Geriatric Nephrology: Responding to a Growing Challenge

Mitchell Rosner,* Emaad Abdel-Rahman,* and Mark E. Williams† for the ASN Advisory Group on Geriatric Nephrology

*Division of Nephrology, University of Virginia, Charlottesville, Virginia; and †Harvard Medical School, Beth Israel Deaconess Medical Center, Joslin Diabetes Center, Boston Massachusetts

Changing demographics of the global population predict that the number of people age 65 years or greater will triple over the coming decades. Because the incidence and prevalence of kidney disease increase with advancing age, nephrologists will be increasingly confronted with a population of patients who are elderly and have a large number of comorbid conditions requiring ongoing care. Furthermore, it is increasingly understood that aging leads to its own unique aspects of nephrologic diagnosis and treatment. Although it is known that elderly patients constitute a group with special needs and present unique challenges to the nephrologist, traditional nephrology fellowship training has not included a focus on the geriatric population. In response to this need for greater education and awareness, the American Society of Nephrology has initiated a program of educational activities in geriatric nephrology and has chartered a specific advisory council. The priority being given to geriatric nephrology is a hopeful sign that issues such as treatment options, the efficacy of treatments, and their effect on quality of life for the elderly patient with kidney disease will be improved in the coming years.

Clin J Am Soc Nephrol 5: 936–942, 2010. doi: 10.2215/CJN.08731209

It is a fact of life—we are getting older. Whether viewed from a national or global perspective, nephrologists need to ready themselves for the implications of this "coming of age." The projected numbers of elderly individuals (defined here as age >65 years) over the next few decades is potentially overwhelming for the health care system. In most of the world, longevity continues to increase. Life expectancy is globally estimated at 67.2 years, averaging 76.5 years in developed countries and 65.4 years in developing countries (1). As a result, with every passing month, another 870,000 people turn 65 years, and this figure is projected to grow to almost 2 million a month over the next 10 years (1). Globally, the number of elderly is expected almost to triple, from 743 million in 2009 to 2 billion in 2050. By that date, the number of older persons (age >65 years) will exceed the number of children under the age of 15 (1).

As discussed in this article, the clinical nephrologist will increasingly encounter an older population of patients with unique care issues. These will range from controversies in the diagnosis and treatment of specific disease entities and the increased number of complicating comorbidities to competing issues of quality of life *versus* aggressive care options. Thus, nephrologists in many parts of the world will face epidemiologic, research, and clinical challenges that did not exist in the past.

The Challenges of an Aging U.S. Population

What is the challenge presented in the United States by these changing demographics? Although the total U.S. population increased 3-fold during the 20th century, the elderly population (age >65 years) increased more than 10-fold. Thus, the elderly population in the United States, having doubled between 1960 and 2000, is expected to double further from the current 36 million to 71 million by 2030 (2,3). Within these numbers are a subgroup of the very elderly (persons 85 years old and over) who are a small but rapidly growing group (Figure 1). This population comprised 3.5 million persons in 1994, 28 times larger than in 1900. This group increased 274% from 1960 to 1994, compared with an increase of 100% for persons 65 years old and over, and an increase of 45% for the total population (2,3). Overall, the very elderly are projected to be the fastest growing part of the elderly population into the next century (2). As a result, kidney disease will increasingly become a geriatric illness.

Because the kidney undergoes important age-related changes in function and structure, the aging of the population is reflected in changes in the overall prevalence of kidney disease (4). Several studies have looked at the prevalence of chronic kidney disease (CKD) and end-stage kidney disease (ESKD) as stratified by age with the similar conclusion that CKD and ESKD are diseases of the elderly (5–11). According to a cross-sectional study of the most recent National Health and Nutrition Examination Survey (NHANES), which used the presence of persistent albuminuria and decreased GFR as determined by the abbreviated Modification of Diet in Renal Disease (MDRD) study equation to define CKD, more than one-third of individuals in the general population aged 70 years and older have moderate CKD (5). An important critique of these data has been that estimates of the prevalence of CKD are very sensitive to difference in how GFR is estimated, how serum creatinine is measured, and how CKD is defined (12). Furthermore, the MDRD equation has been validated for patients with CKD age

Published online ahead of print. Publication date available at www.cjasn.org.

Correspondence: Dr. Mitchell H. Rosner, Division of Nephrology, University of Virginia Health System, Charlottesville, VA 22908. Phone: 434-924-2187; Fax: 434-924-5848; E-mail: mhr9r@virginia.edu

ISSN: 1555-9041/505–0936

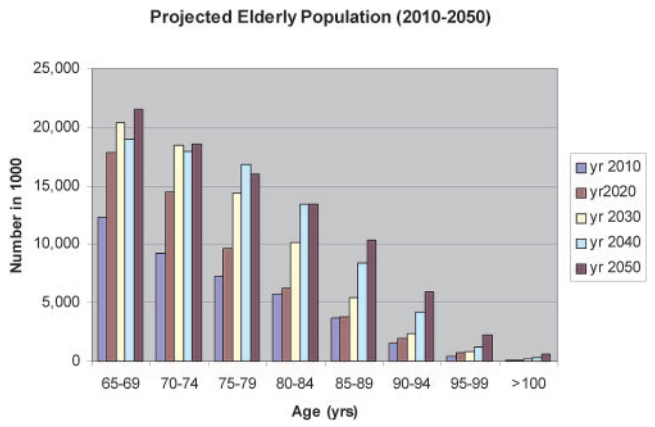

Figure 1. Projected elderly population, 2010 to 2050. Adapted from references 2 and 3.

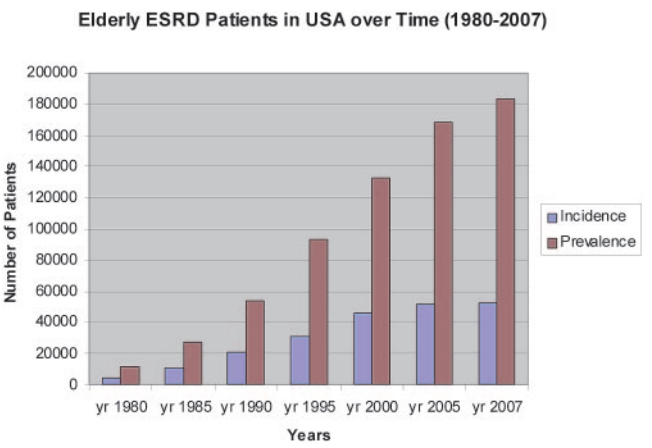

Figure 2. Growth over time of elderly (age >65 years) treated ESKD patients. Adapted from reference 8.

>18 years but <69 years of age and requires the use of a calibrated serum creatinine. Recently, the CKD Epidemiology Collaboration equation for estimated GFR (eGFR) has been proposed as an alternative to the MDRD equation and has demonstrated greater accuracy and less bias (especially at GFR values >60 ml/min/1.73 m^2) (11). However, when applied to the same NHANES dataset, this equation yielded similar estimates of the prevalence of CKD in the elderly with nearly 35% of those aged >70 years with stage 3 (11).

Some have argued that moderate reductions in eGFR can occur as the result of normal aging and should not be equated with CKD in the absence of other abnormalities or clearly defined associated risks (12–14). However, others have noted that reductions in eGFR in the elderly reflect the high prevalence of CKD risk factors and offer substantial prognostic significance in the elderly (15). From either perspective, nephrologists are encountering a growing group of elderly patients with diminished eGFR that require evaluation and management.

Although most elderly CKD patients will die or develop significant cardiovascular events rather than progress to ESKD, the trend of growth in the CKD population has been mirrored in the number of treated (some patients with ESKD will decline dialysis or die before 90 days on dialysis) ESKD patients (8,9,16,17). Compared with 1994, the overall incidence for ESKD in the elderly in 2004 increased 24% for those aged 65 to 74 years and 67% for those 75 years and older (8). U.S. Renal Data System data (Figure 2) show the rapid increase in the incidence and prevalence of treated ESKD patients over the past few decades.

A complicating factor associated with the growth of the elderly CKD population is the presence of a significant number of comorbid conditions, such as atherosclerotic cardiovascular disease, congestive heart failure, hypertension, diabetes, and cognitive and functional impairment (18,19). Several studies have demonstrated that both the prevalence and overall burden of these comorbidities is higher among older patients with CKD (19). Particularly in those over 60 years of age, the most common cause of CKD and ESKD in the United States is diabetic nephropathy. It should be noted that, combined with the general aging of the population, the concurrent epidemic of type 2 diabetes in the United States and elsewhere has led to a marked increase in the number of elderly diabetic patients affected by CKD and ESKD so that one-third of new ESKD cases in people over 75 years of age are due to diabetic kidney disease (9). In part, these complicating comorbidities lead to a higher threshold eGFR at which the risk of death exceeds that of developing ESKD (20). These competing, interacting, and causative comorbid conditions require monitoring by the nephrologist in the context of a holistic, collaborative, and individualized program of care in which decisions regarding treatment of CKD and ESKD have important socioeconomic, functional, psychologic, and ethical implications.

Challenges for the Nephrologist in the Care of Geriatric Patients

Why is there a need for a focus on geriatric nephrology? Certainly, the epidemiologic facts described above substantiate that the patient population cared for by nephrologists is elderly, a fact that most nephrologists clearly understand and experience daily. But what issues in nephrology are specifically affected by age, and how does age affect diagnosis and therapy in important ways? Several recent reviews have addressed some of these issues (12,21,22). Broadly speaking, some of the important issues can be divided into (*1*) knowledge gaps regarding issues of pathogenesis, diagnosis, and therapy in the geriatric patient with kidney disease; and (2) specific and unique aspects of care for geriatric patients that confront the nephrologist.

There are significant needs for future research that addresses unanswered, but critical, areas of kidney disease in the elderly patient. For instance, as briefly discussed above, is CKD in elderly patients the same condition as CKD in younger patients, and should the CKD staging system be applied across all age groups equally? How do age-related changes in the kidney (*e.g.*, fibrosis and cellular senescence) affect CKD progression and are these changes reversible or inevitable consequences of aging? Why are some elderly patients protected from a decline in GFR with aging? Are there better markers of CKD and risk for progression to ESKD in elderly patients than our current

ones? How does CKD affect and interact with other comorbidities in the elderly patients such as cognitive impairment, frailty, cardiovascular disease, and other conditions? What is the effect of dialysis or other CKD therapies on functional status and quality of life in elderly adults (23)? How do we apply the results of clinical trials to geriatric patients that generally exclude patients older than age 65 years? These are critical questions, and their answers will help frame our approach to a rapidly expanding population of adults.

Furthermore, for specific conditions such as hypertension, glomerular diseases, diabetes, cardiovascular disease, and acute kidney injury, the diagnosis and treatment of these entities may be significantly different in the elderly patient *versus* younger patients (Table 1). For instance, plasma renin activity declines with age and is lower in older hypertensive patients as compared with younger patients (24). This has been attributed to age-associated nephrosclerosis affecting the juxtaglomerular apparatus (24). Thus, with these age-related changes, do elderly patients experience the same benefit from drugs that block the renin-angiotensin-aldosterone system in terms of lowering of blood pressure and slowing the progression of kidney disease? These important age-related clinical questions require further investigation so that diagnostic modalities and therapies can be optimally applied.

The Role of the Nephrologist in the Care of Geriatric Patients

In the face of increasing need, the number of physicians seeking specialty training in geriatric medicine may be decreasing (25). Furthermore, it is known that primary care physicians themselves find caring for elderly patients challenging. Three reasons are commonly cited: (*1*) medical complexity and chronicity of conditions, (*2*) coordination of medical and nonmedical conditions, and (*3*) the administrative burden (26,27). These reasons are particularly pertinent to elderly patients with CKD. Elderly CKD patients experience a high rate of complications such as cardiovascular disease, anemia, hypertension, malnutrition, and bone disease. The obstacles to effectively caring for these issues also increase (including interacting comorbidities, impaired physiologic reserve, cognitive dysfunction, and limited economic and social resources). As primary care physicians look for assistance in management of elderly patients with CKD and other kidney problems, the nephrologist will have to confront the interacting effects of aging with kidney disease to be able to adequately address their patients' problems.

Furthermore, for those patients undergoing maintenance dialysis, the nephrologist commonly assumes many of the roles of the primary care physician (28). The nephrologist almost always does this without specific geriatric training (21). Thus, the nephrologist is faced with such issues as fall risk, frailty, dementia, delirium, depression, polypharmacy, and urinary incontinence in patients that they follow longitudinally in the outpatient setting and/or on dialysis. In the face of changes in dialysis reimbursement such as bundling of payments for services, how will management of these comorbid conditions be affected? This requires the dialysis community to be educated about the basics of geriatrics, especially quality of life issues and their assessment. An important example of this issue is the important but time-consuming task of involving patients aged >85 years and their families in informed, shared decisions as to whether to choose dialysis or a more conservative treatment approach as kidney function worsens, and, conversely, how to counsel elderly patients on withdrawal of dialysis (29).

In addition, the nephrologist will confront a wide range of age-related functional and pathologic questions. With aging, there are well documented changes in the anatomy and physiology of the kidneys: according to cross-sectional and longitudinal studies, the GFR decreases by approximately 1 ml/1.73 m^2/yr after approximately age 30 years (4). As a result, elderly patients may be mislabeled as having moderate CKD even when their eGFR corrected for age is normal (4,22). Conversely, reliance on serum creatinine may be misleading; loss of lean body mass may allow a normal serum creatinine despite significant loss of kidney function (4).

Kidney biopsies are increasingly being performed in the elderly and very elderly (30,31). Although highly variable in severity, common findings are age-related kidney fibrosis related to increased collagen accumulation (30,31) and advanced vascular changes, similar to chronically damaged kidneys (4,30,31). This is a different spectrum of pathologies as compared with the younger population and requires a careful assessment of risks and benefits of any potential therapeutic intervention.

In terms of therapeutics in the elderly, one important consideration will be the different pharmacodynamics/pharmacokinetics of drugs that occur with aging (4). When prescribing a drug to this population, the nephrologist has to be aware of the effect of the multiple other drugs these patients are taking—known as polypharmacy, which is all too common in this population and is more likely to cause drug-drug interactions and serious adverse effects. In addition, nephrologists need to realize the socioeconomic burden that the cost of a drug may impose on those who have a fixed income and are left to make difficult decisions regarding the cost of medications *versus* the cost of maintaining a minimum standard of living.

There is one encouraging sign that increasing attention is already being paid to geriatric issues within nephrology. When crossreferencing the terms kidney, nephrology, or renal with the terms geriatrics, elderly, or aged in the Ovid MEDLINE search database, 186,433 publications appeared over the past 60 years. A gradual increase in the number of publications in the area of geriatric nephrology over the years is demonstrated (Figure 3).

The American Society of Nephrology and Geriatric Nephrology

Professional geriatric groups are committed to improving the care of older persons, especially through educational efforts and the development of practice guidelines (21). Several subspecialties within medicine have specific groups and journals chartered to address geriatric issues, including cardiology, gastroenterology, and endocrinology. Geriatric nephrology was first acknowledged as a geriatric subspecialty in 1980 (21,32). In response to unmet current needs and in anticipation of future

Table 1. Unique characteristics of kidney disease in the elderly

Clinical Topic	Characteristic in Elderly	Recommendations/Key Questions
Diabetes		
glycemic control	Less likely to benefit from long-term glycemic control	Closer monitoring of glycemic control and question of risk/benefit for Hgb A1C < 7.0
	More likely to suffer from hypoglycemia	
	Higher risk of drug-associated hypoglycemia (33)	
BP agents and goals	Higher risk for significant decreases in BP (34,35)	Caution when prescribing BP medications, avoid very low BP
	Concerns over lack of benefit and side effects of ACEIs/ARBs (36)	Caution when prescribing ACEIs/ARBs
HTN		
target goal	CV events, cognitive insufficiency, disability, and mortality may pose a greater risk to the elderly patient than progression of kidney disease (37,38)	Consider other outcomes as goal for BP control rather than delay progression of kidney disease
specific agent	Administration of ACEIs/ARBs can cause AKI and hyperkalemia with a higher incidence in the elderly (39)	Need for extra laboratory testing after initiation or dose changes of ACEIs/ARBs
		Dietary modification/chronic administration of ion-exchange resin may be needed
		Limit use of other medications that raise serum potassium
GN	Rates of albuminuria increase with age (40)	Does significance of albuminuria differ in older *versus* younger patients?
	Elderly with proteinuria are at a significant risk of loss of renal function over 5 years (41)	
	Albuminuria associated with increased risk for dementia, HTN, and CV disease (41)	
	Clinical manifestations of glomerular diseases are often blunted in elderly	Question of whether more biopsies should be done in this group and appropriate risk/benefit ratio for treatment with aggressive immunosuppression
Cardiac disease	Diagnosing acute coronary syndromes in older patients with CKD can be challenging because noninvasive tests have different sensitivities and specificities (42), unusual clinical presentations (43), and difficult interpretation of standard laboratory markers (44)	Meticulous effort for workup of acute coronary syndrome in elderly with CKD
Vascular diseases	Increased incidence of renal artery stenosis (45)	Need for markers to predict benefit of interventions for renal vascular disease, caution when using ACEIs/ARBs
	Carotid baroreflex response is often blunted, and vasodilator antihypertensive medications may lead to dizziness and orthostatic hypotension	Caution when using vasodilators
Anemia	High prevalence of anemia (46)	Question of goal Hgb levels, especially if the patient has a history of any kind of vascular disease, prothrombotic state such as malignancy, or poorly controlled HTN
	Unique causes of anemia as inadequate nutrition and malignancy, mainly GI malignancies and hematologic malignancies	Adequate diagnostic workup of anemia may reveal significant disease
AKI	AKI is often iatrogenic and multifactorial with multiple predisposing features	Careful and comprehensive clinical exam of elderly with AKI
prerenal	Decrease in cardiac output or effective circulating volume and dehydration are common with unreliable clinical signs and symptoms of dehydration (47)	Prophylactic measures before intravascular or radiological procedures
renal		
renovascular diseases	Cholesterol embolization after intravascular procedures or surgery or rarely acute renal artery thrombosis	Avoid NSAIDs, caution with ACEIs/ARBs in high-risk patients
hemodynamic	Drugs that impair renal autoregulation or interfere with the vasodilatory capacity as NSAIDs, ACEIs, and ARBs (48,49)	Adequate supportive measure
ATN	Several chronic premorbid conditions such as congestive heart failure, HTN, and diabetes predispose to the development of severe tubular injury.	
	Elderly patients more frequently undergo significant CV surgery and are more susceptible to complications leading to ATN	Avoid polypharmacy, frequent review of medication list
AIN	Elderly patients are at increased risk secondary to the large number of medications that they may be taking.	High degree of suspicion for diagnosis
GN	Elderly patients have a higher incidence of pANCA and anti-GBM associated with RPGN (50)	
postrenal	Increased incidence of postrenal obstructive AKI (51,52)	Noninvasive imaging study of the kidney/urinary tract is critical

ACEIs, angiotensin converting enzyme inhibitors; ARBs angiotensin receptor blockers; AKI, acute kidney injury; AIN, acute interstitial nephritis; ATN, acute tubular necrosis; BP, blood pressure; CV cardiovascular; GBM, glomerular basement membrane; GI, gastrointestinal; Hgb, hemoglobin; HTN, hypertension; NSAIDs, nonsteroidal anti-inflammatory agents; pANCA, perinuclear anti-neutrophil cytoplasmic antibody; RPGN, rapidly progressive GN.

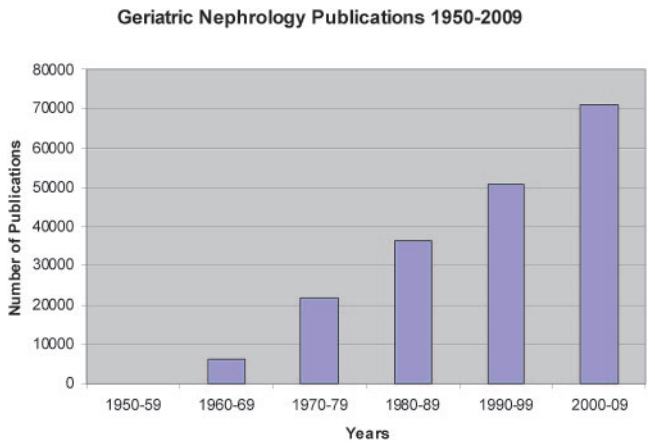

Figure 3. Number of geriatric nephrology publications from 1950 to 2009.

resource requirements, the American Society of Nephrology (ASN) has recognized the imperative of caring for the elderly population with kidney disease. Several initiatives have been taken to address the educational needs of nephrologists. Under the leadership of Drs. Dimitrios Oreopoulos, Jeff Sands, and Jocelyn Wiggins, a 2-day in-depth course on the epidemiologic and clinical challenges of geriatric nephrology has been instituted. This course offers an opportunity for practicing nephrologists to learn about the unique aspects of kidney disease in the elderly. The course is also available free of charge on the ASN website and includes PowerPoint slides with corresponding audio (http://www.asn-online.org/education_and_meetings/*media/geriatrics*). To supplement this course and to offer educational material to fellows in training, this group has also implemented a comprehensive curriculum in geriatric nephrology that is available free of charge on the ASN website (http://www.asn-online.org/education_and_meetings/*geriatrics*). This curriculum was developed in response to the Accreditation Council for Graduate Medical Education (ACGME) mandate that fellows receive formal training in geriatric nephrology. However, nearly 25% of U.S. institutions with ACGME-accredited nephrology training programs do not have comparable training programs in geriatrics. As a result, these institutions lack an educational structure for teaching geriatric nephrology to fellows. It is hoped that this curriculum will be used as a resource for teaching of fellows and for practicing nephrologists who would like more in-depth coverage of geriatric issues. The curriculum consists of 38 short (5-page) chapters that are supplemented with review questions.

Most recently, ASN has chartered a specific advisory group that is charged with development and implementation of specific initiatives in geriatric nephrology including education, research, and policy recommendations. It is hoped that these initial initiatives will jump-start a broader awareness of geriatric nephrology issues as well spur research in geriatric nephrology. Ultimately, the goal will be to provide education to all nephrologists in their care of the elderly and thereby improve care of this vulnerable population.

Acknowledgments

The ASN Geriatric Advisory Group: Chairs: Dimitrios Oreopoulos (Toronto Western Hospital–University Health Network) and Jocelyn Wiggins (University of Michigan). Members: William Bennett (Legacy Good Samaritan Hospital, Portland, Oregon), Sarbjit Jassal (University of Toronto–University Health Network), Richard Glassock (University of California–Los Angeles), Nobuyuki Miyawaki (Winthrop University Hospital), Ann O'Hare (VA Puget Sound Health Care System), Mitchell Rosner (University of Virginia), Nicole Stankus (University of Chicago), Gary Striker (Mount Sinai School of Medicine), Mark Swindler (Mount Sinai School of Medicine), Manju Tamura (Stanford University School of Medicine), Mark Unruh (University of Pittsburgh), and Mark Williams (Harvard University).

Disclosures

None.

References

1. Commission on Population and Development 42nd Session: *Programme Implementation and Future Programme of Work of the Secretariat in the Field of Population World Demographic Trends*. Geneva, Switzerland, United Nations, 2009.
2. Current Population Reports. U.S. Census Bureau. Available online at http://www.census.gov/prod/1/pop/p25-952.pdf. Accessed January 29, 2010.
3. 2008 National Population Projections. U.S. Census Bureau, 2008. Available online at http://www.census.gov/population/www/projections/2008projections.html. Accessed January 29, 2010.
4. Rodriguez-Puyol D: Nephrology forum: The aging kidney. *Kidney Int* 54: 2247–2265, 1998
5. Coresh J, Selvin E, Stevens LA, Manzi J, Kusek JW, Eggers P, Van Lente F, Levey AS. Prevalence of chronic kidney disease in the United States. *JAMA* 298: 2038–2047, 2007
6. Coresh J, Astor BC, Greene T, Eknoyan G, Levey AS: Prevalence of chronic kidney disease and decreased kidney function in the adult US population. Third National Health and Nutrition Examination Survey. *Am J Kidney Dis* 41: 1–12, 2003
7. Hallan SI, Coresh J, Astor BC, Asberg A, Powe NR, Romundstad S, Hallan HA, Lydersen S, Holmen J: International comparison of the relationship of chronic kidney disease prevalence and ESRD risk. *J Am Soc Nephrol* 17: 2275–2284, 2006
8. Hsu C-Y, Vittinghoff E, Lin F, Shlipak M. The incidence of end-stage renal disease is increasing faster than the prevalence of chronic renal insufficiency *Ann Intern Med* 141: 95–101, 2004
9. U.S. Renal Data System: *2009 Annual Data Report: Atlas of Chronic Kidney Disease and End-Stage Renal Disease in the United States*. Bethesda, MD, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, 2009
10. Garg AX, Papaioannou A, Ferko N, Campbell G, Clarke JA, Ray JG: Estimating the prevalence of renal insufficiency in seniors requiring long-term care. *Kidney Int* 65: 649–653, 2004
11. Levey AS, Stevens LA, Schmid CH, Zhang YL, Castro AF III, Feldman HI, Kusek JW, Eggers P, Van Lente F, Greene T, Coresh J; CKD-EPI (Chronic Kidney Disease Epidemi-

ology Collaboration). A new equation to estimate glomerular filtration rate. *Ann Intern Med* 150: 604–612, 2009
12. Campbell KH, O'Hare AM: Kidney disease in the elderly: Update on recent literature. *Curr Opin Nephrol Hypertens* 17: 298–303, 2008
13. O'Hare AM, Bertenthal D, Covinsky KE, Landefeld CS, Sen S, Mehta K, Steinman MA, Borzecki A, Walter LC: Mortality risk stratification in chronic kidney disease: One size for all ages? *J Am Soc Nephrol* 17: 846–853, 2006
14. Roderick P, Atkins RJ, Smeeth L, Mylne A, Nitsch DD, Hubbard RB, Bulpitt CJ, Fletcher AE: CKD and mortality risk in older people: A community-based population study in the United Kingdom. *Am J Kidney Dis* 53: 950–960, 2009
15. Stevens LA, Coresh J, Levey AS: CKD in the elderly—Old questions and new challenges: World Kidney Day 2008. *Am J Kidney Dis* 51: 353–357, 2008
16. Foley RN, Murray AM, Li S, Herzog CA, McBean AM, Eggers PW, Collins AJ: Chronic kidney disease and the risk for cardiovascular disease, renal replacement and death in the United States Medicare Population, 1998 to 1999. *J Am Soc Nephrol* 16: 489–495, 2005
17. Keith DS, Nichols GA, Guillon CM, Brown JB, Smith DH: Longitudinal follow-up and outcomes among a population with chronic kidney disease in a large managed care organization. *Arch Intern Med* 164: 659–663, 2004
18. Shiplak MG, Fried LF, Crump C, Bleyer AJ, Manolio TA, Tracy RP, Furberg CD, Psaty BM: Cardiovascular disease risk status in elderly persons with renal insufficiency. *Kidney Int* 62: 997–1004, 2002
19. Guillon CM, Keith DS, Nichols GA, Smith DH: Impact of comorbidities on mortality in managed care patients with CKD. *Am J Kidney Dis* 48: 212–220, 2006
20. O'Hare AM, Choi AI, Bertenthal D, Bacchetti P, Garg AX, Kaufman JS, Walter LC, Mehta KM, Steinman MA, Allon M, McClellan WM, Landefeld CS: Age affects outcomes in chronic kidney disease. *J Am Soc Nephrol* 18: 2758–2765, 2007
21. Schlanger LE, Bailey JL, Sands JM: Geriatric nephrology: Old or new subspecialty. *Clin Geriatr Med* 25: 311–324, 2009
22. Anderson S, Halter JB, Hazzard WR, Himmelfarb J, Horne FM, Kaysen GA, Kusek JW, Nayfield SG, Schmader K, Tian Y, Ashworth JR, Clayton CP, Parker RP, Tarver ED, Woolard NF, High KP; workshop participants: Prediction, progression and outcomes of chronic kidney disease in older adults. *J Am Soc Nephrol* 20: 1199–1209, 2009
23. Kurella Tamura MK, Covinsky KE, Chertow GM, Yaffe K, Landefeld CS, McCulloch CE: Functional status of elderly adults before and after initiation of dialysis. *N Engl J Med* 361: 1539–1547, 2009
24. Messerli FH, Sundgaard-Riise K, Ventura HO, Dunn FG, Glade LB, Frohlich ED: Essential hypertension in the elderly: Haemodynamics, intravascular volume, plasma renin activity, and circulating catecholamine levels. *Lancet* 2: 983–986, 1983
25. Lipsitz, LA. Caring for the elderly. *Boston Globe* November 25, 2009, p. A13
26. Adams WL, McIlvain HE, Lacy NL, Magsi H, Crabtree BF, Yenny SK, Sitorius MA: Primary care for elderly people: Why do doctors find it so hard? *The Gerontologist* 42: 835–842, 2002
27. Kuder JM, Isen A, Chandra P: Primary care physicians' satisfaction with treating elderly patients: Measurement and policy prescriptions. *Abstr Book Assoc Health Serv Res Meet* 15: 97–98, 1998
28. Nespor SL, Holley JL: Patients on hemodialysis rely on nephrologists and dialysis units for maintenance health care. *ASAIO J* 38: M279–M281, 1992
29. Joly D, Anglicheau D, Alberti C, Nguyen AT, Touam M, Grünfeld JP, Jungers P: Octogenarians reaching end-stage renal disease: Cohort study of decision-making and clinical outcomes. *J Am Soc Nephrol* 14: 1012–1021, 2003
30. Montzouris D-A, Herlitz L, Appel G, Markowitz GS, Freudenthal B, Radhakrishnan J, D'Agati VD: Renal biopsy in the very elderly. *Clin J Am Soc Neph* 4: 1073–1082, 2008
31. Nair R, Bell JM, Walker PD: Renal biopsy in patients aged 80 years and older. *Am J Kidney Dis* 44: 618–626, 2004
32. Oreopoulos DG, Dimkovic N: Geriatric nephrology is coming of age. *J Am Soc Nephrol* 14: 1099–1101, 2003
33. Williams M, Stanton R: Kidney dysfunction in older adults with diabetes. In: *Geriatric Diabetes*, edited by Munshi M, Lipsitz L, New York, Informa Healthcare USA, 2007: 193–205
34. Boshuizen HC, Izaks GJ, van Buuren S, Ligthart GJ: Blood pressure and mortality in elderly people aged 85 and older: Community based study. *BMJ* 316: 1780–1784, 1998
35. Mattila K, Haavisto M, Rajala S, Heikinheimo R: Blood pressure and five year survival in the very old. *BMJ* 296: 887–889, 1988
36. Winkelmayer WC, Glynn RJ, Levin R, Owen WF Jr, Avorn J: Determinants of delayed nephrologist referral in patients with chronic kidney disease. *Am J Kidney Dis* 38: 1178–1184, 2001
37. Hemmelgarn BR, Zhang J, Manns BJ, Tonelli M, Larsen E, Ghali WA, Southern DA, McLaughlin K, Mortis G, Culleton BF: Progression of kidney dysfunction in the community-dwelling elderly. *Kidney Int* 69: 2155–2161, 2006
38. Blood Pressure Lowering Treatment Trialists' Collaboration, Turnbull F, Neal B, Ninomiya T, Algert C, Arima H, Barzi F, Bulpitt C, Chalmers J, Fagard R, Gleason A, Heritier S, Li N, Perkovic V, Woodward M, MacMahon S: Effects of different regimens to lower blood pressure on major cardiovascular events in older and younger adults: Meta-analysis of randomized trials. *BMJ* 336: 1121–1123, 2008
39. Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL Jr, Jones DW, Materson BJ, Oparil S, Wright JT Jr, Roccella EJ: The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: The JNC 7 Report. *JAMA* 289: 2560–2572, 2003
40. Barzilay JI, Fitzpatrick AL, Luchsinger J, Yasar S, Bernick C, Jenny NS, Kuller LH: Albuminuria and dementia in the elderly: A community study. *Am J Kidney Dis* 52: 216–226, 2008
41. Landahl S, Aurell M, Jagenburg R: Glomerular filtration rate at the age of 70 and 75. *J Clin Exp Gerontol* 3: 29–45, 1981
42. Charytan DM, Setoguchi S, Solomon DH, Avorn J, Winkelmayer WC: Clinical presentation of myocardial infarction contributes to lower use of coronary angiography in patients with chronic kidney disease. *Kidney Int* 71: 938–945, 2007
43. Sosnov J, Lessard D, Goldberg RJ, Yarzebski J, Gore JM: Differential symptoms of acute myocardial infarction in

patients with kidney disease: A community-wide perspective. *Am J Kidney Dis* 47: 378–384, 2006
44. Freda BJ, Tang WH, Van Lente F, Peacock WF, Francis GS: Cardiac troponins in renal insufficiency: Review and clinical implications. *J Am Coll Cardiol* 40: 2065–2071, 2002
45. Greco BA, Breyer JA: Atherosclerotic ischemic renal disease. *Am J Kidney Dis* 29: 167–187, 1997
46. Guralnik JM, Eisenstaedt RS, Ferrucci L, Klein HG, Woodman RC: Prevalence of anemia in persons 65 years and older in the United States: Evidence for a high rate of unexplained anemia. *Blood* 104: 2263–2268, 2004
47. Lavizzo-Mourey R, Johnson J, Stolley P: Risk factors for dehydration among elderly nursing home patients. *J Am Geriatr Soc* 36: 213–218, 1998
48. Kleinknecht D, Landais P, Goldfarb B: Pathophysiology and clinical aspects of drug-induced tubular necrosis in man. *Contrib Nephrol* 55: 145–158, 1987
49. Hollenberg NK: Medical therapy of renovascular hypertension: Efficacy and safety of captopril in 269 patients. *Cardiovasc Rev Rep* 4: 852–859, 1983
50. Preston RA, Stemmer CL, Materson BJ, Perez-Stable E, Pardo V: Renal biopsy in patients 65 years of age or older. An analysis of the results of 334 biopsies. *J Am Geriatr Soc* 38: 669–674, 1990
51. Feest TJ, Round A, Hamad S: Incidence of severe acute renal failure in adults: Results of a community-based study. *BMJ* 306: 481–483, 1993
52. Macías-Núñez JF, López-Novoa JM, Martínez-Maldonado M: Acute renal failure in the aged. *Semin Nephrol* 16: 330–338, 1996