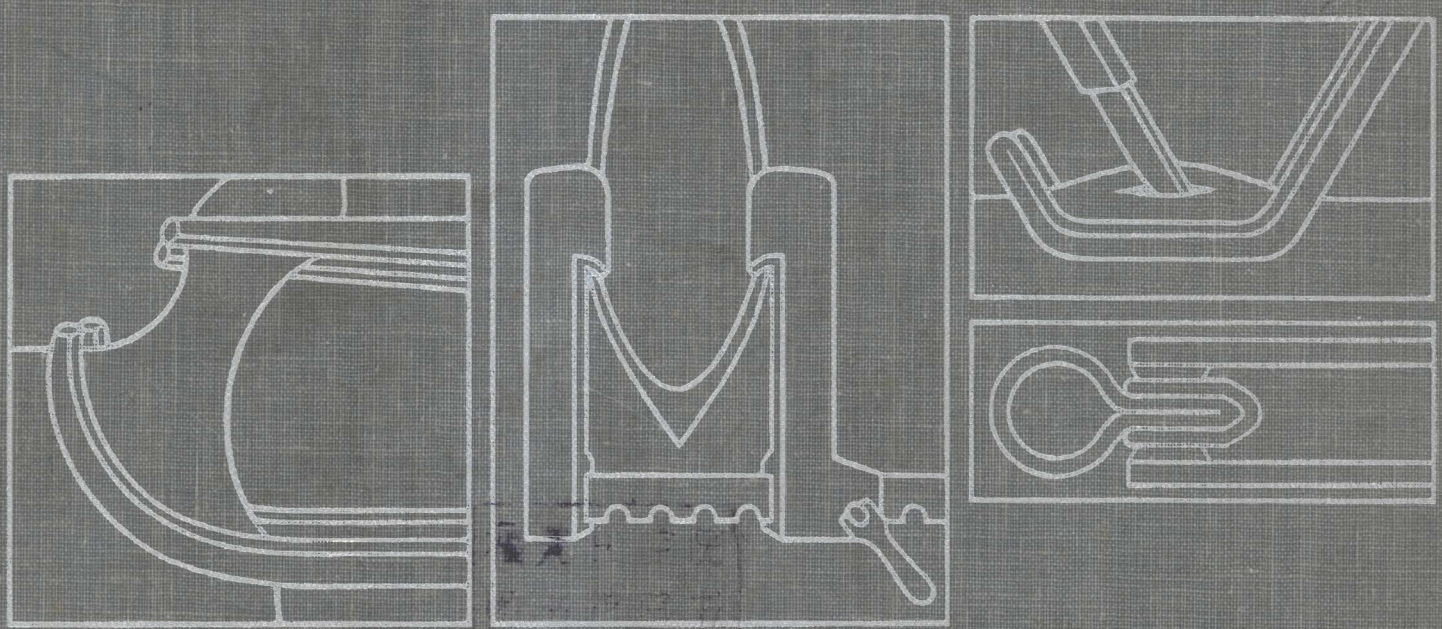
TECHNIQUES IN CARDIAC SURGERY

SECOND EDITION



DENTON A. COOLEY

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SECOND EDITION

DENTON A. COOLEY, M.D.

Surgeon-in-Chief
Clinical Professor of Surgery
The Texas Heart Institute of St. Luke's Episcopal and Texas Children's Hospitals
The Department of Surgery, The University of Texas Medical School at Houston
Houston, Texas

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With contributions from

GEORGE J. REUL, JR., M.D.

Associate Surgeon, Clinical Professor of Surgery,
The Texas Heart Institute of St. Luke's Episcopal and Texas Children's Hospitals
The Department of Surgery, The University of Texas Medical School at Houston
Houston, Texas

O. HOWARD FRAZIER, M.D.

Associate Surgeon, Cardiovascular Surgical Research,
Laboratory Director, Associate Professor of Surgery,
The Texas Heart Institute of St. Luke's Episcopal and Texas Children's Hospitals
The Department of Surgery, The University of Texas Medical School at Houston
Houston, Texas

Foreword by

DWIGHT EMARY HARKEN, M.D.

EVELYN LAWRENCE, B.A., M.B.A.

Coordinator and Editor

MARIANNE KNEIPP, B.A.

Editorial Assistant

Illustrated by

BILL ANDREWS, M.A., TIMOTHY C. HENGST, M.A., BARBARA E. HYAMS, M.A., RUSSELL G. JONES, M.A., and MARY C. WALKER, M.A.

DEDICATION

To my surgical teams—
past, present and future—
this book is dedicated with
respect, gratitude, and affection.

FOREWORD

Years ago I introduced Dr. Denton Cooley as a surgeon capable of Woolworth volume with Tiffany quality. The years since have only underscored that description.

The *good* surgeon has the ability to apply proper standard techniques skillfully. The *very good* surgeon reduces those standard techniques to their simplest terms, improves them, and applies them with scholarly flexibility. The *great* surgeon has all the qualities of the very good surgeon; in addition, he is innovative and creative, and he passes the improved standard and new techniques on to others. Thus, the great surgeon serves many more than one at a time, one at a time.

One form of passing on to others the standard and the new is to produce an atlas such as this. The clear, sharp, black-and-white drawings have the added dimension of time . . . the advantage of the portrait over the photograph.

When surgical procedures are conducted after scholarly decision, expeditiously and precisely, they assume the elegance of ballet, with noble purpose.

The purpose of this atlas in its second edition is to present and extend the state of the art of cardiac surgery.

To see how far we've come, we have only to recall the removal of shell fragments from the heart almost 40 years ago. That was the first consistently successful elective intracardiac surgery. Since that time, we have experienced awesome years of progress.

With contributions from his talented associates, George J. Reul, Jr. and O. Howard Frazier, Dr. Cooley has provided us with a practical manual of cardiac surgery based upon extensive personal experience.

Thank you, Dr. Cooley, for presenting us with a pictorial parade that helps us to appreciate how far cardiac surgery has travelled, with great good to so many.

This book should extend the horizons of physicians and enhance the competence of cardiac surgeons.

DWIGHT EMARY HARKEN
Clinical Professor of Surgery Emeritus
Harvard Medical School
Cambridge, Massachusetts

PREFACE

My purpose in writing the first edition of *Techniques in Cardiac Surgery,* which was published in the fall of 1975, was "to present a resumé of how we do cardiac surgery in our hospital at this time, fully aware that some of the techniques may be destined for obsolescence in the near future." In retrospect this proved to be a grossly understated prediction, since during the ensuing years the majority of techniques were modified and many were discarded. How soon this will occur with the present edition is difficult to predict. Nevertheless, the attempt to provide a state-of-the-art report for cardiac surgery in this decade seems worthwhile and justifies the efforts of my able coworkers and myself.

The book is not intended as a comprehensive review of cardiac surgery. Such an undertaking is beyond my capabilities for many apparent reasons. Moreover, such a production would not fulfill my objective of providing a manual for our residents and fellows who need a basic knowledge of the practice of cardiac surgery in the Texas Heart Institute. For others who are curious and interested enough to seek such information, the methodology is revealed in an unadorned style in keeping with our emphasis here on simplicity.

Much of the information included was derived from extensive clinical experience and association during the past 35 years with many other cardiac surgeons. In fact, the group of trainees who have endured the arduous program at this institution have taught me much. We emphasize the team approach, with free exchange of opinions, good results, poor results, techniques, and errors in judgment. In this atmosphere of open discussion, the achievements and failures of our efforts have served to broaden and improve our ability as students in a rapidly developing and changing specialty.

I am particularly grateful to Evelyn P. Lawrence and Marianne Kneipp for their dedicated and capable effort in bringing forth this edition. Of course, the artists deserve major credit, but the reader will immediately recognize their ability and talent as they peruse the book. To all of these people and many others, I express my thanks.

Denton A. Cooley

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1

INTRODUCTION

Cardiac surgery, more than any other surgical specialty, places heavy demands upon the personnel involved, not only the surgeons but also the nurses, physicians' assistants, laboratory technicians, and clinical engineers responsible for maintenance and operation of special equipment such as monitors, respirators, defibrillators, and circulatory assist devices. Optimum care of the patient undergoing complicated open heart procedures requires around-the-clock vigilance and effort and *intense concentration during and after operation.* To maintain the necessary *esprit de corps,* the surgeon should provide leadership and should set an example of dedication and commitment to each patient. He must decide on a plan of operation, anticipate the procedures required to accomplish this plan, and communicate freely with his associates. Only he can inspire the people involved to give their best efforts, even during moments of impending disaster or final defeat. The same standards apply to the manner in which he relates to those who manage the patient's preoperative preparation and postoperative convalescence.

Since success in cardiac surgery depends on a team effort, good sportsmanship in dealing with teammates is essential. When something goes amiss, the surgeon should not pause to determine who is responsible or who is to blame; he should direct his efforts toward correcting the problem. Placement of blame can wait until the storm abates. The entire team should strive for a congenial and harmonious environment both inside and outside the operating room. When under fire, the surgeon should maintain his composure. The hours may be long and arduous and the responsibilities and pressures heavy, but the time passes quickly when the challenges are exciting and the atmosphere is pleasant.

DECISIONS

Decision making has always been the final responsibility of the surgeon. As diagnostic techniques have improved, the old concept of an "exploratory" has become almost completely discarded. Half a century ago, Dr. Will Mayo was quoted as saying, "The only obstacle to intra-abdominal diagnosis is the abdominal wall."[1] Today, with increasingly sophisticated and precise instruments, most diagnoses are made prior to operation, with complete anatomical and physiological accuracy. Nevertheless, the cardiac surgeon should still maintain his position at the helm and make decisions, assuming the risk of error when necessary.

In the early years of open heart surgery, a panel of surgeons was asked, "What has been the major single factor in lowering the mortality in open heart

surgery?" One answer was the readiness to return a patient to the operating room if postoperative bleeding was excessive. An alert intern or resident with an objective viewpoint often recognizes the need for a second exploratory operation long before the surgeon himself can accept the fact and decide to act. The surgeon need not include the patient's relatives or parents in the decision. If possible, simply inform them that an additional procedure is necessary. Too often, the surgeon seems to be the first to agree to operate but the last to agree to *re-operate.* Many lives have been saved by a second operation to control bleeding, and many so-called "bleeding diatheses" prove to be nothing more than a lacerated internal mammary artery or a loose suture or ligature.

MINIMUM REQUIREMENTS

Emphasis has recently been placed on the minimal requirements needed for a hospital to qualify to perform heart surgery. Such criteria are difficult to establish. A patient load of 1 or 2 operations a week does not necessarily indicate that a program is suboptimal or less acceptable than one in an institution performing 20 or more a week. Nevertheless, one must accept the fact that an open heart team needs practice; pumps and perfusion equipment should be used frequently and kept in good working order, and the house staff and involved personnel must be available for 24-hour coverage of the intensive care unit. Proper surveillance should be maintained.

Open heart surgery requires adequate operating room space. A *minimal size* to accommodate the pump oxygenator, perfusion personnel, anesthesia equipment, monitors, and other special equipment should be about 250 square feet, or a room 16 × 16 feet. Close quarters restrict the movements of the personnel and increase the threat of infection. The room should be provided with cool, filtered dehumidified air. The patient's temperature should always be monitored, particularly during long procedures. Adults may require special measures to prevent heat retention and the development of hyperthermia. On the other hand, one must prevent loss of body heat when operating on newborn or premature infants. For example, we often operate on premature infants weighing less than 1000 grams in a hooded incubator to maintain body temperature in a cool room (Fig. 1–1).

ILLUMINATION AND VISUALIZATION

Essential to cardiac surgery are good visibility and illumination. This applies particularly to operations on infants and direct coronary artery procedures. Since the usual overhead lighting fixtures may be inadequate in many situations, we usually employ a mobile light source attached to a headband. A fiberoptic light with a power source located behind the surgeon provides high-intensity illumination, which can be directed into the field. Binocular lenses for magnification (3 power) have enhanced the surgeon's ability to perform extremely small anastomoses and have proved useful in other operative situations (Fig. 1–1, *inset*).

DISPOSABLES

Infections have become increasingly rare in cardiac surgery, and this can be attributed in part to the enlightened use of antibiotics. The use of disposable

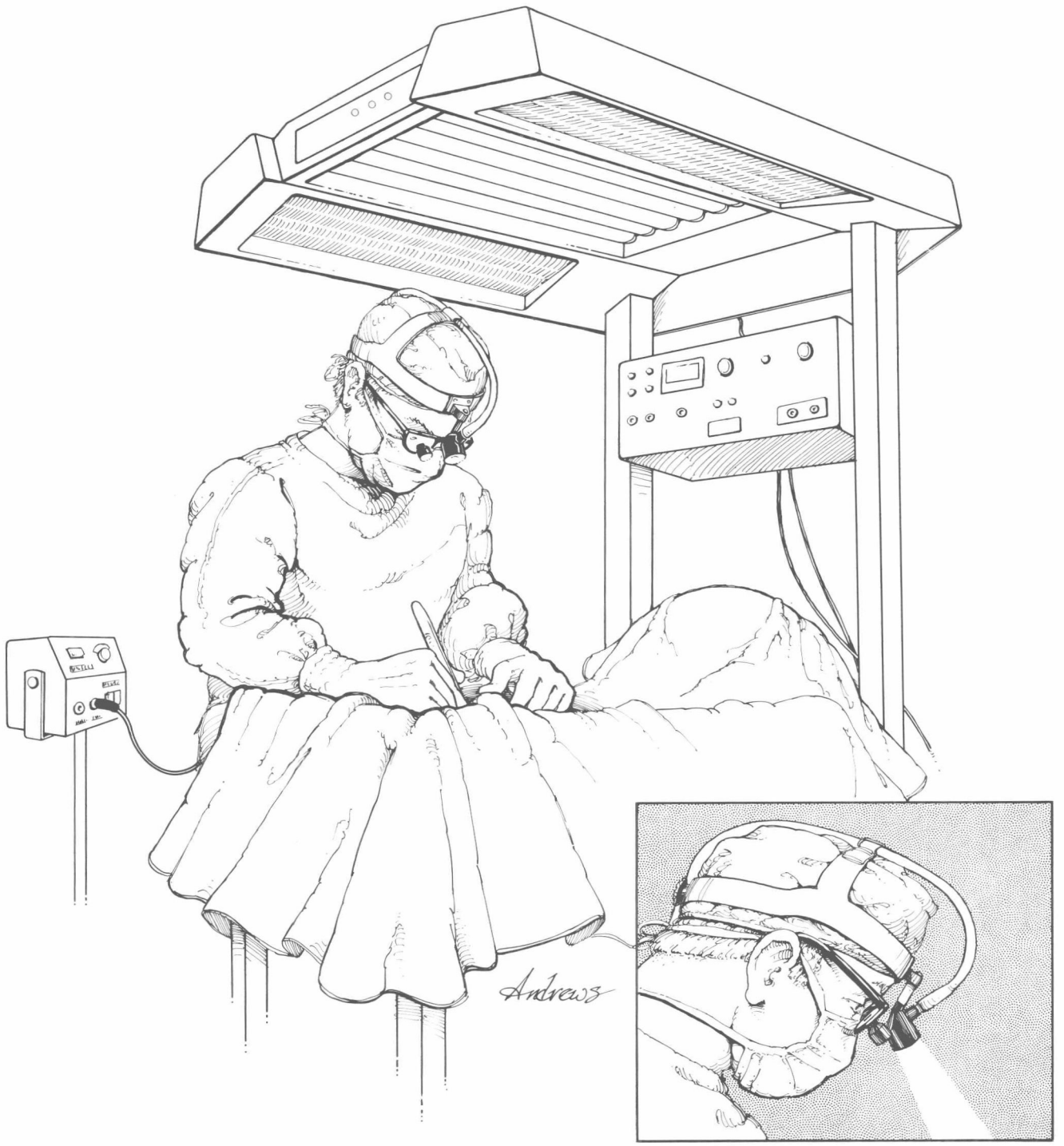

Figure 1–1. Operations performed on small, sometimes premature infants should provide maintenance and support of body temperature. Many can best be conducted under a reflecting hood. *Inset*, For better visualization, the surgeon wears a fiberoptic headlamp and loupes to produce 3- to 4-power magnification.

equipment in the operating room is also an important factor.[2, 3] Surgical gowns, drapes, masks, caps, gauze packs, and many other items that were previously cleaned and re-used have now been replaced with plastic and paper products.

BLOOD TRANSFUSIONS

The incidence of homologous serum jaundice (hepatitis) has also been greatly reduced by various improvements and innovations in blood-banking technology. Nonetheless, it remains a major concern in cardiac surgery. The surgeon should, therefore, make a determined effort to reduce the need for blood transfusions. Careful hemostasis is fundamental. In our hospital, electrolyte and glucose solutions to prime the extracorporeal circuit have strikingly reduced the need for homologous blood transfusions. Indeed, we have demonstrated that extensive open heart procedures may be well tolerated by the patient without his receiving any transfused blood. Of course, the support of a well-equipped blood bank is essential, since excessive blood loss on heparinized patients can occur following extensive cardiac surgery.

Currently, interest has renewed concerning autotransfusion. Although some past methods of autotransfusion have caused serious renal and hematological complications, techniques are now available for salvaging blood during operation, washing the erythrocytes, and returning the blood to the patient. This may be extremely useful in complex procedures such as resection of aneurysms of the aortic arch and the descending or thoracic abdominal aorta.

As more individuals join the Jehovah's Witness religious movement, the cardiovascular surgeon assumes a new burden of weighing risks in performing "bloodless" operations. In addition to the usual medical considerations, serious moral and ethical issues are introduced, which inevitably affect the surgeon's decision. We have performed major cardiovascular surgery on approximately 1000 Jehovah's Witness patients, of whom 750 underwent "open" procedures during cardiopulmonary bypass. The mortality has been gratifyingly low, and of the deaths that have occurred, very few were directly related to lowered blood volume and lack of transfusion.[4-11] For adult patients of this faith who consent to operation and sign an agreement and waiver of liability to the surgeon and the hospital, surgery is almost routinely offered. The possible exception would be a patient with a hemoglobin of less than 10 gm % or a hematocrit of less than 20% who must undergo major cardiac surgery. The major dilemma arises when the patient is a child or infant of a Jehovah's Witness. The decisions then become delicate and require judgment and experience. In general, if operation is mandatory and the risk is not excessive, we proceed with the operation. Our results have been excellent. Sometimes the type of operation selected has been altered; for example, a two-staged approach is used with a palliative procedure first, and then the definitive repair is delayed until the patient is older and has attained increased body size. Jehovah's Witnesses are firm and steadfast in their convictions on the issue of blood transfusion. They have deep faith in their belief and are willing to cooperate, even during trying moments in the postoperative period. We have never had to seek a court order to force a Jehovah's Witness to submit to conventional medical and surgical treatment.

MASSIVE HEMORRHAGE CONTROLLED BY INDUCED CARDIAC FIBRILLATION

Occasionally, the cardiovascular surgeon will encounter hemorrhage of such magnitude and under such anatomical handicaps that he will not be able to

control the blood loss by conventional techniques. The method to be described can be effective even under the most dire circumstances; therefore, death from uncontrolled, sudden, or massive hemorrhage should never occur in the operating room.

Such situations arise when a cardiac chamber is torn or lacerated and cardiopulmonary bypass is not available. Hemorrhage from the ascending aorta or transverse arch may be impossible to stop while the heart is beating. Lacerations of the main pulmonary artery may also occur, and hasty or blind clamping of the artery may lead to unnecessary sacrifice of a lung. The problem is such situations is that the systolic force of the heart and pulse wave causes sutures to disrupt as they are inserted or tied.

The solution lies in deliberate cessation of cardiac contraction by inducing ventricular fibrillation. When the operating field becomes quiet, most surgical repairs of major arteries or the myocardium become relatively straightforward. A period of five to eight minutes of induced fibrillation causes no cerebral anoxic damage. Once the hemorrhage is controlled, cardiac massage is started while preparations are made to deliver a direct current countershock to the heart. Usually, cardiac action resumes, and in a few minutes adequate cardiac output and blood pressure return.

The cardiac fibrillator should be a standard instrument in every cardiovascular operating room. We use one with a rheostat that can deliver an increasing voltage, but usually 25 to 50 volts of alternating current will cause fibrillation. Suitable clamps on electrodes are available with most units. Because of confusion on the part of operating room personnel when the surgeon suddenly calls for the fibrillator, the *de*fibrillator is usually mistakenly presented; consequently, we have painted the fibrillator a fire engine red and refer to it as the *red box.* This device has saved a number of lives in our hospital.

INSTRUMENTS

In the early days of cardiovascular surgery, specialized instruments were not available. The surgeon had to modify those used in general surgery. Apropos is a quotation from Alfred Blalock in his Moynihan lecture delivered in 1954:[12] "Given a sound, fundamental concept in surgical therapy, it is much more apt to be executed successfully if suitable instruments are available." Since the specialty of cardiovascular surgery began, better instruments have been developed and have contributed significantly to better results. The clamp used to occlude an artery or vein has always been referred to as *atraumatic.* Yet most vascular clamps in early use were either excessively traumatic or unreliable for security or control. Often they were just modified hemostats or intestinal clamps that were clumsy or poorly designed for cardiovascular surgery. We have encouraged instrument makers to develop a set of vascular clamps that have the same qualities and feel over an entire range of sizes and shapes, much like a matched set of golf clubs (Fig. 1–2).

One improvement over conventional clamps is the lengthening of ratchets so that seven or eight stops are available to apply the proper degree of compression according to pressure inside the blood vessel. Obviously, the force of compression for the ascending aorta is not the same as that for the superior vena cava or right atrium. With the longer ratchets, the clamp may be released gradually, stop by stop, a factor of considerable importance when releasing the clamp after resection of an aortic aneurysm or coarctation, particularly when a somewhat porous fabric graft is used. Of equal importance is the ability to control the redistribution of the patient's blood volume upon release of a clamp on the