

Epidemiology and Clinical Correlates of Chronic Kidney Disease in the Elderly: A Comprehensive Review

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Abstract—Background: Chronic Kidney Disease (CKD) is a widespread condition in the geriatric population, and is often complicated by common co-morbidities such as diabetes, hypertension, and cardiovascular diseases. The progressive nature of CKD leading to generalized health effects eventually results in substantial morbidity and mortality in the elderly. Confronting CKD in this demographic requires early detection, effective management, and a multidisciplinary approach.

Objectives: This study aimed to investigate the prevalence and co-morbidities and management strategies for CKD among geriatric patients while enlightening on the challenges and future directions in research and clinical practice.

Methods: A comprehensive review of recent literature and clinical guidelines on CKD diagnosis, treatment, and management specifically in the elderly has been carried out. Some of the issues described include new biomarkers, treatment developments, and the growing role of digital health.

Results and Conclusions: Early detection and integrated care models are critical for achieving beneficial outcomes in geriatric patients suffering from CKD. Innovative therapies, personalized types of treatment, and improvement in digital health technologies are also overbearingly promising answers to the challenge of CKD in older patients. But further research must be undertaken to close the gaps in knowledge, particularly with respect to frailty, Polypharmacy, and co-morbidity management.

Index Terms—chronic kidney disease, geriatric population, co-morbidities, diabetes mellitus, hypertension, cardiovascular diseases.

I. INTRODUCTION

Definition And Significance Of CKD:

Chronic Kidney Disease (CKD) refers to the gradual deteriorating of the kidneys which is generally defined as a reduction in the glomerular filtration rate (GFR) or other indicators of renal damage which is evident for three months or longer(1), CKD is becoming a prominent threat all over the world as it is irreversible and can further worsen into end stage renal disease (ESRD) where kidney dialysis or transplantation is the only viable option(2). Also, it is evidenced to have high degree of disability, death and financial costs.

The Burden of CKD In Geriatric Patients Globally and Regionally

The prevalence of CKD has been on the rise, especially among the elderly population more so it is due to increasing age and quality of lifestyle diseases such as diabetes and hypertension (3). The global prevalence of CKD stands at between 10–15 percent and is even more common in older individuals who are above the age of (6)(5)(4). In South Asia and sub-Saharan African countries, there is on one hand CKD and on other a limited healthcare system compounding the problem further(5). In developed countries, increasing lifespan has resulted in an increased population of elderly who as is already known have a high propensity of suffering from CKD (6).

Common Co-Morbidities Associated With CKD

Coexisting conditions are several necrobiosis lipidica diabeticorum actually increases their likelihood of developing CKD, and such conditions do also lead to the advances and complications that CKD has to offer. Diabetic nephropathy estimates suggest that diabetes mellitus is the major contributor of CKD, accompanying a great deal of cases of this type (7). Kidney Glas is an advocate against hypertension but hypertension is one of the causes of kidney disease and something that accompanies CKD progression, thus a cyclic effect (8). CVDs also exist on CKD with much evidence.

II. MECHANISMS CONTRIBUTING TO CKD IN AGING POPULATIONS

Chronic Kidney Disease CKD has most prevalence among geriatric patients due to the natural senescence of kidneys which has constitutive and functional modifications. These changes include glomerulosclerosis, tubular atrophy, and interstitial fibrosis which also leads towards gradual deterioration of renal functions (9). On the other hand, aging also comes with oxidative stress and inflammation further aggravating the cellular assault and the decline of nephron function (10). Another important aspect is the vascular stiffening which hampers the renal blood supply and makes the older people more vulnerable to ischemic damage and hence affect kidney functions (11). So, these mechanisms make the geriatric population more prone to CKD even when there are no other risk factors available.

Role Of Reduced Nephron Function with Age

Aging is associated with gradual loss of functioning nephrons which reduces kidney's capability in filtering waste products and maintaining homeostasis (12). It has been suggested that by age 70, individuals may lose around 50% of their nephrons, resulting in remaining nephrons going into a state of compensatory hyperfiltration which causes glomerular hypertension and proteinuria, which are the major characteristics of CKD (13). The lowered nephron reserve has also increased the vulnerability.

III. EPIDEMIOLOGY OF CKD IN GERIATRIC POPULATIONS

Global And Regional Prevalence of CKD In Older Adults

Chronic Kidney Disease affects approximately 10% to 15% of the global population, while it is highly prevalent among the elderly population⁴. The prevalence of CKD among people aged 65 years and above in high-income countries ranges between 20% and 40%, with stage 3 being the most prevalent; for instance, the prevalence of CKD in the United States is 38% among adults aged 65 years or older⁽⁶⁾⁽¹⁴⁾.

CKD is also continuing to rise, for instance, in parts of the low-income and middle-income countries such as South Asia and sub-Saharan Africa due to increasing rates of hypertension and diabetes due to aging populations with fewer resources for healthcare (2). For instance, estimates of CKD in elderly people are approximately 30% in India, going by geographical and socioeconomical variables (5).

Aged individuals have higher risks for CKD as a result of the morphological and functional alterations in the kidney, which include glomerulosclerosis and a decrease in nephron number (12). These co-morbid conditions include hypertension, diabetes, and cardiovascular diseases that are highly associated with the elderly and that significantly add to the development of CKD (15).

Other contributing factors include:

- **Polypharmacy:** The use of multiple medications in older adults increases the risk of nephrotoxicity and acute kidney injury, which can progress to CKD (16).
- **Socioeconomic Disparities:** A low income translates into poor access to healthcare, which usually results in delayed diagnosis, hence increasing the risks for CKD (3).
- **Genetic Predisposition:** Individuals from certain populations, including African descent, are genetically more prone to CKD because of variants in the APOL1 gene (17).

Time Trends and Patterns in The Prevalence of CKD

The burden of CKD in elderly patients has increased over the last two decades due to demographic changes—higher life expectancy and global diabetes

(18). In addition, improved ascertainment of CKD cases resulting from early detection programs and increased access to healthcare in high-income countries has contributed to the apparent increase in prevalence (5).

On the other hand, in low- and middle-income countries, the absences of systematic screening and delayed diagnosis have been associated with a rising number of late-stage CKD cases (2). CKD is expected to continue rising as a burden globally, with estimates that it will be the fifth leading cause of years of life lost by 2040(19).

IV. COMMON CO-MORBIDITIES IN GERIATRIC PATIENTS WITH CKD

Diabetes Mellitus

Impact Of Diabetes on Renal Function

Diabetes Mellitus is considered one of the major causes of CKD worldwide, responsible for approximately 40% of CKD cases among the elderly population (20). Chronic hyperglycemia in diabetes injures the kidney's microvasculature, leading to glomerular sclerosis and proteinuria, which progressively impair renal function (15). Poor glycemic control accelerates this damage, thereby accelerating CKD progression.

Mechanisms Of Diabetic Nephropathy

Diabetic nephropathy is a result of a combination of both hemodynamic and metabolic factors. Hyperglycemia leads to oxidative stress, the formation of advanced glycosylation end-products, and activation of the RAAS system, which contribute to the thickening of the glomerular basement membrane and mesangial expansion (21). This will further increase intraglomerular pressure with the resultant podocyte injury, leading to further compromise of filtration capacity (22).

Hypertension

Relationship Between CKD and Hypertension in Elderly Patients Hypertension is both a cause and a consequence of CKD. It is prevalent in approximately 85% of CKD patients, particularly in the elderly, and accelerates renal function decline through sustained high intraglomerular pressure (23). CKD exacerbates hypertension by impairing sodium

excretion and activating the RAAS, creating a vicious cycle (24).

Hypertension's Role in The Progression of CKD

Hypertension leads to glomerular damage by way of vascular remodeling, ischemia, and scarring of the renal parenchyma (25). Uncontrolled hypertension, especially in elderly patients, is associated with increased risks of proteinuria and rapid progression to ESRD (26). Antihypertensive therapy, particularly RAAS inhibitors, has an important role in the slowing of CKD progression (27).

Cardiovascular Diseases (CVDs)

Increased Risk of CvdS in CKD Patients

CKD patients, especially elderly ones, carry a very high risk of cardiovascular morbidity and mortality. Mild kidney dysfunction may double the risk of cardiovascular events due to the shared risk factors, which include hypertension, diabetes, and dyslipidemia²⁸. Besides these, specific uremia and mineral metabolism disorders contribute to vascular calcification and heart disease in CKD (29).

Pathophysiological Links Between CKD And Heart Diseases

The interrelationship between CKD and CVD involves many mechanisms, such as endothelial dysfunction, chronic inflammation, and arterial stiffness³⁰. In the elderly with CKD, left ventricular hypertrophy and heart failure are frequent manifestations of increased afterload related to hypertension and volume overload (31). CKD hastens atherosclerosis as well, further increasing risk from coronary artery disease (32).

V. STUDY DESIGN AND METHODOLOGY

Prospective Observational Studies: An Overview of The Methods

A prospective observational study is a systematic observation and gathering of data from a cohort over a defined period, without intervening or changing the medical treatment of the participants (33). Such a design is especially useful in chronic conditions such as CKD, as it enables the researcher to capture the natural history of the disease and its association with co-morbidities.

Participants in this study design are selected based on specific inclusion criteria, such as being above the age of 65 and showing signs of renal impairment, and are then followed longitudinally. At intervals, demographic data, risk factors, disease progression patterns, and health outcomes are collected in order to carry out an analysis (34).

Two strengths of prospective observational studies are firstly the ability to determine the time sequence between exposure and outcome, and secondly the practical nature of such studies. On the other hand, there are some challenges such as loss to follow up of patients and the need for good data management systems.

Importance Of Longitudinal Data Collections in Evaluation of CKD Prevalence and Other Co-Morbid Disorders

Longitudinal data is essential for evaluating the management strategies and the course of chronic kidney disease (CKD) in the older population. One of the characteristics of CKD is that it is a chronic condition with a glacial progression, meaning that years of observation may be required for sufficient changes in the renal function and related complications to be apparent (35).

Such data sets may also help in understanding the impact of evolving comorbidities like diabetes, hypertension in a patient with CKD and their outcomes making it easier to identify, and predict the outcomes of the worst subgroups. Such follow ups are critical in understanding the role of different treatments that have been applied and if they have truly made a difference in the speed of the progression of the disease. In addition, an extended data collection period helps in addressing heterogeneity associated with the level of chronic kidney disease and the factors influencing the elderly with chronic kidney disease.

Parameters To Be Assessed

Multiple clinical and laboratory investigations have a role to play in the evaluation of chronic kidney disease and comorbidities in older patients:

1). Glomerular Filtration Rate (GFR): GFR is a very important parameter to evaluate kidney efficiency. The low GFR ($<60 \text{ mL/min/1.73 m}^2$) which is maintained for three months or more qualifies the

diagnosis of chronic kidney disease¹⁾ (. It is necessary to see the trends of such parameters in order to evaluate the advancement of the illness.

2). Proteinuria: A urine protein defined by the ACR is a sign of kidney injuries and also one of the most reliable predictors for CKD one level or the other (36).

3). Co-Morbidities: Information covering diabetes mellitus, hypertension, heart problems and other diseases are essential for establishing the role of such factors in chronology of the disease and the outcomes (7).

4). Biomarkers: New biomarkers such as cystatin C and neutrophil gelatinase-associated lipocalin (NGAL) add scope on the status of injury and health of the kidneys (37).

VI. MANAGEMENT AND TREATMENT APPROACHES

Screening And Early Diagnosis

Benefits Of Early Detection in Geriatric CKD Patients

It is essential to detect chronic kidney disease in elderly patients as early as possible since it can thwart the progression of the disease, complications, and improvement of the quality of life (38) using lifestyle modifications and medical therapies with the aim of reducing cardiovascular event risks and progress to end-stage renal disease (1). Furthermore, early diagnosis can aid in better managing diabetes and hypertension that are significant contributing factors to chronic kidney disease (39).

Recommended Guidelines for Screening in Older Adults

- Creatinine serum and GFR estimation: It is recommended that eGFR be regularly monitored with equations like CKD-EPI for assessment of renal function (40).
- Urine Albumin-to-Creatinine Ratio (ACR): Annual urine tests for albuminuria are essential for detecting early kidney damage (41).
- Blood Pressure Monitoring: Hypertension, a common risk factor for CKD progression, should be routinely assessed (25).
- Targeted Screening for High-Risk Groups: Elderly individuals with diabetes, cardiovascular disease, or a

family history of CKD should undergo more frequent screenings (24).

- Sodium Restriction: Lowering sodium to 2 g/day calms the blood pressure down and helps keep edema away (42).

- K and P Diet Management: At progressive stages of CKD, dietary monitoring and restriction of potassium and phosphorus are essential in avoiding hyperkalemia and mineral bone disorders (43).

Exercise, Weight Management and Healthy Eating are Important Regular exercise improves cardiovascular health and helps one to achieve a healthy weight for CKD, a key component for both patient groups (44). Moderate-intensity exercise (e.g., walking) for at least 150 minutes per week is an effective way of coping with these medical conditions (44). Monitoring one's weight is also significant in preventing diabetes and hypertension, which are the two leading causes of CKD (38).

The Multidisciplinary Care Approach

It works close among nephrologists, geriatricians, and other specialists to prevent and manage chronic kidney disease (CKD) in elderly patients. Nephrologists, geriatricians, endocrinologists, and dietitians should collaborate on the patient's CKD management and associated comorbidities (45). Regular communication between health care professionals allows for the identification and management of the elderly population's diverse health issues, such as polypharmacy and frailty.

Palliative Care for Advanced CKD Stages in the Elderly For elderly patients with advanced CKD, palliative care focuses on symptom management and quality of life principally in the cases of those who are not eligible for dialysis. Pain control, fatigue management, and psychological support are the most important topics that should be addressed by the care (46). Advanced

complicating identification between the normal process of growing old and the pathological injury related to the kidney (12). Moreover, symptoms of CKD are often unspecific and can cause overlapping with other age-related diseases, therefore, they are not diagnosed frequently (38).

Management of CKD in the elderly is also made more difficult by the existence of comorbidities that are often multiple. It is essential to prioritize the goals of therapy as the number of comorbidities may increase. It is on the correct path by balancing the CKD treatment between diabetes and hypertension which should consider a personalized solution according to one's expected lifetime and health (41).

The Impact of Polypharmacy and Frailty on Treatment Outcomes

Polypharmacy, which is defined as the use of five or more drugs, is common in the elderly population of CKD patients with multiple comorbidities. This is associated with an increased risk of adverse drug reactions, drug-drug interactions, and non-adherence to therapy (16). Nephrotoxic agents, including analgesic agents such as non-steroidal anti-inflammatory drugs (NSAIDs) and some antibiotics, are even a higher risk to renal function in these patients (47).

Frailty

The dismal treatment outcomes are due to the frailty found in elderly CKD patients because of decreased resilience to stressors affecting them, leading to increased number of mortalities and hospital stays (44). Frail people are often ill-disposed to strong treatments like intensifying blood pressure management or mitigating protein deficiency, thus a conservative means to the CKD management is needed (48).

Limitations Of Current Research on CKD And Co-Morbidities in Older Adults

Despite the progress made in the CKD field, the lack of understanding about the disease's peculiar features in the old population remains. Thus, many clinical trials are improbably excluding the older adults with multimorbidities eliminating the potential for the

VII. CHALLENGES AND LIMITATIONS

Challenges In CKD Diagnosis and Management in Geriatric Populations

Diagnosing CKD in geriatric populations is difficult due to age-dependent physiological changes that can simulate kidney disease. A decrease in the glomerular filtration rate (GFR) is regularly a symptom of CKD, but GFR is naturally reduced due to aging, thus

generalizability of the data to be reliable for the elder population (49).

Even study involving the individual comorbidities mostly only touches the surface of rarely considering the effect of the multiple co-morbid conditions upon the CKD growth (50). Guidelines for the management of caudal elderly CKD patients are not clear enough; therefore, clinicians are obliged to make decisions based on the information from other sources or their clinical intuition.

And, of course, the deficiency of extended researches of variant populations has resulted in us having incomplete knowledge of the long-term impacts of interventions and disease progression on the elderly patients with CKD, especially in the low-and middle-income countries (2).

VIII. FUTURE DIRECTIONS AND RESEARCH OPPORTUNITIES

Advances in CKD Biomarkers for Early Diagnosis in Elderly Populations

The utilization of modern biomarkers represents a positive consequence that makes possible the progressive diagnosis of CKD elderly people. Common biomarkers like serum creatinine and GFR mostly are not capable of discovering the early form of CKD, this is particularly the case for seniors whose kidney function is impaired by aging (12). The new biomarkers, for example, cystatin C, neutrophil gelatinase-associated lipocalin (NGAL) and kidney injury molecule-1 (KIM-1), have the capability to be more sensitive in finding subclinical kidney destruction (37).

Urinary Biomarkers: Urinary levels of albumin, B2-microglobulin, and clustering are being investigated to determine whether they are indicators of early tubular injury in elderly CKD patients (51).

Genomic and Proteomic Biomarkers: The developments in genomics and proteomics are creating the foundation for the personal-medicine strategies that are contributing to the identification of genetic predispositions to CKD and the individual responses to the therapies (52).

The taking-up of biomarkers related to the research is known to take up early detection significantly and at best, patient outcomes may be increased in such groups which are of high risk. **Emerging Therapies Targeting CKD Progression and Its Co-Morbidities.**

New therapeutic options aim at the reduction of CKD and the treatment of its associated co- morbidities.

SGLT2 Inhibitors: Medicines such as empagliflozin and dapagliflozin have proven their efficiency in blocking the CKD and thusly diminishing the dangers connected with the heart problem.

IX. CONCLUSION

The various chronic diseases in the geriatric population, chronic kidney disease (CKD) is a principal concern affecting with a high incidence and co-morbidity with diseases such as diabetes, hypertension, and cardiovascular, leading to the health risk and quality biological life. The aim of geriatric CKD treatment should be to carry out early diagnosis of the mentioned disease now by taking such simple means as per the patient's specific needs diagnosis and effective treatment. The cooperation of a geriatrician, nephrologist, dietitian, or other allied health professional has been a disease control measure necessitated to all, for the heart itself and its co-morbidities. An appropriate option for these approaches should be the design of personalized treatment strategies that take into account physiologic age-related changes, multimorbidities, and arbitrary weaknesses. Despite broad advances in the field of diagnostic technology, novel therapy approaches, and digital health solutions our present lack of knowledge of CKD disease progression and an optimal treatment of elderly patients continues. One of these facilitates further research is the attempt to identify the so-called new biomarkers, novel therapies, after that moving on to individual-based care delivery that will alleviate this special group's burden and thus improve their quality of life.

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