

Nutrition and Health
Series Editor: Adrienne Bendich

Laura D. Byham-Gray
Jerrilynn D. Burrowes
Glenn M. Chertow *Editors*

Nutrition in Kidney Disease

Second Edition

 Humana Press

NUTRITION AND HEALTH

Adrienne Bendich, Ph.D., FACN, FASN, SERIES EDITOR

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Laura dedicates this book to her husband, Steven, and her daughters, Erin and Jillian. Jerrilynn dedicates this book to the thousands of patients with kidney disease who will benefit from the information embedded in these pages. The goal is to improve the health and well-being of patients with kidney disease through optimal nutritional practices.

Foreword

Nutrition in Kidney Disease is a book that truly fills a gap as both a desk reference and guide to practice. Dietitians, nurses, and physicians who wish to practice state-of-the-art clinical nutrition therapy for renal patients will benefit from it. Two dietitians with special expertise in renal nutrition and one of the best and brightest nephrologists of this generation have edited the book. All three are active practitioners and researchers and are deeply knowledgeable about both the science and practice of treating renal disease. They have assembled a superb set of authors, each authority one for specific chapters that best show off the writer's expertise.

The book has five parts. It begins with six chapters that introduce kidney disease as a worldwide problem, review the relevant renal physiology and tools for assessing nutritional status. The authors of the chapters are all experts in their own right on the topics they are covering. Each chapter includes an abstract that provides a succinct survey followed by learning objectives, which are thoroughly covered in the ensuing text, accompanied by liberal use of charts, tables, and figures. It concludes with practical suggestions for managing patients.

The second part of the book focuses on chronic kidney disease in adults. Here dietary approaches to managing hypertension, diabetes mellitus, and obesity are considered.

Part III considers the problems of patients receiving renal replacement therapies such as dialysis and transplantation and also the treatment of acute renal injury. Management of protein energy malnutrition and wasting, bone and mineral metabolism and disease, and physical activity and exercise are discussed at length.

Part IV deals with kidney disease among those with special physiological needs due to pregnancy, infancy, childhood and adolescence, and advanced age. Special morbidity-related risks such as nephrotic syndrome and nephrolithiasis are also considered.

Part V is a potpourri of additional considerations on nutrition and kidney disease. The chapters include the use of dietary supplements, micronutrient needs in chronic kidney disease, and more cultural issues such as what is needed in public policy. In addition, it covers cultural issues that may slow dietary adherence and counseling approaches to improve it. A plea is made for more outcomes research. The book concludes with a full chapter on resources for renal experts to consult.

All in all, this is a book full of up-to-date science with progressive and sympathetic approaches to treating renal patients. It is a long overdue and very much welcome addition to my bookshelf, and I suspect it will also be to yours.

Boston, MA

Johanna Dwyer

Preface

The field of kidney disease has evolved over the years to encompass a broad and sophisticated knowledge base. There has been a proliferation of scientific information and technical advances in the field. The clinician involved in the care of patients with kidney disease must have a vast knowledge of nutrition management of the disease. The purpose of this book is to provide a comprehensive reference on the practice of Nutrition in Kidney Disease. It is our belief that this book will become a useful reference and tool for practicing clinicians in the fields of nutrition and nephrology, as well as other disciplines whose research, practice, and education includes nutrition and kidney disease. This book will also be a current resource for undergraduate and graduate level nutrition and allied health profession students, medical students and residents, nutrition and allied health clinicians, including general practitioners, nephrologists, educators, and researchers.

Organization and Content

Nutrition in Kidney Disease is organized into five sections with a variable number of chapters based on breadth and depth of information. Part I addresses kidney function in health and disease and it defines and forecasts healthcare trends and outcomes in kidney disease. A comprehensive review of the components of the nutrition assessment is also provided. In Parts II and III, in-depth information on the prevention of common disorders associated with chronic kidney disease, current treatment options based on the latest scientific evidence, and management of comorbidities such as protein–energy malnutrition/wasting, obesity, and bone disease are covered. Part IV presents the nutrition concerns of special needs populations such as through the life cycle—pregnancy, infancy, childhood, adolescence, and the elderly, and nutrition management of disorders such as acute kidney injury, nephrotic syndrome, and nephrolithiasis. Part V addresses additional nutritional concerns in kidney disease such as complementary and alternative medicine, cultural issues affecting dietary adherence, and outcomes research.

In an attempt to make this textbook as practical as possible, a wide variety of tables, resources, practical tools, clinical practice guidelines, and Internet websites are compiled into one chapter.

Features

The chapters in this textbook have been designed with special features to enhance learning. Each chapter begins with keywords and ends with a summary. Up-to-date references for more in-depth review are included at the end of each chapter. This list provides the clinician and student with an

extensive source of reading for continued study. In addition, several chapters end with a case study, which can be used to assess knowledge of the content area within the context of the didactic curricula. They provide thought-provoking, illustrative questions that will add to the student's learning and clinical application of the material. The answers to the case studies are provided at the end of the book. The problems posed in these chapters enable the clinician and the student to apply the chapter material to "real-life" nutrition-related problems.

The chapters have been written by a collaborative group of distinguished dietitians and physicians in the specialized field of kidney disease and clinical nutrition, and who have devoted their careers to the care of patients with kidney disease. This collaborative effort is a testament to the interdisciplinary approach that is used to provide care to this unique patient population. It is our belief that this book will be used to guide and enhance the care of the patients we serve.

Stratford, NJ
Brookville, NY
Stanford, CA

Laura D. Byham-Gray
Jerrilynn D. Burrowes
Glenn M. Chertow

Series Editor Page

The great success of the Nutrition and Health Series is the result of the consistent overriding mission of providing health professionals with texts that are essential because each includes (1) a synthesis of the state of the science, (2) timely, in-depth reviews by the leading researchers and clinicians 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 patients as well as 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.

"Nutrition in Kidney Disease, Second Edition" edited by Laura D. Byham-Gray, Jerrilynn D. Burrowes, and Glenn M. Chertow is a very welcome addition to the Nutrition and Health Series and fully exemplifies the Series' goals. The first volume was published in 2008 and was given excellent reviews by health professionals in both the nephrology and clinical nutrition health professional communities. Over the past 5 years, there have been major changes in the treatment of individuals with kidney disease and especially those with chronic kidney disease who require dialysis and/or transplantation. Likewise, research on the nutritional requirements of kidney disease patients has expanded and reflects the changes in demographics, technical advances, and further emphasis on the interactions among a number of disease states that increase the risk of kidney disease. This Second Edition volume is therefore especially timely as over 10% of the global adult population currently suffers from kidney disease and the number is increasing as the major comorbidities, obesity and diabetes, continue to increase around the world. As indicated in the Foreword to this volume, written by Dr. Johanna Dwyer, Director of the Frances Stern Nutrition Center, Tufts Medical Center and Professor of Medicine, Tufts University School of Medicine: "All in all, this is a book full of up-to-date science with progressive and sympathetic approaches to treating renal patients. It is a long overdue and very much welcome addition to my bookshelf, and I suspect it will also be to yours."

The three editors of this volume, Laura D. Byham-Gray, Jerrilynn D. Burrowes, and Glen M. Chertow, are internationally recognized leaders in the fields of clinical nutrition and renal disease

research, treatment, and management. Each has extensive experience in academic medicine and collectively, they have over 500 peer-reviewed publications and numerous awards for their efforts to improve the care of those with kidney disease. The editors are excellent communicators and they have worked tirelessly to develop a book that is destined to continue as the benchmark in the field of nutrition and kidney disease. Over the past 5 years, the editors have grown in their prominence in their fields and it is of benefit to the reader that these are the same editors who developed the first edition as they have remained committed to providing readers with the most up-to-date practice-oriented chapters as in their first edition.

Laura D. Byham-Gray, Ph.D., R.D. is an Associate Professor in the Department of Nutritional Sciences, School of Health Related Professions at Rutgers University in Newark, New Jersey. Dr. Byham-Gray practiced in the field of clinical nutrition, with specialty practice in nutrition support, kidney disease, and home care for over 20 years. She has held numerous elected and appointed positions at the national, state, and local levels of the National Kidney Foundation (NKF), the American Society of Parenteral and Enteral Nutrition (ASPEN), and the American Dietetic Association (ADA). Dr. Byham-Gray has been appointed to the *Clinical Standards Committee* for ASPEN because of her expertise in kidney disease, outcomes research, and evidence-based practice guideline development. She also serves as the Associate Editor for the *Journal of Renal Nutrition*. Presently, Dr. Byham-Gray is a consultant for the Academy of Nutrition and Dietetics (AND) as an evidence analyst for the *Evidence Analysis Library* recently launched by the Association. She has authored the self-study publication entitled *Medical Nutrition Therapy in Renal Disease, Second Edition* with Wolf Rinke Associates, and she has co-edited the AND publication, *A Clinical Guide to Nutrition Care for Kidney Disease*. Dr. Byham-Gray has received numerous awards, including the *Outstanding Service Award* by the AND-Renal Dietitians dietetic practice group and the Joel D. Kopple Award of the Council on Renal Nutrition of the National Kidney Foundation.

Jerrilynn D. Burrowes, Ph.D., R.D. is Professor of Nutrition in the School of Health Professions and Nursing at Long Island University (LIU) Post in Brookville, NY. Dr. Burrowes was the research coordinator for the NIH-funded Hemodialysis (HEMO) Study and she practiced as a renal dietitian for over a decade. Dr. Burrowes is currently the Editor-in-Chief of the *Journal of Renal Nutrition* and a Contributing Editor for the Clinical Column in *Nutrition Today*. Dr. Burrowes has held several leadership positions in the National Kidney Foundation (NKF) Council on Renal Nutrition (CRN). She was a member of the NKF Kidney Disease Outcomes Quality Initiative (NKF-KDOQI) Nutrition Work Group and a member of the NKF-KDOQI Advisory Board. Dr. Burrowes was recently appointed to the Research Committee of the Academy of Nutrition and Dietetics (AND). She has been the recipient of the Recognized Renal Dietitian Award and the Joel D. Kopple Award from the NKF-CRN and the *Outstanding Service Award* from the AND Renal Dietitians Practice Group.

Glenn M. Chertow, M.D., M.P.H. is the Norman Coplon/Satellite Healthcare Professor of Medicine and Chief, Division of Nephrology at Stanford University School of Medicine. Dr. Chertow has authored over 300 peer-reviewed articles on Stage 5 chronic kidney disease, acute kidney injury (AKI), mineral metabolism, nutrition, and costs and outcomes of dialysis therapy. Dr. Chertow currently leads or participates in several clinical trials and cohort studies sponsored by the National Institutes of Health-National Institute of Diabetes and Digestive and Kidney Diseases. He is Co-Editor of Brenner & Rector's *The Kidney*, ninth and tenth editions, Dr. Chertow was vice-chair of the NKF-KDOQI Nutrition Work Group in 1998–2000, and also a member of the KDOQI Bone and Mineral Metabolism Work Group from 2000 to 2002. Dr. Chertow has been elected to the American Society of Clinical Investigation and has been a recipient of the President's Award from the National Kidney Foundation and the National Torchbearer Award (2007) and Nephrologist of the Year Award (2011) from the American Kidney Fund.

This updated text, containing 28 practice-oriented chapters, continues to include many unique features, such as highly relevant case studies that help to illustrate the complexity of treating the patient with kidney disease and/or reduced kidney function. The volume is also relevant for

non-practicing healthcare providers as there are in-depth discussions of the basic functioning of the kidney; demographics of the different kidney diseases, and disease conditions that affect the kidney. There are also clear, concise recommendations about dietary intakes and use of drugs and supplements across the stages of kidney disease. Thus, this volume provides the broad knowledge base concerning kidney anatomy, physiology, and pathology required by the practicing health professionals and will also be appreciated by health professionals, students, and faculty who have an interest in the latest, up-to-date information on the consequences of loss of kidney function, treatment of kidney disease, and disease-related morbidity and mortality.

This volume serves a dual purpose of providing in-depth focus on the nutritional aspects of treating individuals throughout the lifespan who have lost some or all of their kidney function as well as examining the current clinical modalities used in treating kidney disease and the consequences of the treatments on nutritional status. The book is organized as a stand-alone resource text that provides the historic beginnings of nutritional interventions in patients and reflects upon the necessity of these historic practices even today in developing countries where dialysis and/or kidney transplants, expensive drugs, and other disease management tools are not readily available and medical nutritional support remains the primary care available to patients with kidney disease. The volume includes extensive, in-depth chapters covering the most important aspects of the complex interactions between kidney functions, diet, obesity, cardiovascular disease, autoimmune disease, and diabetes as examples, and the impact of loss of kidney function on other disease states. Additionally, the nutritional consequences of loss of kidney function in infancy, children, pregnant women, and the aged are examined in depth in separate chapters that also include potential solutions to the nutritional deficits specific for patients with impaired kidney function.

“Nutrition in Kidney Disease, Second Edition” is organized into five relevant sections. The six introductory chapters in the first part, entitled “Foundations for Clinical Practice and Overview” provide readers with the basics so that the more clinically related chapters can be easily understood. The first chapter describes the functions of the kidney and the consequences of decreased kidney function including AKI, chronic kidney disease, nephrotic and nephritic syndromes, tubulointerstitial diseases, vascular diseases of the kidney and diabetic nephropathy. There is a detailed review of the functions of the kidney. Kidneys control the composition and volume of the body fluids and maintain acid-base balance as well as blood pressure. The kidneys remove various nitrogenous metabolic end products and control the contents of the urine. We learn that the kidneys are critical endocrine organs that synthesize hormones including renin, erythropoietin, and the active form of vitamin D. The next chapter examines the global care available for patients with kidney disease and indicates that currently there is a wide range in availability of care throughout the world: as an example, there are no nephrologists in 27 African nations. In the USA and Europe, approximately 10% of the adult population has been diagnosed with kidney disease and usually the patients did not know they had kidney disease prior to diagnosis. The chapter details the statistics, in relevant tables and figures, of the global prevalence of kidney disease and the use of dialysis.

The next four chapters (Chaps. 3–6) provide descriptions of the assessment methodologies available to determine the nutritional status of the patient with kidney disease. The next chapter, containing 120 up-to-date references, describes the process of dietary assessment in healthy individuals and the many tools available for collecting individual and/or population data on intakes. However, as described in detail, the recommended dietary intake of people with kidney disease differs for some nutrients from that of healthy individuals. Guidelines for dietary intake of key nutrients, such as protein for patients with kidney disease, are based on the level of kidney function and the types of treatments. Certain assessment methodologies are recommended for use in patients with kidney diseases. Chapter 4 describes the methods of anthropometry methodologies and the standards used to determine the potential effects of kidney disease on the body’s composition. Nutritional status influences kidney disease progress and its potential comorbidities. Kidney failure and its management can affect diet and nutritional status especially of electrolytes. Thus, the routine monitoring of nutritional status and

body composition is a key component of the management of CKD and the chapter details the measurements that can provide guidance in determining the nutritional needs of the patient. The next chapter identifies and tabulates the biochemical parameters that are critical for the evaluation of patient with kidney disease and reviews the importance of each of these measurements. The chapter includes the recommended frequency of measurement suggested in the Kidney Disease Outcome Quality Initiative (KDOQI) nutrition guidelines and International Society of Renal Nutrition and Metabolism consensus conference for routine, confirmatory, and screening testing. The final chapter in Part I reviews the role of the renal nutrition specialist in performing nutrition-focused physical assessments as suggested by federal, KDOQI, Joint Commission, and the Academy of Nutrition and Dietetics. The detailed and well-referenced chapter includes the Nutrition Physical Exam as the standard used in chronic kidney disease patients for comprehensive physical examination of both micro- and macronutrient status. A unique feature of this chapter is the inclusion of comprehensive nutrient overviews of niacin, vitamin B6, and zinc that summarize nutrient disposition, dietary sources, drug/nutrient interactions, laboratory evaluation, medical comorbidity data, and nutrient-based lesions/functional deficits that are frequently seen in this patient population. Detailed figures illustrating these nutrient deficiencies are included.

Part II, containing four chapters, describes risk factors and consequences of CKD in adults. The first chapter examines the adverse effects of chronic hypertension on kidney function. There are also important descriptions of dietary components as well as diet strategies that have been shown to reduce hypertension in populations that are not affected by CKD; potential alterations targeted to these diets that are of value to the patient with CKD are reviewed. Diabetes mellitus can also affect kidney function. In fact, as indicated in the next chapter, diabetes mellitus is the leading cause of kidney failure in the USA. The chapter reviews the effects of diabetic nephropathy and identifies nutrition recommendations for patients with concurrent comorbidities including diabetes, CKD, hypertension, and/or cardiovascular disease. This detailed, comprehensive chapter, containing over 200 references and relevant case studies clearly sensitizes the reader to the complexities of treating the unique nutritional needs of the patient with diabetes mellitus, whether on insulin or other drugs who is being treated for CKD. Patients with CKD often have hyperlipidemia, described in the next chapter. Included are descriptions of nutritional and pharmacological interventions to help control abnormal lipid levels in the Stage 1 through Stage 5 CKD patient. The last chapter in this section reviews the implications and management of obesity in the CKD patient. The chapter provides the reader with an overview of the epidemiology, basic science, and clinical aspects of obesity as these relate to patients with kidney disease including those on dialysis as well as patients undergoing transplantation. The chapter includes over 200 references, case studies, and helpful tables and figures.

Part III examines the nutritional consequences in adult patients who are being treated with renal replacement therapies. Dialysis is described in the first chapter and includes relevant case studies and a full description of the medical nutrition therapy used to treat patients with end-stage renal disease. The chapter reviews the different types of renal replacement therapies including hemodialysis, peritoneal dialysis, nocturnal home hemodialysis, short daily hemodialysis and describes the corresponding dietary recommendations for calories, protein, sodium, fluid, potassium, calcium, phosphorus, lipids, vitamins, and trace minerals. The next chapter emphasizes the importance of nutrition counseling for kidney transplant recipients. Three phases of nutrition consultations are described including pre-transplantation, acute, posttransplantation, and long-term nutrition counseling. Transplantation-related immunosuppression, effects on bone mineral density, electrolyte handling by the allograft, obesity-related factors such as glucose intolerance and new onset diabetes are reviewed and case studies are included. Protein-energy wasting or uremic malnutrition is described in the next chapter that includes practice-based guidelines for identifying the patient with this serious condition. Assessment strategies of the status of chronic inflammation and other relevant indices as well as current recommendations for improving appetite and caloric intake are reviewed.

AKI can be a temporary condition or may result in permanent damage to the kidneys. Critically ill patients may develop AKI due to comorbid factors including severe illness, surgical stress, injury such as trauma and burns, or the result of multiple organ damage. As a result, the AKI is often related to existing conditions that may already require specialized nutrition support. AKI may also result in the need for specialized medical nutrition therapy. Enteral nutrition may be required to meet the nutritional requirements of the patient with AKI. There may also be patients who cannot absorb nutrients through their gastrointestinal tract and parenteral nutrition is required. This informative chapter reviews all of the potential nutritional needs of the patient with AKI. The chapter also describes the intensive care staging of kidney injury and consequences including both pathological and nutritional effects.

Chronic kidney disease has significant effects on bone and mineral metabolism that are described in the next chapter. Over the last decade, there has been extensive clinical research into the role of electrolyte imbalance and other physiological losses seen in CKD. The chapter defines the terms Chronic Kidney Disease Mineral and Bone Disorder (CKD-MBD) and Renal Osteodystrophy (RO) and includes discussions of the calcium-sensing receptor, the phosphaturic hormone, fibroblastic growth factor 23, the vitamin D receptor, and the regulation of 1, 25-dihydroxy-vitamin D production and metabolism. Evidence-based clinical practice guidelines to help prevent, ameliorate, and/or treat bone and mineral abnormalities in CKD are outlined for the reader. Manifestations of serious abnormal bone and mineral metabolism are tabulated and specific nutritional guidelines are included. Related to this chapter is the final chapter in this section that examines the role of physical activity and exercise in the determination of the nutritional requirements in the patient with advanced CKD. The author provides case studies and reviews the clinical studies that associate low levels of physical activity in the dialysis patient with poor outcomes associated with muscle atrophy, decreased lung function, and frailty.

Part IV contains five chapters that examine the importance of nutrition in the CKD patient with special needs. The first chapter reviews the intensive interdisciplinary efforts required to treat women with CKD who become pregnant. As outlined by the chapter's author, women who become pregnant during early stages of the disease, while undergoing maintenance dialysis or after kidney transplantation are all considered to be at high risk for complications. Care of the pregnant dialysis patient presents a challenge to the renal healthcare team, and requires a multidisciplinary team approach including coordination with a high-risk obstetrics team. More intensive dialysis therapy, modifications in oral and intravenous medications, and emphasis on increased intake of protein, calories, and specific vitamins and minerals are discussed in detail and case studies are included. The next chapter reviews the major causes, treatments, and unique nutritional needs of infants, children, and adolescents with CKD. The most common causes of CKD in children are congenital, hereditary, acquired, or metabolic disorders. Congenital causes include abnormally developed kidneys and obstructive uropathy. The second most common cause is acquired conditions. A major focus of nutritional care is the provision of sufficient protein, calories, and electrolytes and other essential nutrients to help assure the child's growth during dialysis and/or transplantation. The chapter includes ten informative tables, detailed discussions of physical and biochemical assessment methodologies as well as tube feeding options. The effects of aging on the major body systems, including the kidney, are reviewed in the next chapter. Seniors over the age of 65 have reduced kidney function compared to young adults and also have decreases in related functions including thirst signals. In the senior population, CKD typically occurs in individuals with chronic conditions such as diabetes mellitus (as discussed in detail in Chap. 8). More than 20 % of seniors in the USA have three comorbid conditions that impact kidney function: CKD, diabetes, and congestive heart failure or other aspects of cardiovascular disease. The management of the senior patient with CKD and potential consequences of comorbidities including bone effects, body weight, and muscle loss are described and case studies are included.

The last two chapters in this section discuss damages specific to the kidney. Nephrotic syndrome, the topic of the next chapter, results from excessive urinary losses of albumin and other plasma proteins and is characterized by edema, hyperlipidemia, and hypoalbuminemia. The causes, diagnosis,

complications, and treatments including nutritional and pharmacological are reviewed in detail. The chapter on nephrolithiasis also describes the diagnosis, risk factors, complications, and nutritional recommendations for the treatment of patients that develop kidney stones. There are 11 helpful tables that provide details for patient assessment and treatment.

Additional nutritional considerations are included in the final seven chapters of this comprehensive volume. There is an historical perspective that reviews the evolution of public policies and renal nutrition practice guidelines development. It was not until 1972 that Medicare eligibility was extended to individuals under 65 with long-term disabilities and to individuals with end-stage renal disease (ESRD). In 2002 renal patients who were not receiving dialysis were provided Medicare coverage for medical nutrition counselling with a physician referral. Another chapter examines the role of complementary and alternative medicine's use by patients with CKD and concentrates on nonessential nutrient containing dietary supplements. Traditional Chinese medicines are reviewed and a list of relevant websites is provided for the reader. The next chapter reviews the essential vitamin and mineral supplements that may be of value to CKD patients. There is a review of the function, recommended intake, and potential effects of CKD on the nutritional status for each specific nutrient. Gaps in the knowledge-base and areas for future research are identified.

Medical nutrition treatment for the patient with kidney disease requires adherence to complex dietary instructions that change with the level of severity of the kidney disease. A number of factors can influence a patient's ability to follow the recommended dietary instructions. The next chapter reviews the major factors that can improve adherence as well as inhibitors of dietary adherence. The following chapter provides practical approaches to implement behavioral changes that can improve the level of patient adherence. Assessment of the stage of change of each patient, in accordance with the Transtheoretical Model, is recommended. Cognitive behavioral therapy and motivational interviewing in patients who have dietary restrictions are also discussed. Of great importance to the care of CKD patients is the data from well-controlled outcomes research studies. The standards for conducting clinical, patient-oriented, and economic outcome studies in CKD patient populations are reviewed. Practice guidelines for different stages of CKD are also described. The final chapter contains numerous suggested resources, references, and ten valuable tables for the practicing health provider who is treating the patient with KD. The topics covered include information on CKD, nutrition, diabetes mellitus, bone mineral disorders, and other related areas.

The above descriptions of the volume's 28 chapters attest to the depth of information provided by the 39 well-recognized and respected chapter authors. Each chapter includes 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 include the numerous case studies provided in the relevant chapters. The volume includes over 125 detailed tables and informative figures, an extensive, detailed index and more than 1,900 up-to-date references that provide the reader with excellent sources of worthwhile information. Moreover, the final chapter contains a comprehensive list of resources in print as well as via the Internet including a complete listing of the practice guidelines that have been developed under the auspices of the National Kidney Foundation's Kidney Disease Outcomes Quality Initiative (KDOQI); protocols from the Academy of Nutrition and Dietetics (formerly the American Dietetic Association) concerning nutrition therapy for the non-dialysis patient; tables of general as well as specific nutrient contents of foods for individuals with different stages of kidney disease; extensive list of reliable Internet sites as well as examples of relevant assessment tools for the health provider.

In conclusion, "Nutrition in Kidney Disease, Second Edition" edited by Laura D. Byham-Gray, Jerrilynn D. Burrowes and Glenn M. Chertow provides health professionals in many areas of research and practice with the most up-to-date, well-referenced volume on the importance of maintaining the nutritional status of the patient with decreased kidney function regardless of cause and the critical value of medical nutrition evaluation, treatment support, and management for patients with CKD and other kidney diseases. This volume will serve the reader as the benchmark in this complex area of interrelationships between diet, nutritional and non-nutritional supplements, specific nutritional

products for maintaining kidney function, and the functioning of all organ systems that are intimately affected by renal disease. Moreover, these physiological and pathological interactions are clearly delineated so that students as well as practitioners can better understand the complexities of these interactions. Unique chapters that examine the effects of CKD from infancy through the aging process are included along with resources for enhancing behaviors that can increase patient adherence to nutritional therapies. The editors are applauded for their efforts to develop the most authoritative resource in the field of “Nutrition in Kidney Disease” to date and this excellent text is a very welcome addition to the Nutrition and Health Series.

Morristown, NJ, USA

Adrienne Bendich, Ph.D., FACN, FASN
Series Editor

About Series Editor



Dr. Adrienne Bendich, Ph.D., FACN, FASN has served as the “Nutrition and Health” Series Editor for over 15 years and has provided leadership and guidance to more than 100 editors that have developed the 50+ well respected and highly recommended volumes in the Series.

In addition to “Nutrition in Kidney Disease, Second Edition edited by Dr. Laura D. Byham-Gray, Dr. Jerrilynn D. Burrowes and Dr. Glenn M. Chertow”—major new editions in 2012–2013 include:

1. *Handbook of Food Fortification and Health, volume I* edited by Dr. Victor R. Preedy, Dr. Rajaventhana Srirajaskanthan, Dr. Vinood B. Patel, 2013
2. *Handbook of Food Fortification and Health, volume II* edited by Dr. Victor R. Preedy, Dr. Rajaventhana Srirajaskanthan, Dr. Vinood B. Patel, 2013
3. *Diet Quality: An Evidence-Based Approach, volume I* edited by Dr. Victor R. Preedy, Dr. Lan-Ahn Hunter and Dr. Vinood B. Patel, 2013
4. *Diet Quality: An Evidence-Based Approach, volume II* edited by Dr. Victor R. Preedy, Dr. Lan-Ahn Hunter and Dr. Vinood B. Patel, 2013
5. *The Handbook of Clinical Nutrition and Stroke*, edited by Mandy L. Corrigan, MPH, RD Arlene A. Escuro, MS, RD, and Donald F. Kirby, M.D., F.A.C.P., F.A.C.N., FACG, 2013
6. *Nutrition in Infancy, volume I* edited by Dr. Ronald Ross Watson, Dr. George Grimble, Dr. Victor Preedy and Dr. Sherma Zibadi, 2013

7. *Nutrition in Infancy, volume II* edited by Dr. Ronald Ross Watson, Dr. George Grimble, Dr. Victor Preedy and Dr. Sherma Zibadi, 2013
8. *Carotenoids and Human Health*, edited by Dr. Sherry A. Tanumihardjo, 2013
9. *Bioactive Dietary Factors and Plant Extracts in Dermatology*, edited by Dr. Ronald Ross Watson and Dr. Sherma Zibadi, 2013
10. *Omega 6/3 Fatty Acids*, edited by Dr. Fabien De Meester, Dr. Ronald Ross Watson and Dr. Sherma Zibadi, 2013
11. *Nutrition in Pediatric Pulmonary Disease*, edited by Dr. Robert Dumont and Dr. Youngran Chung, 2013
12. *Magnesium and Health*, edited by Dr. Ronald Ross Watson and Dr. Victor R. Preedy, 2012
13. *Alcohol, Nutrition and Health Consequences*, edited by Dr. Ronald Ross Watson, Dr. Victor R. Preedy, and Dr. Sherma Zibadi, 2012
14. *Nutritional Health, Strategies for Disease Prevention, Third Edition*, edited by Norman J. Temple, Ted Wilson, and David R. Jacobs, Jr., 2012
15. *Chocolate in Health and Nutrition*, edited by Dr. Ronald Ross Watson, Dr. Victor R. Preedy, and Dr. Sherma Zibadi, 2012
16. *Iron Physiology and Pathophysiology in Humans*, edited by Dr. Gregory J. Anderson and Dr. Gordon D. McLaren, 2012

Earlier books included *Vitamin D, Second Edition* edited by Dr. Michael Holick; “Dietary Components and Immune Function” edited by Dr. Ronald Ross Watson, Dr. Sherma Zibadi, and Dr. Victor R. Preedy; “Bioactive Compounds and Cancer” edited by Dr. John A. Milner and Dr. Donato F. Romagnolo; “Modern Dietary Fat Intakes in Disease Promotion” edited by Dr. Fabien De Meester, Dr. Sherma Zibadi, and Dr. Ronald Ross Watson; “Iron Deficiency and Overload” edited by Dr. Shlomo Yehuda and Dr. David Mostofsky; “Nutrition Guide for Physicians” edited by Dr. Edward Wilson, Dr. George A. Bray, Dr. Norman Temple, and Dr. Mary Struble; “Nutrition and Metabolism” edited by Dr. Christos Mantzoros and “Fluid and Electrolytes in Pediatrics” edited by Leonard Feld and Dr. Frederick Kaskel. Recent volumes include “Handbook of Drug-Nutrient Interactions” edited by Dr. Joseph Boullata and Dr. Vincent Armenti; “Probiotics in Pediatric Medicine” edited by Dr. Sonia Michail and Dr. Philip Sherman; “Handbook of Nutrition and Pregnancy” edited by Dr. Carol Lammi-Keefe, Dr. Sarah Couch and Dr. Elliot Philipson; “Nutrition and Rheumatic Disease” edited by Dr. Laura Coleman; “Nutrition and Kidney Disease” edited by Dr. Laura Byham-Grey, Dr. Jerrilynn D. Burrowes, and Dr. Glenn M. Chertow; “Nutrition and Health in Developing Countries” edited by Dr. Richard Semba and Dr. Martin Bloem; “Calcium in Human Health” edited by Dr. Robert Heaney and Dr. Connie Weaver and “Nutrition and Bone Health” edited by Dr. Michael Holick and Dr. Bess Dawson-Hughes.

Dr. Bendich is President of Consultants in Consumer Healthcare LLC, and is the editor of ten books including “Preventive Nutrition: The Comprehensive Guide for Health Professionals, Fourth Edition” co-edited with Dr. Richard Deckelbaum (www.springer.com/series/7659). Dr. Bendich serves on the Editorial Boards of the *Journal of Nutrition in Gerontology and Geriatrics*, and *Antioxidants*, and has served as Associate Editor for “Nutrition” the International Journal; served on the Editorial Board of the *Journal of Women’s Health and Gender-based Medicine*, and served on the Board of Directors of the American College of Nutrition.

Dr. Bendich was Director of Medical Affairs at GlaxoSmithKline (GSK) Consumer Healthcare and provided medical leadership for many well-known brands including TUMS and Os-Cal. Dr. Bendich had primary responsibility for GSK’s support for the Women’s Health Initiative (WHI) intervention study. Prior to joining GSK, Dr. Bendich was at Roche Vitamins Inc. and was involved with the groundbreaking clinical studies showing that folic acid-containing multivitamins significantly reduced major classes of birth defects. Dr. Bendich has co-authored over 100 major clinical research studies in the area of preventive nutrition. She is recognized as a leading authority on antioxidants,

nutrition, and immunity and pregnancy outcomes, vitamin safety, and the cost-effectiveness of vitamin/mineral supplementation.

Dr. Bendich received the Roche Research Award, is a *Tribute to Women and Industry* Awardee and was a recipient of the Burroughs Wellcome Visiting Professorship in Basic Medical Sciences. Dr. Bendich was given the Council for Responsible Nutrition (CRN) Apple Award in recognition of her many contributions to the scientific understanding of dietary supplements. In 2012, she was recognized for her contributions to the field of clinical nutrition by the American Society for Nutrition and was elected a Fellow of ASN. Dr. Bendich is Adjunct Professor at Rutgers University. She is listed in *Who's Who in American Women*.

About Volume Editors



Dr. Laura D. Byham-Gray, Ph.D., R.D. is an Associate Professor in the Department of Nutritional Sciences, School of Health Related Professions at Rutgers University. Prior to teaching, Dr. Byham-Gray practiced in the field of clinical nutrition, with specialty practice in nutrition support, kidney disease, and home care for over 20 years. She has held numerous elected and appointed positions at the national, state, and local levels of the National Kidney Foundation (NKF), the American Society of Parenteral and Enteral Nutrition (ASPEN), and the American Dietetic Association (ADA). Dr. Byham-Gray has been appointed to the *Clinical Standards Committee* for ASPEN because of her expertise in kidney disease, outcomes research, and evidence-based practice guideline development. She also serves on the associate editor for the *Journal of Renal Nutrition*. Presently, Dr. Byham-Gray is a consultant for the Academy of Nutrition and Dietetics (AND) as an evidence analyst for the *Evidence Analysis Library* recently launched by the Association.

Dr. Byham-Gray has several peer-reviewed articles and over 50 professional presentations related to kidney disease, dietetics practice, and clinical decision-making as well as management. She has also authored one self-study publication entitled *Medical Nutrition Therapy in Renal Disease, Second Edition* with Wolf Rinke Associates, and she has co-edited the AND publication, *A Clinical Guide to Nutrition Care for Kidney Disease*. Dr. Byham-Gray has received numerous awards, including the *Outstanding Service Award* by the AND-Renal Dietitians dietetic practice group and the Joel D. Kopple Award of the Council on Renal Nutrition of the National Kidney Foundation.



Dr. Jerrilynn D. Burrowes, Ph.D., R.D. is a Professor of Nutrition in the School of Health Professions and Nursing at Long Island University (LIU) Post in Brookville, NY. Prior to obtaining her doctorate in nutrition and dietetics from New York University, Dr. Burrowes was the research coordinator for the NIH-funded Hemodialysis (HEMO) Study and she practiced as a renal dietitian for 10 years prior to her involvement in the HEMO Study. Dr. Burrowes is currently the Editor-in-Chief of the *Journal of Renal Nutrition* and a Contributing Editor for the Clinical Column in *Nutrition Today*. She has published numerous peer-reviewed articles and she has been an invited speaker at over 70 professional conferences on the topic of nutrition and kidney disease. Dr. Burrowes has held several leadership positions in the national and local chapters of the National Kidney Foundation (NKF) Council on Renal Nutrition (CRN). She was a member of the NKF Kidney Disease Outcomes Quality Initiative (NKF-KDOQI) Nutrition Work Group and a member of the NKF-KDOQI Advisory Board. Dr. Burrowes was recently appointed for a 3-year term to the Research Committee of the Academy of Nutrition and Dietetics (AND). She has been the recipient of the Recognized Renal Dietitian Award and the Joel D. Kopple Award from the NKF-CRN and the *Outstanding Service Award* from the AND Renal Dietitians Practice Group.



Dr. Glenn M. Chertow, M.D., M.P.H. is Professor of Medicine and Chief, Division of Nephrology at Stanford University School of Medicine. Dr. Chertow has been a prolific writer and researcher in nephrology and renal nutrition, having authored over 130 peer-reviewed articles on Stage 5 chronic kidney disease, acute kidney injury, mineral metabolism, nutrition, and costs and outcomes of dialysis therapy.

Dr. Chertow currently leads or participates in several clinical trials and cohort studies sponsored by the National Institutes of Health-National Institute of Diabetes and Digestive and Kidney Diseases. He is presently Associate Editor for the *Journal of Renal Nutrition* and the *Journal of the American Society of Nephrology*. Dr. Chertow was vice-chair of the NKF-KDOQI Nutrition Work Group in 1998–2000, and also a member of the KDOQI Bone and Mineral Metabolism Work Group from 2000 to 2002.

Dr. Chertow has been elected to the American Society of Clinical Investigation and has been a recipient of the President's Award from the National Kidney Foundation and the National Torchbearer Award from the American Kidney Fund.

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