MOYER'S FLUID BALANCE:

A Clinical Manual

JOHN C. VANATTA, M.D.

MORRIS J. FOGELMAN, M.D.

Third Edition

YEAR BOOK MEDICAL PUBLISHERS, INC
CHICAGO • LONDON

MOYER'S FLUID BALANCE:

A Clinical Manual

JOHN C. VANATTA, M.D.

Professor of Physiology
Southwestern Medical School
of the University of Texas
Health Science Center
Dallas, Texas

MORRIS J. FOGELMAN, M.D.

Clinical Professor of Surgery
Southwestern Medical School
of the University of Texas
Health Science Center
Dallas, Texas

Third Edition

YEAR BOOK MEDICAL PUBLISHERS, INC.
CHICAGO • LONDON

The toad and the owl on the title page have become symbols that are closely associated with Dr. Vanatta and Dr. Fogelman, respectively. Hence, the drawings have been included in this volume as author "trademarks."

Copyright © 1952, 1976, 1982 by Year Book Medical Publishers, Inc. 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. Printed in the United States of America.

Library of Congress Cataloging in Publication Data

Moyer, Carl A.
Moyer's Fluid balance.

Includes index.
1. Body fluid disorders—Diagnosis. I. Vanatta, John C. II. Fogelman, Morris J. III. Title.
IV. Title: Fluid balance.
RC630.M68 616.3'9 82-2013
ISBN 0-8151-8963-X AACR2

Preface to the First Edition

THE AIM of this manual is to present a simple practical schema of diagnosis pertaining to fluid and electrolyte imbalances which can serve as a practical guide to the tentative selection of appropriate therapeutic measures.

A brief critical evaluation is given of certain signs and symptoms associated with changes in the body's content of fluid and electrolytes.

The clinical manifestations of the common types of fluid and electrolyte derangements seen by the surgeon have been particularly stressed because laboratory data cannot adequately serve as the sole basis for fluid and electrolyte therapy. The major types of complications encountered in parenteral fluid therapy are also discussed.

The bibliographic references at the end of each chapter are not intended to be comprehensive. Many other important articles have provided ideas. Among these, the writings of A. M. Butler, W. M. Marriott, A. Blalock, H. Newburg, and F. P. Underhill are especially important.

I hope that this work will stimulate students of medicine, and more especially surgical residents, to spend the laborious hours of careful study required to develop a real appreciation and understanding of the importance of the body's fluids to life.

C.A.M.

Preface to the Third Edition

THE THIRD EDITION of this book still retains as its goal the presentation of "a simple, practical schema of diagnosis pertaining to fluid and electrolyte imbalances which can serve as a practical guide to the tentative selection of appropriate therapeutic measures."

The book is written for physicians who wish to understand the basic physiologic principles related to the diagnosis and treatment of such fluid and electrolyte imbalances. It is particularly useful to the resident or medical student who is learning to use the various fluids available, but should also be useful to the experienced clinician who wants to keep abreast of more recent developments in the field.

The third edition contains much new material on magnesium and phosphate disturbances, on lactic acidosis, on the anion gap, and on combined acid-base disturbances. In addition, other areas have been updated.

We thank those readers who encouraged us with their compliments and who, in addition, gave us constructive criticism. The new chapter on maintenance fluid therapy is a response to one of these suggestions.

On the other hand, we have again omitted discussions of special disturbances such as surgical shock, burns, and diseases of endocrine glands, which are causes of electrolyte disturbances. Disturbances of calcium blood levels are omitted because they fall into this latter group.

We have based our selections of material on our combined experience of teaching this subject to medical students, residents, physicians, and dentists over 25 years.

Emphasis is placed on the clinical diagnosis of the patient, using history, signs, symptoms, and laboratory findings. The bibliographies are not comprehensive but are intended to aid the reader in his supplemental reading.

We hope that the reader will find the book useful and that it will encourage him to study this area further. The authors wish to thank Beverly A. Hilton, who aided us in preparing the bibliographies; Mr. Russ Weaver, who aided us in learning to use a small computer with a word-processing program

此为试读,需要完整PDF请访问: www.ertongbook.com

for the preparation of the manuscript; and both Mrs. Trish Nickell and Miss Maura Flynn, who prepared the diagrams for this book.

We would like to thank our wives, who kept their heads above water (both free water and salt water) while we spent long hours revising the manuscript.

JOHN C. VANATTA

MORRIS J. FOGELMAN

Contents

1 / History

THE EARLY DEVELOPMENT of knowledge concerning body fluids resulted from the study and treatment of primarily three conditions—cholera, diabetic acidosis, and infantile diarrhea. The chemical analysis of the blood of cholera victims and the correlative clinical signs still serve as the basis for present-day therapy of multiple disorders of body fluids.

The space of this small volume does not permit a complete treatise on the history of fluid and electrolytes. So the salient points are presented in tabular form.

1667—DENYS GIVES FIRST BLOOD TRANSFUSION

The intravenous administration of fluids was probably begun by Denys, who carried out the first transfusion to man, albeit animal blood; the results were bad, although the method was established.

1831—O'SHAUGHNESSY ANALYZES BLOOD IN CHOLERA

W. B. O'Shaughnessy of England described deficits of water, alkali, and saline in the blood of cholera victims. We quote relevant parts of his report.

To the Editor of 'The Lancet'

Sir—Having been enabled to complete the experimental inquiries on which I have for some time back been engaged in Newcastle-upon-Tyne, I beg you will have the kindness to give insertion to the annexed outlines of the results I have obtained:

1. The blood drawn in the worst cases of *the* cholera is unchanged in its anatomical or globular structure.

2. It has *lost a large proportion of its water*, 1,000 parts of cholera serum having but the average of 860 *parts of water*.

3. *It has lost also a great proportion of its* NEUTRAL*saline ingredients*.

4. *Of the free alkali contained in healthy serum, not a particle is present in some cholera cases, and barely a trace in others*.

5. Urea exists in the cases where suppression of urine had been a marked symptom.

6. *All the salts deficient in the blood, especially the carbonate of*

soda, are present in large quantities in the peculiar white dejected matters.

I am, Sir,
Your obedient servant,
W. B. O'Shaughnessy, M.D.

1832—Latta Describes and Treats Sodium Volume Deficit in Aged Female

Thomas Latta, a practitioner in Scotland, was the first to describe and treat a case of extracellular fluid volume deficit.

She had apparently reached the last moments of earthly existence, and now nothing could injure her; indeed, so entirely was she reduced, that I feared I should be unable to get my apparatus ready ere she expired. Having inserted a tube into the basilic vein, cautiously—anxiously, I watched the effects, ounce after ounce was injected, but no visible change was produced. Still persevering, I thought she began to breathe less laboriously. Soon the sharpened features, and sunken eye, fallen jaw, pale and cold, bearing the manifest impress of death's signet, began to glow with returning animation; the pulse which had long ceased, returned to the wrist; at first small and quick, by degrees it became more and more distinct, fuller, slower, and firmer, and in the short space of half an hour, when six pints had been injected, she expressed in a firm voice that she was free from all uneasiness, actually became jocular and fancied that all she needed was a little sleep; her extremities were warm, and every feature bore the aspect of comfort and health. This being my first case, I fancied my patient secure, and from my great need of a little repose, left her in charge of the hospital surgeon; but I had not been long gone, ere the vomiting and purging recurring, soon reduced her to her former state of debility. I was not apprised of the event, and she sunk in five and a half hours after I left her. As she had previously been of sound constitution, I have no doubt the case would have issued in a complete reaction, had the remedy, which had already produced such effect, been repeated.

1883—Stadelman Treats Acidosis with Carbonate Solution

Stadelman proposed that the acidosis of diabetic coma could best be treated by injection of an alkaline solution (2%–3% Na_2CO_3). He isolated betahydroxybutyric acid in diabetic patients.

此为试读,需要完整PDF请访问: www.ertongbook.com

1882—Sydney Ringer Discovers That a Balanced Salt Solution is Best for Tissues

In the years 1882 to 1895, Sydney Ringer, while carrying out a busy medical practice in London and working with frog hearts, discovered that a balanced salt solution could replace blood as a physiologic medium for tissues.

1892—Cantani Used Large Volumes of Sodium Salts for Cholera and Volume Deficit

Cantani of Naples utilized large volumes of sodium chloride (0.4%) plus sodium carbonate (0.3%) subcutaneously. The results were dramatic enough to be described:

> The cold cyanotic, dehydrated, comatose patients, lying pulseless and almost lifeless, became animated after the subcutaneous infusion of warm salt water. Remarkably their pulse and voice often return in a few minutes and they are even able to sit alone in bed. Thereafter many recover permanently with a shorter and less serious reaction than expected; whereas others later die of a severe so-called typhoidal reaction. These observations permit one to say that although the hypodermoclysis was not lifesaving in many instances, it at least had a surer and faster symptomatic effect than all of the house and pharmaceutical stimulants ranging from tea, champagne and punch to the injection of ether.

1912—Hartwell and Houget Begin Fluid Replacement in Surgical Patients

Studying the cause of death in dogs with intestinal obstruction without strangulation, these investigators realized that the fluid loss in intestinal obstruction was in terms of liters, not milliliters. They were able to prolong life for several weeks by the subcutaneous administration of large quantities of physiologic saline solution.

> From these results it is plain that the loss of fluid from the organism is the disturbing influence and is the important factor in explaining the symptoms and death following uncomplicated high intestinal obstruction in dogs. Death is caused by the loss of water which the tissues sustain from the excessive amounts vomited, and death can be prevented by replacing this water by subcutaneous injections of normal salt solution.

1922—Leonard Rowntree Describes and Produces Water Intoxication

Rowntree produced experimental water intoxication and described the condition in man.

1924—Rudolph Matas Utilized Intravenous Drip for Solutions

Rudolph Matas, a New Orleans surgeon, realized the futility of rectal drip and hypodermoclysis in many patients, and devised a glass cannula for intravenous drip. During the next two decades, intravenous drip became the most popular mode of administration of parenteral fluids.

1932—Alexis Hartmann Treats Metabolic Acidosis with Sodium Lactate Solution

Alexis Hartmann, a St. Louis pediatrician, realized the need for continuing fluid administration in large volumes in infants with severe diarrhea. He correctly saw the need for more sodium than chloride in parenteral solutions, and thus lactated Ringer's (Hartmann's) solution was born.

1935—Darrow and Yannet Report on Intracellular-Extracellular Fluid Shifts

Darrow and Yannet reported on experiments in dogs and monkeys. They reported fluid shifts between intracellular and extracellular compartments. They produced these shifts by making the animal's extracellular concentration either high or low. It was remarkable in that they drew accurate conclusions concerning changes in volumes through measurements that did not use radioisotopes, as radioisotope marker techniques were not established at this time.

The authors explained these results using the Yannet-Darrow diagram, which has become so useful in understanding the relationships of volume and concentration of the ECF and ICF compartments. Such diagrams are used in Chapter 4 of this book.

1942—Gamble Provides Experimental and Clinical Data on Extracellular Fluid

The anatomy, physiology, and pathology of the extracellular fluid was greatly advanced by J. L. Gamble, who had not only outlined the movement of extracellular fluid but also quantitated the losses in man.

1949—Darrow Treats Infantile Diarrhea with Potassium Salts

Daniel C. Darrow, at Yale University School of Medicine, studied water and electrolyte balance in infants. In treating more than 250 cases of severe diarrhea in infants less than one year old, he was able to reduce the mortality to less than 5%. He accomplished this by giving a balanced salt solution containing up to 40 mEq/L of KCl. This was accomplished at a time the $[K^+]_p$ was analyzed by a difficult colorimetric procedure; that is, before the development of the flame photometer.

1960—Fogelman and Wilson First Advocate Salt Replacement in Traumatic Hypovolemia

Working with dogs and man, and measuring ECF using 35 SO_4, Fogelman and Wilson demonstrated a reduction in functional ECF volume in trauma and advocated salt replacement in shock, whether or not associated with blood loss.

The extensive contributions of a wide number of research workers and clinicians deserve continual credit. The chemical and clinical discoveries of J. P. Peters, E. H. Starling, E. F. Adolph, L. G. Henderson, and those who congealed their knowledge for clinical application should not be forgotten.

BIBLIOGRAPHY

Cantani A.: Cholerabehandlung. *Berl. Klin. Wchnschr.* 29:913, 1892.

Darrow D.C., et al.: Disturbances of water and electrolytes in infantile diarrhea. *Pediatrics* 3:129, 1949.

Darrow D.C., Yannet H.: The changes in the distribution of body water accompanying increase and decrease in extracellular electrolyte. *J. Clin. Invest.* 14:266, 1935.

Fogelman M.J., Wilson B.J.: A different concept of volume replacement in traumatic hypovolemia: Observations on injured man and animal. *Am. J. Surg.* 99:694, 1960.

Fulton J.F.: *Selected Readings in the History of Physiology*. Springfield, Ill., Charles C Thomas, Publisher. 1930, p. 116

Gamble J.L.: *Chemical Anatomy, Physiology and Pathology of Extracellular Fluid*. Cambridge, Mass., The Harvard Medical School, 1942.

Hartmann A.F., Senn M.J.E.: Studies in the metabolism of sodium r-lactate. I. Response of normal human subjects to the intravenous injection of sodium r-lactate. *J. Clin. Invest.* 11:327, 1932.

Hartwell J.A., Houget J.P.: Experimental intestinal obstruction in dogs with especial reference to the cause of death and the treatment by large amounts of normal saline solution. *J.A.M.A.* 59:82, 1912.

Latta T.: Relative to the treatment of cholera by the copious injection of aqueous and saline fluids into the veins (letter). *Lancet* 2:274, 1831–1832.

Matas R.: The continued intravenous "drip." *Ann. Surg.* 79:643, 1924.

O'Shaughnessy W.B.: Experiments on the blood in cholera. *Lancet* 1:490, 1831–1832.

Ringer S.: Concerning the influence exerted by each of the constituents of the blood on the contraction of the ventricle. *J. Physiol.* 3:380, 1882.

Rowntree L.G.: Water intoxication. *Arch Intern. Med.* 32:157, 1923.

Stadelmann E.: Über die Ursachen der pathologischen Ammoniakausscheidung beim Diabetes Mellitus und des Coma diabeticum. *Arch. Exp. Pathol. Pharmakol.* 17:419, 1883.

2 / The Chemistry of Body Fluids

THE WATER CONTENT of individuals is often stated to be 70% of the body weight. More accurately stated, it is approximately 70% of the body weight of a fat-free individual. The fatty tissue of an individual contains little water. This fatty tissue can vary from 10% to 40% of a person's body weight. This variation in fat content causes the water content of the body, when figured on the basis of total body weight, to vary from about 40% to 70%.The content averages about 60% for males 17–40 years of age and 51% for females in the same age range. Therefore, 60% of the body weight will be used as a reasonable figure for total body water.

The compositions of plasma, interstitial cell fluid, and intracellular fluid are presented in Figure 2–1.

The important points to make about the data presented in this figure are:

1. The values for plasma are the most reliable. Plasma can be obtained in pure form for direct analysis.
2. The values for interstitial cell fluid are best obtained by calculation from the composition of plasma. The calculations assume that interstitial fluid is an ultrafiltrate of plasma. In ultrafiltration, the protein is removed and the composition is changed in accordance with Donnan equilibrium.
3. The composition of cells is difficult to determine because the cells cannot be obtained in pure form. Problems of skeletal muscle analysis are explained in Chapter 3. Even packed red cells will have some fluid trapped between them when they are analyzed. Also, red cells are not typical body cells because their membranes are permeable to Cl^-.
4. Intracellular fluid is actually not a single pure fluid but is a weighted average value of the composition of fluid in nuclei, cytoplasm, and other cellular elements.

UNITS OF MEASURE

The milliequivalent (mEq) is $^1/_{1.000}$ of an equivalent weight of an element or a compound. The milliosmole (mOsm) is $^1/_{1.000}$ of an osmole.

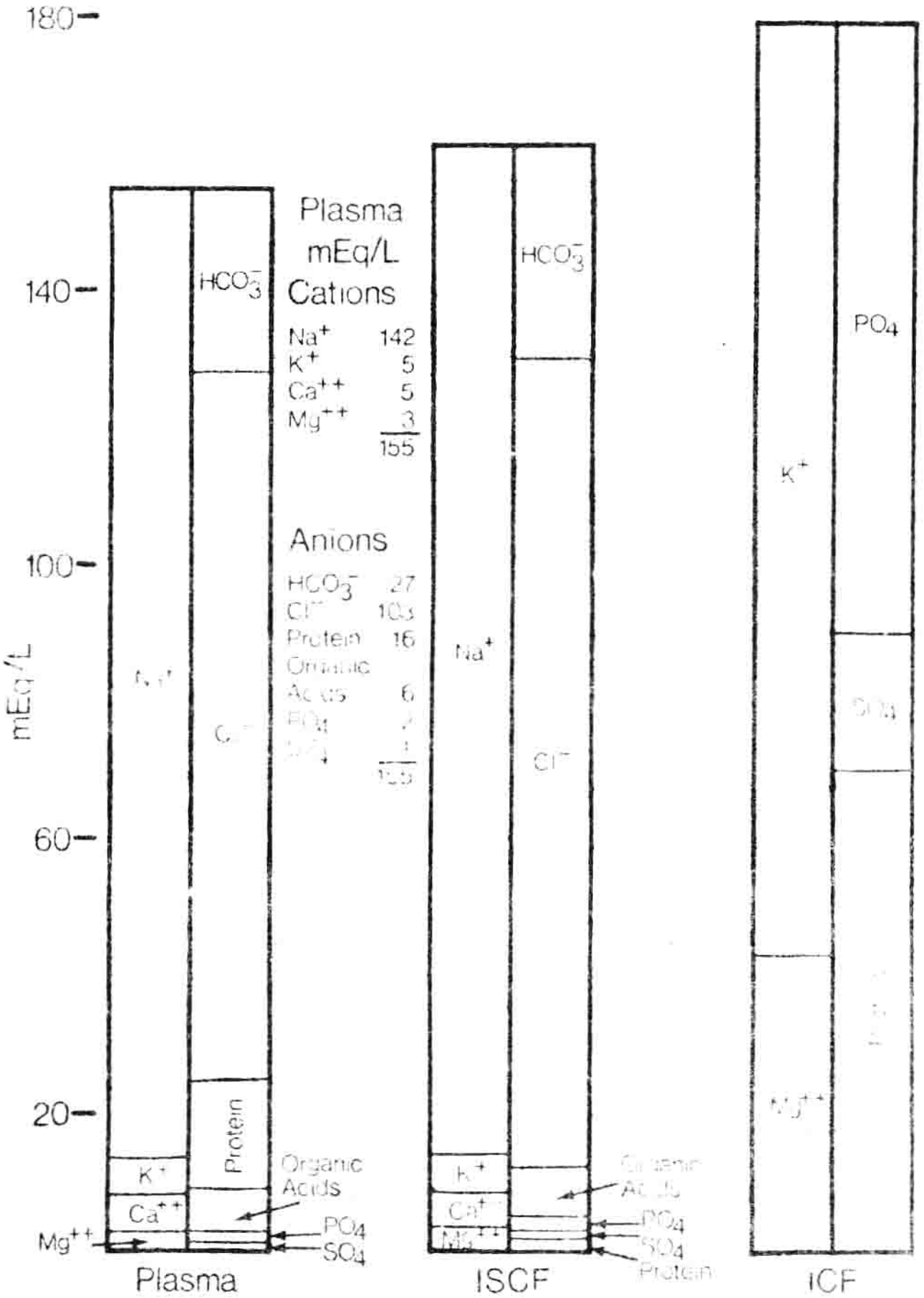

Fig 2–1.—The composition of plasma, interstitial cell fluid *(ISCF)*, and intracellular fluid *(ICF)*. The plasma values are obtained by analysis. The ISCF values were calculated from plasma, correcting for both the difference in water content and for Donnan equilibrium. Some published charts are corrected only for Donnan equilibrium. ICF values are best estimates from analyses. (Adapted from Gamble.)

此为试读,需要完整PDF请访问: www.ertongbook.com