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Mini Review

Cardiovascular Risk Prediction in Chronic Kidney Disease: Integrating Prevent, PCE, SCORE2 and KDIGO Frameworks

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Abstract

Chronic kidney disease and cardiovascular disease are deeply interconnected conditions that together account for a substantial proportion of global morbidity and mortality. Patients with chronic kidney disease exhibit markedly elevated cardiovascular risk, driven by both traditional and non-traditional risk factors, including inflammation, endothelial dysfunction, and metabolic dysregulation. However, conventional cardiovascular risk prediction tools, such as the Pooled Cohort Equations and Systematic Coronary Risk Evaluation 2 (SCORE2), were developed in general populations and often underestimate risk in individuals with impaired kidney function. The recently developed Predicting Risk of Cardiovascular Disease EVENTs (PREVENT) equations represent a paradigm shift by incorporating kidney function and metabolic variables, offering improved calibration and discrimination in contemporary populations. In parallel, the kidney disease: Improving Global Outcomes (KDIGO) classification provides a robust framework for assessing chronic kidney disease progression risk based on estimated glomerular filtration rate and albuminuria. While KDIGO effectively stratifies renal prognosis, it is not designed as a quantitative cardiovascular risk prediction model. This manuscript provides a comprehensive analysis of PREVENT, Pooled Cohort Equations, and SCORE2 models, with particular emphasis on their performance in chronic kidney disease populations, and contrasts them with KDIGO risk categories. We propose an integrated cardiorenal risk assessment approach combining these tools to improve clinical decision-making. Such integration is critical in the era of cardiorenal-metabolic therapeutics, including sodium-glucose cotransporter-2 inhibitors and glucagon-like peptide-1 receptor agonists, which confer benefits across both cardiovascular and renal domains.

Keywords: Epidemiological models; Heart failure; KDIGO; PREVENT; SCORE2; Cardiovascular diseases; Chronic kidney disease

Abbreviations: CKD: Chronic Kidney Disease; eGFR: estimated Glomerular Filtration Rate; KDIGO: Kidney Disease: Improving Global Outcomes; PREVENT: Predicting Risk of Cardiovascular Disease EVENTs; SCORE2: Systematic Coronary Risk Evaluation2

Introduction

Chronic Kidney Disease (CKD) affects approximately 10%-15% of the global population and is a major contributor to cardiovascular morbidity and mortality [1]. Cardiovascular disease represents the leading cause of death among individuals with CKD, exceeding the risk of progression to end-stage kidney disease in many cases [2]. The relationship between CKD and cardiovascular disease is bidirectional and multifactorial, encompassing shared risk factors such as hypertension, diabetes mellitus, and dyslipidemia, as well as CKD-specific mechanisms including uremic toxins, oxidative stress, and vascular calcification [3].

Traditional cardiovascular risk prediction tools, such as the Pooled Cohort Equations, were developed in populations with relatively preserved kidney function and do not incorporate key renal variables [4]. Consequently, these models often underestimate cardiovascular

risk in CKD populations [5]. Similarly, Systematic Coronary Risk Evaluation 2 (SCORE2), developed by the European Society of Cardiology, does not include kidney-specific markers, limiting its applicability in CKD [6,7]. The Predicting Risk of Cardiovascular Disease EVENTs (PREVENT) equations were recently introduced to address these limitations by incorporating renal function and metabolic parameters, thereby improving risk prediction across diverse populations [1,8]. In parallel, the kidney disease: Improving Global Outcomes (KDIGO) classification system stratifies CKD severity based on estimated Glomerular Filtration Rate (eGFR) and albuminuria, providing a validated framework for predicting renal progression and mortality [9]. This manuscript aims to critically evaluate these models and propose an integrated framework for cardiorenal risk assessment.

Methods

This narrative review synthesizes recent guidelines published between 2020 and 2025 together with landmark foundational studies relevant to cardiovascular and renal risk prediction in CKD populations. Literature was identified through PubMed using combinations of the terms "PREVENT", "Pooled Cohort Equations", "SCORE2", "KDIGO", "chronic kidney disease", "cardiovascular risk", "risk prediction", and "albuminuria". Priority was given to clinical practice guidelines, randomized controlled trials, large observational cohort studies, validation studies of cardiovascular risk prediction models, and high-impact review articles relevant to cardiovascular and renal risk assessment in CKD. The selected evidence was narratively synthesized with emphasis on comparisons between PREVENT, Pooled Cohort Equations, SCORE2, and KDIGO risk classification, highlighting their strengths, limitations, and complementary roles in contemporary cardiorenal risk assessment.

PREVENT risk equations

Represent a major advancement in cardiovascular risk prediction. Developed using large, contemporary, and diverse cohorts, PREVENT incorporates traditional risk factors alongside metabolic and renal variables [1].

Variables included

Age, sex, blood pressure, lipid profile, diabetes status, smoking, body mass index and eGFR.

Outcomes predicted

Unlike earlier models, PREVENT predicts atherosclerotic cardiovascular disease, heart failure and cardiovascular mortality. This broader outcome spectrum is particularly relevant in CKD, where heart failure is highly prevalent [10].

Performance in CKD

Validation studies demonstrate that PREVENT provides improved calibration and discrimination compared to Pooled Cohort Equations, especially in populations with metabolic disease and CKD [8]. The inclusion of eGFR significantly enhances risk stratification. More recently, Ko et al. [11] developed a CKD-specific cardiovascular risk equation (EVENTs) equation using data from the Chronic Renal Insufficiency Cohort (CRIC) and the KoreaN Cohort Study for Outcomes in Patients with Chronic Kidney Disease (KNOW-CKD). Unlike general cardiovascular prediction models, this CKD-specific equation was designed to predict adverse cardiorenal outcomes by integrating traditional cardiovascular variables with kidney-specific characteristics. These findings reinforce the concept that CKD- specific prediction models may provide superior risk stratification compared with general population equations and support the incorporation of kidney disease severity into cardiovascular risk assessment [11]. The Pooled Cohort Equations were introduced by the American College of Cardiology/American Heart Association (ACC/AHA) to estimate 10-year atherosclerotic cardiovascular disease risk [4].

Variables

Age, sex, race, total cholesterol, HDL cholesterol, blood pressure, diabetes and smoking.

Limitations in CKD

No inclusion of eGFR or albuminuria, underestimation of risk in CKD populations and limited prediction of heart failure. Recalibration attempts have improved performance but do not fully address these gaps [5].

SCORE2 model

SCORE2 estimates 10-year risk of fatal and nonfatal cardiovascular events using competing risk methodology [6].

Variables

Age, sex, smoking, blood pressure and non-HDL cholesterol.

Limitations

No renal variables, region-specific calibration and less applicable in CKD populations.

KDIGO risk classification

KDIGO provides a standardized framework for CKD staging and prognosis [9].

Components

eGFR (G1-G5) and albuminuria (A1-A3).

Clinical value

KDIGO effectively predicts CKD progression, end-stage kidney disease and mortality.

Albuminuria is a powerful independent predictor of cardiovascular events [12].

Limitations

Not a quantitative cardiovascular risk model and does not include traditional cardiovascular risk factors. Integration of cardiovascular and renal risk: the integration of PREVENT and KDIGO frameworks enables a comprehensive cardiorenal risk assessment. PREVENT primarily estimates cardiovascular risk, whereas KDIGO stratifies renal disease progression risk.

High-risk phenotype

Patients with high PREVENT risk and KDIGO G3b-G5 and A3 represent a cardiorenal high-risk phenotype requiring aggressive intervention.

Therapeutic implications

Recent therapeutic advances have transformed cardiorenal care.

SGLT2 inhibitors

Trials such as Dapagliflozin in Patients with CKD (DAPA-CKD) demonstrated reduced progression and cardiovascular events [13-17]. Glucagon-Like Peptide-1 Receptor Agonists (GLP-1 RAs) reduce cardiovascular events and may improve renal outcomes [18,19].

Blockade of the renin-angiotensin-aldosterone system

Remains foundational in CKD management. Future directions in nephrology include the development of machine learning-based risk models capable of improving prediction of disease progression and clinical outcomes. In addition, the integration of novel biomarkers may enhance early diagnosis, risk stratification, and therapeutic monitoring. Advances in personalized medicine are also expected to optimize treatment strategies by tailoring interventions according to individual genetic, metabolic, and clinical characteristics.

Conclusion

PREVENT represents a major advancement in cardiovascular risk prediction, particularly in CKD populations. KDIGO remains essential for renal risk stratification. Emerging CKD-specific prediction equations, such as the recently proposed EVENTs model, further support the transition toward integrated cardiorenal risk assessment. Together, these approaches provide a comprehensive framework for modern cardiorenal medicine.

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