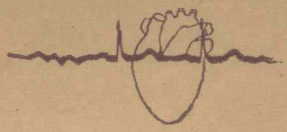
CLINICAL
CARDIOLOGY
MONOGRAPHS



Advances in Cardiovascular Surgery

D.

of Surgery
of Surgery,
lical Center,
ngham.

GRUNE & STRATTON
A Subsidiary of Harcourt Brace Jovanovich, Publishers
New York and London

Advances in Cardiovascular Surgery

Edited by

John W. Kirklin, M.D.

Charles and Fay Kerner Professor of Surgery and Chairman of the Department of Surgery, School of Medicine and the Medical Center, University of Alabama in Birmingham, Birmingham, Alabama

GRUNE & STRATTON
A Subsidiary of Harcourt Brace Jovanovich, Publishers
New York and London

Library of Congress Cataloging in Publication Data
Kirklin, John W 1917-
Advances in cardiovascular surgery.
Includes bibliographical references.
1. Cardiovascular system—Surgery. I. Title.
[DNLM: 1. Cardiovascular system—Surgery.
WG168 K59a 1973]
RD598.K55 617'.41 73-13610
ISBN 0-8089-0797-2

Grune & Stratton, Inc.
111 Fifth Avenue
New York, New York 10003

Library of Congress Catalog Card Number 73-13610
International Standard Book Number 0-8089-0797-2
Printed in the United States of America

Contributors

RODOLFO R. ALLARDE, M.D., Professor of Anesthesia; Director of Cardiovascular Division of Anesthesia, School of Medicine and the Medical Center, University of Alabama in Birmingham, Birmingham, Alabama.

JOSEPH P. ARCHIE, JR., Ph.D., M.D., Research Associate in Cardiovascular Surgery; Resident in Surgery, School of Medicine and the Medical Center, University of Alabama in Birmingham, Birmingham, Alabama.

W. GERALD AUSTEN, M.D., Professor of Surgery, Harvard Medical School. Chief, General Surgical Services, Massachusetts General Hospital, Boston, Massachusetts.

L. M. BARGERON, JR., M.D., Professor of Pediatrics; Director of Division of Pediatric Cardiology, School of Medicine and the Medical Center, University of Alabama in Birmingham, Birmingham, Alabama.

BRIAN G. BARRATT-BOYES, K.B.E., M.B., Ch.M., F.R.A.C.S., Surgeon-in-Charge, Cardiothoracic Surgical Unit, Green Lane Hospital, Auckland, New Zealand.

NINA S. BRAUNWALD, M.D., Associate Professor of Surgery, Harvard Medical School, Boston, Massachusetts.

MORTIMER J. BUCKLEY, M.D., Associate Professor of Surgery, Harvard Medical School. Visiting Surgeon, Massachusetts General Hospital, Boston, Massachusetts.

JAMES W. DUSHANE, M.D., Professor of Pediatrics, Mayo Clinic, Mayo Graduate School and Mayo Medical School, Rochester, Minnesota.

WELTON M. GERSONY, M.D., Director, Division of Pediatric Cardiology, Associate Professor of Pediatrics, College of Physicians and Surgeons, Columbia University. Associate Attending Physician, Babies Hospital-Children's Medical and Surgical Center of New York, Columbia-Presbyterian Medical Center, New York, New York.

HAMNER HANNAH, III, M.D., Chief Resident in Cardiovascular Surgery, School of Medicine and the Medical Center, University of Alabama in Birmingham, Birmingham, Alabama.

ROBERT B. KARP, M.D., Associate Professor of Surgery, School of Medicine and the Medical Center, University of Alabama in Birmingham, Birmingham, Alabama.

JOHN W. KIRKLIN, M.D., Charles and Fay Kerner Professor of Surgery and Chairman of the Department of Surgery, School of Medicine and the Medical Center, University of Alabama in Birmingham, Birmingham, Alabama.

NICHOLAS T. KOUCHOUKOS, M.D., Associate Professor of Surgery, School of Medicine and the Medical Center, University of Alabama in Birmingham, Birmingham, Alabama.

EDWARD C. LAMBERT, M.D., Chief of the Division of Cardiology, Children's Hospital of Buffalo. Professor of Pediatrics, State University of New York at Buffalo School of Medicine, Buffalo, New York.

JAMES R. MALM, M.D., Professor of Clinical Surgery, Columbia University, College of Physicians and Surgeons. Chief, Chest Surgical Service, Presbyterian Hospital and Babies Hospital, The Children's Medical and Surgical Center of New York, New York, New York.

DWIGHT C. MCGOON, M.D., Professor of Surgery, Mayo Graduate School and Mayo Medical School. Chairman, Section of Thoracic and Cardiovascular Surgery, Mayo Clinic, Rochester, Minnesota.

ELDRED D. MUNDTH, M.D., Associate Professor of Surgery, Harvard Medical School. Co-Chief, Division of Cardiovascular Surgery, Massachusetts General Hospital, Boston, Massachusetts.

ALBERT D. PACIFICO, M.D., Assistant Professor of Surgery, School of Medicine and the Medical Center, University of Alabama in Birmingham, Birmingham, Alabama.

FRANK C. SPENCER, M.D., Professor and Chairman of the Department of Surgery, New York University School of Medicine, New York, New York.

JAROSLAV STARK, M.D., Consultant Thoracic Surgeon, The Hospital for Sick Children, Great Ormond Street, London, England.

S. SUBRAMANIAN, M.B., B.S., F.R.C.S. (Eng.), Chief, Department of Cardiovascular Surgery, Children's Hospital of Buffalo, Buffalo, New York.

PETER VLAD, M.D., Director of Cardiovascular Laboratories, Children's Hospital of Buffalo, Professor of Pediatrics, State University of New York at Buffalo, Buffalo, New York.

JAMES D. WISHEART, M.B., B.Sc., F.R.C.S. (Ed.), Senior Registrar in Cardiothoracic Surgery, Middlesex Hospital, London, England.

Foreword

This monograph on Advances in Cardiovascular Surgery (1973) is the result of my being invited by Drs. Willis Hurst and Dean Mason to produce such a work. Being generally unenthusiastic about books with multiple authors, I considered writing this myself. Quickly it became apparent that much of the potential excitement and authority of the monograph would be lost by doing this. So I invited some of the people who have made these advances to join in producing the monograph, and in each instance they have submitted superb analyses and presentations. Some editorial liberties have been taken with these to provide cohesiveness and minimize duplication. The reader will realize that many who have made significant contributions could not be included as authors, and that some recent advances have been omitted.

Clearly cardiac surgery remains as dynamic as it was in the early years after the late John Gibbon first successfully used a pump-oxygenator when he closed an atrial septal defect in an 18 year old girl in 1953. Although numerically not the commonest group of cardiac lesions submitted to operation, congenital heart disease continues to be an interesting and important area for surgical effort. As indicated in the first thirteen chapters, advances are still being made even though the earliest efforts in open intracardiac surgery were made in congenital heart disease.

Advances in the surgical treatment of valvular heart disease center on improvements in the prosthetic devices used for valvar replacement and on cardiac performance late postoperatively and its determinants.

Chapters 14 through 17 present some of the important new knowledge in these areas, and in them is the suggestion that with just a few more breakthroughs, early and late results could improve rather dramatically.

About one-half of the cardiac operations performed in the last few years, in the United States at least, have been for ischemic heart disease. This area is also the newest of the three discussed in the monograph, and accurate information is just beginning to accumulate. A few years from now, many chapters can be written about this aspect of cardiac surgery. At present, a survey of one of the most controversial and difficult areas (Chapter 18), a review of the present status of coronary artery bypass grafting for angina pectoris (Chapter 19), and a presentation of the least controversial area (Chapter 20) seemed all that should be undertaken.

Extensive enlargement and revision of many of these chapters will be required within a few years.

John W. Kirklin, M.D.

Contents

Foreword by John W. Kirklin, M.D.

CONGENITAL HEART DISEASE

1 Introduction 3
John W. Kirklin, M.D.

2 Late Results of Repair of Ventricular Septal Defect on Pulmonary Vascular Disease 9
James W. DuShane, M.D., and John W. Kirklin, M.D.

3 Late Results of Repair of Tetralogy of Fallot 17
Welton M. Gersony, M.D., and James R. Malm, M.D.

4 Late Results of Rashkind's Balloon Atrial Septostomy in Transposition 29
Peter Vlad, M.D., and Edward C. Lambert, M.D.

5 Late Results of Superior Vena Cava-Right Pulmonary Artery Anastomosis for Tricuspid Atresia 37
Robert B. Karp, M.D., and L. M. Bargeron, Jr., M.D.

6 Complex Congenital Malformations: Surgery for Complete Form of Atrioventricular Canal 45
Dwight C. McGoon, M.D.

7 Complex Congenital Malformations: Surgery for Double Outlet Right Ventricle and Double Outlet Left Ventricle 57
Albert D. Pacifico, M.D., John W. Kirklin, M.D. and L. M. Bargeron, Jr., M.D.

8 Complex Congenital Malformations: Surgery for Transposition of the Great Arteries with Ventricular Septal Defect and Pulmonary Stenosis 77
Dwight C. McGoon, M.D.

9 Primary Definitive Intracardiac Operations in Infants: Intraoperative Support Techniques 85
John W. Kirklin, M.D., Albert D. Pacifico, M.D., Hamner Hannah, III, M.D., and Rodolfo R. Allarde, M.D.

10 Primary Definitive Intracardiac Operations in Infants: Transposition of the Great Arteries 101
Jaroslav Stark, M.D.

11 Primary Definitive Intracardiac Operations in Infants: Total Anomalous Pulmonary Venous Connection 127
Brian G. Barratt-Boyes, K.B.E., M.B., Ch.M., F.R.A.C.S.

12 Primary Definitive Intracardiac Operations in Infants: Ventricular Septal Defect 141
S. Subramanian, M.B., B.S., F.R.C.S. (Eng.)

13 Primary Definitive Intracardiac Operations in Infants: Tetralogy of Fallot 155
Brian G. Barratt-Boyes, K.B.E., M.B., Ch.M., F.R.A.C.S.

VALVULAR HEART DISEASE

14 Totally Cloth-Covered Valvular Prostheses 173
Nina S. Braunwald, M.D.

15 Myocardial Blood Flow and Cardiac Surgery 189
Joseph P. Archie, Jr., Ph.D., M.D., and John W. Kirklin, M.D.

16 Problems in Mitral Valve Replacement 205
Nicholas T. Kouchoukos, M.D.

17 The Long Term Effects of Aortic Valve Replacement on Myocardial Function 217
James D. Wisheart, M.B., B.Sc., F.R.C.S. (Ed.), and John W. Kirklin, M.D.

ISCHEMIC HEART DISEASE

18 Surgical Treatment of Acute Myocardial Infarction and Shock 227
Eldred D. Mundth, M.D., Mortimer J. Buckley, M.D., and W. Gerald Austen, M.D.

19 Treatment of Angina Pectoris by Coronary Artery Bypass Grafting 239
Frank C. Spencer, M.D.

20 Surgical Treatment of Complications of Ischemic Heart Disease 249
Robert B. Karp, M.D.

Index 265

PART I

Congenital Heart Disease

PART I

Congenital Heart Disease

John W. Kirklin, M.D.

1 Introduction

Clear thinking about patients with congenital heart disease and proper planning of their surgical therapy requires distinct and defined terminology, orderly categorization of the various defects, a logical method of analyzing the patient's malformation, knowledge of the malformation's natural history, an understanding of the surgical alternatives, and information concerning early and late results of surgical intervention.

In these sections on congenital heart disease, relatively new or newly organized information is presented. Unfortunately, only a part of the available data can be covered.

DEFINITIONS AND CLASSIFICATION

As knowledge of congenital heart disease has increased, a variety of nomenclatures has evolved. The name applied to a malformation or situation is not important, as long as it is defined clearly. We have gradually evolved a language that is definable, employs generally accepted terms, and is surgically useful. This language will be followed in the monograph.

Situs solitus (of viscera, atria, or ventricles) is the usual or common situs, and *situs inversus* is the opposite (in a left-to-right way). A *concordant relation* between atria and ventricles is one in which the morphologically right atrium empties into the right ventricle and the left atrium into the left ventricle. In a concordant relation between

ventricles and great arteries, the right ventricle communicates directly with the pulmonary artery and the left ventricle with the aorta. A *discordant relation* between atria and ventricles means that the right atrium ejects into the left ventricle and the left atrium into the right ventricle. A discordant relation between ventricles and great arteries means that the right ventricle ejects into the aorta and the left ventricle into the pulmonary artery. There is an impurity here, so to speak, because the ventriculoarterial relation is termed concordant if these criteria are met, even though the ventricles are in situs solitus (right ventricle to right, and left ventricle to left) and the aorta is to the left. Therefore, an additional description of the positional interrelations of the great arteries to each other is required. When the aorta is to the right of the pulmonary artery, it is said to be in d-position; when it is to the left, it is in l-position.

A great artery is assigned to a ventricle if more than 50 percent of the area of the artery's semilunar valve communicates directly with the ventricle. When a defect in the ventricular septum is under a semilunar valve, the observer must project the plane of the septum across the defect to the semilunar valve to determine the amount of the valve area over each ventricle. Since this maneuver is somewhat imprecise, we have arbitrarily excluded assigning the vessel exactly 50 percent to each ventricle, and have thereby avoided a series of classifications in which a great artery arises equally from each ventricle.

The *right atrium* contains the crista terminalis, the fossa ovalis, and usually a characteristically broad and short atrial appendage. The *left atrium* has a longer and differently formed atrial appendage. The interior of the *right* (anterior) *ventricle* has large, coarse trabeculae crossed by finer and smaller trabeculae on the free wall. A heavy muscular parietal band sweeps forward to the anterior ventricular wall. The *left* (posterior) *ventricular sinus* is characterized by numerous small, fine, oblique trabeculae along the free wall and over the inferior two-thirds of the septal wall. There is no parietal band. Generally, when with situs solitus of viscera and atria there is a discordant atrioventricular relation, the right (anterior) ventricle is to the left, and the left (posterior) ventricle is to the right.

No classification of congenital heart disease can be entirely pure, and it is not surprising that different disciplines prefer different classifications. Agreement on classifications is not important, but clear definition—especially of the complex malformations—is important. No necessary embryologic order is implied in the classification. Indeed, an entity such as double-outlet left ventricle probably has subtypes arising from different embryologic abnormalities.

The surgical classification of congenital heart disease that we have found useful is given in Table 1–1. Concordance or discordance of atria and ventricles constitutes the basic subdivision. The next subdivision is based on the relation between ventricles and great arteries.

Table 1–1
Surgical Classification of Congenital Heart Disease* †

- Concordant atrioventricular relation
  - Concordant ventriculoarterial relation
    - d-position of aorta (normal)
    - l-position of aorta (anatomically corrected malposition of the great arteries)
  - Discordant ventriculoarterial relation (transposition of great arteries)
  - Double-outlet right ventricle
    - d-position of aorta
    - l-position of aorta
  - Double-outlet left ventricle
    - d-position of aorta
    - l-position of aorta
  - Common arterial trunk
    - d-position of aorta
      - Truncus arteriosus types I, II, III
      - Pseudotruncus arteriosus
      - Nonconfluent right and left pulmonary arteries
      - Absence of main right and left pulmonary arteries (truncus arteriosus type IV)
- Discordant atrioventricular relation
  - Concordant ventriculoarterial relation (isolated ventricular inversion; isolated atrial inversion)
    - l-position of aorta
    - d-position of aorta
  - Discordant ventriculoarterial relation (corrected transposition of the great arteries)
  - Double-outlet right ventricle
    - l-position of aorta
    - d-position of aorta
  - Double-outlet left ventricle
  - Common arterial trunk
- Common Atrium
- Single ventricle
- Cor biloculare, etc.

* The heart may be in levoposition or dextroversion (or their analogues in situs inversus of the viscera).

† These may occur with situs solitus of viscera (and usually the atria) or situs inversus.

When *both* atrioventricular and ventriculoarterial relations are concordant or discordant, the pulmonary and systemic circulations are in series and need not be rearranged as part of a repair. However, when *one* of the relations is discordant, the circulations are in parallel and must be surgically rearranged to be in series. When the malformation has a double-outlet ventricle or a common (single) arterial trunk, an intraventricular or valved external conduit or both are usually required in repair. The aorta tends to be on the side of the morphologic right (sometimes called the anterior) ventricle, but this is not always so. Thus a third subdivision is into d- and l-positions of the aorta (aorta to the right or to the left of the pulmonary artery).

The heart's position (levocardia or dextroversion) is a factor that influences the surgeon's approach, but the position is not a basic part of the malformation. Pulmonary artery stenosis may accompany any of the basic malformations.

Table 1–2
Defects in Patients with Concordant Atrioventricular and Ventriculoarterial Relations and D-Position of Aorta*

Simple intracardiac defects (with left-to-right shunts)
Atrial septal defect
Ventricular septal defect
Common atrioventricular canal
Partial
Complete
Common atrium
Ruptured aneurysm sinus of Valsalva
Aortopulmonary window
Anomalous origin right pulmonary artery from aorta
Patent ductus arteriosus
Anomalous pulmonary venous connection
Partial
Total
Tetralogy of Fallot
Pulmonary stenosis with essentially intact ventricular septum
Aortic stenosis
Tricuspid atresia
Congenital anomalies of mitral valve
Coarctation of aorta
Aortic arch interruption
Vascular rings

* Or analogue in situs inversus of abdominal viscera and atria.