Fluid and Electrolytes in Pediatrics
We are most appreciative for the “long-term” support and understanding from our families who have born a great deal as we have toiled through this and many other projects.

To our loved ones – Barbara, Kimberly, Mitchell, Greg (LF), and Phyllis, Kimberly, Elizabeth, Jessica, and Erica (FK)
Series Editor Introduction

The Nutrition and Health series of books have, as an overriding mission, to provide health professionals with texts that are considered essential because each includes (1) a synthesis of the state of the science, (2) timely, in-depth reviews by the leading researchers in their respective fields, (3) extensive, up-to-date fully annotated reference lists, (4) a detailed index, (5) relevant tables and figures, (6) identification of paradigm shifts and the consequences, (7) virtually no overlap of information between chapters, but targeted, inter-chapter referrals, (8) suggestions of areas for future research, and (9) balanced, data-driven answers to patient/health professionals questions, which are based upon the totality of evidence rather than the findings of any single study.

The series volumes are not the outcome of a symposium. Rather, each editor has the potential to examine a chosen area with a broad perspective, both in subject matter as well as in the choice of chapter authors. The international perspective, especially with regard to public health initiatives, is emphasized where appropriate. The editors, whose trainings are both research and practice oriented, have the opportunity to develop a primary objective for their book, define the scope and focus, and then invite the leading authorities from around the world to be part of their initiative. The authors are encouraged to provide an overview of the field, discuss their own research, and relate the research findings to potential human health consequences. Because each book is developed de novo, the chapters are coordinated so that the resulting volume imparts greater knowledge than the sum of the information contained in the individual chapters.

Of the 31 books currently published in the Series, only four have been given the title of Handbook. These four volumes, (1) *Handbook of Clinical Nutrition and Aging*, (2) *Handbook of Drug-Nutrient Interactions*, (3) *Handbook of Nutrition and Ophthalmology*, and (4) *Handbook of Nutrition and Pregnancy*, are comprehensive, detailed and include extensive tables and figures, appendices and detailed indices that add greatly to their value for readers. Moreover, Handbook contents cut across a wide array of health professionals’ needs as well as medical specialties. The Nutrition and Health Series now will include its fifth Handbook volume, “Fluid and Electrolytes in Pediatrics: A Comprehensive Handbook.”

*Fluid and Electrolytes in Pediatrics: A Comprehensive Handbook* edited by Leonard G. Feld, M.D., Ph.D., M.M.M. and Frederick J. Kaskel, M.D., Ph.D. is a very welcome addition to the Nutrition and Health Series and fully exemplifies the Series’ goals for Handbooks. This volume is especially relevant as there is currently no comprehensive up-to-date text on the management of fluid and electrolyte disorders in pediatrics. This Handbook provides essential practice guidance that can help to improve the care of infants and young children in a wide variety of pediatric settings. This text, with over 200 relevant tables, equations, algorithms and figures, and close to 1000 up-to-date references, serves as a most valuable resource for the general practitioner, family
practitioner, emergency medicine physicians, residents, medical students, nurses, physician assistants as well as many medical and surgical specialties that care for the disorders seen daily in the children admitted to neonatal intensive care units, pediatric intensive care units, inpatient units, day hospitals, surgical units, emergency care facilities, and outpatient care units. The Handbook provides detailed instructions about the signs and symptoms as well as the treatments that can help to restore the fluid balance and protect the vital organs from severe damage that can occur over a matter of hours. Health providers to the pediatric population who can benefit from the wealth of tables, figures and formulas as well as the analyses of numerous relevant case studies in the volume include specialties mentioned above as well as endocrinologists, neurologists, clinical nutritionists, gastroenterologists, neonatologists, emergency room physicians and support staff as well as researchers who are interested in the complexities of maintaining fluid and acid–base balance in the preterm, term infant, child and adolescent under acute conditions as well as for those children who have chronic conditions that predispose them to fluid and electrolyte imbalances. Moreover, graduate and medical students as well as academicians and medical staff will benefit from the detailed descriptions that are provided concerning environmental factors, such as drugs, infections, and other potential agents that can cause changes in body fluid balance. Tables of normal values for electrolytes, protein, glucose, and other components of the blood are given as detailed explanations of the compositions of the many fluids that can be provided to the patient intravenously, or by parenteral, enteral or oral routes in order to return the patient to normal levels of these essential electrolytes and fluid balance. Relevant equations are discussed and examples of how these can be helpful in treatment choices are illustrated.

This text has many unique features, such as highly detailed case studies, that help to illustrate the complexity of treating the pediatric patient with reduced capability to balance the body’s fluids. There are in-depth discussions of the basic functioning of the kidneys, skin, and the lungs. Each chapter describes the etiology and demographics, biological mechanisms, patient presentation characteristics, therapy options and consequences of optimal treatment as well as delayed treatment. There are also clear, concise recommendations about fluid intakes, adverse effects of dehydration, and use of drugs and therapies that can quickly improve patient outcomes. Thus, this volume provides the broad knowledge base concerning normal fluid and electrolyte balance, kidney function, cellular physiology and the pathologies associated with changes in fluid balance, and the therapies that can help to restore normal function.

Comprehensive descriptions are provided that concentrate on the importance of various homeostatic mechanisms that interact with organ systems. Diabetes insipidus is reviewed and the differences between central and nephrogenic causes are included as well as guidance for patient management. Individual chapters containing highly relevant clinical examples and background information review the topics of water and sodium balance, potassium balance, disorders of calcium, magnesium and phosphorus balance; metabolic acidosis, metabolic alkalosis, respiratory acidosis, and respiratory alkalosis. These chapters include valuable discussions of fetal accretion of electrolytes and the consequences of preterm birth on fluid balance. The final section includes in-depth chapters on the consequences of liver disease and ascites, renal failure and transplantation, and endocrine diseases, all of which impact fluid and electrolyte balance. There are also
chapters that examine genetic diseases, effects of enteral and parenteral nutrition, consequences of excess uric acid and the last chapter contains a comprehensive review of the special situations that can arise in the neonatal intensive care unit.

The editors of this volume, Dr. Leonard G. Feld and Dr. Frederick J. Kaskel are internationally recognized leaders in the fields of fluid and electrolyte balance and renal disease research, treatment, and management. Dr. Feld is the Sara H. Bissell and Howard C. Bissell Endowed Chair in Pediatrics, Chief Medical Officer at the Levine Children’s Hospital and Clinical Professor of Pediatrics at the University of North Carolina School of Medicine and Dr. Kaskel is the Director of Pediatric Nephrology, Professor and Vice Chairman of Pediatrics at Albert Einstein College of Medicine in New York. Each has extensive experience in academic medicine and collectively, they have over 300 peer-reviewed articles, chapters, and reviews and Dr. Feld is the editor of the classic volume, “Hypertension in Children.” Both have been recognized by their peers for their efforts to improve pediatric medicine especially under conditions where the proper acute care can have major effects on mortality and/or morbidity for preterm and term neonates, infants, and children. The editors are excellent communicators and they have worked tirelessly to develop a book that is destined to be the benchmark in the field of pediatric fluid and electrolyte balance because of its extensive, in-depth chapters covering the most important aspects of this complex field.

Fluid and Electrolytes in Pediatrics: A Comprehensive Handbook contains 18 chapters and each title provides key information to the reader about the contents of the chapter. In addition, relevant chapters begin with a list of Key Points, containing concise learning objectives as well as key words. The introductory chapters provide readers with the basics so that the more clinically related chapters can be easily understood. The editors have chosen 26 well-recognized and respected chapter authors who have included complete definitions of terms with the abbreviations fully defined for the reader and consistent use of terms between chapters. Key features of this comprehensive volume are the detailed discussions found in the more than 50 case studies. In conclusion, Fluid and Electrolytes in Pediatrics: A Comprehensive Handbook, edited by Leonard G. Feld and Frederick J. Kaskel provides health professionals in many areas of research and practice with the most up-to-date, well-referenced volume on the importance of the maintenance of fluid and electrolyte concentrations in the pediatric population, especially under acute care. This volume will serve the reader as the benchmark in this complex area of interrelationships between kidney function, and the functioning of all organ systems that are intimately affected by imbalances in total body water. Moreover, the physiological and pathological examples are clearly delineated so that practitioners and students can better understand the complexities of these interactions. The editors are applauded for their efforts to develop the most authoritative resource in the field to date and this excellent Handbook is a very welcome addition to the Nutrition and Health Series.

Adrianne Bendich, PhD, FACN
Fluid and Electrolytes in Pediatrics (a comprehensive handbook) is the latest in a series of multi-authored monographs on the Nutrition and Health Series of books from Springer/Humana.

Drs. Leonard G. Feld and Frederick J. Kaskel, pediatric nephrologists, and previous collaborators were selected as the handbook’s editors. It was a wise choice, for they have each distinguished themselves as exemplary clinicians, investigators, and, most importantly, as teachers in this field for over 25 years.

A team of 28 experts in all of the topics presented was assembled with thoughtful consideration of differing writing styles and perspectives on the subject matter that is often a function of the author’s depth, breadth, and duration of experience in this field. The editors are to be commended for this approach, which is rarely seen in the many publications on this general subject over the past 60 years.

Chapters 1 and 2 in Part I really “sets the stage” for all that follows, both in terms of structure/outline and content. For this reason, several important features are worth highlighting:

1. The authors are careful to highlight the critically important differences in the evaluation of disorders of water and sodium balance.
2. To the extent possible, they separate the clinical approaches to both groups of disorders while acknowledging the fact that they are inescapably linked. This is facilitated by the skillful use of clinical scenarios that the authors work through in a stepwise fashion.
3. As a natural consequence of their prior discussion of first principles of sodium and water physiology, it is particularly noteworthy in Chapter 1 that the dissociation of total body water from total body sodium is illustrated by examples of hyponatremia, isonatremia, and hypernatremia, each of which may be seen in the context of decreased, normal, or increased total body water, respectively (e.g., see Figs. 6 and 9).
4. The importance of including case scenarios in every one of the chapters underscores the time-honored importance of taking a thorough history and performing a complete physical examination; armed with this preliminary information, the astute clinician is usually able to initiate the most appropriate additional diagnostic studies and therapy.

The handbook is well organized into the four classical components of any book on this general subject, starting from the most common to the least common disorders encountered in pediatrics. Narratives are clearly expressed, tables and figures were chosen to enhance the reader’s understanding of the text, and references seemed manageable in number and scope.
**Foreword**

*Fluid and Electrolytes in Pediatrics* is a handbook worth having now for anyone who either plans to or is already looking after the health-care needs of all pediatric patients.

Charlotte, NC

Michael E. Norman, M.D., FAAP

December 1, 2009
Preface

One of the time-honored foundations of the practice of pediatric medicine is the understanding and application of the principles of fluid, electrolyte, and acid–base disorders. In *Fluid and Electrolytes in Pediatrics: A Comprehensive Handbook* we have selected authors with a passion, appreciation of the contributions of pioneers in pediatric medicine, and an expertise for their respective areas. Although medicine has changed enormously from the days of Gamble, Cooke, Holliday, Segar, Winters, and many other great pediatric clinical investigators, the evaluation and management of fluid, electrolyte, and acid–base disorders still form the basis of acute care and inpatient pediatrics. Today pediatric admissions are more complex and the survival of premature infants as young as 24 weeks gestation provides challenges for the generalist and specialist alike. Regardless of the location of care – from the neonatal unit, pediatric critical care, inpatient service to the emergency rooms – the clinician almost always obtains a set of electrolytes and a urinalysis on their patients and must interpret the results with regard to the specific clinical presentation.

In each chapter the authors have provided in-depth discussions, with the assistances of many scenarios in order to exemplify the major clinical pearls that will guide our continuing understanding and appreciation of the unique characteristics of pediatric fluid and electrolytes homeostasis. We have provided the authors some leeway in placing scenarios in the text or at the end of the section/chapter. In prescribing fluid and electrolyte therapies to our infants, children, and adolescents, we must apply critical analyzing skills to provide the most precise recommendations in order to assure a safe and effective environment for our precious future – our children. An example is that 5% Dextrose in Water with ½ isotonic saline does not work for everyone. The jargon of giving 1.5 or 2 times maintenance fluid therapy is not appropriate because it is the crudest of “estimates.”

In the first section, the chapters on Disorders of Water Homestasis by Feld, Massengill, and Friedman provide an in-depth examination of hypo- and hypernatremic disorders with detailed scenarios supported by many illustrations and tables. In the subsequent chapter on Disorders of Sodium Homeostasis, Woroniecki et al. present a discussion of sodium balance, renal regulation from the neonatal period, and the approach to assessing renal sodium excretion and the different volume states.

Disorders of Potassium Homeostasis is a key chapter because of the dire consequences of abnormal potassium balance and serum concentrations. The discussion emphasizes the practical and methodical approach to potassium abnormalities to avoid catastrophic consequences to the children.

In the second section, Charles McKay presents an elaborate review of both Disorders of Calcium and Magnesium Homeostasis. Although calcium disorders with both its low and high values are quite common, the analysis of the evaluation and treatment with detailed scenarios helps the reader to achieve a clear understanding of this important
mineral. When faced with an abnormal serum magnesium concentration, this chapter will be an invaluable resource.

Valerie Johnson presents the chapter on Disorders of Phosphorus Homeostasis with an exceptional expertise and understanding. Similar to magnesium, this chapter is a ready resource to assist the clinician in the evaluation, diagnosis, and treatment of phosphorus disorders.

Part III covers Disorders of Acid–Base Homeostasis. The section editor Uri Alon has done a magnificent job in helping to guide the authors in these five chapters. Mahesh and Shuster start with an overview of normal acid–base balance, followed by Howard Corey and Uri Alon covering the ever difficult area of metabolic acidosis. Their insights in this field bring a challenging area into simpler terms. Wayne Waz reviews metabolic alkalosis and illustrates the value of the “lonely” urine electrolyte – chloride. Young and Timmons emphasize the importance of understanding respiratory disorders of acid–base physiology.

Part IV highlights Special Situations of Fluid and Electrolyte Disorders. Although it is nearly impossible to cover all areas, we have tried to include a chapter on the neonatal ICU, liver as well as renal failure, unique situations of the endocrine system, the importance of nutrition and understanding Uric Acid by Bruder Stapleton. The book would not be complete without a chapter on the genetic syndromes that affect the body’s balance of water and electrolytes. In some instances there is intentional overlap of some information in this section to the first three sections of the book.

We truly hope that you will find this book an indispensable handbook and guide to the management of your patients as well as a critical resource for medical and graduate students.

SPECIAL ACKNOWLEDGEMENT AND THANK YOU

We are truly appreciative for all of the hard work and excellent efforts that were made by all of the contributing authors. The expertise in the preparation of the book is credited to Richard Hruska, Amanda Quinn and the staff at Humana/Springer. Richard was with us from the inception of this book to the final stages of production. A special thanks to Dr. Adrianne Bendich, PhD, for her helpful comments, guidance, and insightfulness in being Series Editor of the outstanding Nutrition and Health series.

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