

CARDIAC ARREST & RESUSCITATION

HUGH E. STEPHENSON, Jr.
M.D., F.A.C.S., A.B., B.S.

Professor of Surgery,
University of Missouri School of Medicine,
Columbia, Missouri

FOURTH EDITION

with 379 illustrations

THE C. V. MOSBY COMPANY

FOURTH EDITION

Copyright © 1974 by The C. V. Mosby Company

All rights reserved. No part of this book may be reproduced in any manner without written permission of the publisher.

Previous editions copyrighted 1958, 1964, 1969

Printed in the United States of America

Distributed in Great Britain by Henry Kimpton, London

Library of Congress Cataloging in Publication Data

Stephenson, Hugh E

Cardiac arrest and resuscitation.

Bibliography: p.

1. Cardiac resuscitation. 2. Heart failure.

I. Title. [DNLM: 1. Heart arrest. 2. Resuscitation.

WG205 S836c 1974]

RC682.S78 1974 616.1'2 73-16163

ISBN 0-8016-4780-0

CE/CB/B 9 8 7 6 5 4 3 2

CONTRIBUTORS

ELWYN L. CADY, Jr., J.D., B.S.Med.

Medicolegal Consultant of the Independence,
Kansas City, and St. Louis, Missouri, bars

STEPHEN W. CARVETH, M.D.

Medical Director of Mobile Heart Unit, Lincoln,
Nebraska

DENTON A. COOLEY, M.D.

Surgeon-in-Chief, Texas Heart Institute,
St. Luke's Episcopal and Texas Children's
Hospitals, Houston, Texas

CLARENCE D. DAVIS, M.D.

Professor of Obstetrics and Gynecology,
Yale University School of Medicine,
New Haven, Connecticut

EDWARD B. DIETRICH, M.D.

Director and Chief of Cardiovascular Surgery,
Arizona Heart Institute, St. Joseph's Hospital and
Medical Center, Phoenix, Arizona

ALEX L. FINKLE, M.D., Ph.D.

Associate Clinical Professor of Urology,
University of California Medical School,
San Francisco, California

ARCHER S. GORDON, M.D., Ph.D.

Research Physiologist, Department of
Anesthesiology, UCLA Medical Center,
Los Angeles, California

HAROLD H. HILLMAN, M.D., B.Sc., Ph.D.

Reader in Physiology, University of Surrey,
Guilford, Surrey; Editor of "Resuscitation,"
England

ROBERT HOOK, M.D.

Associate Clinical Professor of Anesthesiology;
Chief of Obstetrical Anesthesia, Yale-New Haven
Hospital, Yale University School of Medicine,
New Haven, Connecticut

ADRIAN KANTROWITZ, M.D.

Professor and Chairman, Surgical Services,
Wayne State University College of Medicine,
Detroit, Michigan

DAVID G. KILPATRICK

President, Kilpatrick Associates, Inc., Consulting
Biomedical Engineers, Bala Cynwyd, Pennsylvania

WILLEM J. KOLFF, M.D., Ph.D.

Professor and Chairman, Division of Artificial
Organs, Department of Surgery,
University of Utah Medical Center, and
Director, Institute for Biomedical Engineering,
University of Utah, Salt Lake City, Utah

CLIFFORD S. KWAN-GETT, M.D.

Associate Research Professor in Surgery; Assistant
Research Professor in Electrical Engineering,
College of Engineering, University of Utah;
Associate Director of Engineering—Division of
Artificial Organs, University of Utah College of
Medicine, Salt Lake City, Utah

**B. G. B. LUCAS, M.D., F.F.A., R.C.S.,
C.I. Mech.E.**

Consultant Anesthetist to the National Heart Hospital, the Brompton Hospital, the Hospital for Sick Children, Great Ormond Street, and University College Hospital, London, England

RICHARD H. MARTIN, M.D.

Professor of Medicine and Director, Division of Cardiology, University of Missouri School of Medicine, Columbia, Missouri

JACK M. MARTT, M.D.

Professor of Medicine, Department of Cardiology, Scott-White Clinic, Temple, Texas

HERBERT L. McDONALD, M.D.

Kansas City, Missouri

**TONY A. DON MICHAEL, M.D.,
F.A.C.C.**

Chairman, Department of Internal Medicine, and Director of Cardiology, Kern General Hospital; Associate Professor of Medicine, the UCLA School of Medicine, and Associate Cardiologist, Cedars-Sinai Medical Center, Los Angeles, California

**FRANK L. MITCHELL, B.S., M.D.,
F.A.C.S.**

Professor of Surgery and Director, Emergency Medical Services, University of Missouri School of Medicine, Columbia, Missouri

VLADIMIR A. NEGOVSKII, M.D.

Director, Laboratory of Experimental Physiology on Resuscitation of the Organism, Academy of Medical Sciences of the U.S.S.R., Moscow, U.S.S.R.

WERNER OVERBECK, Professor Dr. Med.

Städtisches Krankenhaus, Chirurgische Klinik, Kaiserslautern, Germany

JOHN C. SCHUDER, Ph.D.

Professor of Surgery (Biophysics), Department of Surgery, University of Missouri School of Medicine, Columbia, Missouri

WILLIAM A. SODEMAN, M.D.

Professor Emeritus and Dean Emeritus, Jefferson Medical College, Thomas Jefferson University, Philadelphia, Pennsylvania

GLENN O. TURNER, M.D.

The Clinic of Internal Medicine, Springfield, Missouri

JURO WADA, M.D.

Professor and Chairman, Department of Cardio-Thoracic Surgery, Sapporo Medical College and Hospital, Sapporo City, Japan

VALLEE L. WILLMAN, M.D.

Professor and Chairman, Department of Surgery, St. Louis University School of Medicine, St. Louis, Missouri

DON C. WUKASCH, M.D.

Associate Surgeon, Texas Heart Institute, St. Luke's Episcopal and Texas Children's Hospital, Houston, Texas

Dr. Werner Overbeck's contribution translated from German to English by

CARL H. IDE, M.D.

Professor of Ophthalmology, University of Missouri School of Medicine, Columbia, Missouri

With the editorial assistance of

**ROBERT S. KIMPTON, A.B., B.S.,
M.Ed.**

Journalistic Consultant, Columbia, Missouri

FOREWORD

The status of this authoritative volume on cardiac arrest and resuscitation and the great activity in this field have demanded a new, fourth edition. The fact that over 90 percent of sudden deaths (those occurring within one hour of onset of illness) result from cardiovascular disease in our country, and especially the fact that over half of those so afflicted die before entrance to a hospital make the problem of cardiac arrest an issue of broad concern, not only in the hospital and the operating room, but also in the home and elsewhere throughout the community. It is indeed one of our most important health problems.

While of special importance to the surgeon, this volume brings up-to-date concepts and approaches to a problem that is vitally important to everyone: the physician, the patient, the public. As a source book for such information it is superb—well written, clear, informative in depth, and understandable for all. The new edition comes at a critical time in this field. It comes with authority. It comes when we need updated information.

W. A. Sodeman, M.D.

*Professor Emeritus and Dean Emeritus,
Jefferson Medical College*

PREFACE

Sudden unexpected death, in terms of absolute loss of life, poses our greatest single medical problem today. It is the most common mode of death in our adult population. Some have suggested that the actual incidence of sudden death represents 30 percent of all natural deaths.

Many of our earlier concepts concerning the frequency and significance of ventricular arrhythmias in the early stages of acute myocardial infarction are now outdated, particularly those regarding ventricular tachyarrhythmias. The enhanced automaticity of some of the Purkinje fibers with resultant ectopic beats is now being rather effectively managed.

Almost two decades ago Beck and Leighninger, in urging the application of cardioresuscitation techniques, repeatedly referred to hearts that were "too good to die." The soundness of their perception has been borne out increasingly by many studies showing an essentially normal myocardium with minimal disease of the coronary arteries and no evidence of thrombotic occlusion at the time of autopsy in patients dying suddenly.

We continue to be indebted to the pioneering efforts of Kowenhoven, Jude, and Knickerbocker. Unquestionably, a new era in cardiac resuscitation was begun by their efforts and its immediate by-products are visible in a host of major changes in the

approach to the patient, such as utilization of the intensive care and mobile coronary care units.

Since the publication of the third edition in 1969, significant contributions have been made toward a broader understanding of the mechanisms of ventricular fibrillation and cardiac asystole. This, the fourth edition, supplements and updates material in the previous editions. Once again the bibliography is practically all new. Because of the tremendous volume of bibliographical material, it is suggested that the reader refer to previous editions for references not included here. The scope and volume of scientific information on cardiac arrest and resuscitation have expanded far beyond the easy accessibility of even those with more than a casual interest in the field. As one of our objectives in this revision, we have endeavored to condense, collate, and categorize much of this information in a manner that may provide easier access to the reader.

It is estimated that fibrillation in structurally good hearts occurs over 900 times a day in the United States in victims outside a hospital. Ventricular fibrillation is a major cause of death from coronary heart disease. This fatal ventricular dysrhythmia occurs most frequently shortly after the onset of infarction. Although the concept of mobile

coronary care has yet to obtain universal support among members of the medical profession, it seems obvious that means must be found to monitor and prevent ventricular fibrillation outside the hospital and during transportation to the hospital. More than half of those who die of heart attacks each year never reach a hospital, but serious attempts are being made to reduce this figure. The chapter on a mobile coronary care unit and resuscitation outside the hospital represents a considerable change in the approach to the problem over the last few years. The lifesaving benefits of cardiac monitoring in resuscitation of the coronary infarction patient outside the hospital are now well documented. Spain and Bradess estimate that there are approximately 500,000 deaths in the United States every year from acute myocardial infarction with about 50 percent of these patients dying before adequate medical care is available. The presence of a recent coronary thrombus in these sudden and unexpected fatalities (approximately 20 percent) lends encouraging support to the concept of mobile coronary care.

Approximately 70 percent of deaths from arteriosclerotic heart disease occur in persons who die outside a hospital or who are dead on arrival. This book reflects the advancements and refinements in resuscitation information that are coming from an increasingly wider variety of disciplines: the engineering sciences, medical systems developers, psychiatrists, sociologists, nurses, lawyers, biochemists, statisticians, and others.

As our knowledge of the mechanisms of cardiac arrest continues to increase, it is encouraging to note how it can be applied to clinical situations. A good example is the well-documented story of succinylcholine-induced hyperkalemia and the propensity of patients with severe trauma and burns to develop cardiac arrest. It is our hope that hospital cardiac resuscitation committees will find the book valuable as a continuing source of reference to aid them in their periodic evaluation of cases occurring in the hospital.

There seems to be little question that an effective committee can contribute significantly to a reduction in mortality from sudden death within the hospital.

Few individuals have contributed so significantly to the further extension of successful resuscitation efforts as has the nurse. With the active defibrillation of patients by nursing personnel in intensive care and coronary care units, a major breakthrough in resuscitation has occurred.

A new addition to the book is the chapter by Dr. Carveth concerning the "spectator heart." His studies, as well as others, are providing worthwhile experience and information from the management of resuscitation among high-density populations, such as those experienced at football games.

It is encouraging to note the increasing emphasis given to cardiopulmonary resuscitation by a wide variety of organizations, including the American College of Chest Physicians, American College of Cardiology, American Heart Association Committee on Cardiopulmonary Resuscitation and Emergency Cardiac Care, American College of Emergency Care Physicians, Society of Critical Care Medicine, American National Red Cross, Industrial Medical Association, and United States Public Health Service.

The Registry of Emergency Medical Technicians—Ambulance is strongly committed to improved medical care through better emergency transportation facilities and well-trained ambulance attendants. The Ambulance Association of America, International Association of Chiefs of Police, International Association of Fire Chiefs, International Rescue and First Aid Association, National Ambulance, and Medical Supplies Association, National Funeral Directors' Association, and the National Sheriffs' Association are all committed to the goals of the Registry and each provides a director to its board.

Other organized groups interested in this problem include the Equipment Committee of the American Society of Anesthesiologists and the Association for the Advancement of

Medical Instrumentation. Numerous types of equipment have been advocated in the management of cardiopulmonary resuscitation. Fortunately, the effectiveness of most of these has been scrutinized by the Cardiopulmonary Resuscitation Committee of the American Heart Association or the National Science Council. For example, the Emergency Care Research Institute at Philadelphia under Dr. Nobel maintains a full-time interdisciplinary scientific staff to evaluate acute care devices. Since the medical device field has become extremely complex, it is imperative that qualified biomedical engineers or physicians trained in engineering disciplines be actively involved.

Numerous reports indicate that electronic devices used in hospitals in the United States in the care of cardiac patients have significant deficiencies. The need for regular inspection of equipment, uniform standards, and increasing familiarity with medical electronics has prompted the inclusion of Chapter 7, by David Kilpatrick. The magnitude of the problem of excessive leakage of electrical current appears to be significant.

The first cardiac transplantation was undertaken on December 3, 1967. In the following two years, approximately 147 heart recipients were recorded. While the tempo of this activity has decreased considerably, it seems likely that a resumption will occur once major progress in coping with the rejection phenomena occurs. The chapters on preservation of the heart and on resuscitation of transplanted hearts should prove of interest to many readers. By including as much

material as possible relevant to the field of cardiac resuscitation in this book, we hope that our efforts will give added perspective to workers in this field. To those readers not actively involved, it is our hope that this edition will provide an updated and reliable account of the "state of the art."

A chapter on the historical aspects of cardiac resuscitation is again included. Readers tell us that they enjoy the chapter and that it effectively places the progress of resuscitation in its proper perspective.

We have continued to devote considerable space to the variety of factors influencing the mechanism of cardiac arrest, as it is our conviction that the relatively low rate of successful resuscitation in hospitals is partially due to a lack of realization of therapeutic requirements for specific situations. Broad generalizations are helpful for educational purposes, but the field of cardiac resuscitation has become sufficiently sophisticated to require in-depth knowledge of modifications in resuscitation efforts as individually required.

If one views the significant contributions made to the field of cardiac resuscitation over a span of years it is apparent that advances seem to be the product of different disciplines and different times. For example, after the advances by Shiff and other physiologists, there evolved a long era dominated by surgeons and subsequently by anesthesiologists. Certainly, it would seem that the last decade belongs to the cardiologist.

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

CONTENTS

PART ONE

INTRODUCTORY

- 1 Introduction: reanimatology—the science of resuscitation, 3
Vladimir A. Negovskij
- 2 Death, 28
Harold H. Hillman

PART TWO

DETECTION AND AVOIDANCE OF RISK FACTORS IN CARDIAC ARREST

- 3 Prevention of cardiac arrest, 35
- 4 Cardiac arrest and myocardial infarction, 65
- 5 The coronary care unit, 74
Jack M. Martt
- 6 Elective conversion of cardiac arrhythmias with precordial shock, 77
Richard H. Martin
- 7 Detection and correction of electrical hazards within the hospital, 86
David G. Kilpatrick
- 8 Warning signs and early detection of cardiac arrest, 119

PART THREE

MECHANISM OF CARDIAC ARREST

- 9 Pathophysiology of cardiac arrest, 141
- 10 Role of anoxia and hypoxia in etiology of cardiac arrest, 166
B. G. B. Lucas
- 11 Anesthetic agents and their relationship to cardiac arrest, 175

- 12 Effect of anoxia on myocardial contractility, 192
- 13 Acid-base and electrolyte imbalance, 194
Herbert L. McDonald
- 14 Toxic response and cardiac arrest, 207
- 15 Specific medical relationships to cardiac arrest, 215
- 16 Surgical and diagnostic procedures related to cardiac arrest, 223
- 17 Embolic mechanisms, 229
- 18 Ventricular fibrillation, 240

PART FOUR

TECHNIQUES OF CARDIOPULMONARY RESUSCITATION

- 19 The technique of resuscitation: general considerations, 255
- 20 Artificial respiration and resuscitation, 257
- 21 Artificial maintenance of circulation: precordial percussion and closed-chest resuscitation, 277
- 22 Adjuncts for circulatory assistance, 297
- 23 Artificial maintenance of circulation: open-chest resuscitation, 310
- 24 Closed-chest massage versus direct manual compression of the heart, 324
- 25 Ventricular defibrillation: general considerations, 336
- 26 Cardiac defibrillation, 344
Juro Wada
- 27 Open-chest electrical cardiac defibrillation, 348
- 28 The difficult resuscitation: recurrent episodes of ventricular fibrillation, 357
- 29 Relationship between wave form and effectiveness in transthoracic countershock for termination of ventricular defibrillation, 366
John C. Schuder
- 30 Totally implanted standby ventricular defibrillation systems, 374
John C. Schuder
- 31 Resuscitation of the near-drowning victim, 378
- 32 Resuscitation after lightning shock, 386
- 33 Accidental electrocution, 389
- 34 The stone heart syndrome: ischemic myocardial contracture, 396
Denton A. Cooley and Don C. Wukasch
- 35 Cardiogenic shock, 404
Tony A. Don Michael
- 36 Resuscitation requiring specific surgical approaches, 409

- 37 Artificial hearts: total replacement and circulatory assist devices, 416
Clifford S. Kwan-Gett and Willem J. Kolff
- 38 Cardiac augmentation by means of intra-aortic phase-shift balloon pumping, 430
Adrian Kantrowitz
- 39 Electric cardiac pacing, 443
John C. Schuder
- 40 Resuscitation of the newborn infant, 453
Robert Hook and Clarence D. Davis
- 41 Resuscitation after exsanguinating hemorrhage, 459

PART FIVE

PHARMACOLOGY OF RESUSCITATION

- 42 Pharmacology of resuscitation: vasopressors, 475
- 43 Pharmacology of resuscitation: antiarrhythmic agents, 486
- 44 Pharmacology of resuscitation: management of the acidosis of cardiac arrest, 493
- 45 Vagolytic, cardiotonic, "anti-sludging," and glucose-loading agents, 498
- 46 Pharmacology of resuscitation: a summary, 503

PART SIX

ORGANIZATION AND APPLICATION OF EFFECTIVE RESUSCITATION

- 47 The logistics of resuscitation within the hospital, 513
Glenn O. Turner with the assistance of Dick Ames
- 48 A hospital plan of action for cardiac arrest, 587
- 49 Resuscitation by the nurse, 596
- 50 Mobile cardiac resuscitation cart, 601
- 51 Ambulance and mobile resuscitation care, 611
Frank L. Mitchell
- 52 Stadium resuscitation (a life-support unit), 625
Stephen W. Carveth with the assistance of H. E. Reese and R. J. Buchman
- 53 Adjunctive techniques and equipment for cardiopulmonary resuscitation, 634
Archer S. Gordon

PART SEVEN

POSTRESUSCITATIVE CARE

- 54 Postresuscitative care: general considerations, 669
- 55 Effect of cardiac arrest on renal function, 675
Alex L. Finkle

PART EIGHT

PITFALLS, PRECAUTIONS, AND COMPLICATIONS IN CARDIAC RESUSCITATION

- 56 Cerebral anoxia and neurologic sequelae after cardiac arrest, 681
- 57 Cardiac complications, 708
- 58 Complications to other organs and systems in cardiac resuscitation, 717
- 59 Medicolegal aspects of cardiac arrest and resuscitation, 737
Elwyn L. Cady, Jr.

PART NINE

ELECTIVE CARDIOPLEGIA

- 60 Elective cardiac arrest: general considerations, 769
- 61 Electrically induced fibrillation, 783
Juro Wada
- 62 Cardiac preservation, 796
Edward B. Diethrich
- 63 Cardiac resuscitation in cardiac transplantation, 803
Vallee L. Willman

PART TEN

INCIDENCE AND CURRENT STATUS OF CARDIAC RESUSCITATION

- 64 Incidence and relative importance of cardiac arrest, 807
- 65 Guidelines for abandoning efforts at cardiac resuscitation, 822
- 66 Cardiac resuscitation: what is being accomplished? 827

PART ELEVEN

EPILOGUE

- 67 The past: historical views concerning cardiac arrest and resuscitation, 847
Werner Overbeck
- 68 A look toward the future, 862

APPENDIX

Standards for cardiopulmonary resuscitation (CPR) and emergency cardiac care (ECC), 867

BIBLIOGRAPHY, 910

INTRODUCTORY

INTRODUCTION: REANIMATOLOGY—THE SCIENCE OF RESUSCITATION

Vladimir A. Negovskii

The Laboratory of Experimental Physiology on the Resuscitation of the Organism was founded in Moscow in 1936 in connection with the N. N. Burdenko Institute of Neurosurgery.

The laboratory was organized by Professor V. A. Negovskii, who has served as its director since it was founded. A small group of young scientists (six or seven) began working with him at that time. They set as their goal the study of the general pathophysiologic regularities of the processes of the extinction and restoration of the vital functions, that is, the heart, the respiration, and the central nervous system (CNS), and also the research of scientifically based methods of resuscitation.

In 1948, in line with a decision of the Council of Ministers of the U.S.S.R., the laboratory was reorganized as an independent scientific research department under the auspices of the Academy of Medical Sciences.

Over the course of 37 years, the laboratory's staff has grown considerably (to sixty-five), and the scope of the work that is carried out has been broadened. The functions of the cardiovascular system, the respiratory center, and the CNS during terminal states and in the restorative period and also the functions of such interior organs as the liver, the kidneys, and the endocrine system as well as biochemical changes arising from the disturbance of metabolic processes and related considerations—all are subjected to detailed study with the help of modern research methods.

Along with its purely experimental department, the laboratory also maintains a clinical department of resuscitation at the S. P. Botkin Hospital. Patients in terminal or near-terminal conditions are brought there from the hospital's various departments. The department of resuscitation also maintains a mobile center, which ensures treatment of terminal patients in hospitals where there is a lack of personnel well-qualified in the area of resuscitation.

Along with applied work in the department of resuscitation, scientific research work dedicated to the study of various clinical aspects of resuscitology is carried out.*

One of the important facts of contemporary science is the ever deeper and more attentive study of the mechanisms of death and resuscitation. Now we are fully justified in speaking of the appearance of a special science dedicated to the study of this question. Cessation of cardiac activity, cessation of respiration, extinction of the functions of the CNS, suppression of the cortical regulation of the physiologic functions, the dynamics of the restoration of functions in the process of resuscitation, and a series of other similar matters make up the content of this science.

Historically it has come about that, along with the rapid development of our knowledge in the treatment of the most varied diseases, we were, even recently, using purely empirical methods thousands of years old regarding the treatment of the dying organism. Attempts at resuscitation were made in ancient times. Apparently, however, only the modern level of development of biologic and medical knowledge provides the prerequisites for a comprehensive study of all the problems relating to resuscitation. Detailed study of the processes of the extinction and restoration of the organism's vital functions, elucidation of

*The Laboratory of Experimental Physiology on the Resuscitation of the Organism, Academy of Medical Sciences of the U.S.S.R., Moscow, U.S.S.R.

the essence of transitional states between life and death, and specifics of the organism's life in terminal states and in the so-called post-reanimation period, and, likewise, elaboration of more modern methods of reanimation—such are the basic problems which, arisen from the needs of life, appealed for their solution to a new medical science: the science of reanimatology.

One of the factors that contributed to the development of reanimatology was the necessity to reconsider fundamentally the concept that had previously been accepted regarding the absolute impossibility of a battle with a "groundless" death. Theoretically the idea was corroborated regarding the reversibility of the death processes when the viable organism is still perishing and the possibility of prevention and, in indicated cases, treatment of terminal states (agony and clinical death).

Although closely linked with a series of such experimental and clinical disciplines as pathophysiology, surgery, anesthesiology, obstetrics and gynecology, and therapeutics (particularly emergency therapeutics), reanimatology, at the same time, finds its own place among these disciplines. Reanimatology generalizes from the material of the above disciplines, not infrequently employing methods already used in them to find a solution to its specific problems. In turn reanimatology enriches these sciences with the results of its own theoretical and clinical investigations. Yet, all the same, reanimatology poses quite original problems for itself, problems whose solutions it approaches from the positions of those theoretical concepts it has elaborated.

Later I shall examine the main problems of the dynamics of the extinction and restoration of the organism's vital functions, consider some debatable questions regarding various methods of resuscitation, and touch on some of the current problems in reanimatology such as the treatment of a resuscitated patient, prognosis, and so forth.

I would like to point out here the differ-

ence in the meaning of the two words *re-animatology*—a theoretical science, and *re-animation*—practical measures used for the restoration of vital functions of the organism.

Extinction of functions of cerebral cortex—the first stage of CNS dying

Complete restoration of the functions of the cerebral cortex after terminal states is often impossible because of death of the cerebral neurons, which are extremely sensitive to anemia, hypoxia, intoxication by incompletely oxidized substances of metabolism, and other noxious influences. Relative resistance of ancient, life-ensuring systems (vegetative nervous formation), formed during phylogenesis, and increased sensitivity to pathogenic factors of the highly developed systems (cortex of the hemispheres and some subcortical formations) control the regular sequence of extinction of functions of the central nervous system.

In the very early period of dying, hypoxia causes reflex stimulation of chemoreceptors, angioreceptors, and cerebral vegetative formations including the respiratory and the vasomotor centers and the reticular formation of the brainstem. This reflex stimulation, one of the body's important defense-adaptive factors, is aimed at compensating for failing functions, ensuring homeostasis, and preserving the higher sectors of the central nervous system. It causes accelerated and deeper respiration, acceleration of cardiac contractions, increase of the minute volume of the heart and of arterial blood pressure, constriction of the peripheral blood vessels and of the blood vessels of the abdominal cavity, and dilatation of the capillary network of the brain. Activation of function of the central nervous system is manifested by excitation, motor anxiety, partial restoration of consciousness (in animals, restoration of some conditioned reflexes), the reaction of desynchronization evidenced on electroencephalogram, and other signs. However, in the dying process the activation of the compensatory-defensive process is followed by the equally important