

Comparison of Different Glomerular Filtration Rate Formulas in the Prediction of Coronary Artery Disease Severity and Extent

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Abstract

Background: Chronic kidney disease (CKD) is an established risk factor for coronary artery disease (CAD), displaying a linear relationship with glomerular filtration rate (GFR). The prognostic role of the different formulas for the estimation of GFR is still debated.

Objective: To evaluate the impact of GFR calculation in the prediction of angiographically assessed CAD.

Methods: In consecutive patients undergoing coronary angiography, GFR was assessed at admission with the formulas Cockcroft-Gault, Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI), and Modification of Diet in Renal Disease Study (MDRD). A 2-sided p-value < 0.05 was considered statistically significant.

Results: Among 1742 patients, 79.8% displayed CAD. No difference in the mean values of GFR was observed in patients with and without CAD with the three different GFR formulas. We observed a significant association between severe CAD and GFR, by Cockcroft Gault (26.6% vs 35% vs 36.9%, $p < 0.001$), MDRD (27.1% vs 36.9% vs 39%, $p < 0.001$), and CKD-EPI (28.9% vs 39.2% vs 22.2%, $p = 0.03$). In multivariate analysis, only MDRD remained statistically significant (adjusted OR[95%CI] = 1.27[1.01-1.59], $p = 0.04$). In ROC curve analysis, we identified the value of 12.4 ml/min/1.73m² as the best predicting value for severe CAD with the MDRD formula. Higher rates of calcifications, restenosis, and chronic occlusion were observed for the Cockcroft-Gault and MDRD formulas.

Conclusion: The present study showed a significant association between the extent of angiographically-defined CAD and GFR, estimated by the MDRD, but not for the Cockcroft-Gault and CKD-EPI formulas. MDRD values below 12.4 ml/min/1.73m² best predicted more severe CAD.

Keywords: Chronic Kidney Disease; Glomerular Filtration Rate; Coronary Artery Disease.

Introduction

Chronic kidney disease (CKD) represents a rising health problem, affecting around 10-15% of the population worldwide, although its prevalence is largely underestimated, not being correctly diagnosed in up to two out of three patients.^{1,2} Nevertheless, the negative prognostic role of CKD, even in initial stages, has been well established, displaying an incremental increase in the risk of mortality and cardiovascular disease in association with the degree of albuminuria and the decrease of glomerular filtration rate (GFR).³⁻⁵

However, several controversies still exist on the most accurate method for the assessment of GFR, since direct measurements are costly and technically demanding, and the different formulas for its indirect estimates, based on serum creatinine or cystatin C, have shown great discrepancies. Currently, the 2009 Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) creatinine equation is recommended in guidelines¹ for the estimation of renal filtration, being less biased, especially for higher GFR values and in younger individuals, women, and white ethnicity,⁶ and additionally displaying a greater correlation with long-term risk of end-stage renal disease and mortality.⁷ However, these formulas are less validated in certain subsets of higher-cardiovascular risk patients, as the elderly, where the identification of even mild forms of CKD could significantly impact risk-stratification and the outcomes.⁸ In fact, in these settings and in patients with established cardiovascular disease, the body surface area-adjusted Cockcroft-Gault formula has been suggested to result in more accurate prediction of cardiovascular mortality,⁹ although in other studies the Modification of Diet in Renal Disease Study (MDRD) formula provided better prediction of the severity of coronary artery disease (CAD) and cardiovascular risk in patients with myocardial infarction.¹⁰ However, most of the

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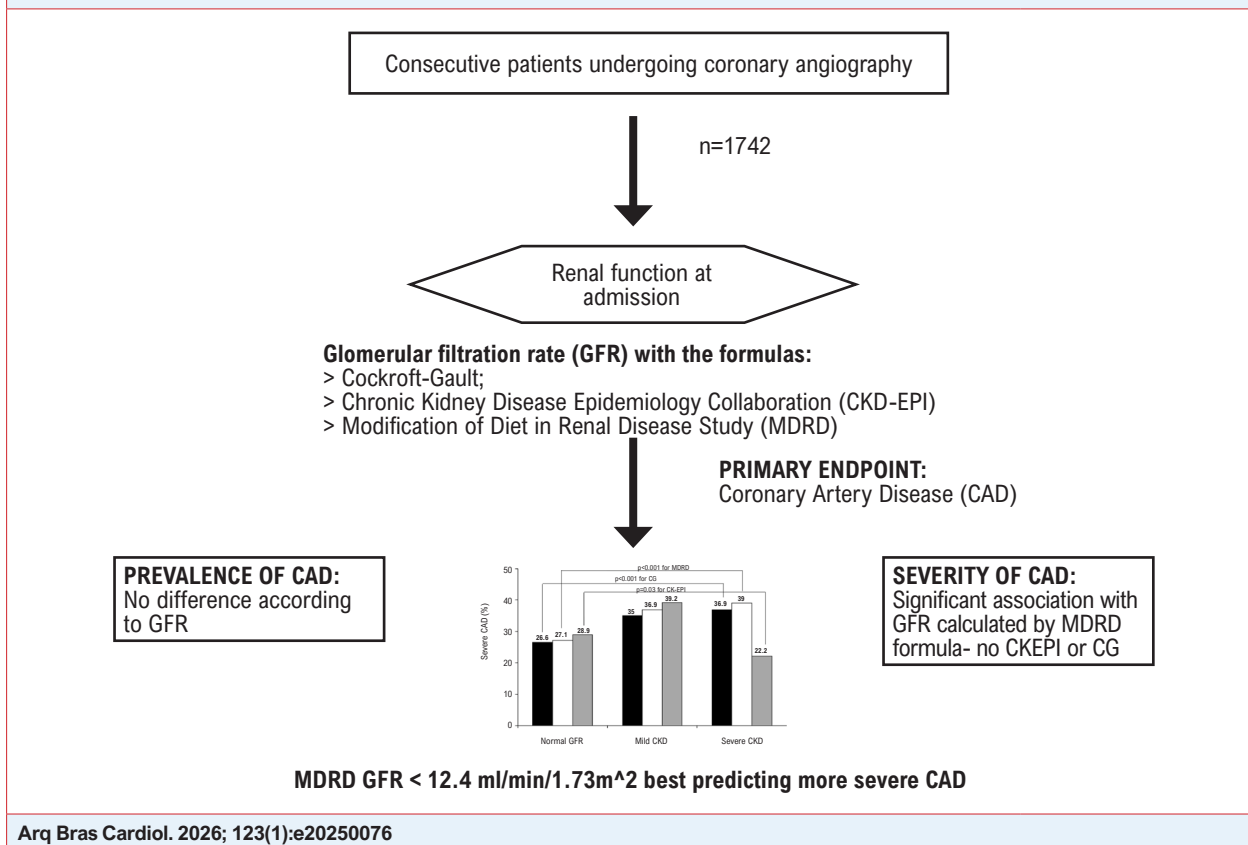
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data published so far in these subsets of patients were derived from small registries and non-randomized cohorts, where the definition of cardiovascular disease was often self-reported, therefore not supporting the Kidney Disease: Improving Global Outcome (KDIGO) guidelines to provide conclusive indications for the assessment of GFR in high-cardiovascular risk populations.^{11,12}

The aim of the present study was, then, to compare the 3 most common formulas for GFR calculation (CG, MDRD, CKD-EPI) in the estimation of CKD and in the prediction of angiographically assessed CAD presence, extent, and severity.

Methods

This observational registry included an “all-comers” population of consecutive patients undergoing coronary angiography in a single center from January 2019 to June 2020 for elective indication (stable angina, silent ischemia, arrhythmias, or valvular disease) or acute coronary syndrome. The study was approved by our local Ethical Committee. Main demographic, clinical, and angiographic data, together with the indication for coronary angiography, were recorded at admission and included in a dedicated database, protected by a password. The main cardiovascular risk factors were identified. Hypertension was defined as systolic pressure

> 140 mm Hg and/or diastolic pressure > 90 mmHg or if the individual was taking antihypertensive medications. The diagnosis of diabetes was based on a previous history of diabetes treated with or without drug therapies, fasting glucose > 126 g/dl, or HbA1c > 6.5% at the moment of admission. Chronic renal failure was considered for a history of renal failure or an admission GFR < 60 ml/min/1.73 m² by different formulas.

Coronary angiography

Coronary angiography was routinely performed by the Judkins technique, with a preferential radial approach, using 5 or 6-French right and left heart catheters. Quantitative coronary angiography was performed by experienced interventional cardiologists, by an automatic edge-detection system (a software associated with the angiographer).¹³ We measured minimal luminal diameter (MLD), reference diameter (RD), percent diameter stenosis, and length of the lesion. In previously bypassed patients, both native arteries and grafts were taken into account in the evaluation of the extension of CAD (number of diseased vessels). CAD was defined as at least one stenosis > 50%, whereas severe CAD was defined as left main and/or 3-vessel disease. A stenosis was considered significant if more than 70%.

Chemistry parameters and glomerular filtration rate

A fasting blood sample was taken upon admission for the determination of blood count, blood glucose levels, creatinine, electrolytes, uric acid, myocardial-specific enzymes, lipid profile, coagulation parameters, and vitamin D.

In particular, creatinine levels were determined by the Creatinine Jaffe Gen.2 (CRE)2, Roche Diagnostic International LFD, Switzerland) test from samples stored in tubes containing heparin as an anticoagulant, after centrifugation at 3700 rpm for 10 min.

GFR was assessed with the following formulas:

- Cockcroft-Gault: $eCCr = (140 - \text{Age}) \times \text{Mass (kg)} \times [0.85 \text{ if female}] / 72 \times [\text{Serum Creatinine (mg/dL)}]$
- Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI): $eGFR_{cr} = 142 \times \min(S_{cr}/\kappa, 1) \alpha \times \max(S_{cr}/\kappa, 1)^{-1.200} \times 0.9938 \text{ Age} \times 1.012 \text{ [if female]}$
- Modification of Diet in Renal Disease Study (MDRD): $GFR (mL/min/1.73 m^2) = 175 \times (S_{cr})^{-1.154} \times (\text{Age})^{-0.203} \times (0.742 \text{ if female}) \times (1.212 \text{ if African American})$

Statistical analysis

Statistical analysis was performed using the SPSS 23.0 statistical package. Continuous data were expressed as mean $\pm$ standard deviation (SD) and categorical data as percentages. The chi-square test was used for categorical variables, whereas the unpaired Student's t-test and one-way analysis of variance (ANOVA) were applied for continuous variables, after confirming the normal distribution of the data, for the comparison of 2 or more groups, respectively. Patients were grouped according to CAD prevalence and extent and according to GFR, calculated with the 3 different formulas (< 30 ; ≥ 60 mL/min/1.73m²). Multivariate logistic regression analysis was performed to evaluate the relationship between GFR and Coronary disease, after correction for baseline differences (all variables displaying a significant association at univariable analysis, i.e., chi-square or ANOVA accordingly), that were entered in the model "in block". Receiver-operating Curve (ROC) analysis was applied to identify the GFR value best predicting severe CAD.

A 2-sided p-value < 0.05 was considered statistically significant.

Results

Our population is represented by 1742 patients, among them $n=1391$ (79.8%) displayed CAD and $n=519$ (29.8%) severe CAD. Table 1 displays the main clinical and laboratory parameters according to the prevalence of angiographically-defined CAD. No difference in the mean values of GFR was observed in patients with and without CAD with the three different GFR formulas (Cockcroft-Gault, $p=0.87$; MDRD, $p=0.22$; CK-EPI, $p=0.71$).

Patients were divided according to renal function (severe CKD < 30 mL/min/1.73m²; mild CKD: 30-60 mL/min/1.73m²; normal function ≥ 60 mL/min/1.73m²) with the three different formulas.

As shown in Table 2, the majority of the patients displayed normal renal function with all the formulas;

however, GFR values were lower with the Cockcroft-Gault formula, identifying 6% ($n=105$) of the patients with severe CKD, being only 0.5% with CKD-EPI ($n=9$).

As shown in Figure 1, the concordance among the formulas in the classification of the severity of CKD was low for all the comparisons.

The clinical features of the population according to the severity of CKD are shown in Supplementary Tables 1, 2, and 3 for Cockcroft-Gault, MDRD, and CK-EPI, respectively.

The complete design and results of the study are summarized in the Central Illustration.

The prevalence of CAD was not associated with renal function, estimated with the Cockcroft-Gault formula, MDRD formula, and CKD-EPI, as shown in Figure 2.

We observed a significant association between severe CAD and GFR, estimated with the three different formulas: Cockcroft-Gault, MDRD, and CKD-EPI, as in Figure 3.

The angiographic features of the population, distributed according to the renal function estimated with the three GFR formulas, are shown in Table 3, Table 4, and Table 5, for Cockcroft-Gault, MDRD, and CK EPI, respectively. Higher rates of calcifications were observed with all the formulas, while the relationship with restenosis and chronic occlusion was significant only for the Cockcroft-Gault and MDRD formulas.

An inverse association was observed between renal function and intracoronary thrombus.

At multivariate analysis, after correction for baseline differences (age, gender, hypercholesterolemia, diabetes, active smoking, previous coronary interventions, acute presentation, statins at admission), we confirmed the lack of association between CAD and the renal function with the three formulas (Cockcroft-Gault (adjusted OR[95%CI]= 0.92[0.69-1.21], $p=0.54$), MDRD (adjusted OR[95%CI]= 0.96[0.72-1.27], $p=0.75$) and CKD-EPI (adjusted OR[95%CI]= 0.88[0.54-1.43], $p=0.60$).

On the contrary, only the MDRD formula remained significantly associated with severe CAD, adjusted OR[95%CI]= 1.27[1.01-1.59], $p=0.04$), whereas no association was found for Cockcroft-Gault (adjusted OR[95%CI]= 1.25[0.99-1.57], $p=0.06$) and CKD-EPI (adjusted OR[95%CI]=1.21[0.82-1.8], $p=0.34$).

At ROC curve analysis, we identified the value of 12.4 mL/min/1.73m² as the best predicting value for severe CAD with the MDRD formula (Figure 4).

Discussion

The present study represents one of the largest cohorts of patients where we compared the three most common formulas for the estimation of GFR in the prediction of the prevalence and extent of angiographically defined CAD.

We observed that the MDRD was the only formula significantly associated with more severe CAD at angiography, while no association was found for the other formulas.

Table 1 – Clinical and demographic features according to the presence of coronary artery disease

Baseline Clinical Characteristics	No CAD N= 351	CAD N= 1391	p-value
Age > 75 years (%)	68.8	70.8	0.004
Male Sex (%)	53.8	74	<0.001
Hypertension (%)	67.5	69.7	0.41
Hypercholesterolemia (%)	33	43.6	<0.001
Active Smokers (%)	34.8	44.9	0.001
Diabetes mellitus (%)	25.6	33	0.01
Renal failure (%)	10	11.4	0.51
History of MI (%)	5.4	27.7	<0.001
Previous PCI (%)	4.8	33.9	<0.001
Previous CABG (%)	0.9	7.3	<0.001
Acute coronary syndrome (%)	27.9	60.5	<0.001
Therapy at admission			
ACE inhibitors (%)	30.9	36.3	0.06
ARB (%)	21.7	20.7	0.71
Beta blockers (%)	53.1	52.4	0.81
Nitrates (%)	6.9	10.1	0.07
Calcium antagonists (%)	21.4	24.1	0.32
Diuretics (%)	32.4	27.9	0.10
Statins (%)	28.6	45.4	<0.001
ASA (%)	36.9	54.7	<0.001
P2Y12 inhibitors (%)	4.9	17.6	<0.001
Main chemistry			
Glycemia (mg/dl; mean± SD)	117±39.5	132±61.0	<0.001
Creatinine (mg/dL; mean± SD)	1.17±0.97	1.15±0.74	0.64
Platelets (10 ³ /μl; mean± SD)	232±67.2	231±68.4	0.86
Hemoglobin (g/dl; mean ± SD)	13.5±1.8	13.5±1.9	0.69
Total cholesterol (mg/dl; mean± SD)	165±42.0	161±45.4	0.16
Tryglicerides (mg/dl; mean± SD)	108±49.9	118±58.9	0.013
Clearance Cockcroft-Gault (mean±SD)	72.3±31.7	72.0±31.5	0.87
Clearance MDRD (mean ± SD)	72.9±25.0	74.9±26.3	0.22
Clearance CKD-EPI (mean ± SD)	79.5±15.4	79.1±15.8	0.71

CAD: Coronary artery disease; MI: Myocardial infarction; PCI: Percutaneous coronary intervention; CABG: Coronary artery bypass graft surgery; ACE inhibitor: Angiotensin-converting enzyme inhibitor; ARB: Angiotensin receptor blocker; ASA: Acetylsalicylic acid; MDRD: modification of diet in renal disease study; CKD-EPI: Collaboration in Chronic Kidney Disease Epidemiology.

CKD represents an established risk factor for cardiovascular disorders and, in particular, CAD.¹⁴⁻¹⁶ The persistence in the circulatory field of substances not excreted by the kidneys has been generally appointed as

pro-inflammatory and pro-thrombotic trigger, in addition to the imbalance in the renin-aldosterone system and calcium homeostasis, leading to endothelial dysfunction and atherosclerotic degeneration of the arterial wall.¹⁷

Table 2 – Classification of renal function according to different formulas for glomerular filtration rate calculation

Formula	Normal function	Mild CKD (GFR 30-60)	Severe CKD (GFR <30)
Cockcroft-Gault	62.1	31.9	6
MDRD	72.7	22.6	4.7
CKD-EPI	90.4	9.1	0.5

CKD: chronic kidney disease; GFR: glomerular filtration rate.

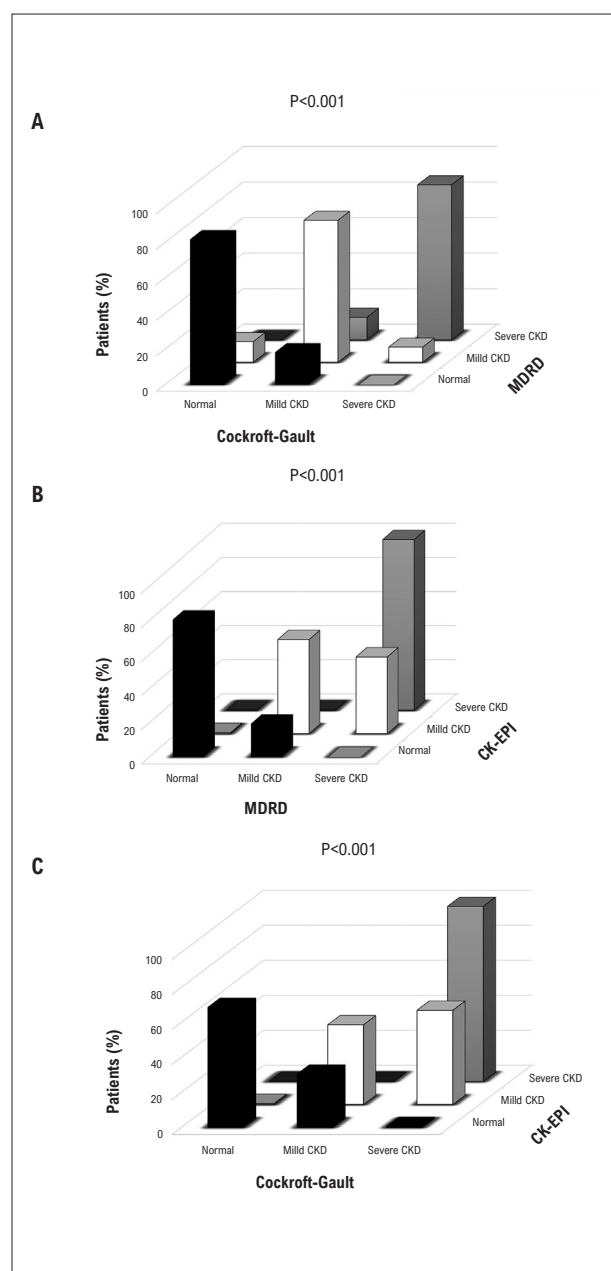


Figure 1 – Distribution of patients according to renal function estimated with different formulas: Cockcroft-Gault vs MDRD (1A), MDRD vs CKD-EPI (1B), Cockcroft-Gault vs CKD-EPI (1C).

Epidemiological data have pointed to the particular relevance of the problem, since 9.1 to 13.4% of the worldwide population has CKD and cardiovascular disease has been identified in 20-30% of them.^{2,18,19}

A linear increase in the risk of developing CAD has been shown along with the decrease of GFR, for values below 60 to 75 ml/min/1.73 m² and in patients with severe CKD (GFR between 15 and 60 ml/min/1.73 m²), where the risk of CVD mortality is two/three-fold increased respect to patients without CKD.²⁰ In fact, in patients with severe renal disease or dialysis, cardiovascular causes account for 1 out of 4 deaths, translating into around 6% yearly mortality.²¹

Furthermore, traditional cardiovascular risk factors, as advanced age, diabetes, and hypertension, are also more frequent in patients with CKD, therefore requiring a more attentive risk stratification and management.²²

However, despite the established association between CKD and cardiovascular disease, several methods and formulas have been proposed for the assessment of renal function, and their role in the prediction of CAD and outcomes is still controversial. Currently, the KDIGO guidelines¹ state that the CKD-EPI equation is more accurate than the MDRD Study equation, especially at higher GFR, therefore representing the most widely used formula worldwide. In effect, higher GFR values, lessening the rates of CKD, could increase the specificity of this formula in the risk estimation.²³

Piscitelli et al. documented in a large cohort of 1017 patients undergoing coronary angiography that lower GFR, estimated by the CKD-EPI formula, significantly amplified the risk of all-cause mortality associated with three-vessel disease.²⁴ Similar results were reported by Doganer et al. in a smaller cohort of 356 patients, where Cockcroft-Gault, MDRD, and CKD-EPI formulas could predict the severity of CAD in men, but not in women.²⁵

Conversely, in a multicenter prospective registry involving 1699 consecutive patients with acute coronary syndrome, Rivera-Caravaca et al.²⁶ observed that the Cockcroft-Gault equation presented superior predictive ability for major adverse cardiovascular events, major bleeding, and all-cause mortality compared with the MDRD-4 equation, and superior predictive ability for major bleeding compared with the CKD-EPI equation.

Different findings were reported in a retrospective study on 3744 patients undergoing coronary bypass surgery, where the Mayo formula was found to be superior to the other formulas

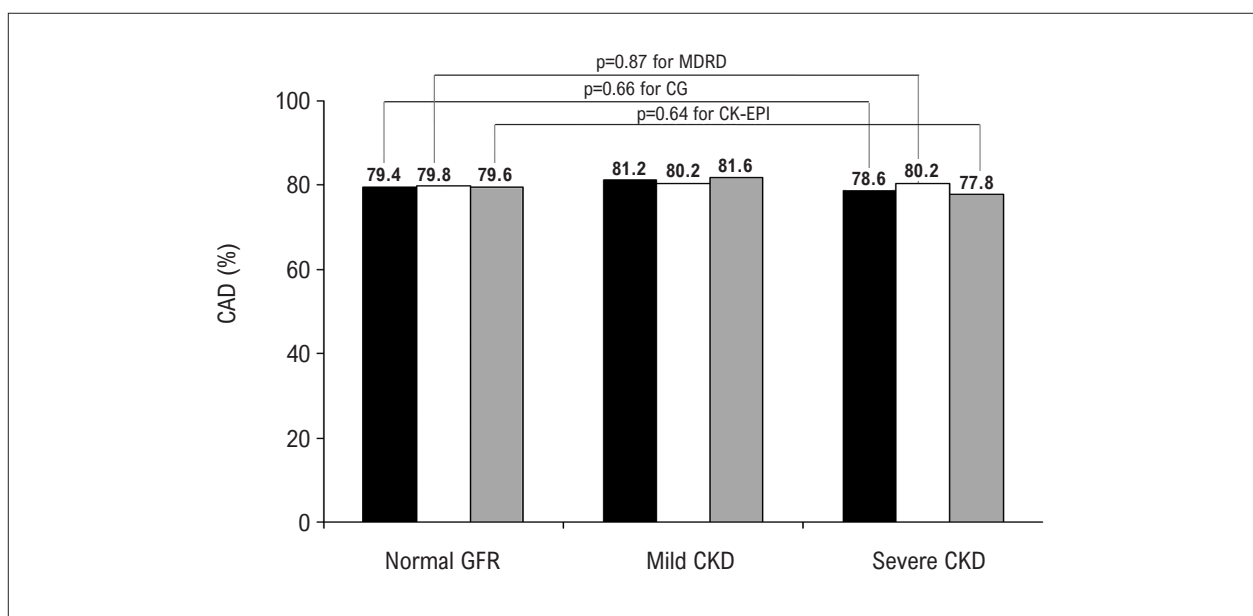


Figure 2 – Prevalence of coronary artery disease according to renal function estimated with different formulas: Cockcroft-Gault, MDRD, and CKD-EPI. CAD: coronary artery disease; GFR: glomerular filtration rate; CKD: chronic kidney disease.

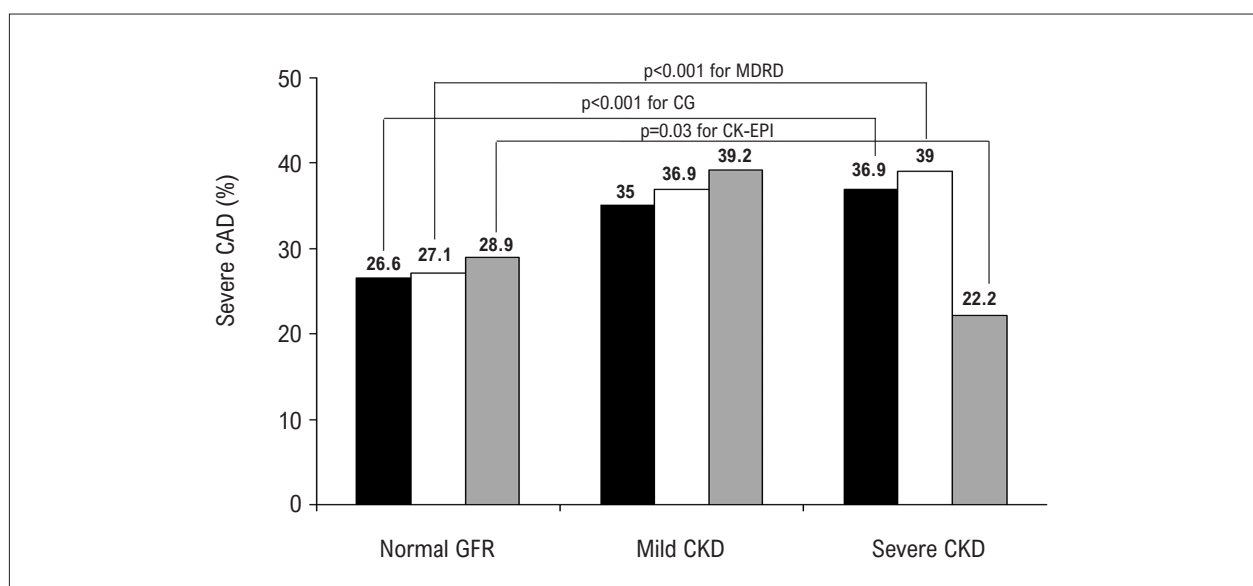


Figure 3 – Prevalence of severe coronary artery disease according to renal function estimated with different formulas: Cockcroft-Gault, MDRD, and CKD-EPI. CAD: coronary artery disease; GFR: glomerular filtration rate; CKD: chronic kidney disease.

in prognosticating mortality.²⁷ Superiority of the Mayo formula was also demonstrated by Orvin et al. in patients with acute coronary syndrome.²⁸

Another study dedicated to ACS patients concluded that the use of cystatin, instead of creatinine, could provide better results in the prediction of mortality.²⁹

However, the latter results were obtained in more selected patients with established CAD or acute ischemic events, whereas in our study, we enrolled one of the largest

unrestricted populations, including patients undergoing coronary angiography for non-coronary indications, as valvular disease, arrhythmias, or heart failure.

We demonstrated low concordance among the three different formulas, Cockcroft-Gault, MDRD, and CKD-EPI, in the definition of renal function and CKD, the latter tending to overestimate GFR as compared to the other formulas.

Although we observed no difference in the mean values of GFR between patients with and without CAD, more severe

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Table 3 – Procedural and angiographic features according to renal function estimated by the Cockcroft-Gault glomerular filtration rate (GFR) formula

Procedural features	Normal N=1678	Mild CKD N= 951	Severe CKD N=185	p-value
Lesion length (mm, mean $\pm$ SD)	22.3 $\pm$ 12.1	22.3 $\pm$ 13.1	22.5 $\pm$ 13.3	0.96
Target Vessel diameter (mm, mean$\pm$ SD)	3.0 $\pm$ 0.58	3.0 $\pm$ 0.56	3.0 $\pm$ 0.51	0.84
Stenosis (% , mean $\pm$ SD)	86.3 $\pm$ 12.6	85.7 $\pm$ 12.9	85.5 $\pm$ 13.0	0.43
Target vessel				
Right Coronary Artery (%)	46.1	56.1	63.7	<0.001
Left Main (%)	6.3	11.7	14.0	<0.001
Left Anterior Descending (%)	63.7	65.3	63.0	0.55
Circumflex branch (%)	39.2	45.3	47.2	<0.001
Calcifications (%)	18.4	29.1	40.5	<0.001
Thrombus (%)	14.1	10.1	9.2	0.001
TIMI flow (%)				0.43
3	74.9	73.0	75.1	
2	1.5	0.8	2.2	
1	3.4	3.0	2.7	
0	20.3	23.1	20.0	
In-stent restenosis (%)	5.9	7.5	9.8	0.017
Chronical occlusion (%)	12.4	16.2	15.7	0.012
Bifurcations (%)	15.6	17.2	13.5	0.94

CKD: chronic kidney disease.

CKD was significantly related to the severity of CAD. However, after correction for baseline differences, this association was confirmed only for the MDRD formula. Thus, besides nephrology, KDIGO guidelines¹⁵ suggest that the CK-EPI formula should be preferred for the estimation of GFR in patients with cardiovascular disease; the MDRD formula could offer additional advantages for a better risk definition.

Our results are in line with the findings of Barra et al.,¹⁰ concluding that in patients with acute myocardial infarction, the MDRD formula was significantly more accurate in predicting the severity of CAD and two-year CV risk.

Similarly, Chen et al.³⁰ confirmed in over 8000 patients that a modified MDRD formula specific for the Chinese population emerged as the most convenient for the prognostic stratification of patients undergoing percutaneous coronary interventions (PCI).

In effect, the MDRD formula is more restrictive in the estimation of GFR values, being the most accurate in patients with impaired renal function, especially for GFR <60 mL/min/1.73 m², which are also the ones with higher cardiovascular risk.³¹ Thus, it might be postulated that the

association between CKD and CAD could have emerged more clearly with the formula best predicting renal disease.

Moreover, we observed a significant association between renal dysfunction and coronary calcifications, representing an early marker of CAD, but also the mirror of more complex lesions, translating into poorer outcomes when treated with percutaneous coronary intervention (PCI).³² Similarly, Bundy et al. showed that despite the prognostic value of calcifications being similar to that in the general population, the progression of coronary calcification is faster with worsening of CKD.³³

Indeed, despite the pathophysiological mechanisms linking renal dysfunction with the development of cardiovascular disease being well established, as the negative prognostic role of decreasing GFR, the most accurate method for the assessment of renal disease still needs to be defined. Future dedicated studies are needed to better define the differential predictive power of the available formulas for the estimation of GFR in different subsets of patients, and whether a tailored approach according to patients' risk profile could provide a better stratification of their cardiovascular risk.

Table 4 – Procedural and angiographic features according to renal function estimated by the MDRD glomerular filtration rate formula

Procedural features	Normal N=2005	Mild CKD N= 679	Severe CKD N=154	p-value
Lesion length (mm. mean $\pm$ SD)	22.2 $\pm$ 12.2	22.4 $\pm$ 13.1	22.6 $\pm$ 13.4	0.91
Target Vessel diameter (mm. mean $\pm$ SD)	3.0 $\pm$ 0.57	3.0 $\pm$ 0.58	3.0 $\pm$ 0.52	0.34
Stenosis (%. mean $\pm$ SD)	86.2 $\pm$ 12.6	85.7 $\pm$ 13.0	85.4 $\pm$ 13.1	0.57
Target vessel				
Right Coronary Artery (%)	46.1	56.1	63.7	<0.001
Left Main (%)	7.0	12.4	12.4	<0.001
Left Anterior Descending (%)	64.1	63.0	67.8	0.74
Circumflex branch (%)	39.5	47.5	48.2	<0.001
Calcifications (%)	20.3	31.2	34.4	<0.001
Thrombus (%)	13.7	9.4	9.7	0.004
TIMI flow (%)				0.21
3	74.9	72.3	73.4	
2	1.4	0.7	2.6	
1	3.4	2.7	3.9	
0	20.3	24.3	20.1	
In-stent restenosis (%)	5.8	8.7	8.5	0.010
Chronical occlusion (%)	12.4	17.8	15.6	0.003
Bifurcations (%)	16.2	15.6	15.6	0.62

[§]per patient definition. CKD: chronic kidney disease.

Limitations

A first limitation can be represented by the heterogeneity of the clinical and angiographic characteristics of the enclosed population, although representing also a potential additional value of the study, reflecting the real-life clinical practice.

Moreover, we did not perform a systematic follow-up of our patients; therefore, we could not define the role of the different GFR formulas on the outcomes.

Additionally, the definition of CAD and severe CAD was based only on angiographical data, since intracoronary imaging or functional assessment were not systematically performed in all the patients and could not be, therefore, included in the present analysis.

Finally, we did not measure other parameters for the estimation of GFR, as cystatin C, nor were we able to repeat sampling for creatinine analysis at follow-up to assess the evolution of renal function.

Conclusion

The present study showed, in a large cohort of patients undergoing coronary angiography, that the prevalence

of CAD does not differ according to renal function. A significant association was found between the extent of angiographically-defined CAD and GFR, estimated by the MDRD formula, but not for Cockcroft-Gault and CKD-EPI, with values below 12.4 ml/min/1.73m² the best predicting more severe CAD.

Author Contributions

Conception and design of the research: Verdoia M. Acquisition of data: Verdoia M, Clemente A. Analysis and interpretation of the data: Verdoia M, Clemente A. Statistical analysis: Verdoia M. Writing of the manuscript: Verdoia M, Montini AMC, Rognoni Critical revision of the manuscript for intellectual content: Verdoia M, Montini AMC, Rognoni A.

Potential conflict of interest

No potential conflict of interest relevant to this article was reported.

Sources of funding

There were no external funding sources for this study.

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Table 5 – Procedural and angiographic features according to renal function estimated by the CKD-EPI glomerular filtration rate formula

Procedural features	Normal N=2526	Mild CKD N= 294	Severe CKD N=18	Normal N=1085
Lesion length (mm. mean $\pm$ SD)	22.2 $\pm$ 12.4	23.4 $\pm$ 13.7	17.8 $\pm$ 10.9	0.080
Target Vessel diameter (mm. mean $\pm$ SD)	3.0 $\pm$ 0.58	3.0 $\pm$ 0.53	2.9 $\pm$ 0.50	0.65
Stenosis (%. mean $\pm$ SD)	86.0 $\pm$ 12.8	86.8 $\pm$ 12.1	78.3 $\pm$ 14.2	0.021
Target vessel				
Right Coronary Artery (%)	48.7	63.8	57.6	<0.001
Left Main (%)	8.1	13.0	0.0	0.004
Left Anterior Descending (%)	63.8	66.5	66.7	0.19
Circumflex branch (%)	40.7	51.5	33.3	<0.001
Calcifications (%)	22.3	34.7	33.3	<0.001
Thrombus (%)	12.9	9.5	0.0	0.027
TIMI flow (%)				0.89
3	74.3	72.4	88.9	
2	1.3	1.4	0.0	
1	3.1	4.1	5.6	
0	21.3	22.1	5.6	
In-stent restenosis (%)	6.4	8.9	5.6	0.17
Chronical occlusion (%)	13.5	17.1	11.1	0.18
Bifurcations (%)	16.2	15.0	11.1	0.44

CKD: chronic kidney disease.

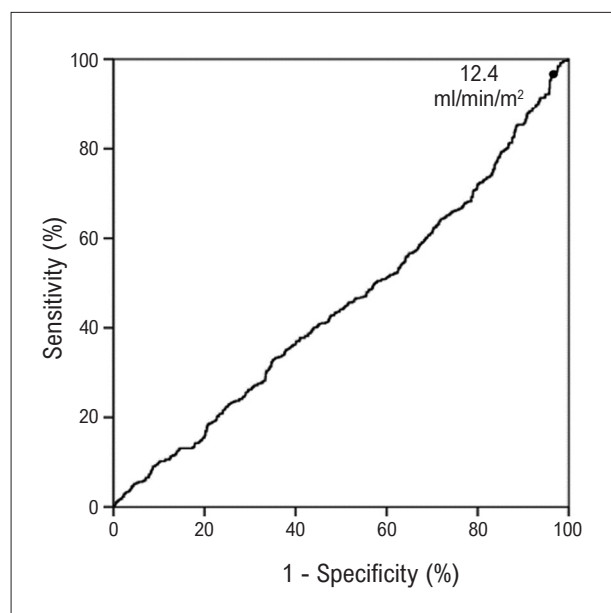


Figure 4 – ROC curve analysis showing that the value of glomerular filtration rate better estimates severe coronary artery disease with the MDRD formula.

Study association

This article is part of the thesis of master submitted by Alyssa Clemente from Università del Piemonte Orientale.

Ethics approval and consent to participate

This study was approved by the Interinstitutional Ethics Committee of Novara under the protocol number CE 151/18. All the procedures in this study were in accordance with the 1975 Helsinki Declaration, updated in 2013. Informed consent was obtained from all participants included in the study.

Use of Artificial Intelligence

The authors did not use any artificial intelligence tools in the development of this work.

Data Availability Statement

The underlying content of the research text is contained within the manuscript.

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*Supplemental Materials

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