The Kidney and Body Fluids in Health and Disease

Edited by
SAULO KLAHR, M.D.

The Kidney and Body Fluids in Health and Disease

Edited by
SAULO KLAHR, M.D.
Washington University School of Medicine
St. Louis, Missouri

PLENUM MEDICAL BOOK COMPANY
NEW YORK AND LONDON

Library of Congress Cataloging in Publication Data

Main entry under title:

The Kidney and body fluids in health and disease.

Includes bibliographies and index.

1. Kidneys—Diseases. 2. Body fluid disorders. 3. Kidneys. 4. Body fluids. I. Klahr, Saulo. [DNLM: 1. Body fluids. 2. Kidney—Physiology. 3. Kidney diseases—Physiopathology. 4. Water-electrolyte balance. 5. Water-electrolyte imbalance—Physiopathology. WJ 300 K455]

[RC903.K45 1984] 616.6'1 84-1983

ISBN 0-306-41660-3 (pbk.)

Plenum Medical Book Company is an imprint of
Plenum Publishing Corporation

Printed in the United States of America

Contributors

Elsa Bello-Reuss, M.D., Assistant Professor of Medicine, Departments of Medicine, and Physiology and Biophysics, Washington University School of Medicine and The Jewish Hospital of St. Louis, St. Louis, Missouri 63110

John Buerkert, M.D., Associate Professor of Medicine, Department of Medicine, Washington University School of Medicine and The Jewish Hospital of St. Louis, St. Louis, Missouri 63110

Barbara R. Cole, M.D., Associate Professor of Pediatrics, Department of Pediatrics, Washington University School of Medicine, St. Louis, Missouri 63110

James A. Delmez, M.D., Assistant Professor of Medicine, Department of Medicine, Washington University School of Medicine, St. Louis, Missouri 63110

Jeffrey Freitag, M.D., Chief Medical Resident, Department of Medicine, Washington University School of Medicine, St. Louis, Missouri 63110. *Present address:* Saginaw General Hospital, Saginaw, Michigan 48602

Herschel R. Harter, M.D., Associate Professor of Medicine, Department of Medicine, Washington University School of Medicine, St. Louis, Missouri 63110

Phillip Hoffsten, M.D., Assistant Professor of Medicine, Department of Medicine, Washington University School of Medicine, St. Louis, Missouri 63110. *Present address:* Medical Associates Clinic, Pierre, South Dakota 57501

Keith Hruska, M.D., Associate Professor of Medicine, Department of Medicine, Washington University School of Medicine and The Jewish Hospital of St. Louis, St. Louis, Missouri 63110

Saulo Klahr, M.D., Professor of Medicine, Department of Medicine, Washington University School of Medicine, St. Louis, Missouri 63110

Kevin Martin, M.D., Assistant Professor of Medicine, Department of Medicine, Washington University School of Medicine, St. Louis, Missouri 63110

Aubrey R. Morrison, M.D., Assistant Professor of Medicine and Pharmacology, Departments of Medicine and Pharmacology, Washington University School of Medicine, St. Louis, Missouri 63110

Luis Reuss, M.D., Professor of Physiology and Biophysics, Department of Physiology and Biophysics, Washington University School of Medicine, St. Louis, Missouri 63110

Alan M. Robson, M.D., Professor of Pediatrics, Department of Pediatrics, Washington University School of Medicine, St. Louis, Missouri 63110

Hector J. Rodriguez, M.D., Ph.D., Assistant Professor of Medicine, Department of Medicine, Washington University School of Medicine, St. Louis, Missouri 63110. *Present address:* 9400 Brighton Way, Beverly Hills, California 90210

Eduardo Slatopolsky, M.D., Professor of Medicine, Department of Medicine, Washington University School of Medicine, St. Louis, Missouri 63110

Andres J. Valdes, M.D., Clinical Assistant Professor of Pathology and Associate Pathologist and Director of Clinical Immunology, Department of Pathology, Washington University School of Medicine and St. John's Mercy Medical Center, St. Louis, Missouri 63110

Preface

This volume was designed as a text for medical students, house officers, and even clinicians. It deals with the most common problems in nephrology, providing new insight into how to improve clinical skills. A comprehensive overview of renal physiology and electrolyte disorders lays the groundwork for a clear presentation of the pathophysiological principles that underlie these disorders and a step-by-step presentation of the mechanisms behind the signs and symptoms of kidney failure.

The origins of this book can be traced to the teaching of a Renal Pathophysiology course at the Washington University School of Medicine, beginning in the mid-1960s. When changes in the medical school curriculum took place in the early 1970s, an effort was made to synthesize the minimum core curriculum for sophomore medical students, and the distillation of "essential material" to be covered in the area of renal pathophysiology led to the development of the first edition of a renal syllabus. This syllabus has been used in our department since 1974, and, following some of the recommendations and critiques of students and faculty, it has been entirely reworked many times to improve its effectiveness and value.

This book is a direct extension of that syllabus, integrated with contributions from faculty members in our Renal Division, and expanded to include a section on therapy in most chapters. It is our hope that this format will serve the needs of not only sophomore and senior medical students, but also house officers, nephrology fellows, and clinicians.

The book is divided into seven sections. Section I describes the basic concepts of fluid, electrolyte, and renal physiology and comprises three chapters entitled "Introduction to the Physiology of Body Fluids," "Homeostatic and Excretory Functions of the Kidney," and "Nonexcretory Functions of the Kidney." The second section discusses the pathophysiology of fluid and electrolyte disorders, including the regulation of volume sodium metabolism, the development of edema and edema-forming states, the pathophysiological basis for alterations in water balance, the pathophysiology of potassium metabolism, the pathophysiology of acid–base metabolism, and

the pathophysiology of calcium, magnesium, and phosphorus metabolism. Section III comprises a single chapter devoted to the pathophysiology of hypertension. Section IV, "Pathophysiology of Proteinuric Renal Disease," is divided into two chapters, "Proteinuria and the Nephrotic Syndrome" and "Pathology and Pathophysiology of Proteinuric Glomerular Disease." Section V, "Renal Failure," contains chapters on the pathophysiology of acute renal failure, the pathophysiology of chronic renal failure, and the pathophysiological principles underlying the treatment of patients with renal failure. Section VI contains a single chapter, "Pathophysiology of Nephrolithiasis," and Section VII discusses renal pharmacology.

Every attempt has been made to make the chapters uniform. No attempt has been made to be comprehensive and exhaustive, but we believe that most of the fundamental developments in each field have been included. All the authors of this book are or have been affiliated with the Washington University School of Medicine; most of them have been long-standing members of the Division of Pediatric or Renal Medicine at Washington University, a fact that greatly facilitated the writing and editing of this book. We hope that our readers will find this volume useful, and look forward to their constructive criticism for use in future editions.

Saulo Klahr, M.D.

Contents

I. Basic Concepts of Fluid, Electrolyte, and Renal Physiology

1. Introduction to the Physiology of Body Fluids

Luis Reuss and Elsa Bello-Reuss

2. Homeostatic and Excretory Functions of the Kidney

Elsa Bello-Reuss and Luis Reuss

3. Nonexcretory Functions of the Kidney

Saulo Klahr

II. Pathophysiology of Fluid and Electrolyte Disorders

4. Pathophysiology of Volume Regulation and Sodium Metabolism

Elsa Bello-Reuss

8. Pathophysiology of Acid–Base Metabolism

Keith Hruska

9. Pathophysiology of Calcium, Magnesium, and Phosphorus Metabolism

Eduardo Slatopolsky

III. Pathophysiology of Hypertension

IV. Pathophysiology of Proteinuric Renal Disease

V. Renal Failure