Conceptual Model of CKD: Applications and Implications

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The conceptual model of chronic kidney disease (CKD) was developed by the National Kidney Foundation's Kidney Disease Quality Outcome Initiative (NKF-KDOQI) in 2002 and subsequently revised and adopted by an international consensus under the auspices of KDIGO (Kidney Disease: Improving Global Outcomes) in 2005. This model includes concepts of definition, staging, outcomes, and treatment, as well as risk factors for the development, progression, and complications of CKD. Treatments are available for patients with risk factors and for each stage of CKD; these include slowing the progression of kidney disease, preventing and treating the complications of decreased glomerular filtration rate, and reducing cardiovascular disease risk factors and treating cardiovascular disease. In principle, measures to improve the prevention, detection, and treatment could reduce adverse outcomes, improve the quality of life, and prolong the survival of individuals with CKD. The conceptual model for CKD is now being applied to a public health approach for the prevention of the development, progression, and complications of CKD. Primary prevention is defined as prevention of CKD; secondary and tertiary prevention are defined as improving outcomes of patients with CKD stages 1 to 4 and kidney failure (CKD stage 5), respectively. The conceptual model has also fostered debate about important questions: Is CKD a disease or a cardiovascular disease risk-factor condition? Do all patients with CKD need to be referred to a nephrologist? What does CKD care include? Should the classification be modified to include cause of disease and prognosis? Can CKD evolve from acute kidney disease, and is CKD reversible? Is albuminuria a manifestation of a kidney disease or systemic endothelial dysfunction? Is the age-related decrease in glomerular filtration rate normal or abnormal, and should we change the definition of CKD in the elderly? A combination of immediate action, data gathering, and research to establish the efficacy, effectiveness, and costs related to CKD are needed to respond to CKD as a public health problem.

Am J Kidney Dis 53(S3):S4-S16. © *2009 by the National Kidney Foundation, Inc.*

INDEX WORDS: Disease model; prevention; chronic kidney disease.

The conceptual model of chronic kidney disease (CKD) currently in use was first detailed by the National Kidney Foundation's Kidney Disease Outcomes Quality Initiative (NKF-KDOQI) in 2002 and subsequently revised and adopted by international consensus under the auspices of KDIGO (Kidney Disease: Improving Global Outcomes) in 2005.[1-3] The Centers for Disease Control and Prevention is now applying this model in the public health approach for the prevention of the development, progression, and complications of CKD.[4] The purpose of this article is to review the conceptual model, including the definition, staging, outcomes, and treatment of patients with CKD, as well as risk factors for the development, progression, and complications of CKD. We also highlight the historical perspective of the conceptual model and some of the recent debate about the implications of these concepts for clinical practice, research, and public health. Some material in this article is reprinted from previous reports.[1-3]

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0272-6386/09/5303-0102$36.00/0

doi:10.1053/j.ajkd.2008.07.048

HISTORICAL PERSPECTIVE

The introduction of improved techniques for clinical chemistry and pathology in the mid-20th century dramatically expanded knowledge of the clinical characteristics, pathogenesis, natural history, diagnosis, and treatment of many types of CKD. At the same time, the development of dialysis and transplantation offered life-saving treatment to patients with kidney failure, irrespective of the cause of the disease, but were too expensive to be widely applied. The 1967 report by the Committee on Chronic Kidney Diseases, convened by the federal government and chaired by Carl Gottschalk, opens with the letter in Box 1.[5] The Gottschalk report suggested a federal system of care, paving the way for the 1972 legislation creating the end-stage renal disease program in

Box 1. Excerpt From Cover Letter From the Committee on Chronic Kidney Disease

"You charged the Committee with the responsibility of considering all aspects of the problems posed by chronic kidney disease and of making recommendations directed towards meeting these problems. . . . Prevention is obviously preferable to treatment of disease. Unfortunately, knowledge concerning the causes and prevention of end-stage kidney disease is limited and this is an area in which an expanded research effort is required. Furthermore, even if a completely successful method of prevention is developed it will have no significant impact on the numbers of people dying from end-stage kidney disease for many years. Therefore, the Committee recommends a national treatment program aimed at providing chronic dialysis and/or transplantation for all of the American population for whom it is medically indicated . . ."

Note: Text from 1967 letter from Carl W. Gottschalk, MD, to Charles L. Schultze, Director of the US Bureau of the Budget.[5]

the United States by enabling Medicare coverage for dialysis and transplantation for patients with chronic kidney failure regardless of age.[6]

In the following decades, Brenner et al,[7] investigating animal models of CKD, formulated a hypothesis for the progressive nature of kidney disease irrespective of cause, including the potential for treatment to ameliorate progression. Their hypothesis stimulated additional laboratory and clinical investigation and eventual large clinical trials. At the same time, new treatments became available for patients with some of the most important complications of kidney failure and earlier stages of CKD, including anemia and bone and mineral disorders.[8] The high burden of cardiovascular disease in patients with CKD was recognized, and CKD was identified as a new risk factor for cardiovascular disease.[9]

In the past 20 years, evidence from many sources indicated that CKD had become a public health problem in the United States and around the world. There was an increasing incidence and prevalence of kidney failure, with poor outcomes and high cost. There was an even greater prevalence of earlier stages of CKD. It became appreciated that CKD was under-diagnosed and undertreated, resulting in lost opportunities for prevention. The NKF convened a work group, chaired by 2 of the authors of this article, to develop clinical practice guidelines for CKD concerning evaluation, classification, and stratification of risk. KDOQI co-chairs Eknoyan and Levin wrote in the preface to the KDOQI CKD guidelines, "Thus, while dialysis has made it possible to prolong the lives of patients with ESRD, today it is also possible to retard the course of progression of kidney disease, to treat accompanying comorbidity earlier, and to improve the outcomes and quality of life of all individuals afflicted with kidney disease, well before replacement therapy becomes necessary. Yet, the application of these advances remains inconsistent, resulting in variation in clinical practice and, sadly, in avoidable differences in patient outcomes".[1]

One reason for poor outcomes was believed to be the lack of agreement about a definition and classification of stages in the progression of CKD. As stated in the introduction to the executive summary of the guidelines, "A clinically applicable classification would be based on laboratory evaluation of the severity of kidney disease, association of level of kidney function with complications, and stratification of risks for loss of kidney function and development of cardiovascular disease."[1]

CONCEPTUAL MODEL

Figure 1 shows the KDOQI conceptual model for the development, progression, and complications of CKD with modifications relevant to a public health approach.[1,4] The conceptual model identifies kidney failure as the end stage of CKD and links it to earlier stages. According to this concept, kidney failure is preceded by a decrease in glomerular filtration rate (GFR), which is preceded by kidney damage. CKD typically evolves over a long time, beginning with a lengthy latency period when the disease may go undetected, followed by late onset of symptoms caused by complications of decreased kidney function. Thus, it should be possible to detect CKD before kidney failure by testing for markers of kidney damage and/or estimating GFR. The horizontal arrows in Fig 1 pointing from left to right emphasize the progressive nature of CKD. However, the rate of progression is variable, and not all patients progress; thus, a diagnosis of CKD does not equate with eventual development of kidney failure. Interventions in earlier stages may slow or prevent the progression to later stages.