

86683

BEHRMAN'S

Neonatal-perinatal medicine

DISEASES OF THE FETUS AND INFANT

EDITED BY

AVROY A. FANAROFF

M.B., F.R.C.P. (Edinburgh), D.C.H.

Professor of Pediatrics, Case Western Reserve University School of Medicine, University Hospitals (Rainbow Babies and Childrens Hospital), Cleveland, Ohio

RICHARD J. MARTIN

M.B., F.R.A.C.P., F.R.C.P. (Canada)

Assistant Professor of Pediatrics, Case Western Reserve University School of Medicine, University Hospitals (Rainbow Babies and Childrens Hospital), Cleveland, Ohio

ASSOCIATE EDITOR

IRWIN R. MERKATZ, M.D.

Professor and Chairman, Department of Obstetrics and Gynecology, Albert Einstein College of Medicine, New York, New York

THIRD EDITION

with 642 illustrations

The C. V. Mosby Company

ST. LOUIS • TORONTO • LONDON 1983



A TRADITION OF PUBLISHING EXCELLENCE

Editor: Karen Berger
Assistant editor: Theresa Van Schaik
Manuscript editors: Marjorie L. Sanson, Susan K. Hume
Book design: Jeanne Bush
Production: Carol O'Leary, Judy England, Jeanne A. Gullledge

THIRD EDITION

Copyright © 1983 by The C.V. Mosby Company

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission from the publisher.

Previous editions copyrighted 1973, 1977

Printed in the United States of America

The C.V. Mosby Company
11830 Westline Industrial Drive, St. Louis, Missouri 63141

Library of Congress Cataloging in Publication Data

Main entry under title:

Behrman's Neonatal-perinatal medicine.

Rev. ed. of: Neonatal-perinatal medicine /
edited by Richard E. Behrman. 2nd ed. 1977.

Includes bibliographies and index.

1. Infants (Newborn)—Diseases. 2. Fetus—
Diseases. I. Behrman, Richard E., 1931-
II. Fanaroff, Avroy A. III. Martin, Richard J.
IV. Neonatal-perinatal medicine. [DNLM: 1. Fetal
diseases. 2. Infant, Newborn, Diseases. WS
420 N439]

RJ254.B453 1983 618.92'01 82-6371
ISBN 0-8016-0580-6 AACR2

TS/CB/B 9 8 7 6 5 4 3 2 1 01/C/009

Contributors

GARY M. AMUNDSON, M.D.

Assistant Professor, Alberta Children's Hospital, University of Calgary, Department of Pediatrics, Calgary, Alberta, Canada

THOMAS L. ANDERSON, M.D.

Assistant Professor of Pediatrics, Department of Pediatrics, University of South Alabama College of Medicine, Mobile, Alabama

JACOB V. ARANDA, M.D., Ph.D.

Associate Professor, Pediatrics, Pharmacology and Therapeutics; Director of Developmental Pharmacology and Perinatal Research Unit, McGill University, Montreal Children's Hospital, Montreal, Quebec, Canada

TOM P. BARDEN, M.D.

Professor and Chairman, Department of Obstetrics and Gynecology, University of Cincinnati, Cincinnati, Ohio

RICHARD E. BEHRMAN, M.D.

Professor, Department of Pediatrics, and Dean, Case Western Reserve University School of Medicine, Cleveland, Ohio

KURT BENIRSCHKE, M.D.

Professor of Pathology and Reproductive Medicine, Pathology Department and Reproductive Medicine Department, University of California, San Diego; Director of Research, San Diego Zoo, La Jolla, California

JAY BERNSTEIN, M.D.

Director, Department of Anatomic Pathology, William Beaumont Hospital, Royal Oak, Michigan

THOMAS A. BLUMENFELD, M.D.

Director of Medical Affairs and Associate Professor of Clinical Pathology, Presbyterian Hospital, Columbia University College of Physicians and Surgeons, New York, New York

JEFFREY L. BLUMER, Ph.D., M.D.

Assistant Professor, Departments of Pediatrics and Pharmacology, Case Western Reserve University School of Medicine, Cleveland, Ohio

ALFRED W. BRANN, Jr., M.D.

Professor, Departments of Pediatrics and Gynecology/Obstetrics, Emory University, Atlanta, Georgia

PATRICK J. BRYAN, M.B., F.R.C.R.

Associate Professor of Radiology, Case Western Reserve University, Cleveland, Ohio

LUIS A. CABAL, M.D.

Assistant Professor of Pediatrics, University of Southern California School of Medicine; Director of Newborn Intensive Care Unit, Los Angeles, California

DEBORAH L. CALLANAN, M.D.

Pediatric Intensive Care Fellow and Resident, Baylor College of Medicine, Houston, Texas

ROBERT K. DANISH, M.D.

Assistant Professor of Pediatrics, Case Western Reserve University School of Medicine; Pediatric Endocrinologist, Cleveland Metropolitan General Hospital, Cleveland, Ohio

HAROLD M. DICK, M.D.

Clinical Professor of Orthopaedic Surgery, Department of Orthopaedics, Columbia University College of Physicians and Surgeons; Chief of Pediatric Orthopaedic Surgery, Babies Hospital, Columbia-Presbyterian Medical Center, New York, New York

LEROY J. DIERKER, M.D.

Assistant Professor, Department of Obstetrics and Gynecology, Cleveland Metropolitan General Hospital, Case Western Reserve University, Cleveland, Ohio

JOHN M. DRISCOLL, Jr., M.D.

Associate Professor of Clinical Pediatrics; Director of Neonatal ICU, Premature and Normal Nurseries, Department of Pediatrics, Columbia University College of Physicians and Surgeons, New York, New York

METHOD A. DUCHON, M.D.

Assistant Professor, Department of Reproductive Biology, Case Western Reserve University, Cleveland, Ohio

CHESTER M. EDELMANN, Jr., M.D.

Professor of Pediatrics and Associate Dean for Clinical Affairs, Albert Einstein College of Medicine; Attending Pediatrician, Bronx Municipal Hospital Center, Montefiore Hospital Medical Center, and Hospital of the Albert Einstein College of Medicine, Bronx, New York

NANCY B. ESTERLY, M.D.

Head, Division of Dermatology, Department of Pediatrics, The Children's Memorial Hospital; Professor of Pediatrics and Dermatology, Northwestern University Medical School, Chicago, Illinois

AVROY A. FANAROFF, M.B., F.R.C.P. (Edinburgh), D.C.H.

Professor of Pediatrics, Case Western Reserve University School of Medicine, University Hospitals (Rainbow Babies and Childrens Hospital), Cleveland, Ohio

PHILIP M. FARRELL, M.D., Ph.D.

Professor, Department of Pediatrics, University of Wisconsin Center for Health Sciences, Madison, Wisconsin

RALPH D. FEIGIN, M.D.

J.S. Abercrombie Professor and Chairman, Department of Pediatrics, Baylor College of Medicine; Physician-in-Chief, Texas Children's Hospital; Physician-in-Chief, Pediatric Service, Harris County Hospital District; Chief, Pediatric Service, The Methodist Hospital, Houston, Texas

BARRY D. FLETCHER, M.D., C.M.

Professor of Radiology, Case Western Reserve University; Director, Division of Pediatric Radiology, Rainbow Babies and Childrens Hospital, University Hospitals, Cleveland, Ohio

WILLIAM W. FOX, M.D.

Associate Professor of Pediatrics, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania

ROGER K. FREEMAN, M.D.

Medical Director, Women's Hospital, Memorial Hospital Medical Center of Long Beach; Professor, Obstetrics and Gynecology, University of California at Irvine, Orange, California

LAWRENCE M. GARTNER, M.D.

Professor and Chairman, Department of Pediatrics, Pritzker School of Medicine, University of Chicago; Director, Wyler Children's Hospital, Chicago, Illinois

†LOWELL A. GLASGOW, M.D.

Professor and Chairman, Department of Pediatrics, University of Utah School of Medicine; Medical Director, Primary Children's Medical Center, Salt Lake City, Utah

MORTON F. GOLDBERG, M.D.

Professor and Head, Department of Ophthalmology, University of Illinois, Chicago, Illinois

ELIZABETH M. GORDON, M.D.

Assistant Clinical Professor of Pediatrics, Case Western Reserve University School of Medicine, Cleveland, Ohio

JUDITH GIBBS, M.D., C.M.

Director of Neonatology, Allentown Hospital, Allentown, Pennsylvania

STANLEY N. GRAVEN, M.D.

Professor, Department of Child Health; Director of International Health, University of Missouri School of Medicine, Columbia, Missouri

SAMUEL GROSS, M.D.

Professor of Pediatrics, University of Florida, College of Medicine, Gainesville, Florida

MICHAEL T. GYVES, M.D.

Assistant Professor, Department of Reproductive Biology, Case Western Reserve University, Cleveland, Ohio

MAUREEN HACK, M.B., Ch.B.

Associate Professor, Department of Pediatrics; Director of High Risk Follow-up Program, Case Western Reserve University, Cleveland, Ohio

BARBARA F. HALES, Ph.D.

Assistant Professor, Department of Pharmacology and Therapeutics, McGill University, Montreal, Quebec, Canada

WILLIAM C. HEIRD, M.D.

Associate Professor of Pediatrics, Columbia University College of Physicians and Surgeons, New York, New York

ROGER H. HERTZ, M.D.

Associate professor, Department of Obstetrics and Gynecology, Cleveland Metropolitan General Hospital, Case Western Reserve University, Cleveland, Ohio

†Deceased.

JOAN E. HODGMAN, M.D.

Professor of Pediatrics, University of Southern California School of Medicine; Director, Newborn Division, Los Angeles County, University of Southern California Medical Center, Los Angeles, California

L. STANLEY JAMES, M.D.

Professor of Pediatrics and Obstetrics and Gynecology; Director, Division of Perinatology, Department of Pediatrics, Columbia University College of Physicians and Surgeons, New York, New York

SHELBY E. JARRELL, M.D.

Assistant Professor of Clinical Obstetrics and Gynecology, Medical College of Virginia, Richmond, Virginia

MAJIDA N. JASSANI, M.D.

Assistant Professor of Obstetrics and Gynecology and Radiology, Case Western Reserve University, Cleveland, Ohio

JOHN KATTWINKEL, M.D.

Director, Newborn Services, and Associate Professor of Pediatrics, University of Virginia Medical Center, Charlottesville, Virginia

JOHN H. KENNEL, M.D.

Professor of Pediatrics, Case Western Reserve University, Rainbow Babies and Childrens Hospital, Cleveland, Ohio

KATHERINE C. KING, M.D.

Associate Professor of Pediatrics, Case Western Reserve University; Director, Neonatal Intensive Care Unit and Newborn Service, and Co-director, Perinatal Clinical Research Center, Cleveland Metropolitan General Hospital, Cleveland, Ohio

MARSHALL H. KLAUS, M.D.

Professor and Chairman, Department of Pediatrics and Human Development, Michigan State University, East Lansing, Michigan

ROBERT M. KLEGMAN, M.D.

Assistant Professor of Pediatrics, Case Western Reserve University, Rainbow Babies and Childrens Hospital and Cleveland Metropolitan General Hospital, Cleveland, Ohio

THADDEUS W. KURCZYNSKI, M.D. Ph.D.

Director, Genetics Center; Associate Professor of Pediatrics and Neuroscience, Department of Pediatrics, Medical College of Ohio, Toledo, Ohio

ROBERT E. LASKY, Ph.D.

Assistant Professor of Clinical Pediatrics, Department of Pediatrics, University of Texas Health Sciences Center at Dallas, Dallas, Texas

KWANG-SUN LEE, M.D.

Associate Professor of Pediatrics and Director of Newborn Services, Pritzker School of Medicine, University of Chicago, Chicago, Illinois

MARTIN H. LEES, M.D., F.R.C.P.

Professor of Pediatrics and Perinatology, Department of Pediatrics, Oregon Health Sciences University, Portland, Oregon

LAWRENCE D. LILIEN, M.D.

Attending Neonatologist, Cook County Children's Hospital; Assistant Professor of Pediatrics, Abraham Lincoln School of Medicine, University of Illinois College of Medicine, Chicago, Illinois

HENRY H. MANGURTEN, M.D.

Director, Section of Neonatology, Lutheran General Hospital, Park Ridge; Associate Professor of Clinical Pediatrics, Abraham Lincoln School of Medicine, University of Illinois College of Medicine, Chicago, Illinois

RICHARD J. MARTIN, M.B., F.R.A.C.P., F.R.C.P. (Canada)

Assistant Professor of Pediatrics, Case Western Reserve University School of Medicine, University Hospitals (Rainbow Babies and Childrens Hospital), Cleveland, Ohio

JOHN S. McDONALD, M.D.

Professor and Chairman, Department of Anesthesiology, Ohio State University College of Medicine, Columbus, Ohio

MICHAEL T. MENNUTI, M.D.

Associate Professor of Obstetrics and Gynecology, Human Genetics, and Pediatrics, Department of Obstetrics and Gynecology, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania

IRWIN R. MERKATZ, M.D.

Professor and Chairman, Department of Obstetrics and Gynecology, Albert Einstein College of Medicine, New York, New York

CHARLES H. MITCHELL, M.D.

Pediatric Gastroenterologist, Madigan Army Medical Center, Fort Lewis, Washington

RACHEL MORECKI, M.D.

Professor, Department of Pathology, Albert Einstein College of Medicine, Bronx, New York

AKIRA MORISHIMA, M.D., Ph.D.

Associate Professor and Director, Division of Pediatric Endocrinology, Department of Pediatrics, Columbia University College of Physicians and Surgeons, New York, New York

JEFFREY P. MORRAY, M.D.

Assistant Professor of Anesthesiology, University of Washington School of Medicine, Seattle, Washington

MARTIN A. NASH, M.D.

Associate Professor and Clinical Pediatrics, Columbia University College of Physicians and Surgeons; Director of Pediatric Nephrology, Babies Hospital, Columbia-Presbyterian Medical Center, New York, New York

MICHAEL R. NEUMAN, Ph.D., M.D.

Associate Professor of Biomedical Engineering in Reproductive Biology, Department of Reproductive Biology and Perinatal Clinical Research Center, Case Western Reserve University, Cleveland, Ohio

JOHN F. NICHOLSON, M.D.

Associate Professor of Pediatrics and Pathology, Columbia University College of Physicians and Surgeons; Director of Children's Diabetic Clinic; Director of Clinical Chemistry Service; Associate Attending Physician in Pediatrics, Columbia-Presbyterian Hospital and Medical Center, New York, New York

EMI OKAMOTO, M.D.

Assistant Professor of Pediatrics, Columbia University College of Physicians and Surgeons, New York, New York

JAMES C. OVERALL, Jr., M.D.

Professor of Pediatrics and Pathology; Chief, Pediatric Infectious Diseases; Director, Diagnostic Virology Laboratory, University of Utah School of Medicine, Salt Lake City, Utah

ROBERT H. PERELMAN, M.D.

Assistant Professor, Department of Pediatrics, University of Wisconsin Center for Health Sciences, Madison, Wisconsin

PAUL H. PERLSTEIN, M.D.

Professor of Pediatrics, Obstetrics and Gynecology, University of Cincinnati College of Medicine and Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio

ROSITA S. PILDES, M.D.

Chairman, Division of Neonatology, Cook County Children's Hospital; Professor of Pediatrics, Abraham Lincoln School of Medicine, University of Illinois College of Medicine, Chicago, Illinois

ROY M. PITKIN, M.D.

Professor and Chairman, Department of Obstetrics and Gynecology, University of Iowa, College of Medicine, Iowa City, Iowa

WILLIAM B. PITTARD III, M.D.

Assistant Professor of Pediatrics, Case Western Reserve University School of Medicine, Cleveland, Ohio

RICHARD A. POLIN, M.D.

Associate Professor of Pediatrics, University of Pennsylvania, Philadelphia, Pennsylvania

STEPHEN H. POLMAR, Ph.D., M.D.

Professor of Pediatrics, Washington University School of Medicine; Director, Division of Allergy and Immunology, St. Louis Children's Hospital, St. Louis, Missouri

JOHN T. QUEENAN, M.D.

Professor and Chairman, Department of Obstetrics and Gynecology, Georgetown University School of Medicine, Washington, D.C.

JOHN E. READ, M.D.

Clinical Associate Professor, Department of Ophthalmology, University of Illinois, Chicago, Illinois

TOVE S. ROSEN, M.D.

Assistant Professor of Pediatrics, Columbia University College of Physicians and Surgeons, New York, New York

THOMAS V. SANTULLI, M.D.

Professor of Surgery, Columbia University College of Physicians and Surgeons; Attending Surgeon, Columbia-Presbyterian Medical Center, New York, New York

JAMES F. SCHWARTZ, M.D.

Professor, Departments of Pediatrics and Neurology, Emory University, Atlanta, Georgia

THOMAS H. SHAFFER, Ph.D.

Associate Professor of Physiology, Temple University School of Medicine, Philadelphia, Pennsylvania

SUSAN B. SHURIN, M.D.

Assistant Professor of Pediatrics, Case Western Reserve University School of Medicine, Cleveland, Ohio

BIJAN SIASSI, M.D.

Associate Professor of Pediatrics, University of Southern California, School of Medicine, Los Angeles, California

FRANK R. SINATRA, M.D.

Assistant Professor of Pediatrics and Director of Pediatric Gastroenterology Program, University of Southern California School of Medicine, Children's Hospital of Los Angeles, Los Angeles, California

JOHN C. SINCLAIR, M.D.

Professor, Departments of Pediatrics and Clinical Epidemiology and Biostatistics, McMaster University, Hamilton, Ontario, Canada

MARY ELLEN L. SKALINA, M.D.

Staff Neonatologist, Cooper Medical Centre; Assistant Clinical Professor, University of Medicine and Dentistry, Rutgers Medical School, Camden, New Jersey

LAWRENCE M. SOLOMON, M.D.

Professor and Head, Department of Dermatology, University of Illinois, Chicago, Illinois

RICARDO U. SORENSEN, M.D.

Associate Professor of Pediatrics, Case Western Reserve University, Cleveland, Ohio

ADRIAN SPITZER, M.D.

Professor of Pediatrics and Director of Division of Nephrology, Department of Pediatrics, Albert Einstein College of Medicine; Attending Pediatrician, The Hospital of the Albert Einstein College of Medicine and Montefiore Hospital Medical Center, Bronx, New York

JEAN J. STEICHEN, M.D.

Associate Professor of Pediatrics, Obstetrics and Gynecology, Department of Newborn Pediatrics, University of Cincinnati College of Medicine, Cincinnati, Ohio

CECILLE O. SUNDERLAND, M.D.

Professor of Pediatrics, Oregon Health Sciences University, Portland, Oregon

PHILIP SUNSHINE, M.D.

Professor of Pediatrics, Stanford University Medical Center, Palo Alto, California

REGINALD C. TSANG, M.B.B.S.

Professor of Pediatrics, Obstetrics and Gynecology, Department of Newborn Pediatrics, University of Cincinnati College of Medicine, Cincinnati, Ohio

**DAVID TUDEHOPE, M.B.B.S. (Monash),
M.R.A.C.P., F.R.A.C.P.**

Director of Neonatology, Mater Mothers Hospital, South Brisbane, Queensland, Australia

JON E. TYSON, M.D.

Assistant Professor of Pediatrics and Obstetrics and Gynecology, Department of Pediatrics, University of Texas Health Science Center at Dallas, Dallas, Texas

BARRY S. YULISH, M.D.

Assistant Professor of Radiology, Division of Pediatric Radiology, Case Western Reserve University School of Medicine, Rainbow Babies and Childrens Hospital, University Hospitals, Cleveland, Ohio

FREDERICK P. ZUSPAN, M.D.

Professor and Chairman, Department of Obstetrics and Gynecology, The Ohio State University, Columbus, Ohio

Preface

The goal of this third edition of *Neonatal-Perinatal Medicine* is to present a comprehensive description of the disorders that affect the fetus and neonatal infant. The emphasis remains on the pathophysiology, clinical and laboratory manifestations, and prevention and treatment of diseases that have their onset in utero or during the neonatal period. We hope that this text will provide obstetricians, pediatricians, family physicians, and nurses with a basis for understanding and managing a broad spectrum of clinical problems, as well as provide them with an overall perspective about a field in which there continues to be a rapid acceleration of knowledge and technology.

Recognizing the increasing problems related to administration of neonatal intensive care units, as well as the critical educational roles of tertiary centers, we have

addressed these issues in this edition. Furthermore, pharmacologic principles related to the fetus and newborn have been introduced, and expanded knowledge concerning the sensorimotor development of preterm infants has been included. Many new authors have been solicited in an attempt to update, revise, and more graphically present all sections.

We gratefully acknowledge the sterling efforts of our many contributors, Karen Berger, Terry Van Schaik, and Marjorie Sanson at Mosby, as well as Connie McSweeney and Ellen Rome, without whose valuable assistance this book could not have been completed.

**Avroy A. Fanaroff
Richard J. Martin
Richard E. Behrman**

Contents

- 1 The field of neonatal-perinatal medicine, 1
Richard E. Behrman
- 2 Organization of nursery services, 4
PART ONE The organization of perinatal health services, 4
Stanley N. Graven
Avroy A. Fanaroff
PART TWO Perinatal outreach education, 11
John Kattwinkel
PART THREE Stress and the performance of the intensive care unit staff, 15
Jon E. Tyson
Robert E. Lasky
- 3 Diabetes in pregnancy, 22
Method A. Duchon
Michael T. Gyves
Irwin R. Merkatz
- 4 Preeclampsia-eclampsia (pregnancy-induced hypertension), 27
Frederick P. Zuspan
- 5 Erythroblastosis fetalis, 34
John T. Queenan
- 6 Polyhydramnios and oligohydramnios, 44
John T. Queenan
- 7 Intrauterine growth retardation: determinants of aberrant fetal growth, 49
Robert M. Kliegman
Katherine C. King

- 8 Antenatal ultrasound, 81
Patrick J. Bryan
Majida N. Jassani
- 9 Estimation of the placental function and reserve, 95
PART ONE Fetal heart rate monitoring, 95
Roger K. Freeman
PART TWO Antepartum fetal assessment, 107
Leroy J. Dierker
Roger H. Hertz
PART THREE Intrapartum fetal assessment, 112
Roger H. Hertz
Shelby E. Jarrell
- 10 Neonatal clinical cardiopulmonary monitoring, 119
Luis A. Cabal
Bijan Slassi
Joan E. Hodgman
- 11 Obstetric management of prematurity, 133
PART ONE Estimation of fetal maturity, 133
Roy M. Pitkin
PART TWO Premature labor, 139
Tom P. Barden
- 12 Developmental pharmacology, 150
Jacob V. Aranda
Barbara F. Hales
Judith Gibbs
- 13 Anesthesia for labor and delivery, 174
John S. McDonald

- 14 Emergencies in the delivery room, 179
L. Stanley James
- 15 Birth weight, gestational age, and neonatal risk, 196
John C. Sinclair
David I. Tudehope
- 16 Placental pathology, 206
Kurt Benirschke
- 17 Birth injuries, 216
Henry H. Mangurten
- 18 Care of the mother, father, and infant, 240
Marshall H. Klaus
John H. Kennell
- 19 Routine and special care, 254
PART ONE Physical examination, 254
John M. Driscoll, Jr.
PART TWO Physical environment, 259
Paul H. Perlstein
PART THREE Biomedical engineering aspects of neonatal monitoring, 277
Michael R. Neuman
PART FOUR Care of the newborn, 289
John M. Driscoll, Jr.
- 20 Nutrition, body fluids, and acid-base homeostasis, 302
PART ONE Nutritional requirements of the low birth weight infant, 302
William C. Heird
Emi Okamoto
Thomas L. Anderson
PART TWO Methods of nutrient delivery for the low birth weight infant, 308
William C. Heird
Thomas L. Anderson
PART THREE Provision of water and electrolytes, 314
Martin A. Nash
PART FOUR Disturbances of acid-base equilibrium, 320
William C. Heird
- 21 The sensorimotor development of the preterm infant, 328
Maureen Hack
- 22 Central nervous system disturbances, 347
Alfred W. Brann, Jr.
James F. Schwartz
- 23 The respiratory system, 404
PART ONE The developmental biology of the lung, 404
Philip M. Farrell
Robert H. Perelman
PART TWO Assessment of pulmonary function, 419
William W. Fox
Thomas H. Shaffer
PART THREE The respiratory distress syndrome and its management, 427
Richard J. Martin
Avroy A. Fanaroff
Mary Ellen L. Skalina
PART FOUR Other pulmonary problems, 443
Avroy A. Fanaroff
Richard J. Martin
PART FIVE Chronic pulmonary diseases of the neonate, 467
William W. Fox
Jeffrey P. Morray
Richard J. Martin
- 24 The gastrointestinal system, 477
PART ONE Development, 477
Philip Sunshine
Frank R. Sinatra
Charles H. Mitchell
Thomas V. Santulli
PART TWO Gastrointestinal emergencies, 483
Philip Sunshine
Frank R. Sinatra
Charles H. Mitchell
Thomas V. Santulli
PART THREE Gastrointestinal disorders, 490
Philip Sunshine
Frank R. Sinatra
Charles H. Mitchell
Thomas V. Santulli
- 25 The cardiovascular system, 536
Martin H. Lees
Cecille O. Sunderland
- 26 Immunology, 632
Stephen H. Polmar
Ricardo U. Sorenson
William B. Pittard III

- 27** Postnatally acquired infections, 650
Ralph D. Feigin
Deborah L. Callanan
- 28** Viral and protozoal perinatal infections, 692
Lowell A. Glasgow
James C. Overall, Jr.
- 29** The blood and hematopoietic system, 708
Samuel Gross
Susan B. Shurin
Elizabeth M. Gordon
- 30** Jaundice and liver disease, 753
PART ONE Unconjugated hyperbilirubinemia, 754
Lawrence M. Gartner
Kwang-Sun Lee
PART TWO Conjugated hyperbilirubinemia, 771
Rachel Morecki
Lawrence M. Gartner
Kwang-Sun Lee
- 31** The kidney and urinary tract, 785
Adrian Spitzer
Jay Bernstein
Chester M. Edelmann, Jr.
- 32** Inborn errors of metabolism, 815
John F. Nicholson
- 33** Metabolic and endocrine disorders, 845
PART ONE Carbohydrate metabolism in the fetus and neonate, 845
Rosita S. Pildes
Lawrence D. Lillen
PART TWO Disorders of calcium and magnesium metabolism, 870
Reginald C. Tsang
Jean J. Steichen
PART THREE Thyroid disorders, 883
Akira Morishima
PART FOUR Abnormalities of sexual differentiation, 900
Robert K. Danish
PART FIVE Infants of addicted mothers, 933
Tove S. Rosen
- 34** The skin, 939
Nancy B. Esterly
Lawrence M. Solomon
- 35** The eye, 967
John E. Read
Morton F. Goldberg
- 36** Orthopedic problems, 1004
Harold M. Dick
- 37** Genetic disease and chromosomal abnormalities, 1013
Richard A. Polin
Michael T. Mennuti
- 38** Congenital malformations, 1035
Thaddeus W. Kurczynski
- 39** Diagnostic radiology, 1064
Barry D. Fletcher
Barry S. Yulish
Gary M. Amundson
- Appendix A** Blood specimen collection in the newborn, 1089
Thomas A. Blumenfeld
- B** Therapeutic agents, 1092
Jeffrey L. Blumer
Thomas A. Blumenfeld
- C** Tables of normal values, 1098
Thomas A. Blumenfeld

CHAPTER 1

The field of neonatal-perinatal medicine

The term *perinatal* is used to designate the period from the twelfth week of gestation through the twenty-eighth day after birth. The *neonatal period* is defined as the first 4 weeks of life and is the period of the greatest mortality in childhood, with the highest risk occurring during the first 24 hours of life. The continuing high mortality and morbidity during this period are closely related to the fact that it is part of a continuum of fetal growth and development. Factors acting during gestation and delivery, as well as during the postnatal period, have a major impact on the health of both the fetus and neonate. Social, economic, and cultural influences are superimposed on genetic, metabolic, and physiologic intrauterine and extrauterine environmental effects.

The high incidence of disease during the perinatal period and the excessive neonatal and perinatal death rates make it important to identify as early as possible those fetuses and infants who are at greatest risk. Of equal importance is the need to lower the morbidity, especially for handicapping conditions such as mental retardation, resulting from untoward prenatal and neonatal factors. Our development as a species ultimately depends on the quality of the babies who are produced and their potential talents. There is increasing evidence that early recognition of the high-risk pregnancy and high-risk infant and appropriate antenatal and intrapartum management along with special neonatal intensive care will reduce the incidence of handicapping conditions and will reduce both the perinatal and neonatal death rates (p. 5).

Despite changes in population growth, little change has occurred in the incidence of infants of low birth weight (defined as infants weighing less than 2,500 gm) in the United States. It has remained at a mean rate of about 8% of total births with a range of 6% to 16+ % for decades. The lower figure is usually approached by mid-

dle to upper income communities, and the higher figure is approached in urban ghettos and deprived rural communities. The latter figure is probably underestimated, since a number of babies born to the poor may not be included in the statistics. Of the 250,000 low birth weight babies born each year, in the United States, 40,000 to 45,000 die within the first month of life, and about as many term fetuses die each year in utero. This represents a substantial improvement in survival over past decades in all weight classes, but especially for infants weighing from 1,000 to 2,000 gm. Improvement in survival has also occurred in infants under 1,000 gm.

A number of infants will live a long life but remain significantly afflicted with disease or disability. The infants of very low birth weight are particularly vulnerable. Those who die are a source of anguish and grief to their parents and relatives for a varying but relatively brief period, whereas those who survive with disabilities and disease may be a continuing source of pain, anguish, and loss of resources for their parents and society, in addition to the personal suffering they may endure. They may also impose a very real biologic burden on future generations. Tragically, there are at least three times as many of these unfortunate infants in the black portion of the population in the United States. It has been estimated that about 60,000 of the 250,000 low birth weight babies born each year may be at high risk for serious lifetime disability. In addition to the human tragedy, the fiscal impact of this problem on our society is estimated to be in the billions of dollars each year. The major problems of cerebral palsy, mental retardation, sensory and cognitive disabilities, and a diminished ability to successfully adapt socially, psychologically, and physically to an increasingly complex environment are some of the results observed in children and adults who were low birth weight infants.

Table 1-1. Fetal organ blood flows (percent of the cardiac output \pm SD)

	Brain	Heart	Lungs	Kidneys	Adrenal glands	Placenta
Control	15.7 \pm 2.8	2.7 \pm 0.9	10.7 \pm 6.4	2.7 \pm 1.0	0.4 \pm 0.1	47.5 \pm 4.9
Fetal distress	30.6 \pm 11.3	4.9 \pm 1.5	3.2 \pm 2.4	1.9 \pm 1.4	0.8 \pm 0.5	29.2 \pm 9.4
Statistical significance	$p < 0.01$	$p < 0.02$	$p < 0.05$	NS*	$p < 0.05$	$p < 0.005$

Adapted from Behrman, R. E., and others: Am. J. Obstet. Gynecol. 108:956, 1970.

*NS, Not significant. Mean values \pm 1 SD are presented.

In addition to these population and societal dimensions of the field of neonatal-perinatal medicine, it is becoming increasingly evident that important antecedents of many adult diseases, such as coronary artery disease, chronic renal and liver disease, obesity, and other human maladies, may be present in early development, at which stage there is real opportunity for prevention. Further improvement in longevity and decreased morbidity are likely to result from increased understanding of the origins of adult diseases in fetal life and infancy and the prevention and early management of these diseases.

More immediate clinical by-products are likely to result from the continuing expansion of our understanding of and ability to measure fetal physiologic and biochemical homeostasis. As our appreciation of the mechanics controlling the protective circulatory adjustments of the fetus to the stress of hypoxia continues to increase along with our understanding of fetal pharmacology, we are likely to develop new means not only to detect but also to medically treat the fetus before and during labor. In 1960 our ability to detect *fetal asphyxia* consisted of clinical auscultation of the fetal heart rate during labor and observation of the amniotic fluid for meconium staining when the membranes ruptured. We now know the sequence of events in the fetus that occurs in response to maternal hypotension, or hypoxia. The heart rate and blood pressure initially increase; then with the rapid onset of fetal bradycardia and hypotension the fetus develops a mixed metabolic and "placental" respiratory acidosis. The cardiac output and umbilical blood flow decrease sharply. A greater portion of the oxygenated umbilical vein blood is shunted past the liver into the inferior vena cava and returned to the heart. The cardiac output to the brain, heart, and adrenals is preferentially maintained so that tissue perfusion of these organs does not decrease significantly (Table 1-1). In contrast, the fetal lungs and cortex of the kidneys have a decreased perfusion. The oxygen consumption of the fetus decreases by over 50%. When this sequence of events becomes far enough advanced in the Rhesus monkey, baboon, and probably in the human, the problem is detectable by continuous monitoring of the fetal heart rate and uterine pressure curves; characteristic high-risk

patterns such as those for cord occlusion or placental insufficiency can be identified (p. 101). Nevertheless, the treatments for fetal asphyxia currently available are limited to surgical intervention, oxygen, or position changes. Monitoring of fetal transcutaneous oxygen and carbon dioxide tensions provides us with more sensitive tools to detect early fetal hypoxia, and improved understanding of the hormonal and neural regulation of the patterns of fetal pathophysiologic response may broaden our pharmacologic approach to treatment before birth. Our ability to diagnose and/or treat some diseases before birth, such as erythroblastosis, respiratory distress syndrome (hyaline membrane disease), and a large number of genetic defects, has changed dramatically in recent years.

Research on the pregnant sheep and nonhuman primate is likely to continue to produce important models for the human but the focus of investigation has changed from systems and organs to the cellular level of development. We have progressed from simple determinations of whether a substance crosses the placenta, and the characterization of placental permeability by the molecular weights of the solutes transferred and the anatomic description of the placenta, to an appreciation of the interactions of the lipid membrane transport systems of the placenta, the kinetics of maternal uterine and fetal umbilical blood flows, and the protein binding of solutes and gases in these two circulations. This has laid the groundwork for developing a real pharmacology for the uterus, placenta, and fetus, which may be critical to our understanding the control of labor and thus, eventually, to our ability to decrease the incidence of low birth weight or premature infants. Prenatal diagnosis and biochemical and ultrasonic fetal monitoring may be the first steps to future treatments that may include hybridization of cells in the early blastocyst or embryo to correct inborn errors of metabolism, the stimulation of embryogenesis of organs, and the acceleration of organ maturation. The latter has already proved to be effective in the prevention of respiratory distress syndrome by treating mothers of selected third trimester fetuses with betamethasone (Chapter 23).

Finally, advances in the field of neonatal-perinatal medicine have focused attention on a number of ethical

and legal issues. There is mounting concern about life and death decision making in neonatal intensive care units. New and complex physician-patient-family-nursing staff-societal relationships exist in these units, and this development has had an enormous impact on the process of making medical decisions. Regionalization has brought these issues into a sharper and more demanding focus. Criteria have to be formulated for making certain decisions that previously were made on a chance basis of access to the health system, which was strongly influenced by the economic position of a family. For example, should a 750-gm infant with a poor prognosis for intact survival be accepted in a regional neonatal intensive care unit when it means one cannot accept a 2,000-gm infant who is at high risk but has a good prognosis if he or she survives, just because the referring physician in the case of the 750-gm infant calls first or because the infant is born in the same hospital where the intensive care unit is located? The nature of the evolving customs or prelegal restraints differ in some important respects from those impinging on the traditional physician-patient relationship outside neonatal intensive care centers. Participation in discussions antecedent to decision making involves a diversity of people, the discussions are more explicitly informative, and the demands on the physician's ability to perceive what is meant from what is said are more exacting. Ironically, but not surprisingly, as the technology of care increases in these units, the difficult choices for the physician are not the technical medical decisions, but matters of judgment that require evaluating, analyzing, and interpreting the complex human interests and concerns of the relatives, their friends and advisors, and the staff, and the various consequences for the people involved. These have always been the most challenging and demanding decisions for physicians that cannot be delegated to others. The new elements are the frequency and complexity of these judgments in regional neonatal intensive care centers.

Whatever decision-making process is used to improve the quality of care provided to the individual patient,

certain principles are important, but often not easy to apply. The fundamental responsibility of all who are concerned is to do no harm or, at least, no harm without a reasonable expectation of a compensating benefit for the patient. A corollary principle is that there must be continuous objective, critical scientific evaluation of the care being currently provided and of proposed innovations. Activities should not be initiated or continued that on balance do harm to the well-being of a newborn infant. The definition of "well-being" is the major problem, since the varying ethical values, religious commitments, and life experiences of all those who care for and about the infant, as well as legal restraints, must be taken into consideration. In general, the elements of well-being include a life prolonged beyond infancy, without excruciating pain, and with the potential of participating in human experience to a minimal degree.

Awareness of the above diverse considerations has contributed to the impetus for further clinical specialization within pediatrics, and obstetrics and gynecology, resulting in the formation of a field of clinical medicine for the fetus and neonatal infant: neonatal-perinatal medicine. This field has already expanded to encompass the developing embryo before as well as after organ formation and older infants whose immaturity or disease process makes them best cared for in neonatal intensive care centers.

Richard E. Behrman

BIBLIOGRAPHY

- Behrman, R.E., and others: Distribution of the circulation in the normal and asphyxiated fetal perinate, *Am. J. Obstet. Gynecol.* 108:956, 1970.
- Hodgen, G.D.: Antenatal diagnosis and treatment of fetal skeletal malformations, *J.A.M.A.* 246:1079, 1981.
- Janis, A.R., and others: Critical issues in newborn intensive care: a conference report and policy proposal, *Pediatrics* 55:756, 1975.
- Report and recommendations research on the fetus, The National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, Department of Health, Education, and Welfare Pub. No. (OS) 76-127, 1975.

Organization of nursery services

PART ONE

The organization of perinatal health services

The successful delivery of high-quality care to perinatal patients requires not only excellence from physicians, nurses, and other health professionals as individuals, but also community involvement and a mechanism or system of organization that permits them to function as cohesive and well-coordinated teams.

Regionalization implies the development, within a geographic area, of a coordinated cooperative system of maternal and perinatal health care in which, by mutual agreements between hospitals and physicians and based upon population needs, the degree of complexity of maternal and perinatal care each hospital is capable of providing is identified so as to accomplish the following objectives: quality care to all pregnant women and newborns, maximal utilization of highly trained perinatal personnel and intensive care facilities, and assurance of reasonable cost effectiveness.*

BACKGROUND AND HISTORICAL PERSPECTIVE

Before 1940, perinatal care services were delivered in the United States, Canada, and Europe without any particular organization or structure. Most of the care was provided by an individual physician or midwife. In many areas the majority of the deliveries occurred in the home. A number of maternity hospitals developed in the larger urban areas, usually serving as teaching hospitals. These

maternity hospitals often had home delivery services and neighborhood clinics serving a geographic area.

During the 1940s and early 1950s a number of cities developed centers for the care of premature infants. Most of these centers were located in urban areas. In Illinois, premature centers were located to serve the rural areas as well. In the late 1940s and 1950s many of the European countries, particularly in Scandinavia and the Netherlands, developed systems of care for the perinatal patient based on the development of primary perinatal care clinics staffed largely by midwives with district and regional hospitals for the care of mothers with complications. During the 1950s a number of states developed maternal mortality committees. These committees developed data that were used as a basis for activities directed at preventing maternal mortality.

From 1964 to 1968, studies were undertaken in Massachusetts, Wisconsin, and Arizona to analyze causes of neonatal mortality and morbidity. In Massachusetts the studies led to the development of standards and regulations for maternity units. Their implementation resulted in a decrease in the number of maternity units in Massachusetts from 102 in 1967 to 65 in 1975. In Wisconsin the studies led to the development of a statewide education-consultation program and regional newborn intensive care centers. These units subsequently evolved into regional perinatal centers. In 1967, as a result of a study of premature mortality, Arizona developed a statewide transport program for premature and other high-risk neonates. Three additional factors that promoted the movement toward the development of regional care plans were the study and report of the Joint Committee of the Society of Obstetricians and Gynaecologists of Canada and the Canadian Paediatric Society, entitled

*From Ryan, G.M.: Toward improving the outcome of pregnancy, Report of the Committee on Perinatal Health (AAFP, AAP, ACOG, AMA), 1976, Obstet. Gynecol. 46:375, 1975. Reprinted with permission from The American College of Obstetricians and Gynecologists.

"Regional Services in Reproductive Medicine"; the adoption of a statement on regionalization of perinatal care by the American Medical Association; and the report of the joint Committee on Perinatal Health of the American Medical Association, the American College of Obstetricians and Gynecologists, the American Academy of Family Physicians, and the American Academy of Pediatrics, entitled "Toward Improving the Outcome of Pregnancy." These reports, along with the data from Wisconsin, Massachusetts, and Arizona, have stimulated activities in most states toward development of regional organizations for perinatal care services. Additional impetus has been derived from the establishment of regional perinatal centers in the United States by the Robert Wood Johnson Foundation.

NEED FOR AN ORGANIZED PERINATAL CARE SYSTEM

There are marked disparities in the perinatal mortality for various nations. These disparities are particularly striking among various European nations, the United States, and Canada. There are also marked differences between states or districts within a country and between areas within the same district or state. Marked differences in perinatal mortality exist between census tracts within the same urban area. Those nations with well-organized systems for perinatal care have better perinatal mortality and morbidity statistics.

Often high fetal and neonatal mortality is attributed to socioeconomic conditions, educational deficiencies, and related social factors. In some areas, however, high perinatal mortality may exist simultaneously with very low mortality for older age groups, suggesting that the lack of adequate health care services for the pregnant woman and neonate is a major factor responsible for the high perinatal mortality.

In the studies from Massachusetts and Wisconsin, 30% to 65% of the fetal and neonatal mortalities were judged preventable. Of the preventable deaths, approximately half were judged preventable within the resources of the community hospital and its staff; the other half required the resources of a specialized regional center with team-derived resources. Studies of infants following neonatal intensive care have shown a marked reduction in the frequency of permanent neurologic sequelae. Thus the development of neonatal intensive care results not only in reduction in mortality but also in a reduction in serious morbidity. Maternal intensive care units and high-risk obstetric programs decrease fetal mortality and also reduce the frequency of neonatal problems requiring intensive care. The decrease in the number of deaths and improvement in the outcome for the survivors of both maternal and neonatal intensive care have justified the cost investment in these programs.

PRINCIPLES OF ORGANIZATION

There are general principles that form the basis for the development of regional health care services for perinatal patients. These principles derive from an understanding of the care needs of the mother, fetus, and family during pregnancy, and of the mother, newborn, and family following birth.

Accountability for population

Regionalization denotes a geographic area or population with definable care needs. The regional center and the network of related institutions are accountable for the overall perinatal health care for the region. The data on mortality and morbidity, frequency of problems, and quality of care are assessed for the entire population in the area. The availability and quality of care in any given institution become the responsibility of all the institutions, including the perinatal center.

One standard of quality

Regionalization is based on the premise that there should be a single standard of quality perinatal care. Any mother or infant should have equal access to all the components of a functioning perinatal system (see Table 2-1).

Differing care capabilities of institutions

Institutions operating within a region will differ in their capability for providing perinatal care. These differences reflect number of patients, educational background and experience of medical and nursing staff, and availability of equipment and facilities. Each institution is expected to deliver high-quality care up to the level of its capability. When care requirements exceed its capability, the patient is referred to the closest facility that has the capability.

The majority (60% to 80%) of problems associated with increased risk for the mother, fetus, or newborn are detectable sufficiently in advance of the crises to permit either the appropriate care resources to be made available locally or transfer of the patient to where appropriate resources are available. Even under ideal circumstances certain patients will have to move from one facility to another during the course of care. Thus institutions within a region must be effectively linked to permit ease of patient movement.

Minimal patient movement

The organization of the regional care network should be designed to make it possible for patients to receive care appropriate to their needs as close to their homes as possible. Only those patients with care needs exceeding that of their community facility should need to be referred to another institution. Through outreach educa-