa, M.D.,
Max Harry Weil, M.D., Ph.D., and
Wanchun Tang, M.D.*
2. EPIDEMIOLOGY: ETIOLOGY,
INCIDENCE, AND SURVIVAL
RATES 13
Lance B. Becker, M.D.
3. AIRWAYS AND INTUBATION 28
*Miroslav Klain, M.D., Ph.D., and
Nicholas G. Bircher, M.D.*
4. ELECTRICAL CAUSES OF CARDIAC
ARREST AND THEIR
MANAGEMENT 37
*Xiaohua Jin, M.D.,
Andrej Parnat, M.D.,
and Joe Bisera, M.S.E.E.*
5. AUTOMATED EXTERNAL
DEFIBRILLATION 53
*Jean-Jacques Béraud, M.D.,
Gad Amith, E.M.T.-P.,
and Joe Bisera, M.S.E.E.*
6. MECHANICAL
INTERVENTIONS 67
*Wanchun Tang, M.D., and
Max Harry Weil, M.D., Ph.D.*
7. PHARMACOLOGIC INTERVENTIONS;
I. ADRENERGIC AND
NONADRENERGIC
VASOPRESSORS 77
*Shijie Sun, M.D.,
Wanchun Tang, M.D.,
and Max Harry Weil, M.D., Ph.D.*
8. PHARMACOLOGIC INTERVENTIONS;
II. ANTIARRHYTHMICS 91
*Ricardo A. Samson, M.D.,
and Robert A. Berg, M.D.*
9. ACID-BASE AND ELECTROLYTIC
MANAGEMENT 101
Martin von Planta, M.D.
10. ACUTE MYOCARDIAL
INFARCTION 123
*Craig B. Key, M.D.,
Jay L. Falk, M.D., and
Scott D. Greenwood, M.D.*
11. COMPLICATIONS AND THEIR
MANAGEMENT 151
*Norman A. Paradis, M.D., and
Christopher M. Davison, B.A.*
12. MONITORING
EFFECTIVENESS 165
*Jay L. Falk, M.D., and
David R. Theodorson, M.D.*
13. NEURONAL FAILURE,
RESUSCITATION, AND
PROGNOSIS 172
Robert E. Adams, M.D.
14. POSTRESUSCITATION
MANAGEMENT 179
*Raúl J. Gazmuri, M.D., Ph.D., and
Frank A. Maldonado, M.D.*
15. RESUSCITATION IN THE INFANT
AND CHILD 192
Warren G. Guntheroth, M.D.
16. THE PREHOSPITAL EMERGENCY
MEDICAL SERVICES SETTING 198
Marvin L. Birnbaum, M.D., Ph.D.
17. ACQUIRED INFECTIONS : RISK AND
PREVENTION 229
*George C. Mejicano, M.D., and
Dennis G. Maki, M.D.*