Third edition

Cardiac arrest and resuscitation

HUGH E. STEPHENSON, JR.

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To

My parents,

Dr. J. William Hinton,

and my dear wife,

Sally

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Foreword to first edition

It is a privilege to write a few words for this authoritative volume about cardiac arrest. I have followed the career of the author from his residency days to his appointment as Professor of Surgery. During these years, in addition to his active teaching and clinical duties, he has carried on a dedicated study of cardiac arrest in all of its different phases. The list of references alone is an index of the enormity of this work. Historians of the subject will have to begin where he has left off, because it is complete as of now and will save these investigators countless hours of tedious work. How many of us knew that hearts were massaged some 60 years ago?

The analysis of over 1,700 of these cases has resulted in a registry that was carried on singlehandedly. All surgeons, after reading this volume, cannot help but feel a great debt of gratitude to all the research workers, physiologists, pharmacologists, pathologists, clinicians, and others who have recorded their observations, which directly and indirectly are applicable to the treatment of cardiac arrest. Likewise, I believe all surgeons and anesthesiologists owe Dr. Stephenson great praise for this volume. I know of the great interest and encouragement given him by his former teachers, Dr. William Hinton and Dr. L. Corsan Reid. I know also that he would have added their names as coauthors, but they admirably and justifiably refused.

One cannot help but believe after reviewing cardiac arrest that, in the main, it is a preventable anesthetic problem for which the surgeon must assume the responsibility. After all, the patient comes to the surgeon, not to the anesthesiologist. The surgeon must be the first one to evaluate the patient's condition completely and to cooperate in every way with the anesthesiologist while not making undue or unreasonable demands of him.

In the chapter on prevention, many possible factors are mentioned which might be contributory to cardiac arrest. Probably the most important are the ones that are simple to carry out. It is essential before the operation that the patient's condition be properly evaluated, that he not be oversedated, and that the atropine be given at the proper time and in the proper dosage. I have always felt that if induction of a patient is accompanied by too many difficulties, and if atypical symptoms, particularly cardiac symptoms such as a marked tachycardia, bradycardia, or arrhythmias, develop, he should not be given any more anesthetic agents but should be allowed to recover, sent back to his bed, and brought back to the operating room the following day. I have seen many patients take this second anesthetic without difficulty of any kind. During the operation, time after time every surgeon has told his anesthesiologist that the blood in the operative field is slightly cyanotic or dark, only to be told by the anesthesiologist that the patient is pink "up here." At the same time, however, he does turn on some oxygen from his machine, and by the time you tell him that you are not operating "up there" the cyanosis is beginning to clear.

My deep concern for the problem was

aroused suddenly when, after a 25-year experience in surgery, during which time I was almost totally unfamiliar with the occurrences of cardiac arrest, I saw a group of patients in whom I thought the multiplicity of drugs and the ensuing deep anesthesia were factors in the production of cardiac arrest. I am not enough of a pharmacologist to know how, when, and where all of these agents act and interact and why one more injection of a small amount of a drug should cause an arrest. In a surgical mortality conference following a death from a cardiac arrest, it does not seem to make much of an impression simply to cite these numerous drugs and agents, but if they are numbered and written on a blackboard, the anesthesiologist, the surgeon, and the audience may be amazed—they may include one or two barbiturates, morphine, atropine, Pentothal for induction, cocaine for the endotracheal tube, nitrous oxide, ethylene, ether, cyclopropane. When one relaxant is not effective, another one may be used. With the exception of the atropine, there probably could have been simple substitutes for all of them.

Much has been written about the advantages and disadvantages of light or deep anesthesia. Always an advocate of light anesthesia, I wonder sometimes whether a better term would not be "adequate anesthesia." Adequate anesthesia varies with the individual surgeon, and it varies particularly with the young surgeon who has just completed his training. In the beginning, he is likely to use the same type of anesthesia his Chief used and with which he is familiar. If his Chief used local anesthesia as an adjunct, he probably will always use it; if he did not, he will probably never use it to its full value. As he goes on in his career, and because of some unhappy experience, he will probably develop fixed ideas and aversions about certain agents and thus prohibit their use in his operating room. There is little doubt that deep anesthesia is more prevalent than generally suspected. The advent of recovery rooms in practically all hospitals has demonstrated that there are many more postoperative unconscious patients than we had supposed. It would be interesting to know how many unconscious patients there are in the recovery rooms across the land at two o'clock today. Will cardiac arrests be seen more frequently in recovery rooms?

Everyone admits that there are times that relaxation should be completely adequate. It need not, however, be cadaveric from skin incision to skin closure—small amounts of procaine at certain times might have sufficed. With me, procaine has been an innocuous drug. During the days when inhalation anesthetics were used almost exclusively, it was possible for anesthesiologists to lower the planes of anesthesia during certain phases, and then have a semiconscious patient at the completion of the operation. This argument will probably always continue.

Surgeons and anesthesiologists in this country are facing the bare fact that they must resuscitate several thousand men, women, and children yearly. They must also remember that if these people had not had an operation, instrumentation, or an anesthetic, it would actually not be much of a problem. The patient cannot be blamed.

Moynihan used to speak about operations being done in good faith but with errors in judgment. With this problem, no one questions that the operation is always done in good faith, but we must add to our armamentarium the complete knowledge of cardiac arrest, its etiologic factors and its prevention, and of the proper methods for a definite, accurate, and prompt resuscitation should the tragedy occur.

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Preface to third edition

With each new edition an attempt has been made to accurately portray the recent advances and techniques, many in ancillary areas, that make up the total picture of present-day cardiopulmonary resuscitation. The task of placing new data and techniques into a position of proper perspective is not always easy. The volume of literature reflecting interest and activity in the field of cardiac arrest and resuscitation continues to increase.

The overall impact of contributions made in the field of cardiopulmonary resuscitation has had a tremendous influence on medicine. Having long since departed from the more strictly confined operating room and recovery area, ramifications of the field have reached out to involve all physicians in every type of endeavor. Large groups of lay persons have already been trained in cardiopulmonary resuscitation techniques and an extension of these efforts will occur.

With extension of cardiopulmonary resuscitation efforts outside the hospital environment, the need for training selected lay personnel becomes obvious. The American Heart Association has accepted a large bulk of this responsibility and has devoted many of its resources to the establishment of standards, materials, and procedures for training in cardiopulmonary resuscitation. In the hope that many thousands of individuals requiring cardiopulmonary resuscitation will have it available at the appropriate time, the American Heart Association has embarked upon a major effort to promote teaching of cardiopulmonary resuscitation to dentists, nurses, inhalation therapists, and rescue personnel such as police, lifeguards, and ambulance attendants. The American Heart Association has made available a number of manuals for instructors, guides for community organizations, manikins, and films. Although the degree of effectiveness and feasibilty of such a training program are not yet determined, it is hoped that a system of testing and certification of lay personnel will prove meaningful.

The increasing interest shown by both medical and lay groups in a widespread and universally available resuscitation program has not only accelerated the search for answers but has, in addition, engendered a demand for higher standards of emergency care, including a range of activities extending from elaborate and well-designed ambulance systems providing en route resuscitation to the coronary care unit complete with the latest advances in electronic and computerized equipment.

Patient care patterns reflected in the increasing use of sophisticated intensive care units have now become commonplace. As dividends from a more widespread application of cardiopulmonary resuscitation information increase, so does the obligation of the individual physician increase. It is now the practice of a number of hospitals to require competence in cardiopulmonary resuscitation as a prerequisite for staff appointment to the hospital. In one eastern hospital, for example, a physician recently had to try six times before he could successfully satisfy the Cardiopulmonary Resuscitation Committee with regard to his ability in and knowledge of cardiopulmonary resuscitation.

Within the last several years, interest in the field of cardiopulmonary resuscitation has grown with such rapidity that our reference library now contains almost five thousand references on the subject. Over three dozen books have been published dealing exclusively with cardiac arrest and resuscitation. Almost every standard textbook in medicine, surgery, and anesthesiology has chapters or sections devoted to resuscitation. Because of the increasing applications of resuscitative techniques to emergencies outside of the hospital, publications on the subject no longer are limited to medical journals. Other professional journals, the lay press, and popular publications deal with the subject. In addition, the American Red Cross, the Boy Scouts of America, policemen, firemen, ambulance drivers, lifeguard groups, and a host of others are actively engaged in the training of personnel capable of recognizing and managing situations requiring cardiopulmonary resuscitation. All soldiers inducted into the United States Army are given training in resuscitative techniques. In medicine, the area of cardiopulmonary resuscitation has developed such a body of knowledge as to be categorized as a subspecialty.

The goal of providing rapid and expert resuscitative efforts for victims needing cardiopulmonary resuscitation has, of course, greatly expanded. Once primary to the operating or recovery rooms, such efforts are now generally available throughout the hospital. It is, however, of perhaps even greater importance to realize that many catastrophies can be prevented by the recognition of early warnings provided by monitoring techniques that allow the physician to detect and treat troublesome arrhythmias at an early period.

Over two decades have now passed since Claude Beck and his associates first successfully defibrillated a heart in the operating room with electric countershock. The recipient of this successful therapy, a 14-year-old boy, recovered to play 3½ years of varsity basketball; now, after more than 20 years, he is actively engaged in his own business, and is married and has a family. At this point in time, however, emphasis is shifting toward a *prevention* of these previously fatal cardiac arrhythmias. For this reason, considerable space has been devoted in this third edition to the preventative aspects of cardiac arrest.

Although it is impossible to add all of the new material to this third edition, we have endeavored to digest and summarize much of this material for the reader. On certain points we have perhaps been too dogmatic. In other areas we have tried to present the various points of view on controversial issues.

Many extensive changes in the format of this new edition have occurred. We have continued, however, to present each of certain broad topics under a variety of headings, although in so doing we have tried to avoid needless duplication. We recognize that many of our readers use this book as a reference and, rather than reading straight through from cover to cover, they prefer to refer to specific sections from time to time.

A virtual avalanche of new literature on cardiopulmonary resuscitation has made it impossible to include references from the previous two editions. The reader will find it necessary to refer to the first and second editions for bibliographic information that has been displaced by the demands on space provoked by the newer literature on the subject. In several instances older references not previously included are listed in this edition. Usually this is either because the reference was inadvertently overlooked or because it now seems particularly appropriate to refer to the paper. In many instances authors are referred to but the reference is not included in the third edition bibliography. The author's name is mentioned to facilitate the investigator in locating this particular item by referring to an earlier edition. We have attempted to give proper credit, as nearly as possible to the

original source of each concept, theory, original observation, or set of experimental data.

We hope that this book will continue to be of assistance to the physician who is more than superficially involved in the subject. Many authors have expressed their appreciation for the help this volume has provided them in preparing their manuscripts on the subject. We hope that the third edition will continue to be of assistance to the investigator.

Professor Werner Overbeck of Freiburg, Germany, kindly contributed a concise historical perspective of cardiopulmonary resuscitation. As all historians must realize, there is never the "ultimate" history. With an increased depth of research on any subject, more information becomes available and earlier priorities may be established. Historical reviews emphasize the extent to which we build on the shoulders of those who have gone before.

The fact that scientific investigation and clinical medicine know no national boundaries is well illustrated by the geographic locations of the various contributors to the third edition.

My first association with a case of cardiac arrest and resuscitation was experienced during my surgical residency while assisting the late Dr. Evarts A. Graham with a patient being explored for a ventricular aneurysm. This was 20 years ago at the Barnes Hospital in St. Louis, Missouri. My indebtedness is, however, especially to Dr. J. William Hinton who, as Professor and Chairman of the Department of Surgery at the New York University Postgraduate Medical School and Chief of Surgery, Fourth Surgical Division, Bellevue Hospital, New York City, provided every possible type of help and encouragement in the work on this problem. Dr. Hinton encouraged us to establish the first cardiac arrest registry and the mobile cardiac resuscitation unit. It was Dr. Hinton who decided that a course should be made available to physicians on cardiopulmonary resuscitation through the facilities of the New York University Postgraduate Medical School. Through the years, Dr. Hinton has continued to be a source of stimulation and encouragement for a continuation of this work.

Contributions on cardiopulmonary resuscitation come from various parts of the world. It seems appropriate that some who have made these contributions be among those adding to this volume. For example, Professor Juro Wada of Sapporo, Japan, has had extensive experience with elective cardioplegia. I am most pleased to have him as a new contributor.

Few physicians have devoted more years of effort to exploring the riddles of resuscitation than has Professor V. A. Negovskii of Moscow. I am honored to have him as one of the contributors to this edition. In his chapter, Professor Negovskii gives us a a broad summary of his views on the subject, and one is able to become acquainted with the work now in progress at his Institute of Resuscitation in Moscow.

We are given some new insights on the early contributions in the field of cardiac arrest and resuscitation. Dr. Overbeck has extensively researched the German experience and has uncovered a number of heretofore unknown contributions. Although this is a very scholarly chapter, I would also wish to have the reader who is interested in the historical aspects of resuscitation refer as well to the chapter on history by Dr. Norman Morris in the first and second editions. Dr. Franklin L. Mitchell, Dr. Jack M. Martt, and Dr. Richard Martin have also joined the list of new contributors and have greatly enhanced this third edition.

Because of his pioneer efforts in cardiac augmentation systems, it is appropriate that Dr. Adrian Kantrowitz be a contributor to the chapter on this subject. Certainly this is a most logical extension of cardiac resuscitative efforts.

I am also most grateful for the many pleasant associations brought about by my contacts with fellow workers in the field of cardiac arrest and resuscitation. I am particularly indebted to the many physicians who continue to send detailed records of their interesting experiences with cases of cardiopulmonary resuscitation. They have helped keep me informed of advances in many of the related areas of resuscitation. I also appreciate the reader's calling attention to any oversight or omission that can be remedied in the next edition.

For the third time, Dr. Paul Craig Todd has returned to Columbia in order that he might again be in charge of indexing this book, a considerable sacrifice of time and expense in taking off from an active practice of medicine.

I wish to again acknowledge the kindness of Dr. W. W. Woodward of Tasmania, Australia. Dr. Woodward forwarded to me a communication from Lady Ramsay, widow of the late Sir John Ramsay. This is in connection with a successful case of cardiac resuscitation by means of compression of the heart through an epigastric incision of a 27-year-old woman on August 2, 1906, in Launceston Hospital, Tasmania, Australia. At the time of the original publication, only one successful case of cardiac resuscitation was known to Sir John. It is interesting that for many years after the successful resuscitation, according to Lady Ramsay, the driver of a tourist coach would say, on passing the patient's house, "A woman in that house died and was brought back to life."

Acknowledgments should go to Dean A. Schmidt, Associate Librarian in charge of the University of Missouri Medical Library, and his assistant librarian, Miss Beverly Allen. They were very tolerant of the many hours I camped in their library.

Miss Ruth McCown has again devoted many days, nights, and weekends to the required typing and secretarial assistance. Obviously, such a book would not be possible without her effective, cheerful, and dedicated efforts. She has been very tolerant of the many revisions and retypings necessary with each edition.

Finally, our Journalistic Consultant, Mr. Robert S. Kimpton, has worked many long hours helping to edit and correct the manuscript. For his untiring efforts, I am most grateful.

My family has been very tolerant of the extra time required for this new edition. I hope their encouragement and support is justified.

Hugh E. Stephenson, Jr., M.D.

Preface to second edition

The problem of cardiac arrest and resuscitation has, within a few years, changed its dimension. Having passed from the stage in which it was allocated a few paragraphs or an occasional two- to three-page section as more or less an afterthought in many medical or surgical texts, cardiac arrest and resuscitation can now be considered a subspecialty in itself. Unfortunately, however, by becoming a large body of specialized information, it cannot be extended the same treatment that we, as physicians, tend to accord other specialized fields. The problems of cardiac arrest and resuscitation encompass such a wide area of medicine that it is difficult for any physician to be complacent in his own field of interest. Therefore, knowledge concerning cardiac arrest and resuscitation joins the ever-enlarging body of information necessary both for the general practitioner and for the specialist.

Unfortunately, it has become increasingly clear that cardiac resuscitation is not always as simple a procedure as wall charts and postcard-like direction sheets would suggest. Almost every successful case testifies to the varied nature and requirements of individual resuscitative efforts. Advances have come from many areas well outside the confines of cardiac arrest and resuscitation laboratories. One thinks immediately of contributions from persons working in the field of cardiac electrophysiology; from biophysicists; from neurophysiologists, neurologists, and neurosurgeons; from biochemists; from electrical engineers; and from the whole gamut of medical specialists. A fascinating jigsaw puzzle is provided in piecing together the all-useful additions of worthwhile information.

One of the refreshing aspects inherent in the efforts of each new generation of clinicians and research investigators is the refusal to accept entirely the dictum passed down to them. Throughout this book, there are examples of contributions by physicians to areas that were already considered "closed chapters." We know, for example, that even the whole field of surgery on the heart was once considered outside of the realm of the "sensible and ethical" physician of 60 years ago.

The present widespread interest in the enormous scope of activity related to the problems of cardiac arrest and resuscitation is reflected in the research grants index (fiscal year, 1961) of the Public Health Service of the United States Department of Health, Education, and Welfare. The Division of Research Grants of the National Institutes of Health in that year list grants in excess of $500,000,000 under the subject of "heart arrest." This does not include financial support given for studies on cardiac pacemakers, the cardiac conduction system, various related aspects of cardiac function, and heart rhythm. Coupled with grants from other private and governmental sources, it is estimated that total expenditures for research and investigation of problems pertaining to cardiac resuscitation may exceed $5,200,000 for 1963.

Vast amounts of pertinent information are becoming available from clinical observations and investigative efforts not only from physicians in this country but also from medical sources throughout the world. Considerable support, for example, is given the field of cardiac resuscitation by the Academy of Medicine in the U.S.S.R. When I visited Professor Negovskii's laboratories in Moscow in the summer of 1962, I was impressed by the breadth and scope of the approach.

The need for a bringing together of this available information in a form that can be assimilated by the physician seems apparent. It is a purpose of this second edition to bring up to date, digest, and evaluate these widespread efforts and observations. While trying to be objective, I have nevertheless taken the liberty to relegate the information to various levels of importance and emphasis. A book of this nature attempts to be of value to physicians with varying degrees of interest. An extensive bibliography has again been included because of the conviction that there should be at least one source which can provide a relatively complete index of reference. A careful editing of the bibliography has been necessary, however, due to the massive proportions of its growth. As a result, the reader should refer to the first edition for many older references that have been deleted to make room for new ones.

For the physician likely to encounter the occasional patient requiring cardiac resuscitation, this book intends to provide the basic factual information. Opportunities for resuscitation have been sufficiently extended and refinement of resuscitation technique so appreciably improved that brief and sketchy condensation may not be entirely desirable. However, an attempt has been made to be concise and to the point.

No longer is it enough for the cardiac surgeon to master the technical aspects of heart surgery. He must be versed in all of the physiologic aspects of the heart and their pathologic aberrations. For the cardiovascular surgeon, it is hoped that this book will serve as a source of augmented information, particularly as it involves the area of elective cardioplegia. It is intended that the text will be of sufficient depth and quality to serve as a frequent source of reference for the investigator in this field.

In summary, an attempt has been made to evaluate and to put into proper perspective newer techniques, suggestions, and laboratory data relative to the broad area of cardiac arrest and resuscitation. With obvious and widespread ramifications, knowledge of cardiac arrest and resuscitation continues to inch forward.

It is hoped that the next few years will see as rapid an augmentation of knowledge of cardiac arrest and resuscitation as have the few years since the first edition was published. If this be the case, considerable help will be in the offing for the patient whose heart has suddenly ceased to be the effective muscular pump necessary for survival.

Hugh E. Stephenson, Jr., M.D.

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