
Nutrition and Health

Series Editors:

Adrienne Bendich, PhD, FACN, FASN
Wellington, FL, USA

Connie W. Bales, PhD, RD
Durham VA Medical Center
Duke University School of Medicine
Durham, NC, USA

The Nutrition and Health series has an overriding mission in providing health professionals with texts that are considered essential since each is edited by the leading researchers in their respective fields. Each volume includes: 1) a synthesis of the state of the science, 2) timely, in-depth reviews, 3) extensive, up-to-date fully annotated reference lists, 4) a detailed index, 5) relevant tables and figures, 6) identification of paradigm shifts and 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 a single study. Nutrition and Health is a major resource of relevant, clinically based nutrition volumes for the professional that serve as a reliable source of data-driven reviews and practice guidelines.

More information about this series at <http://www.springer.com/series/7659>

Haewook Han • Walter P. Mutter
Samer Nasser
Editors

Nutritional and Medical Management of Kidney Stones

 Humana Press

Editors

Haewook Han
Department of Nephrology
Harvard Vanguard Medical Associates
Boston, MA
USA

Walter P. Mutter
Division of Nephrology
Newton-Wellesley Hospital
Newton, MA
USA

Samer Nasser
Department of Nephrology
Harvard Vanguard Medical Associates
Boston, MA
USA

Nutrition and Health

ISBN 978-3-030-15533-9 ISBN 978-3-030-15534-6 (eBook)
<https://doi.org/10.1007/978-3-030-15534-6>

© Springer Nature Switzerland AG 2019

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors, and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Humana imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Foreword

Kidney stones are common and, in recent years, have increased in prevalence, affecting numerous people in the United States and in many other countries. In addition, they are appearing or increasing in populations in whom stones had been relatively uncommon, including children, women, and African Americans. Because they are often recurrent, they can affect sufferers repeatedly with sudden distressing symptoms, leading to multiple visits to the emergency room or the surgical suite. We now know that they are also accompanied by less obvious problems, such as bone disease, cardiovascular disease, and chronic kidney disease. For all these reasons, prevention of recurrent kidney stones is good medicine and should engage the active interest of the multiple specialists who care for stone patients including primary care practitioners, urologist, nephrologists, and dieticians.

Our understanding of the causes of stone disease is advancing, although not as rapidly as we would hope. The genetic underpinnings of stone formation are gradually emerging, and we are beginning to appreciate the role the gut microbiome may play in oxalate degradation. Nonetheless, it is becoming increasingly clear that dietary factors play a significant role in stone formation and need to be addressed in successful prevention plans.

The book you hold in your hands fills a unique niche in the small collection of books devoted to management of kidney stones. In addition to the well-written chapters on the epidemiology, pathophysiology, and surgical treatment of stones, it includes chapters that cover the range of kidney stone types, both idiopathic and those due to systemic diseases. Most of these chapters are coauthored by a physician and a nutritionist, emphasizing the importance that diet plays in the pathogenesis and treatment of stones.

The book has six parts. The first two parts include chapters on epidemiology and pathophysiology of kidney stones and a chapter on genetic, environmental, and dietary risk factors for stone formation, which form an excellent introduction to the later chapters. Part III provides guidance on diagnostic evaluation of stone formers and an update on surgical stone removal techniques.

Parts IV, V, and VI offer the reader something not easily available in other books on stone disease – an integrated approach to the medical and dietary management of kidney stones, provided by experts in both areas. Part IV has chapters on the most common types of stones, including calcium, uric acid, cystine, and struvite, as well as a useful (and unique) chapter on management of stone formers in whom kidney stone type is unknown, an all-too-common situation. Part V takes up stones in special settings, including separate

chapters on stones in the setting of bariatric surgery, an increasingly common presentation, and in patients with other types of gastrointestinal disease. The special considerations appropriate to evaluation and treatment of kidney stones in pediatric patients are the subject of another dual-authored chapter. This part also contains a chapter about management of stones in patients with chronic kidney disease or transplant, a topic not often addressed. Finally, the part presents a much needed review of dietary myths that often crop up in the care of kidney stone patients and discusses herbal supplements.

Part VI contains valuable resources that will aid practitioners in dietary management and excellent discussions of evidence-based practice in nutritional therapy and current areas of ongoing research in this area. The appendix contains additional information that can be used to support patient care and education in the areas of stone disease and nutritional management.

This book can serve as both a reference and a guide to the comprehensive medical and nutritional care of patients with kidney stones. In most kidney stone patients, nutritional therapy is a cornerstone of their care and may be sufficient to prevent many stone recurrences. In those patients who require medication, dietary counseling is essential to assure that patients get maximal benefit from the medication they are taking. By placing nutritional evaluation and management on an even footing with medical therapy, this book provides a great service to patients with kidney stones and the practitioners who care for them.

Chicago, IL, USA

Elaine Worcester, MD

Preface

The effective management of nephrolithiasis requires a coordinated effort among providers from various specialties. Starting with an emergency room visit for renal colic, patients may wind up seeing urologists for stone removal, nephrologists for recurrent kidney stone prevention, and dietitians for nutritional management.

This comprehensive book focuses on the treatment and prevention of nephrolithiasis from the perspective of nephrologists, urologists, and dietitians. For physicians, medical students, or researchers, the opening chapters on epidemiology, genetics, and physiology of kidney stones give a foundation to understand the mechanisms and risk factors for stone formation. A surgical section follows with an up-to-date review of the surgical indications and available procedures in practice. Physicians and dietitians who treat kidney stone patients will find medical chapters followed by dietary chapters on the evaluation, management of the different types of stones, and management of stones in certain populations and high-risk groups. The book continues with chapters on myth debunking in the dietary management of kidney stones, dietary supplements, and evidence-based databases that are available in the literature.

This book contains a wealth of information that would be hard to digest in one sitting, but the sections and chapters are organized in a fashion that provides easy access to practical advice and clinical pearls. The contributing authors start each chapter with key points and keywords and end them with a summary followed by references that will provide the reader with resources for further reading. The authors have supported their chapters with informative graphics and tables that are either original or adapted from previous publications. The appendix of this book is rich with relevant cases, urine test order forms, dietary education material, and frequently asked questions.

As editors, we are very excited about the publication of this book. We hope that it will solidify the reader's knowledge of nephrolithiasis, serve as a medical and nutritional reference for evaluation and management of kidney stones, and most importantly improve the cooperation of specialists in caring for their stone patients.

Boston, MA, USA
Boston, MA, USA
Newton, MA, USA

Samer Nasser, MD
Haewook Han, PhD, RD
Walter P. Mutter, MD

Acknowledgments

We would like to thank Springer Publications and Dr. Adrienne Bendich for the opportunity to publish *Nutritional and Medical Management of Kidney Stones* as a book and Dr. Julian Seifter and Dr. Stephen Knohl for their previous mentorships that amplified our knowledge and interest on the subject. Last but not least, we express our gratitude and appreciation to all of the contributors in this book for their commitment and patience throughout the process.

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, interchapter referrals; (8) suggestions of areas for future research; and (9) balanced, data-driven answers to patient 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 and 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.

Nutritional and Medical Management of Kidney Stones edited by Haewook Han, Walter Mutter, and Samer Nasser is a very welcome and timely addition to the *Nutrition and Health* Series and fully exemplifies the Series' goals. Kidney stones have afflicted individuals over the centuries as documented in the kidneys of a 5000-year-old mummy. The causes, treatment, and prevention have been studied by early Greek and Roman physicians on every continent and have been found in patients with every type of dietary intake. With the advent of more accurate diagnostic tools, identification of the site, size, and number of stones has become more routine. Yet, kidney stones remain a significant medical issue. Moreover, there has been a continuous stream of basic as well as clinical research over the last decade linking the association between increased risk of kidney stone formation and obesity, metabolic syndrome, and diabetes incidence. Additionally, the recent findings of the nutritional aspects of stone type make this volume even more relevant to medical practice.

Kidney stones, from whatever cause, are referred to as nephrolithiasis by the medical community. Thus, it is of great importance to those involved in the medical care of patients, researchers, and students that this book is edited by three of the foremost physicians in the field of kidney stone disease in the USA and thus provides the reader with objective, up-to-date data that spans the cellular to therapeutic aspects of this painful disease. Kidney stones affect about 9% of the population, and their incidence is increasing, which may be due to the increasing age of the US population, environmental factors, and other causes that are reviewed in depth in the 28 informative chapters that contain numerous tables and figures as well as up-to-date reference lists. The volume is organized into six parts that cover the major clinical and research areas associated with kidney stone diagnosis and management. The editors have also included valuable appendices that contain case studies and informative tables, sample diets for the seven most common diet programs for individuals with various types of kidney stones, informative tables listing the calcium content and oxalate content of commonly consumed foods, a targeted list of frequently asked questions, and concise responses and examples of relevant diagnostic forms.

Part I: Overview

Part I contains a single chapter, Chap. 1, that provides a broad overview that includes discussions of the demographics, dietary intake, genetic and environmental factors, and chronic medical conditions that influence the risk of nephrolithiasis occurrence and recurrence. We learn that even though calcium kidney stones are the most common form and are increasing in incidence in females, there is also an increase in the proportion of uric acid stone formation associated with elevated BMI and low urine pH. With regard to risk factors for occurrence and recurrence of kidney stones, large-scale studies indicate that patients with a family history of kidney stones tend to develop stones at younger ages and with a higher rate of recurrence. The chapter includes a review of dietary factors that are thought to play an important role in formation of kidney stones and the composition of the urine including intakes of calcium, sodium, fructose, fluids (including water and other beverages), and vitamin C. The 5 figures and tables and over 90 references add greatly to the value of this important introductory chapter.

Part II: Basics of Kidney Stones

Part II contains three chapters that prepare the reader for the more detailed discussions of specific aspects of nephrolithiasis. Chapter 2 describes the pathophysiology of kidney stone formation and potential mechanisms to reduce the risk of primary and recurrent stones. All of the major types of stones are described in detail including calcium-based, uric acid, struvite, stones resulting from genetic factors, and potential drug adverse effects. The mechanisms involved in crystal formation and supersaturation of urine with the stone-forming components are described in detail. This practice-oriented chapter includes 9 excellent figures, 4 informative tables, and 89 relevant references. Chapter 3

reviews the genetic and environmental factors linked to stone formation. There is a description of each component of the kidney and their known genetic defects that can result in stone formation. Over 20 genetic defects are reviewed including several defects that do not involve the kidney but may affect bone calcium balance. Several genetically based cancers are also described that affect endocrine gland functions. Many of the genetic defects described result in rare diseases whose effects are seen early in childhood, including kidney stones. The environmental factors described include living in US areas with increased temperature, especially in the South East, poverty, and chronic reduced intake of liquids. Chapter 4 includes concise information on dietary intakes, including fluid intake and specific recommendations that can help reduce the risk of recurrent kidney stones containing calcium and uric acid, primarily. Other nutrients reviewed include animal protein, sugars, fiber, phosphates, vitamin B6, magnesium, sodium, and potassium.

Part III: Diagnosis and Treatment

The two chapters in this part examine the importance of an accurate diagnosis and relevant treatment. Chapter 5 provides an in-depth review of the critical steps involved in the kidney stone diagnosis, acute care in the emergency room, and follow-up care; the chapter includes seven informative tables and figures. The authors indicate that almost half of first-time stone formers have a recurrent episode. Thus, a primary goal of diagnosis is to reduce recurrence. The steps involved in the evaluation of the patient for stone-forming risk factors are reviewed and include medical history (with a detailed discussion of the 20 drugs that have been implicated in increasing the risk of kidney stones), CT scan imaging, stone analysis, and metabolic work-up. Patient history focuses on medications, diseases, diet, and work habits that may increase the risk of kidney stones. Imaging with computed tomography and ultrasound helps determine the size, number of stones, and their location in the urinary tract. Chemical and/or microbial analysis can help to determine the type of stone. Metabolic work-up consists of targeted blood work and urinalysis as well as a 24-hour urine collection. The 24-hour urine collection, especially in recurrent stone formers, is a valuable tool to determine the future risk of stone formation. The 24-hour urine values guide medical management and dietary modifications for the prevention of recurrence, and follow-up collections determine the effectiveness of the therapy. Chapter 6 presents the surgical possibilities available to the patient that does not spontaneously pass the kidney stone. The numerous treatment choices are described in detail, and the author indicates that urologists have many techniques currently available to assure that patients have good prospects for minimal surgery.

Part IV: Prevention, Medical, and Nutritional Managements for Different Types of Stones

Part IV is comprised of eight chapters that review the clinical management of patients with kidney stones and also strategies to prevent recurrence. For each subject discussed, there is first a chapter on medical issues followed by a

chapter that concentrates on the nutritional aspects of stone disease. Chapter 7 emphasizes the pathophysiology, prevention, and medical management of calcium oxalate and phosphate stones. The chapter includes a detailed review of the clinical studies that examined the role of calcium and related dietary nutrients in stone formation as well as a comprehensive description of the process of stone formation within the kidney. Clinical presentation and evaluation are also reviewed. Chapter 8 describes the synergistic role of nutrition and dietary advice in the management of kidney stone formation and recurrence. The chapter contains the recommendations on dietary issues from leading medical societies and governments that emphasize increased fluid intake, reduced intake of certain foods, and increased intake of certain nutrients that are detailed in the text and tabulated for the reader.

Uric acid stones are the second most common type of kidney stones and are reviewed first in the chapter that describes their medical management followed by the chapter describing the dietary factors associated with uric acid stone formation as well as the preventive strategies currently recommended. Chapter 9 discusses the significant morbidity associated with uric acid stones and outlines the risk factors that include gout and certain cancers, low urine volume, increased uric acid production or excretion, a high purine diet, and acidic urinary pH. The chapter lists the dietary factors that can increase stone risk and recommendations to prevent uric acid stones that include increasing fluids to produce greater than 2 liters of urine a day and a reduction of animal protein and alcohol. Medications to treat uric acid stones are also reviewed. Chapter 10 reviews in detail the dietary factors that can reduce the risk of uric acid stone formation. Low urine volume, hyperuricosuria, and low urine pH are the three most important risk factors amenable to dietary intervention. Low urinary volume and low urine pH are generally viewed as the most modifiable contributing factors to stone formation. Metabolic factors that increase risk include obesity, metabolic syndrome, and diabetes, and weight reduction is recommended. Patients with chronic diarrhea or high output ostomies have an increased risk of uric acid stone formation. Excessive fructose consumption, dehydration, and reduction in animal protein intake are reviewed and tabulated.

The next chapter, Chap. 11, describes the relatively rare form of kidney stones, struvite stones, that contain the compound struvite which is composed of magnesium ammonium phosphate. The stones are associated with higher ammonia concentrations in urine and consequently a higher pH. The stones are most often associated with genitourinary infections, and as treatment for these conditions has advanced, infection-related stones have become rarer. When identified, primary treatment involves surgery and treatment of infection; no dietary recommendations are currently given.

Another rare type of kidney stone is one composed of cystine, a dimer of cysteine. Chapter 12 describes cystine stones that are associated with high morbidity. The stones occur in patients with cystinuria, a rare genetic defect in tubular reabsorption of cationic amino acids leading to high concentrations of cystine in their urine. Inheritance is autosomal and two major genetic types have been identified. Cystine nephrolithiasis and related kidney disease are usually the only clinically pertinent manifestation of this genetic disorder. The chapter stresses that dietary management is critical with the focus on increasing the urine volume and pH. Pharmacological therapy includes the use of urine-alkalizing agents and cystine-binding thiol drugs.

Chapters 13 and 14 describe the medical evaluation of patients with nephrolithiasis without knowledge of the composition of the stone. Chapter 13 describes the situations that may lead to not knowing a stone's composition and the steps taken to manage the patient's treatment. Medical history and concomitant diseases are clues to the potential stone type especially as the vast majority of stones are calcium-based. Dietary factors are considered and are covered in depth in the next chapter. Diagnostic tests of urine pH and other urinary analyses are of primary importance and can often discriminate between calcium and uric acid stones; urinary tract infection diagnosis is often seen with struvite stones. Chapter 14 describes the generally safe and reasonable dietary recommendations for reducing stone recurrence when stone composition is unknown that include adequate fluid intake of 2.5–3 liters a day, low sodium, adequate intake of dietary calcium, animal protein restriction, and weight loss, if necessary. In addition to diagnostic tests described in the above chapter, diet history and nutrient analyses that are recommended include serum calcium, phosphorus, parathyroid hormone level, vitamin D, uric acid, and 24-hour urine composition. Dietary recommendations are also reviewed.

Part V: Special Consideration

The nine chapters in this Part examine unique situations where there are links between the age of the patient, the patient's disease or surgical procedure, and particular dietary intake that increases the risk of kidney stone formation. The first topic examines the risk of kidney stone formation since this increases two- to threefolds in patients with malabsorptive bariatric surgery compared to controls. Chapter 15 looks at the medical and dietary effects of bariatric surgery that increase stone risk and includes an in-depth examination of the types of weight loss surgeries currently being used and the comorbidities often found in patients undergoing surgery. We learn that the most common type of stone in bariatric surgery patients contains calcium salts and risk is highest in patients undergoing Roux-en-Y surgery. Dietary recommendations for patients are reviewed in depth and then modified based upon stone types. Critical issues are the low intake of fluids and the potential alteration in urine pH following surgery. Chapter 16 examines the stone risk level associated with different malabsorptive gastrointestinal diseases. The malabsorptive gastrointestinal disorders reviewed include inflammatory bowel diseases, with or without bowel resection, chronic pancreatitis, and celiac disease. The malabsorption of water, sodium, oxalate, bicarbonate, and fat leads to increased urinary concentration of stone-forming factors. The most common stones contain calcium oxalate or uric acid. This technical, practice-oriented chapter provides practical recommendations for patients with ileostomy as well as the other serious conditions indicated above, and the chapter includes 70 relevant references. Chapter 17 provides an overview of the importance of the gut's microbiome and the adverse effects of gastrointestinal diseases and/or surgery on the microbiome. Additionally, the cellular and subcellular transport of oxalate is reviewed in detail, and the types of malabsorptive syndromes are discussed with regard to their mechanisms of increasing the risk of stone formation.

Chapters 18, 19, and 20 examine the interactions between nephrolithiasis and chronic kidney disease (CKD). Chapter 18 includes a review of the clinical research studies that have examined the impact of nephrolithiasis on the risk of future CKD and end-stage renal disease (ESRD) as well on those genetic diseases that most often share both as complications. The chapter includes comprehensive tables and an extensive list of almost 100 references. Chapter 19 discusses the potential for kidney stones in patients undergoing kidney transplant. We learn that there may be the presence of small stones in a donor kidney and this may increase risk of kidney stones in the transplant patient; the incidence of kidney stones following transplant is lower than found in the general public and may be the result of denervation of the transplant. Management of a kidney stone in transplanted patients is similar to management described above for patients with kidney stones; however, if the stone is in the healthy kidney, there could be further loss of kidney function. The chapter includes a helpful case study. Chapter 20 includes eight comprehensive tables that summarize the specific nutrition management necessary to prevent recurrence of stones as well as the requirements to meet adequate nutritional status for CKD patients. Nutritional assessment, drug-nutrient interactions, and nutrition recommendations are reviewed, and the chapter emphasizes that treatment should be individualized. The CKD patient that develops stones is described, and nutritional recommendations are provided based upon the stage of CKD and concurrent diseases.

Chapters 21 and 22 provide unique chapters that delve into the current uses and risks associated with dietary supplement use and kidney stone incidence. Chapter 21, entitled “Kidney Stone: Diet, Myth and Reality,” highlights the common mistakes of dietary prevention of kidney stones and current recommendations included in the American Urology Guidelines. General guidelines include intake of adequate amounts of calcium, plenty of fluid intake, moderate amounts of animal protein, appropriate fruits and vegetables, and specific vitamin/mineral supplements. Myths that are clarified include “a high calcium diet causes kidney stones”; “water is the only beverage that can help prevent kidney stones”; “kidney stone formers should limit intake of vitamin C”; “eating meat causes kidney stones”; “fruits and vegetables cause kidney stones because of their high oxalate content”; “kidney stone medications for their prevention will work without any changes to diet”; “minerals and electrolytes cannot protect against kidney stones”; and “low purine diets do no good.” Each myth is followed by an evidence-based review of the clinical data relevant to the myth, and the tables and references document these discussions. Chapter 22 reviews the data on the use of herbal supplements for kidney stone treatment. Currently, there are very few randomized studies using herbal supplements so that recommendations are not provided. The informative tables and references provide guidance concerning herbs and commercial products containing herbs that suggest benefits for kidney stone formers.

The final two chapters in Part V examine the medical and nutritional management of pediatric kidney stone patients. Chapter 23 looks at medical management of kidney stones in children. The impact of kidney stones presenting in the pediatric age group is lifelong, and children are at increased risk of recurrent stones. There can be genetic factors and related family history as well as metabolic risk factors in these children. We learn that children that

required neonatal intensive care and were exposed to certain drugs are also at increased risk of stones. The chapter includes a detailed case study and more than 50 important references. Chapter 24 describes the importance of diet-related factors in the prevention and management of the growing rate of childhood kidney stones. As with adults described in earlier chapters, overweight and obesity significantly increase the risk of stones in children and are thus preventable. Additionally, some of the nutritional risk factors that can be moderated by diet include excessive sodium intake, excessive animal protein intake, inadequate fluid intake, inadequate citrate and potassium intake due to lack of fruits and vegetables, excessive oxalate intake, and inadequate calcium and phytate intakes due to lack of fiber-rich foods.

Part VI: Resources

Part VI, the last section in this comprehensive volume, provides four, resource-based chapters concerning the foods that contain oxalates as well as Internet sources of information related to oxalate's role in the formation of kidney stones, an in-depth description of the development and value of evidence-based clinical studies, and a final chapter on current clinical research in nephrolithiasis. Chapters 25 and 26 provide excellent examples of the in-depth information presented on the Internet and in related sources. Chapter 25 discusses the importance of knowing the foods that are high in oxalate concentration in the clinical management of patients at risk for occurrence as well as recurrence of kidney stones. Foods with the highest concentration of oxalate are plant-based and include spinach, rhubarb, beets, chard, wheat bran, nuts, chocolate, and tea. The oxalate content of these and other foods is included in a comprehensive table. Relevant books, journals, USDA websites, and other national databases and academic resources, such as those from Harvard and academic institutions from Australia and Bangladesh, are reviewed. The different databases online provide access to food weights using the metric and US systems. We learn that the USDA maintains a database on the oxalate content of plants that also contain phytochemicals and botanical compounds. Sources of mobile apps that are available are also listed. Chapter 26 contains an extensive compilation of Internet websites relevant to physicians, dietitians/nutritionists, patients with kidney stones, and those who are at risk of nephrolithiasis. The websites are listed in order of their specialty and include many from the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK).

Chapter 27 applies the principles of evidence-based practice to medical nutrition therapy for kidney stones and reviews the best available resources including evidence-based practice guidelines, searching and evaluation of primary literature, as well as systematic outcomes tracking. The chapter reviews the steps undertaken to develop the most respected source of nutritional information on kidney stone guidelines, the American Urological Association Guideline on the Medical Management of Kidney Stones. Many other authoritative sources are reviewed and tabulated. Chapter 28, the final chapter, examines the research endeavors that are ongoing to help those with kidney stones and those at risk. The chapter reviews clinical studies published

between 2012 and 2017 and examined the outcomes. The conclusion of this analysis is that medical management research investigating patients with kidney stones focused on fluid intake and obesity as the major issues. Individual studies are compared and relevant data are presented.

Conclusions

The above description of the volume's 28 chapters attests to the depth of information provided by the 43 highly respected chapter authors and volume editors. Each chapter includes complete definitions of terms with the abbreviations fully defined and consistent use of terms between chapters. Key features of the comprehensive volume include 88 detailed tables and informative figures; an extensive, detailed index; and more than 1100 up-to-date references that provide the reader with excellent sources of worthwhile practice-oriented information that will be of great value to nephrologists and related health providers as well as graduate and medical students. Additionally, several chapters include case studies, and there are valuable appendices that also contain case studies and informative tables for each, sample diets for the seven most common diet programs for individuals with various types of kidney stones, informative tables listing the calcium content and oxalate content of commonly consumed foods, a targeted list of frequently asked questions (FAQs), and concise responses and examples of relevant diagnostic forms.

In conclusion, *Nutritional and Medical Management of Kidney Stones* edited by Haewook Han, Walter Mutter, and Samer Nasser provides health professionals in many areas of kidney stone research and practice with the most current and well-referenced volume on nephrolithiasis and the critical need to assure the overall health of the individual with kidney stone disease and individuals who are at known risk for kidney stone formation. The in-depth reviews of the types of kidney stones and their medical treatment strategies focused on reducing the risk of adverse effects in these patients, especially those who also suffered from other chronic and/or infectious diseases. The volume serves the reader as the benchmark for integrating the complex interrelationships between nutritionally related risk factors such as obesity, genetic inherited predispositions to stone formation, and the risks and/or benefits of consumption of dietary components, including oxalate, relevant minerals and vitamins, protein, and sugars. Practice-oriented chapters examined the medical diagnosis, management, and prevention of stone recurrence. The final chapters of this valuable volume provide unique and concise data on the most relevant Internet resources on all aspects of kidney function and diseases associated with kidney stones. The recommended resources are from national research centers, academic departments, and related organizations that provide reliable, up-to-date information based upon the totality of the research on kidney stones. The broad scope as well as in-depth reviews found in each chapter makes this excellent volume a very welcome addition to the *Nutrition and Health Series*.

Adrienne Bendich, PhD, FACN, FASN

About the Series Editors



Adrienne Bendich, PhD, FASN, FACN has served as the *Nutrition and Health* Series Editor for more than 20 years and has provided leadership and guidance to more than 200 editors that have developed the 80+ well-respected and highly recommended volumes in the Series.

In addition to *Nutritional and Medical Management of Kidney Stones* edited by Haewook Han, Walter Mutter, and Samer Nasser, major new editions published in 2012–2019 include:

1. **Vitamin E in Human Health** edited by Peter Weber, Marc Birringer, Jeffrey B. Blumberg, Manfred Eggersdorfer, Jan Frank, 2019
2. **Handbook of Nutrition and Pregnancy, Second Edition**, edited by Carol J. Lammi-Keefe, Sarah C. Couch and John P. Kirwan, 2019
3. **Dietary Patterns and Whole Plant Foods in Aging and Disease**, edited as well as written by Mark L. Dreher, Ph.D, 2018
4. **Dietary Fiber in Health and Disease**, edited as well as written by Mark L. Dreher, Ph.D., 2017
5. **Clinical Aspects of Natural and Added Phosphorus in Foods**, edited by Orlando M. Gutierrez, Kamyar Kalantar-Zadeh and Rajnish Mehrotra, 2017
6. **Nutrition and Fetal Programming** edited by Rajendram Rajkumar, Victor R. Preedy and Vinood B. Patel, 2017
7. **Nutrition and Diet in Maternal Diabetes**, edited by Rajendram Rajkumar, Victor R. Preedy and Vinood B. Patel, 2017
8. **Nitrite and Nitrate in Human Health and Disease, Second Edition**, edited by Nathan S. Bryan and Joseph Loscalzo, 2017
9. **Nutrition in Lifestyle Medicine**, edited by James M. Rippe, 2017
10. **Nutrition Guide for Physicians and Related Healthcare Professionals 2nd Edition** edited by Norman J. Temple, Ted Wilson and George A. Bray, 2016
11. **Clinical Aspects of Natural and Added Phosphorus in Foods**, edited by Orlando M. Gutiérrez, Kamyar Kalantar-Zadeh and Rajnish Mehrotra, 2016

12. **L-Arginine in Clinical Nutrition**, edited by Vinood B. Patel, Victor R. Preedy, and Rajkumar Rajendram, 2016
13. **Mediterranean Diet: Impact on Health and Disease** edited by Donato F. Romagnolo, Ph.D. and Ornella Selmin, Ph.D., 2016
14. **Nutrition Support for the Critically Ill** edited by David S. Seres, MD and Charles W. Van Way, III, MD, 2016
15. **Nutrition in Cystic Fibrosis: A Guide for Clinicians**, edited by Elizabeth H. Yen, M.D. and Amanda R. Leonard, MPH, RD, CDE, 2016
16. **Preventive Nutrition: The Comprehensive Guide For Health Professionals, Fifth Edition**, edited by Adrienne Bendich, Ph.D. and Richard J. Deckelbaum, M.D., 2016
17. **Glutamine in Clinical Nutrition**, edited by Rajkumar Rajendram, Victor R. Preedy and Vinood B. Patel, 2015
18. **Nutrition and Bone Health, Second Edition**, edited by Michael F. Holick and Jeri W. Nieves, 2015
19. **Branched Chain Amino Acids in Clinical Nutrition, Volume 2**, edited by Rajkumar Rajendram, Victor R. Preedy and Vinood B. Patel, 2015
20. **Branched Chain Amino Acids in Clinical Nutrition, Volume 1**, edited by Rajkumar Rajendram, Victor R. Preedy and Vinood B. Patel, 2015
21. **Fructose, High Fructose Corn Syrup, Sucrose and Health**, edited by James M. Rippe, 2014
22. **Handbook of Clinical Nutrition and Aging, Third Edition**, edited by Connie Watkins Bales, Julie L. Locher and Edward Saltzman, 2014
23. **Nutrition and Pediatric Pulmonary Disease**, edited by Dr. Youngran Chung and Dr. Robert Dumont, 2014
24. **Integrative Weight Management** edited by Dr. Gerald E. Mullin, Dr. Lawrence J. Cheskin and Dr. Laura E. Matarese, 2014
25. **Nutrition in Kidney Disease, Second Edition** edited by Dr. Laura D. Byham-Gray, Dr. Jerrilynn D. Burrowes and Dr. Glenn M. Chertow, 2014
26. **Handbook of Food Fortification and Health, volume I** edited by Dr. Victor R. Preedy, Dr. Rajaventhana Srirajaskanthan, Dr. Vinood B. Patel, 2013
27. **Handbook of Food Fortification and Health, volume II** edited by Dr. Victor R. Preedy, Dr. Rajaventhana Srirajaskanthan, Dr. Vinood B. Patel, 2013
28. **Diet Quality: An Evidence-Based Approach, volume I** edited by Dr. Victor R. Preedy, Dr. Lan-Ahn Hunter and Dr. Vinood B. Patel, 2013
29. **Diet Quality: An Evidence-Based Approach, volume II** edited by Dr. Victor R. Preedy, Dr. Lan-Ahn Hunter and Dr. Vinood B. Patel, 2013
30. **The Handbook of Clinical Nutrition and Stroke**, edited by Mandy L. Corrigan, MPH, RD Arlene A. Escuro, MS, RD, and Donald F. Kirby, MD, FACP, FACN, FACG, 2013
31. **Nutrition in Infancy, volume I** edited by Dr. Ronald Ross Watson, Dr. George Grimble, Dr. Victor Preedy and Dr. Sherma Zibadi, 2013
32. **Nutrition in Infancy, volume II** edited by Dr. Ronald Ross Watson, Dr. George Grimble, Dr. Victor Preedy and Dr. Sherma Zibadi, 2013
33. **Carotenoids and Human Health**, edited by Dr. Sherry A. Tanumihardjo, 2013

34. **Bioactive Dietary Factors and Plant Extracts in Dermatology**, edited by Dr. Ronald Ross Watson and Dr. Sherma Zibadi, 2013
35. **Omega 6/3 Fatty Acids**, edited by Dr. Fabien De Meester, Dr. Ronald Ross Watson and Dr. Sherma Zibadi, 2013
36. **Nutrition in Pediatric Pulmonary Disease**, edited by Dr. Robert Dumont and Dr. Youngran Chung, 2013
37. **Nutrition and Diet in Menopause**, edited by Dr. Caroline J. Hollins Martin, Dr. Ronald Ross Watson and Dr. Victor R. Preedy, 2013.
38. **Magnesium and Health**, edited by Dr. Ronald Ross Watson and Dr. Victor R. Preedy, 2012.
39. **Alcohol, Nutrition and Health Consequences**, edited by Dr. Ronald Ross Watson, Dr. Victor R. Preedy, and Dr. Sherma Zibadi, 2012
40. **Nutritional Health, Strategies for Disease Prevention, Third Edition**, edited by Norman J. Temple, Ted Wilson, and David R. Jacobs, Jr., 2012
41. **Chocolate in Health and Nutrition**, edited by Dr. Ronald Ross Watson, Dr. Victor R. Preedy, and Dr. Sherma Zibadi, 2012
42. **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 Burrowes, and Dr. Glenn 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 served as President of Consultants in Consumer Healthcare LLC and has edited ten books including *Preventive Nutrition: The Comprehensive Guide for Health Professionals, Fifth Edition*, coedited 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 & 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 coauthored 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 (FASN). Dr. Bendich served as an Adjunct Professor at Rutgers University. She is listed in Who's Who in American Women.



Connie W. Bales, PhD, RD is a Professor of Medicine in the Division of Geriatrics, Department of Medicine, at the Duke University School of Medicine and Senior Fellow in the Center for the Study of Aging and Human Development at Duke University Medical Center. She is also Associate Director for Education/Evaluation of the Geriatrics Research, Education, and Clinical Center at the Durham VA Medical Center. Dr. Bales is a well-recognized expert

in the field of nutrition, chronic disease, function, and aging. Over the past two decades, her laboratory at Duke has explored many different aspects of diet and activity as determinants of health during the latter half of the adult life course. Her current research focuses primarily on enhanced protein as a means of benefiting muscle quality, function, and other health indicators during geriatric obesity reduction and for improving perioperative outcomes in older patients. Dr. Bales has served on NIH and USDA grant review panels and is Past-Chair of the Medical Nutrition Council of the American Society for Nutrition. She has edited three editions of the *Handbook of Clinical Nutrition and Aging*, is Editor-in-Chief of the *Journal of Nutrition in Gerontology and Geriatrics*, and is a Deputy Editor of *Current Developments in Nutrition*.

About the Editors



Haewook Han, PhD, RD, CSR, LDN is a renal nutrition specialist at the Department of Nephrology at Harvard Vanguard Medical Associates (HVMA) and a clinical assistant professor of nutrition at Tufts University, The Gerald J. and Dorothy R. Friedman School of Nutrition Science and Policy, in Boston. She completed her clinical training at Emory University and completed her doctoral degree at Tufts University, The Gerald J. and Dorothy R. Friedman School of Nutrition Science and Policy, in Boston. She worked as a renal dietitian at various dialysis units for many years before she

worked as a research coordinator and dietitian for the NIH-funded Hemodialysis (HEMO) Study. She worked as a clinical nutrition research manager for many years at Tufts Medical Center (TMC) before she joined HVMA in Boston. Currently, she is a senior renal nutrition specialist at the Department of Nephrology at HVMA, Frances Stern Nutrition Center/ Division of Nephrology at TMC, and Brigham and Women's Hospital (BWH), where her major roles include nutrition management of all stages of CKD and kidney stone patients. She developed numerous diet education materials for these institutes especially for CKD and kidney stone patients. She published several chapters in nutritional management of kidney stones. She sees all stone patients at HVMA with nephrologists for nutritional care to prevent recurrence of stones.

Dr. Han has been a member of Journal of Renal Nutrition Editorial Board since 2011 and Nutrition Today. She presented multiple lectures in nutritional management of CKD and stones in the United States and international conferences. She has been serving as the RenaLink editor since 2016 as a member of National Kidney Foundation Council on Renal Nutrition (NKF-CRN) Executive Committee. She is recipient of the Outstanding Service Award from the Academy of Nutrition and Dietetics (AND), Renal Practice Group; Recognition of Outstanding Research in Nutritional Science and Practice by the Korean Nutrition Society, American Society of Nutrition; and the Recognized Renal Dietitian Award from the NKF-CRN.



Walter P. Mutter, MD is Chief of Nephrology at Newton-Wellesley Hospital in Newton Massachusetts which is an academic community hospital affiliated with Partners Health Care. Throughout his career, he has maintained a strong interest in kidney stone prevention. Dr. Mutter received his MD from the University of Massachusetts Medical School and completed residency and fellowship in Nephrology at Beth Israel Deaconess Medical Center in Boston. Following fellowship, he was a member of the Nephrology Division at Beth Israel Deaconess and an Instructor in Medicine at

Harvard Medical School. He also practiced at Harvard Vanguard Medical Associates, where he collaborated clinically, with Dr. Haewook Han, in the care of many patients with nephrolithiasis.



Samer Nasser, MD, FASN is a nephrologist with clinical interest in chronic kidney disease and kidney stone prevention. He practices at a large multispecialty group with an academic affiliation. This allows steady referral of kidney stone patients from primary care providers and urologists with dietician support for all cases. He has coauthored the chapter “Nutrition Management for Kidney Stones” in *A Clinical Guide to Nutrition Care in Kidney Disease* (in publication), “Evaluation of Patients with Nephrolithiasis (Diagnosis of

Nephrolithiasis)” in this book, and an Oxalate Nephropathy case report in the *American Journal of Kidney Diseases*. He has peer-reviewed articles for the *Journal of Renal Nutrition*.

Dr. Nasser’s interest in kidney stone prevention started back in SUNY Upstate Medical University, Syracuse, New York, where he has completed his residency and fellowship training and where fellows participated in a dedicated stone prevention clinic. Prior to that, he completed his BS in Biology and Medical Degree at the American University of Beirut. He worked in private practice with Renal Care Consultants in Johnstown, Pennsylvania, after which he joined the faculty at Beth Israel Deaconess Medical Center and Atrius Health in Massachusetts.

Contents

Part I Overview

- 1 Epidemiology of Kidney Stones in the United States** 3
Jeffrey H. William

Part II Basics of Kidney Stone

- 2 Pathophysiology of Kidney Stone Formation** 21
Elaine M. Worcester
- 3 Genetic and Environmental Risk Factors for Kidney Stones** 43
Hala Yamout and Seth Goldberg
- 4 Basics of Kidney Stones: Dietary Risk Factors of Kidney Stones** 53
Rania El Tawil and Zeina Bachir

Part III Diagnosis and Treatment

- 5 Evaluation of Patients with Nephrolithiasis (Diagnosis of Nephrolithiasis)** 63
Matthew Lynch and Samer Nasser
- 6 Kidney Stone Removal Procedures and Emerging Therapies** 83
Lawrence T. Zhang and Peter L. Steinberg

Part IV Prevention, Medical and Nutritional Managements for Different Types of Stones

- 7 Calcium Stone: Pathophysiology, Prevention, and Medical Management** 93
Wan Ahmad Hafiz Wan Md Adnan and Sagar U. Nigwekar
- 8 Nutritional Management of Calcium Stones** 107
Donna E. Gjesvold
- 9 Medical Management of Uric Acid Stones** 117
Shimontini Mitra and Robert A. Cohen
- 10 Nutritional Management of Uric Acid Stones** 123
Anne-Marie Desai

11	Struvite Stones	133
	Walter P. Mutter	
12	Cystine Stones	141
	Nikhil Agrawal and Kambiz Zandi-Nejad	
13	Medical Management of Unknown Stone Types	149
	Eric S. Kerns, Kenneth Ralto, and Adam M. Segal	
14	Nutritional Management of Unknown Types of Stones	157
	Diana El Jundi and Zeina Younes	

Part V Special Consideration

15	Bariatric Surgery and Stone Risk	169
	Jillian Reece, R. Wesley Vosburg, and Nitender Goyal	
16	Nephrolithiasis in Patients with Gastrointestinal Disorders ...	181
	Gebran Abboud	
17	Gastrointestinal Disease and Stone Risk: Nutritional Management	191
	Desiree de Waal	
18	Nephrolithiasis in Chronic Kidney Disease	199
	Adam Zayac, Semaan Kobrossi, and Stephen Knohl	
19	Nephrolithiasis in Kidney Transplant	221
	Nitender Goyal	
20	Nutritional Management of Nephrolithiasis in Chronic Kidney Disease	227
	Haewook Han, Pamela S. Kent, and Judith A. Beto	
21	Kidney Stone: Diet, Myth, and Realty	243
	Lisa Vosatka and Haewook Han	
22	Herbal Use in the Nutrition Management of Kidney Stones	255
	Judith A. Beto	
23	Evaluation and Management of Pediatric Nephrolithiasis ...	261
	Michelle A. Baum	
24	Nephrolithiasis Nutrition Therapy in the Pediatric Population	273
	Kyle J. Lamprecht	

Part VI Resources

25	Dietary Database of Oxalates	283
	June Leung	
26	Kidney Stone Disease: Online and Educational Resources ...	291
	Catherine M. Goeddeke-Merickel	

27	Medical Nutrition Therapy and Evidence-Based Practice	295
	Rosa K. Hand	
28	Stone Disease Research	303
	Jerrilynn D. Burrowes and Laura D. Byham-Gray	
	Appendices	319
	Index	345

Contributors

Gebran Abboud, MD Conemaugh Memorial Medical Center, Johnstown, PA, USA

Wan Ahmad Hafiz Wan Md Adnan, MB, MRCPI University Malaya Medical Centre, Kuala Lumpur, Malaysia

Nikhil Agrawal, MD Division Nephrology, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, USA

Zeina Bachir, MSc Burj Views, Tower C, Dubai, United Arab Emirates

Michelle A. Baum, MD Pediatric Nephrology, Boston Children's Hospital, Harvard Medical School, Boston, MA, USA

Judith A. Beto, PhD, RDN, FAND, LDN Division of Nephrology and Hypertension, Loyola University of Chicago, Health Sciences Division, Maywood, IL, USA

Jerrilynn D. Burrowes, PhD, RD, CDN, FNKF Department of Nutrition, Graduate Program in Nutrition, Long Island University Post, Brookville, NY, USA

Laura D. Byham-Gray, PhD, RDN, FNKF Department of Clinical and Preventive Nutrition Sciences, School of Health Professions, Rutgers University, Newark, NJ, USA

Robert A. Cohen, MD Nephrology Division, Department of Medicine, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, USA

Desiree de Waal, MS, RD, CD, FAND University of Vermont Medical Center, Nephrology, Burlington, VT, USA

Anne-Marie Desai, RD Dietetics and Integrated Renal Service, Eastern Health, Box Hill, VIC, Australia

Diana El Jundi, RD, MSc Dubai Diabetes Center, Dubai, UAE

Donna E. Gjesvold, RDN, LD Hennepin Healthcare Kidney Center, Minneapolis, MN, USA

Catherine M. Goeddeke-Merickel, MS, RDN, LD, FNKF Advance Practice & Clinical Dietitian and Clinical Instructor, Phoenix, AZ, USA

Seth Goldberg, MD Washington University in St. Louis, St. Louis, MO, USA

Nitender Goyal, MD Tufts Medical Center, Boston, MA, USA

Rosa K. Hand, PhD, RDN, LD, FAND Department of Nutrition, Case Western Reserve University, Cleveland, OH, USA

Haewook Han, PHD, RD, CSR, LDN Department of Nephrology, Harvard Vanguard Medical Associates, Boston, MA, USA

Pamela S. Kent, MS, RD, CSR, CDE, LD ESCP Operations, Centers for Dialysis Care, Shaker Heights, OH, USA

Eric S. Kerns, MD Division of Nephrology, Department of Medicine, Lahey Hospital and Medical Center, Burlington, MA, USA

Stephen Knohl, MD SUNY Upstate Medical University, Syracuse, NY, USA

Semaan Kobrossi, MD SUNY Upstate Medical University, Syracuse, NY, USA

Kyle J. Lamprecht, MS, RD, CSP, CSR, CD-N Pediatric Renal Dietitian, Jackson Heights, NY, USA

June Leung, PhD, RD Manchester, NH, USA

Matthew Lynch, MD Brown Medicine, East Providence, RI, USA

Shimontini Mitra, MD Nephrology Division, Department of Medicine, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, USA

Walter P. Mutter, MD Division of Nephrology, Newton-Wellesley Hospital, Newton, MA, USA

Samer Nasser, MD Department of Nephrology, Atrius Health, Quincy, MA, USA

Sagar U. Nigwekar, MD, MMSc Harvard Medical School, Massachusetts General Hospital, Boston, MA, USA

Kenneth Ralto, MD UMass Memorial Medical Group, Worcester, MA, USA

Jillian Reece, RD, LDN, CSOWM Tufts Medical Center, Weight and Wellness Center, Boston, MA, USA

Adam M. Segal, MD Division of Nephrology, Department of Medicine, Lahey Hospital and Medical Center, Burlington, MA, USA

Peter L. Steinberg, MD Division of Urology, Beth Israel Deaconess Medical Center, Boston, MA, USA

Rania El Tawil, MSc Nutrition House, Ottawa, Ontario, Canada

Lisa Vosatka, MS, RD, LDN Palm Garden Healthcare, Clearwater, FL, USA

R. Wesley Vosburg, MD Mount Auburn Hospital, Waltham, MA, USA

Jeffrey H. William, MD Harvard Medical School, Boston, MA, USA
Beth Israel Deaconess Medical Center, Boston, MA, USA

Elaine M. Worcester, MD University of Chicago Medicine, Chicago, IL, USA

Hala Yamout, MD VA St. Louis Health Care, St. Louis University, St. Louis, MO, USA

Zeina Younes, MSc The Greens, Dubai, United Arab Emirates

Kambiz Zandi-Nejad, MD Division Nephrology, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, USA

Adam Zayac, MD SUNY Upstate Medical University, Syracuse, NY, USA

Lawrence T. Zhang, BS Tufts University, School of Medicine, Boston, MA, USA