Débit de filtration glomérulaire : comment mesurer et estimer correctement ?

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26 mai 2022

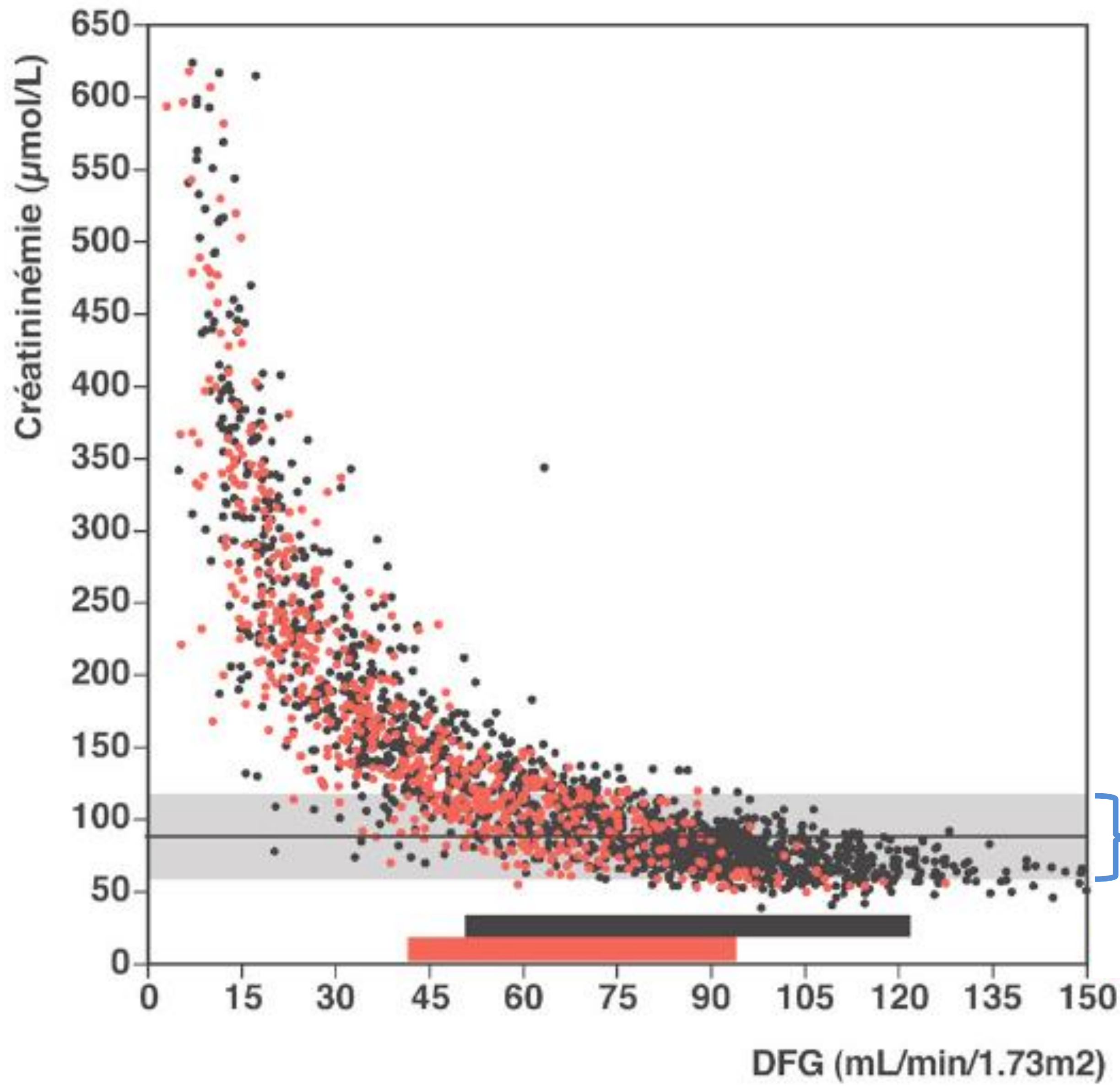
CHU de Liège

- Estimation du DFG
- Mesure du DFG

Créatinine sérique

- Une des analyses les plus prescrites
- …mais important d'en connaitre les limitations
- Limitations physiologiques
- Limitations analytiques
- Limitations "mathématiques"

Perrone RD, Clin Chem, 1992, 38, 1933
Delanaye P, Ann Biol Clin (Paris), 2010, 68, 531



Cohorte NephroTest (France)
Quel DFG correspond à une concentration de créatinine mesurée à 0.9 mg/dL (80 µmol/L) ?

IC 95% pour sujets <65 ans
IC 95% pour sujets >65 ans

Valeurs normales de créatinine

Avec la permission de Marc Froissart

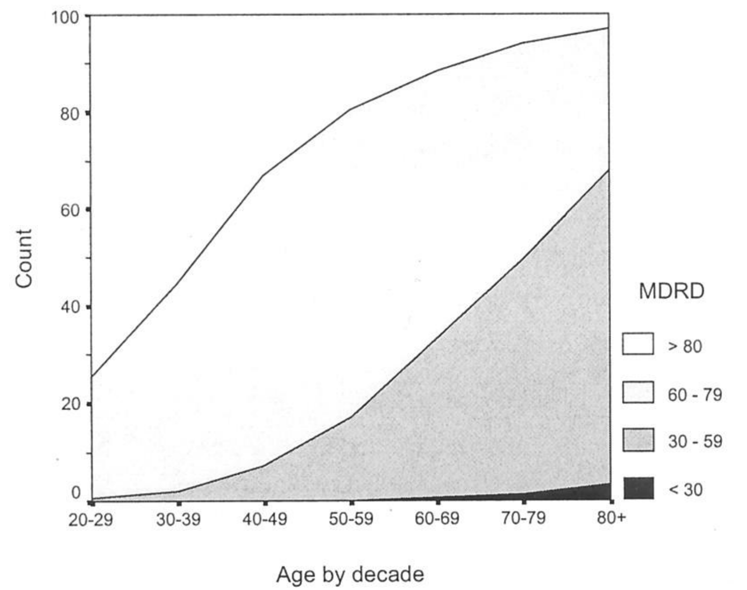
Mesure de la créatinine sérique
Limitations analytiques

- Méthodes de Jaffe
- Méthodes enzymatiques
- Différentes méthodes mais aussi différents « assays »
- Interférences

Perrone RD, Clin Chem, 1992, 38, 1933
Delanaye P, Ann Biol Clin (Paris), 2010, 68, 531

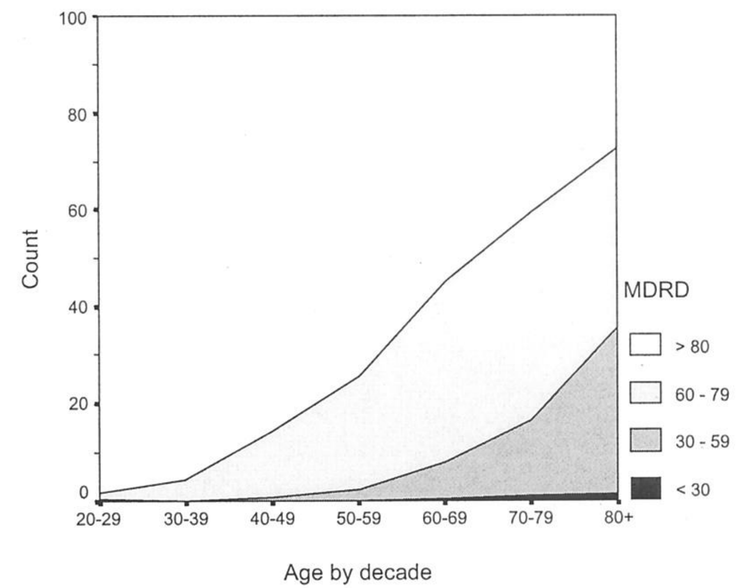
Mesure de la créatinine sérique
Limitations analytiques

UNCALIBRATED



N	3037	2827	2138	1422	1670	1241	916	Total 13251
≥ 80	74.6%	55.2%	33.0%	19.5%	11.7%	6.1%	2.8%	41.8%
60-79	24.8%	42.7%	59.7%	63.3%	54.9%	44.2%	29.4%	45.4%
30-59	0.6%	2.0%	7.2%	17.2%	32.7%	48.5%	64.6%	12.5%
< 30	<0.1%	<0.1%	<0.1%	<0.1%	0.7%	1.2%	3.2%	0.3%

CALIBRATED



3037	2827	2138	1422	1670	1241	916	Total 13251
98.3%	95.7%	85.7%	74.4%	55.1%	40.7%	27.5%	82.1%
1.5%	4.2%	13.5%	23.3%	36.9%	42.7%	37.0%	14.5%
0.2%	<0.1%	0.8%	2.4%	7.6%	15.7%	34.3%	3.2%
<0.1%	<0.1%	<0.1%	<0.1%	0.5%	0.9%	1.2%	0.2%

Coresh, J. et al. J Am Soc Nephrol 2002;13:2811-2816

Beaucoup de progrès ces dernières années…

Clinica Chimica Acta 412 (2011) 2070–2075

Contents lists available at ScienceDirect

Clinica Chimica Acta

journal homepage: www.elsevier.com/locate/clinchim

A multicentric evaluation of IDMS-traceable creatinine enzymatic assays

Laurence Piéroni [a], Pierre Delanaye [b,*], Anne Boutten [c], Anne-Sophie Bargnoux [d], Eric Rozet [e], Vincent Delatour [f], Marie-Christine Carlier [g], Anne-Marie Hanser [h], Etienne Cavalier [i], Marc Froissart [j], and Jean-Paul Cristol [d]
On behalf of the Société Française de Biologie Clinique [1]

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[b] Nephrology–Dialysis–Transplantation, University of Liège, CHU Sart Tilman, Liège, Belgium
[c] Biochimie, CHU Bichat, APHP, Paris, France
[d] Biochimie, CHU Lapeyronie, Montpellier, France
[e] Analytical Chemistry Laboratory, CIRM, University of Liège, Liège, Belgium
[f] Laboratoire National de Métrologie et d'Essais, Paris, France
[g] Biochimie, Hôpitaux de Lyon Sud, Lyon, France
[h] Biochimie, Hospices civils, Colmar, France
[i] Clinical Chemistry, University of Liège, CHU Sart Tilman, Liège, Belgium
[j] Physiologie Rénale, Hôpital Européen Georges Pompidou, APHP, Paris, France

Limitations physiologiques

- Sécrétion tubulaire de créatinine

10 to 40%

Sécrétion augmente alors que DFG diminue

Non prédictible à l'échelon individuel

- Production extra-rénale

Perrone RD, Clin Chem, 1992, 38, 1933
Delanaye P, Ann Biol Clin (Paris), 2010, 68, 531

Limitations physiologiques

- Production (relativement) constante d’origine musculaire => la concentration de créatinine dépend de la masse musculaire, pas seulement du DFG

    - genre
    - âge
    - Ethnicité ?
    - Masse musculaire

Perrone RD, Clin Chem, 1992, 38, 1933
Delanaye P, Ann Biol Clin (Paris), 2010, 68, 531

Créatinine et médicaments

- Inhibiteurs de la sécrétion tubulaire
  cimétidine, triméthoprime, dolutegravir

- Fibrates
- Interactions « à hautes concentrations »
  acétylcystéine, dobutamine, lidocaine, ascorbate

Perrone RD, Clin Chem, 1992, 38, 1933
Delanaye P, Ann Biol Clin (Paris), 2010, 68, 531
Delanaye P, Nephron Clin Pract, 2011, 119, c187

Créatinine: à la poubelle?

- Bon marché! (0.04€ /Jaffe)
- Bonne spécificité
- Bon CV analytique
- Préférence pour les méthodes enzymatiques

Clairance de créatinine

- N'est recommandée par aucun guidelines
- Sécrétion tubulaire
- Manque de précision:

erreurs dans la collecte

22 à 27% chez les patients « entrainés »
50 to 70 % pour les autres

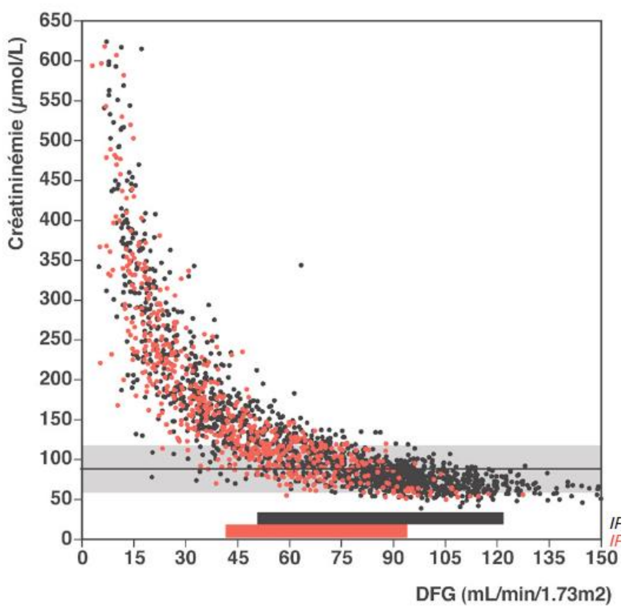
importante variabilité intra-individuelle de l'excrétion urinaire de créatinine

KDIGO, Kidney Int, 2012, 3
Perrone RD, Clin Chem, 1992, 38, 1933
Delanaye P, Ann Biol Clin (Paris), 2010, 68, 531

Equations basées sur la créatinine

But des équations:

- Conceptualiser la relation hyperbolique
- Adapter la créatinine pour l'âge, le genre, l'ethnicité
- Diminuer l'IC (?)

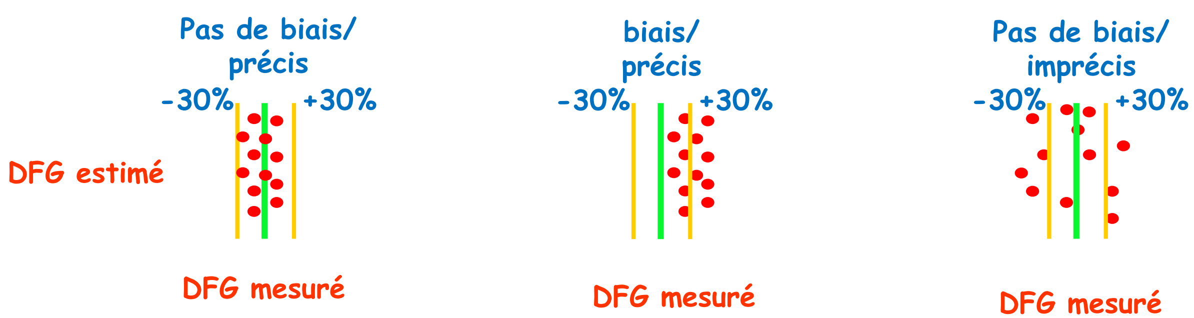


Quelles équations?

- Cockcroft
- MDRD
- CKD-EPI
- EKFC

Statistiques

- Corrélation: une condition “*sine qua non*” mais insuffisante!
- Biais: différence moyenne entre 2 valeurs = erreur systématique
- Précision: SD autour de ce biais = erreur aléatoire
- Exactitude 30% = % du DFG estimée dans ± 30% du DFG mesuré



Bland JM, Altman DG, Lancet, 1986, 8476, 307

Delanaye P, Nephrol Dial Transplant, 2013, 28, 1396

Table 1. MDRD study equations and Cockcroft equation commonly used for GFR estimation

Cockcroft and Gault

$$\text{GFR (ml/min)} = \frac{(140 - \text{age}) \times \text{weight (kg)}}{7.2 \times \text{SCr (mg/dl)}} \times 0.85 \text{ if woman}$$

4-Variable MDRD study equation (IDMS traceable)

$$\text{GFR (ml/min/1.73 m}^2) = 175 \times \text{SCr (mg/dl)}^{-1.154} \times \text{age}^{-0.203} \times 0.742 \text{ (if woman)} \times 1.21 \text{ for Black-American}$$

Cockcroft DW, Nephron, 1976, 16, p31
Levey AS, Ann Intern Med, 1999, 130, p461

Cockcroft Vs MDRD Vs CKD-EPI

	Cockcroft	MDRD	CKD-EPI
Population	Canada 1976	USA 1999	« International » 2009
N	249	1628	5504+2750+3896
DFG moyen	73	40	68
DFG de référence	Clairance de créatinine	Iothalamate	Divers mais référence
Assay	« Jaffe »	Jaffe calibré	Jaffe calibré
% femmes	4	40	43-45%
% noir	0 (?)	12	10-32%
Age moyen	18-92	51	47-50
Poids moyen	72	79.6	79-82
Indexation pour BSA	Non	Oui	Oui
Validation interne	Non	Oui	Oui

Cockcroft DW, Nephron, 1976, 16, p31
Levey AS, Ann Intern Med, 1999, 130, p461
Levey AS, Ann Intern Med, 2009, p604

POIDS !!

Received: 24 June 2021 | Revised: 4 October 2021 | Accepted: 19 October 2021
DOI: 10.1111/bcp.15132

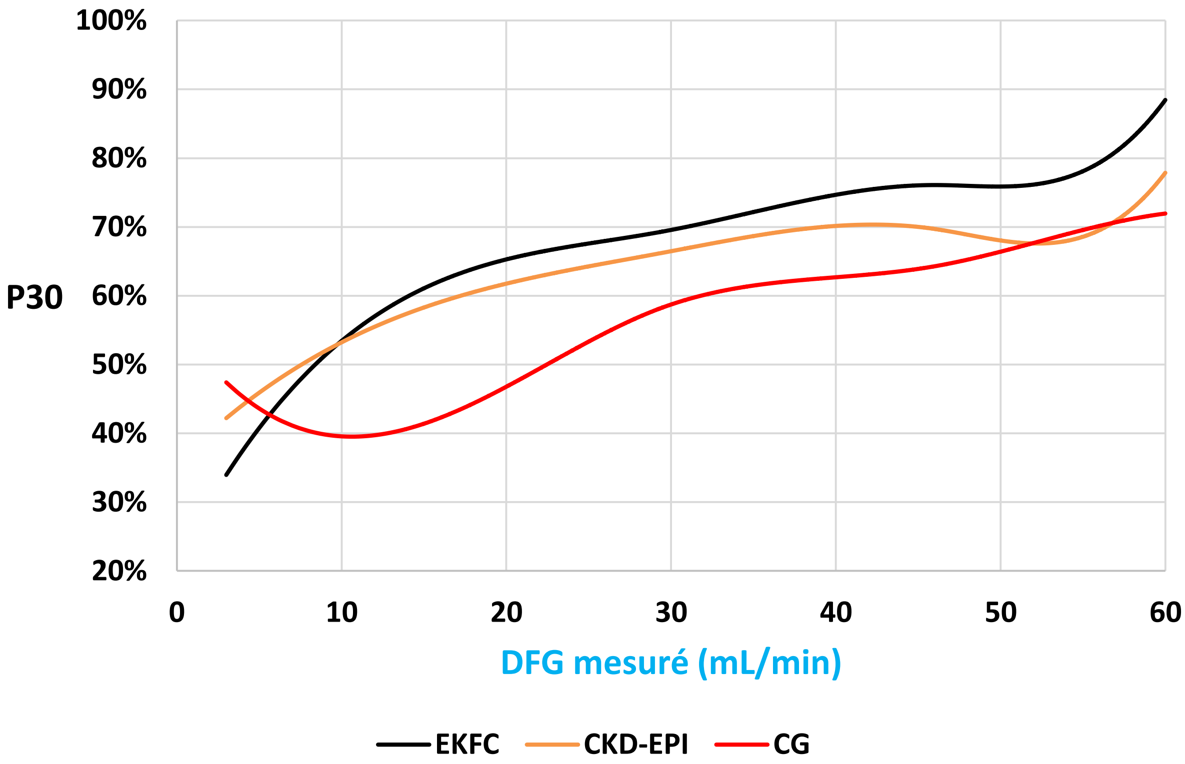
ORIGINAL ARTICLE

Performance of creatinine-based equations to estimate glomerular filtration rate with a methodology adapted to the context of drug dosage adjustment

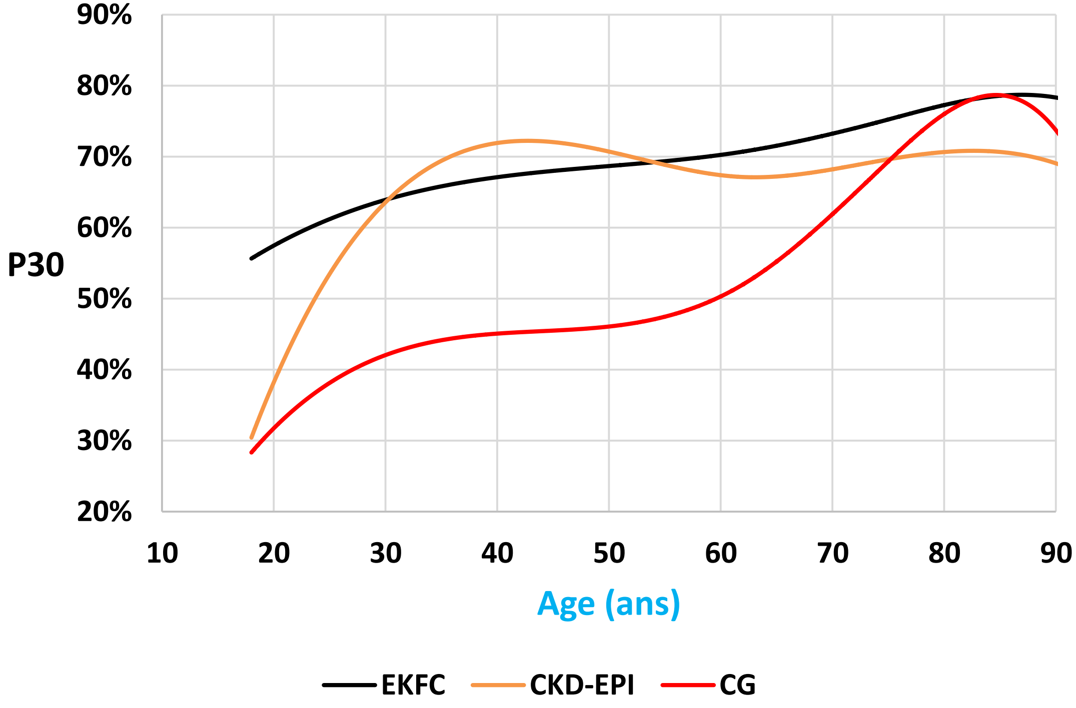
Pierre Delanaye[1,2] | Jonas Björk[3,4] | Marie Courbebaisse[5] | Lionel Couzi[6] | Natalie Ebert[7] | Björn O. Eriksen[8] | R. Neil Dalton[9] | Laurence Dubourg[10] | Francois Gaillard[11] | Cyril Garrouste[12] | Anders Grubb[13] | Lola Jacquemont[14] | Magnus Hansson[15] | Nassim Kamar[16] | Edmund J. Lamb[17] | Christophe Legendre[18] | Karin Littmann[19] | Christophe Mariat[20] | Toralf Melsom[8] | Lionel Rostaing[21] | Andrew D. Rule[22] | Elke Schaeffner[7] | Per-Ola Sundin[23] | Ulla B. Berg[24] | Kajsa Åsling-Monemi[24] | Luciano Selistre[25] | Anna Åkesson[3,4] | Anders Larsson[26] | Arend Bökenkamp[27] | Hans Pottel[28] | Ulf Nyman[29]

Br J Clin Pharmacol. 2021;1–10.

- 14,804 participants (adultes)
- Cockcroft, CKD-EPI et EKFC
- De-indexé
- Focus sur DFG< 60 mL/min (n=4328)



P30
100%
90%
80%
70%
60%
50%
40%
30%
20%
0
10
20
30
40
50
60
DFG mesuré (mL/min)
EKFC
CKD-EPI
CG


90%
80%
70%
60%
P30
50%
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10
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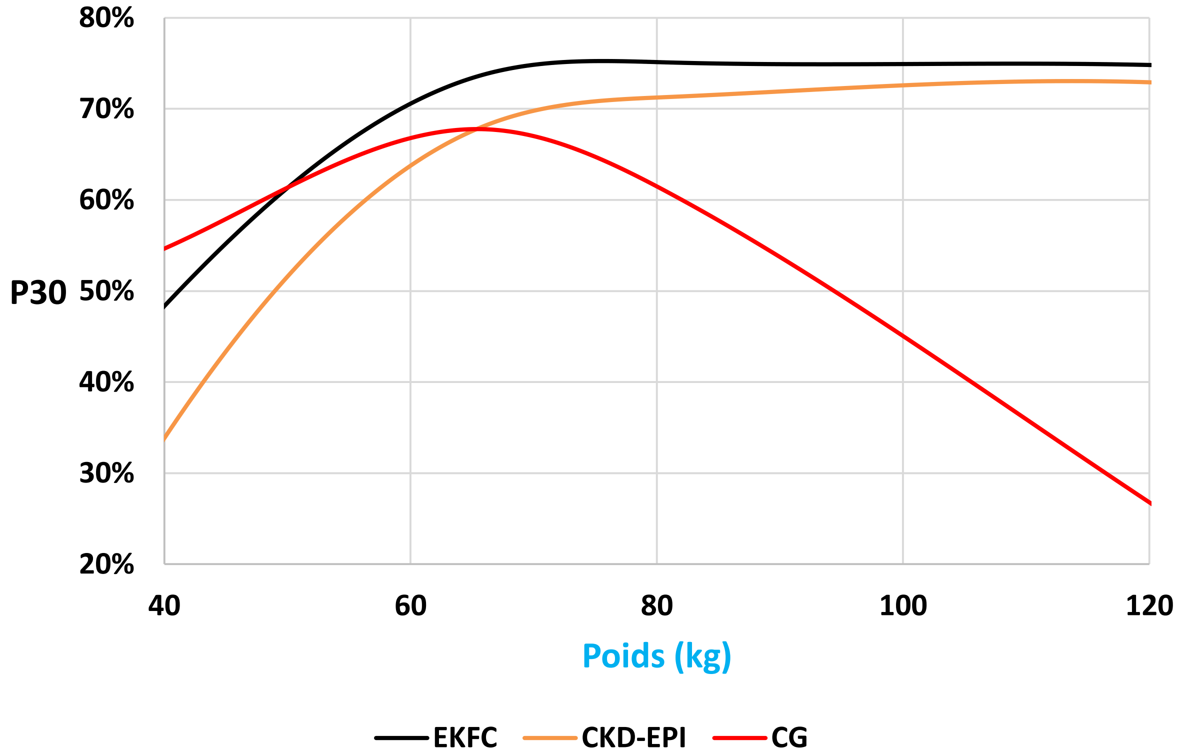
30
40
50
60
70
80
90
Age (ans)
EKFC
CKD-EPI
CG


80%
70%
60%
50%
40%
30%
20%
P30
40
60
80
100
120
Poids (kg)
EKFC
CKD-EPI
CG

Equation CKD-EPI

ARTICLE | Annals of Internal Medicine

A New Equation to Estimate Glomerular Filtration Rate

Andrew S. Levey, MD; Lesley A. Stevens, MD, MS; Christopher H. Schmid, PhD; Yaping (Lucy) Zhang, MS; Alejandro F. Castro III, MPH; Harold I. Feldman, MD, MSCE; John W. Kusek, PhD; Paul Eggers, PhD; Frederick Van Lente, PhD; Tom Greene, PhD; and Josef Coresh, MD, PhD, MHS, for the CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration)*

Ann Intern Med. 2009;150:604-612.

Table 2. The CKD-EPI Equation for Estimating GFR on the Natural Scale*

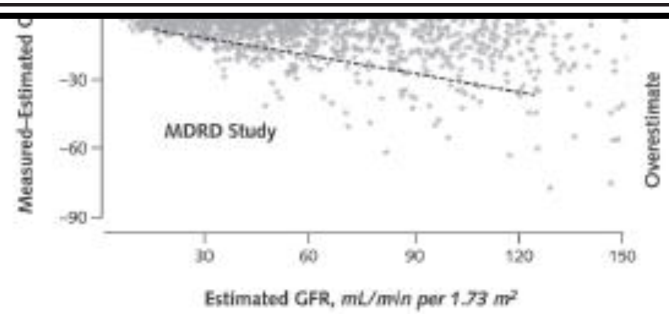
Race and Sex	Serum Creatinine Level, *µmol/L (mg/dL)*	Equation
Black		
Female	≤62 (≤0.7)	$GFR = 166 \times (Scr/0.7)^{-0.329} \times (0.993)^{Age}$
	>62 (>0.7)	$GFR = 166 \times (Scr/0.7)^{-1.209} \times (0.993)^{Age}$
Male	≤80 (≤0.9)	$GFR = 163 \times (Scr/0.9)^{-0.411} \times (0.993)^{Age}$
	>80 (>0.9)	$GFR = 163 \times (Scr/0.9)^{-1.209} \times (0.993)^{Age}$
White or other		
Female	≤62 (≤0.7)	$GFR = 144 \times (Scr/0.7)^{-0.329} \times (0.993)^{Age}$
	>62 (>0.7)	$GFR = 144 \times (Scr/0.7)^{-1.209} \times (0.993)^{Age}$
Male	≤80 (≤0.9)	$GFR = 141 \times (Scr/0.9)^{-0.411} \times (0.993)^{Age}$
	>80 (>0.9)	$GFR = 141 \times (Scr/0.9)^{-1.209} \times (0.993)^{Age}$

- CKD-EPI
- “Development dataset”: n=5504
- “Internal validation”: n=2750
- “External validation”: n=3896
- Créatinine calibrée
- DFG médian = 68 mL/min/1.73 m^2

Figure. Performance of the CKD-EPI and MDRD Study equations in estimating measured GFR in the external validation data set.

Table 3. Comparison of the CKD-EPI and MDRD Study Equations in Estimating Measured GFR in the Validation Data Set*

Variable and Equation	All Patients	Patients With Estimated GFR <60 mL/min per 1.73 m²	Patients With Estimated GFR ≥60 mL/min per 1.73 m²
Median difference (95% CI), *mL/min per 1.73 m²*†			
CKD-EPI	2.5 (2.1–2.9)	2.1 (1.7–2.4)	3.5 (2.6–4.5)
MDRD Study	5.5 (5.0–5.9)	3.4 (2.9–4.0)	10.6 (9.8–11.3)
Interquartile range for differences (95% CI), *mL/min per 1.73 m²*‡			
CKD-EPI	16.6 (15.9–17.3)	11.3 (10.7–12.1)	24.2 (22.8–25.3)
MDRD Study	18.3 (17.4–19.3)	12.9 (12.0–13.6)	25.7 (24.4–27.1)
P_{30} (95% CI), %§			
CKD-EPI	84.1 (83.0–85.3)	79.9 (78.1–81.7)	88.3 (86.9–89.7)
MDRD Study	80.6 (79.5–82.0)	77.2 (75.5–79.0)	84.7 (83.0–86.3)
Root mean square error (95% CI)			
CKD-EPI	0.250 (0.241–0.259)	0.284 (0.270–0.298)	0.213 (0.203–0.223)
MDRD Study	0.274 (0.265–0.283)	0.294 (0.280–0.308)	0.248 (0.238–0.258)



MDRD – CKD-EPI: What else?

- Equation Bis
- Equation Lund-Malmö
- Equation EKFC
- Autre biomarqueurs: cystatine C

Schaeffner, Ann intern Med, 2012, 157, 471
Bjork, Scand J Urol Nephrol, 2012, 46, 212
Pottel H, Nephrol Dial Transplant, 2016
Seronie-Vivien, CCLM, 2008

Ann Intern Med. 2021;174:183-191. doi:10.7326/M20-4366

Annals of Internal Medicine

ORIGINAL RESEARCH

Development and Validation of a Modified Full Age Spectrum Creatinine-Based Equation to Estimate Glomerular Filtration Rate

A Cross-sectional Analysis of Pooled Data

Hans Pottel, PhD*; Jonas Björk, PhD*; Marie Courbebaisse, MD, PhD; Lionel Couzi, MD, PhD; Natalie Ebert, MD, MPH; Björn O. Eriksen, MD, PhD; R. Neil Dalton, PhD; Laurence Dubourg, MD, PhD; François Gaillard, MD, PhD; Cyril Garrouste, MD; Anders Grubb, MD, PhD; Lola Jacquemont, MD, PhD; Magnus Hansson, MD, PhD; Nassim Kamar, MD, PhD; Edmund J. Lamb, PhD; Christophe Legendre, MD; Karin Littmann, MD; Christophe Mariat, MD, PhD; Toralf Melsom, MD, PhD; Lionel Rostaing, MD, PhD; Andrew D. Rule, MD; Elke Schaeffner, MD, PhD, MSc; Per-Ola Sundin, MD, PhD; Stephen Turner, MD, PhD; Arend Bökenkamp, MD; Ulla Berg, MD, PhD; Kajsa Åsling-Monemi, MD, PhD; Luciano Selistre, MD, PhD; Anna Åkesson, BSc; Anders Larsson, MD, PhD; Ulf Nyman, MD, PhD†; and Pierre Delanaye, MD, PhD†

- Sujets avec DFG mesuré et créatinine standardisée
- n=11,251 “développement et validation interne”
- n=8,378 “validation externe”
- n=1,254 âge entre 2 et 18 ans
- 7 + 6 cohortes
- « Caucasiens »

Figure 1. The new EKFC equation.

Age	SCr/Q	Equation
2–40 y	<1	$107.3 \times (SCr/Q)^{-0.322}$
	≥1	$107.3 \times (SCr/Q)^{-1.132}$
>40 y	<1	$107.3 \times (SCr/Q)^{-0.322} \times 0.990^{(Age - 40)}$
	≥1	$107.3 \times (SCr/Q)^{-1.132} \times 0.990^{(Age - 40)}$

Q Values

For ages 2–25 y:

Males:

$\ln(Q) = 3.200 + 0.259 \times Age - 0.543 \times \ln(Age) - 0.00763 \times Age^2 + 0.0000790 \times Age^3$

Females:

$\ln(Q) = 3.080 + 0.177 \times Age - 0.223 \times \ln(Age) - 0.00596 \times Age^2 + 0.0000686 \times Age^3$

For ages >25 y:

Males:

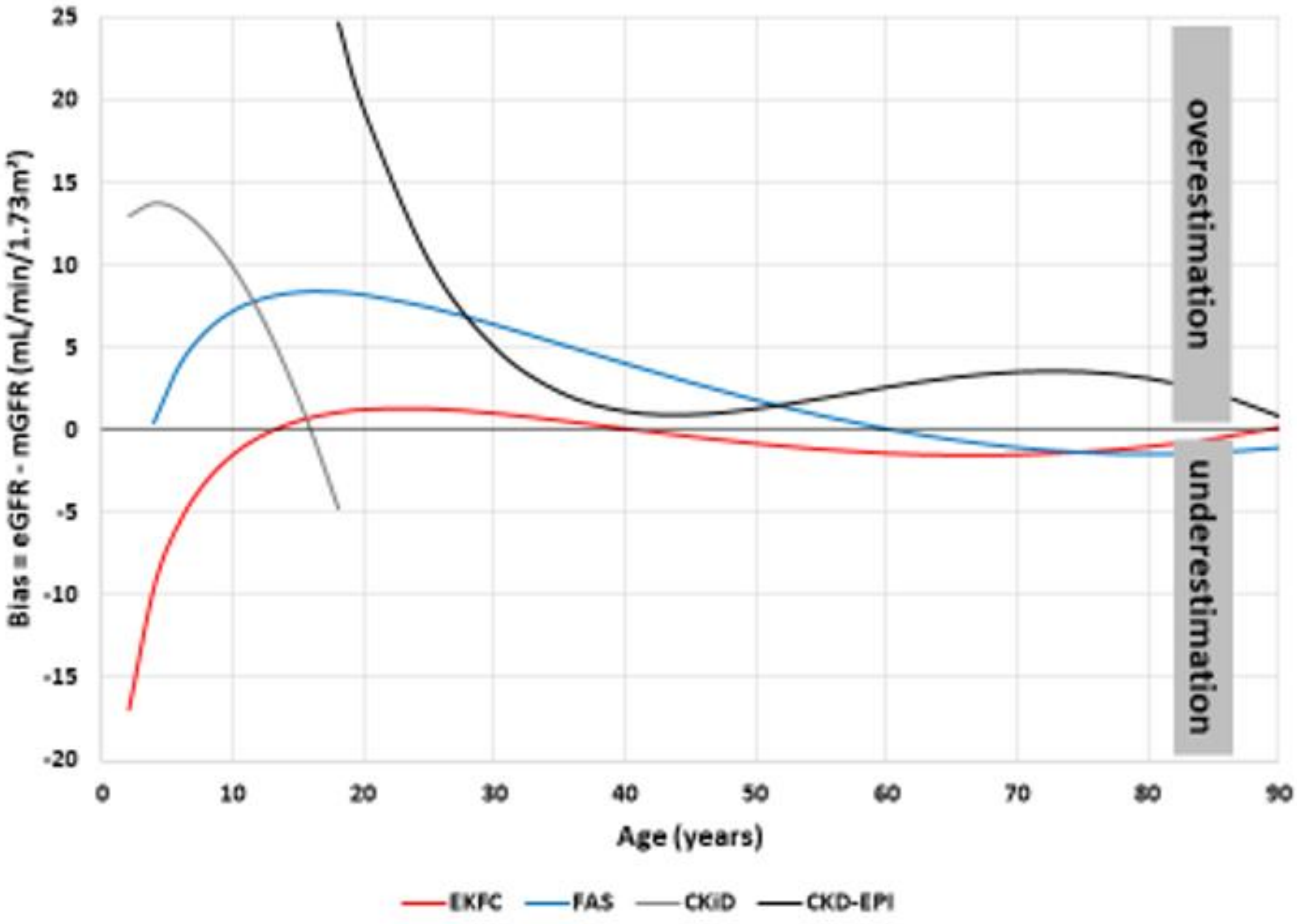
Q = 80 µmol/L (0.90 mg/dL)

Females:

Q = 62 µmol/L (0.70 mg/dL)

SCr and Q in µmol/L (to convert to mg/dL, divide by 88.4)

Q values (in µmol/L or mg/dL) correspond to the median SCr values for the age- and sex-specific populations. EKFC = European Kidney Function Consortium; SCr = serum creatinine.



25
20
15
10
5
0
-5
-10
-15
-20
Bias = eGFR - mGFR (mL/min/1.73m²)
0
10
20
30
40
50
60
70
80
90
Age (years)
overestimation
underestimation
EKFC
FAS
CKiD
CKD-EPI

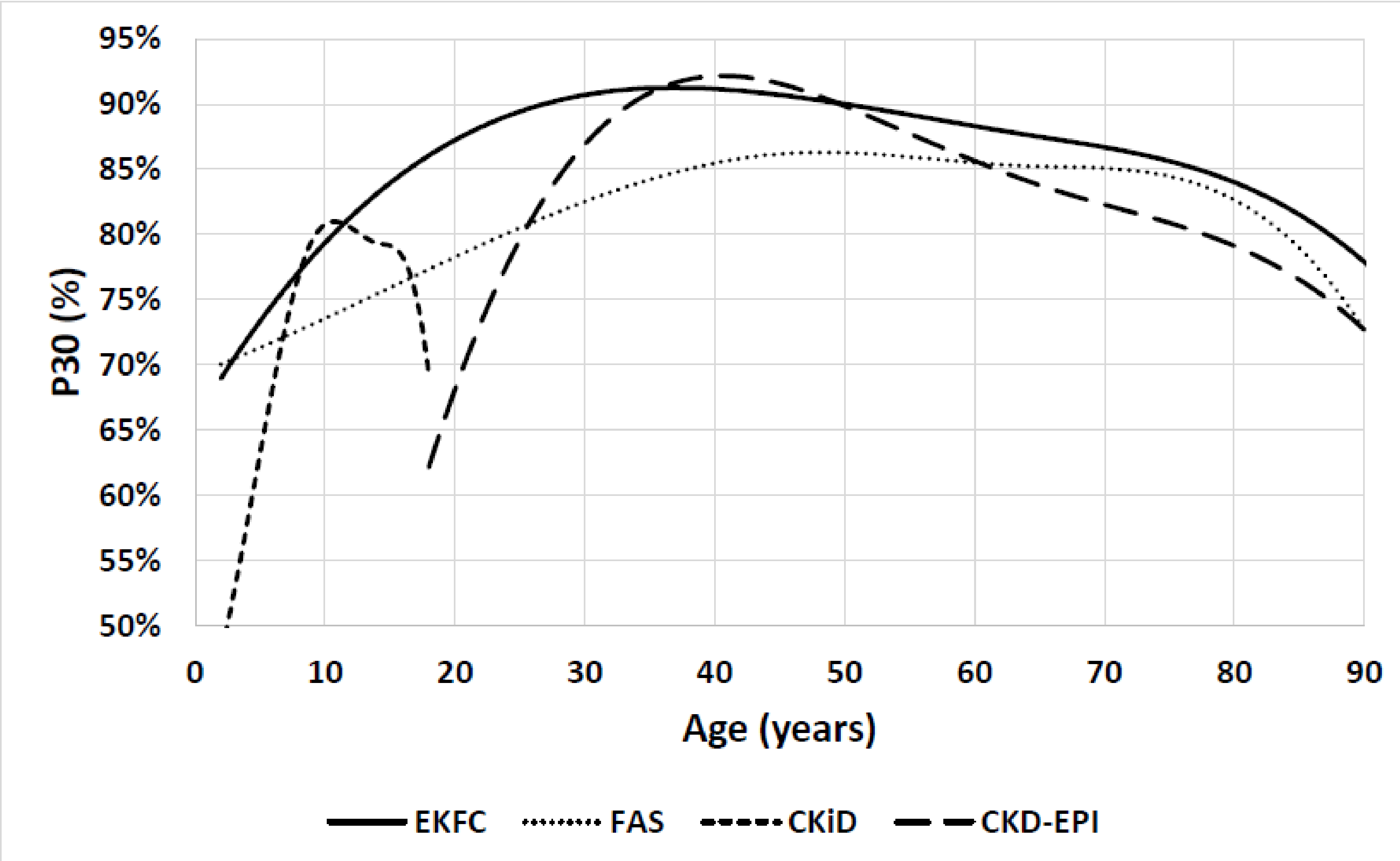


Figure S8. P30-accuracy against age for the EKFC, FAS, CKiD and CKD-EPI equation in the external validation dataset. P30 (%) was graphically presented across the age spectrum using cubic splines with two free knots and using 3rd degree polynomials.

Avantages de EKFC

- Meilleures performances (pas plus cher)
- Plus « physiologique »: correction au niveau de la créatinine (âge, sexe, « race »), âge mieux conceptualisé, « Q » spécifique pour des populations spécifiques
- Valide à tout âge (et pas de « jump » à 18 ans)
- Enfant: pas besoin de la taille
- Même formule (« concept ») pour la cystatine C (et les autres biomarqueurs)

Cystatine C

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Estimating Glomerular Filtration Rate from Serum Creatinine and Cystatin C

Lesley A. Inker, M.D., Christopher H. Schmid, Ph.D., Hocine Tighiouart, M.S., John H. Eckfeldt, M.D., Ph.D., Harold I. Feldman, M.D., Tom Greene, Ph.D., John W. Kusek, Ph.D., Jane Manzi, Ph.D., Frederick Van Lente, Ph.D., Yaping Lucy Zhang, M.S., Josef Coresh, M.D., Ph.D., and Andrew S. Levey, M.D., for the CKD-EPI Investigators*

N Engl J Med 2012;367:20-9.

Table 1. Characteristics of Study Participants, According to Data Set.*

Characteristic	Development and Internal Validation (N = 5352)	External Validation (N = 1119)	P Value
Age — yr	47±15	50±17	<0.001
Age group — no. (%)			
<40 yr	2008 (38)	357 (32)	<0.001
40–65 yr	2625 (49)	530 (47)	
>65 yr	719 (13)	232 (21)	
Male sex — no. (%)	3107 (58)	663 (59)	0.46
Black race — no. (%)†	2123 (40)	30 (3)	<0.001
Diabetes — no. (%)	1726 (32)	594 (53)	<0.001
Body-mass index‡			
Mean	28±6	25±4	<0.001
<20 — no. (%)	214 (4)	81 (7)	<0.001
20–24 — no. (%)	1585 (30)	503 (45)	
25–30 — no. (%)	1881 (35)	386 (35)	
>30 — no. (%)	1671 (31)	149 (13)	
Mean weight — kg	83±20	74±15	<0.001
Mean height — cm	171±10	170±9	0.017
Mean body-surface area — m^2	1.94±0.24	1.85±0.21	<0.001
Mean serum cystatin C — ml/liter	1.4±0.7	1.5±0.8	0.01
Mean serum creatinine — mg/dl§	1.6±0.9	1.6±1.1	0.15
Mean measured GFR — ml/min/1.73 m^2 of body-surface area	68±39	70±41	0.13
Measured GFR — no. (%)			
<15 ml/min/1.73 m^2	160 (3)	51 (5)	<0.001
15–29 ml/min/1.73 m^2	785 (15)	166 (15)	
30–59 ml/min/1.73 m^2	1765 (33)	316 (28)	
60–89 ml/min/1.73 m^2	1105 (21)	215 (19)	
90–119 ml/min/1.73 m^2	862 (16)	199 (18)	
>120 ml/min/1.73 m^2	675 (13)	172 (15)	

Table 2. Creatinine Equation (CKD-EPI 2009), Cystatin C Equation (CKD-EPI 2012), and Creatinine–Cystatin C Equation (CKD-EPI 2012) for Estimating GFR, Expressed for Specified Sex, Serum Creatinine Level, and Serum Cystatin C Level.*

Basis of Equation and Sex	Serum Creatinine†	Serum Cystatin C	Equation for Estimating GFR
	mg/dl	*mg/liter*	
CKD-EPI creatinine equation‡			
Female	≤0.7		$144 \times (\text{Scr}/0.7)^{-0.329} \times 0.993^{\text{Age}}$ [× 1.159 if black]
Female	>0.7		$144 \times (\text{Scr}/0.7)^{-1.209} \times 0.993^{\text{Age}}$ [× 1.159 if black]
Male	≤0.9		$141 \times (\text{Scr}/0.9)^{-0.411} \times 0.993^{\text{Age}}$ [× 1.159 if black]
Male	>0.9		$141 \times (\text{Scr}/0.9)^{-1.209} \times 0.993^{\text{Age}}$ [× 1.159 if black]
CKD-EPI cystatin C equation§			
Female or male		≤0.8	$133 \times (\text{Scys}/0.8)^{-0.499} \times 0.996^{\text{Age}}$ [× 0.932 if female]
Female or male		>0.8	$133 \times (\text{Scys}/0.8)^{-1.328} \times 0.996^{\text{Age}}$ [× 0.932 if female]
CKD-EPI creatinine–cystatin C equation¶			
Female	≤0.7	≤0.8	$130 \times (\text{Scr}/0.7)^{-0.248} \times (\text{Scys}/0.8)^{-0.375} \times 0.995^{\text{Age}}$ [× 1.08 if black]
		>0.8	$130 \times (\text{Scr}/0.7)^{-0.248} \times (\text{Scys}/0.8)^{-0.711} \times 0.995^{\text{Age}}$ [× 1.08 if black]
Female	>0.7	≤0.8	$130 \times (\text{Scr}/0.7)^{-0.601} \times (\text{Scys}/0.8)^{-0.375} \times 0.995^{\text{Age}}$ [× 1.08 if black]
		>0.8	$130 \times (\text{Scr}/0.7)^{-0.601} \times (\text{Scys}/0.8)^{-0.711} \times 0.995^{\text{Age}}$ [× 1.08 if black]
Male	≤0.9	≤0.8	$135 \times (\text{Scr}/0.9)^{-0.207} \times (\text{Scys}/0.8)^{-0.375} \times 0.995^{\text{Age}}$ [× 1.08 if black]
		>0.8	$135 \times (\text{Scr}/0.9)^{-0.207} \times (\text{Scys}/0.8)^{-0.711} \times 0.995^{\text{Age}}$ [× 1.08 if black]
Male	>0.9	≤0.8	$135 \times (\text{Scr}/0.9)^{-0.601} \times (\text{Scys}/0.8)^{-0.375} \times 0.995^{\text{Age}}$ [× 1.08 if black]
		>0.8	$135 \times (\text{Scr}/0.9)^{-0.601} \times (\text{Scys}/0.8)^{-0.711} \times 0.995^{\text{Age}}$ [× 1.08 if black]

Table 3. Use of the CKD-EPI Creatinine Equation (2009), CKD-EPI Cystatin C Equation (2012), and CKD-EPI Creatinine–Cystatin C Equations (2012) in the External-Validation Data Set Comprising 1119 Participants.*

Variable	Estimated GFR			
	Overall	<60	60–89	≥90
	ml/min/1.73 m^2 of body-surface area			
Bias — median difference (95% CI)				
Creatinine equation	3.7 (2.8 to 4.6)	1.8 (1.1 to 2.5)	6.6 (3.5 to 9.2)	11.1 (8.0 to 12.5)
Cystatin C equation	3.4 (2.3 to 4.4)	0.4 (−0.5 to 1.4)	6.0 (4.6 to 8.5)	8.5 (6.5 to 11.2)
Creatinine–cystatin C equation	3.9 (3.2 to 4.5)	1.3 (0.5 to 1.8)	6.9 (5.0 to 8.9)	10.6 (9.5 to 12.7)
Average of creatinine and cystatin C†	3.5 (2.8 to 4.1)	0.4 (−0.3 to 0.8)	6.5 (4.6 to 8.4)	11.9 (9.9 to 13.9)
Precision — IQR of the difference (95% CI)				
Creatinine equation	15.4 (14.3 to 16.5)	10.0 (8.9 to 11.0)	19.6 (17.3 to 23.2)	25.0 (21.6 to 28.1)
Cystatin C equation	16.4 (14.8 to 17.8)	11.0 (10.0 to 12.4)	19.6 (16.1 to 23.1)	22.6 (18.8 to 26.3)
Creatinine–cystatin C equation	13.4 (12.3 to 14.5)	8.1 (7.3 to 9.1)	15.9 (13.9 to 18.1)	18.8 (16.8 to 22.5)
Average of creatinine and cystatin C equations†	13.9 (12.9 to 14.7)	7.9 (7.1 to 9.0)	15.8 (13.9 to 17.7)	18.6 (16.1 to 22.2)
Accuracy — % (95% CI)‡				
$1-P_{30}$				
Creatinine equation	12.8 (10.9 to 14.7)	16.6 (13.6 to 19.7)	10.2 (6.4 to 14.2)	7.8 (5.1 to 11.0)
Cystatin C equation	14.1 (12.2 to 16.2)	21.4 (18.2 to 24.9)	12.7 (8.5 to 17.4)	2.2 (0.6 to 3.9)
Creatinine–cystatin C equation	8.5 (7.0 to 10.2)	13.3 (10.7 to 16.1)	5.3 (2.7 to 8.2)	2.3 (0.9 to 4.2)
Average of creatinine and cystatin C equations†	8.2 (6.7 to 9.9)	12.1 (9.5 to 14.8)	6.4 (3.6 to 9.7)	2.9 (1.3 to 4.9)
$1-P_{20}$				
Creatinine equation	32.9 (30.1 to 35.7)	37.2 (33.1 to 41.2)	31.1 (25.1 to 37.4)	26.5 (21.7 to 31.4)
Cystatin C equation	33.0 (30.3 to 35.7)	42.1 (38.2 to 46.1)	29.3 (23.6 to 35.4)	19.4 (15.4 to 23.7)
Creatinine–cystatin C equation	22.8 (20.4 to 25.2)	28.6 (25.1 to 32.4)	17.8 (13.3 to 22.9)	16.2 (12.4 to 20.5)
Average of creatinine and cystatin C equations†	23.7 (21.3 to 26.1)	29.1 (25.7 to 32.8)	17.6 (13.2 to 22.4)	18.8 (14.6 to 23.2)

BIS2: $767 \times \text{cystatin C}^{-0.61} \times \text{creatinine}^{-0.40} \times \text{age}^{-0.57} \times 0.87$ (if female)

CKD-EPI:

$$\text{eGFR} = 130 \times \text{cystatin C}^{-1.069} \times \text{age}^{-0.117} - 7$$

$$\text{FAS}_{\text{cysC}} = \frac{107.3}{\frac{\text{ScysC}}{Q_{\text{cysC}}}} \times \left[0.988^{(\text{Age}-40)} \text{ when age} > 40 \text{ years}\right].$$

$$\text{FAS}_{\text{combi}} = \frac{107.3}{\alpha \times \frac{\text{Scr}}{Q_{\text{crea}}} + (1-\alpha) \times \frac{\text{ScysC}}{Q_{\text{cysC}}}} \times \left[0.988^{(\text{Age}-40)} \text{ when age} > 40 \text{ years}\right].$$

Cystatine C

- Combinée
- Pas de facteur(s) ethnique(s), ni de genre
- “Cost-effectiveness?”
- Une certaine imprécision reste au niveau individuel
- Standardisation de la mesure pas complète pour la cystatine C
- (Pas remboursé en Belgique sauf greffe ou pédiatrie)

Facteur ethnique CKD/EPI - MDRD

NON

RESEARCH LETTER

Performance of GFR Estimating Equations in African Europeans: Basis for a Lower Race-Ethnicity Factor Than in African Americans

Flamant M et al   Am J Kidney Dis, 2013, 62, p179

PLOS | ONE

RESEARCH ARTICLE

Performance of glomerular filtration rate estimation equations in Congolese healthy adults: The inopportunity of the ethnic correction

Justine B. Bukabau[1]*, Ernest K. Sumaili[1], Etienne Cavalier[2], Hans Pottel[3], Bejos Kifakiou[1], Aliocha Nkodila[1], Jean Robert R. Makulo[1], Vieux M. Mokoli[1], Chantal V. Zinga[1], Augustin L. Longo[1], Yannick M. Engole[1], Yannick M. Nlandu[1], François B. Lepira[1], Nazaire M. Nseka[1], Jean Marie Krzesinski[4], Pierre Delanaye[4]

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Check for updates

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https://doi.org/10.1155/2020/2141038

Hindawi

Research Article

No Race-Ethnicity Adjustment in CKD-EPI Equations Is Required for Estimating Glomerular Filtration Rate in the Brazilian Population

Amanda D. Rocha,[1] Suzane Garcia,[2] Andressa B. Santos,[3] José C. C. Eduardo,[3] Claudio T. Mesquita,[2,4] Jocemir R. Lugon,[1,3] and Jorge P. Strogoff-de-Matos[1,3]

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Yayo ES, Nephrol Ther, 2016, 12, 454
Flamant M, Am J Kdiney Dis, 2013, 62, 179
Bukabau JB, Plos One, 2018, 13, e0193384

ARTICLE IN PRESS

www.kidney-international.org

clinical investigation

Performance of creatinine- or cystatin C–based equations to estimate glomerular filtration rate in sub-Saharan African populations

Justine B. Bukabau[1,7], Eric Yayo[2,7], Appolinaire Gnionsahé[3], Dagui Monnet[2], Hans Pottel[4], Etienne Cavalier[5], Aliocha Nkodila[1], Jean Robert R. Makulo[1], Vieux M. Mokoli[1], François B. Lepira[1], Nazaire M. Nseka[1], Jean-Marie Krzesinski[6], Ernest K. Sumaili[1,7] and Pierre Delanaye[6,7]

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- N=494
- Iohexol
- Créatinine calibrée

Table 3 | Performance of equations in the whole cohort (N = 494)

Equation	Absolute bias (95% CI)	Absolute SD	Accuracy within 30% (95% CI)	Lin's CCC (95% CI)
CKD-EPI	0.0 (−1.6 to 1.6)	18.1	77.7 (74.1 to 81.4)	0.81 (0.76 to 0.84)
CKD-EPI ef	13.3 (11.4 to 15.2)	21.3	64.6 (60.3 to 68.8)	0.71 (0.66 to 0.76)

eGFR

VIEWPOINT

Reconsidering the Consequences of Using Race to Estimate Kidney Function

Nwamaka Denise Eneanya, MD, MPH
Renal-Electrolyte and Hypertension Division, Perelman School of Medicine, University of Pennsylvania, Philadelphia; and Palliative and Advanced Illness Research Center, Perelman School of Medicine, University of Pennsylvania, Philadelphia.

Estimated GFR equations are distinct because they assert that existing organ function is different between individuals who are identical except for race.

JAMA Published online June 6, 2019

- Race is a social construct rather than a biological one
- Black coefficient in MDRD and CKD-EPI equations
- How is race defined?
- Problem of mixed people (Brazil)
- Muscular mass impact is not proven
- A 50 years old woman with creatinine at 2.0 mg/dL

CKD-EPI: 28 mL/min/1.73m^2 if non-Black vs 33 mL/min/1.73m^2 if Black => difference in referral to nephrologists, to be included in RCT, and to be wait-listed **for a kidney transplant (20 mL/min/1,73m^2)**

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

New Creatinine- and Cystatin C–Based Equations to Estimate GFR without Race

L.A. Inker, N.D. Eneanya, J. Coresh, H. Tighiouart, D. Wang, Y. Sang, D.C. Crews, A. Doria, M.M. Estrella, M. Froissart, M.E. Grams, T. Greene, A. Grubb, V. Gudnason, O.M. Gutiérrez, R. Kalil, A.B. Karger, M. Mauer, G. Navis, R.G. Nelson, E.D. Poggio, R. Rodby, P. Rossing, A.D. Rule, E. Selvin, J.C. Seegmiller, M.G. Shlipak, V.E. Torres, W. Yang, S.H. Ballew, S.J. Couture, N.R. Powe, and A.S. Levey, for the Chronic Kidney Disease Epidemiology Collaboration*

N Engl J Med. 2021 Nov 4;385(19):1737-1749.

Table 3. Accuracy of Current and New Approaches for GFR Estimation as Compared with Measured GFR in the Validation Data Set.

Filtration Marker and Equation*	Black Participants	Non-Black Participants	Difference between Black Participants and Non-Black Participants (95% CI)†
	Bias: Median Difference between Measured GFR and eGFR (95% CI)‡		
	milliliters per minute per 1.73 square meters		
Creatinine			
eGFRcr(ASR), current	−3.7 (−5.4 to −1.8)	−0.5 (−0.9 to 0.0)	−3.2 (−5.0 to −1.3)
eGFRcr(ASR-NB), new	7.1 (5.9 to 8.8)	−0.5 (−0.9 to 0.0)	7.6 (6.1 to 9.0)
eGFRcr(AS), new	3.6 (1.8 to 5.5)	−3.9 (−4.4 to −3.4)	7.6 (5.6 to 9.5)
Creatinine			
eGFRcr(ASR), current	85.1 (82.2 to 87.9)	89.5 (88.5 to 90.4)	−4.4 (−7.6 to −1.2)
eGFRcr(ASR-NB), new	86.4 (83.4 to 89.1)	89.5 (88.5 to 90.4)	−3.1 (−6.2 to 0)
eGFRcr(AS), new	87.2 (84.5 to 90.0)	86.5 (85.4 to 87.6)	0.7 (−2.4 to 3.8)

Unpublished (submitted) data from Europe and Africa

Performance of creatinine-based equations to estimate glomerular filtration rate in White and Black populations in Europe, Brazil, and Africa

Pierre Delanaye[1,2*], Emmanuelle Vidal-Petiot[3*], Jonas Björk[4,5], Natalie Ebert[6], Björn O. Eriksen[7], Laurence Dubourg[8], Anders Grubb[9], Magnus Hansson[10], Edmund J. Lamb[11], Karin Littmann[12], Christophe Mariat[13], Toralf Melsom[7], Elke Schaeffner[6], Per-Ola Sundin[14], Arend Bökenkamp[15], Ulla B. Berg[16], Kajsa Åsling-Monemi[16], Anna Åkesson[4,5], Anders Larsson[17], Etienne Cavalier[18], R. Neil Dalton[19], Marie Courbebaisse[20], Lionel Couzi[21], Francois Gaillard[22], Cyril Garrouste[23], Lola Jacquemont[24], Nassim Kamar[25] Christophe Legendre[26], Lionel Rostaing[27], Thomas Stehlé[28,29], Jean-Philippe Haymann[30], Luciano da Silva Selistre[31], Jorge P. Strogoff-de-Matos[32], Justine B. Bukabau[33], Ernest K. Sumaili[33], Eric Yayo[34], Dagui Monnet[34], Ulf Nyman[35], Hans Pottel[36], Martin Flamant[37**]**

Table S3: Method and patients characteristics

Mean and SD of age and measured glomerular filtration

Center	Country	Cohort	n	Method	Exogenous marker	Age	mGFR (mL/min/1.73m²)	% of female
White populations								
Amsterdam	The Netherlands	CAPA-study[5] + referrals	48	Plasma clearance	Inulin	18.7±0.9	93.7±27.9	25.0
Berlin	Germany	BIS-Study[6]	657	Plasma clearance	Iohexol	78.4±6.1	60.3±21.5	41.7
France	France	Kidney Donor Study[7]	2,572	Plasma/renal clearance	Iohexol/^{51}Cr-EDTA/inulin	50.4±11.8	100.1±22.2	61.9
Kent	UK	GFR in old adults[8]	394	Plasma clearance	Iohexol	80.4±4.6	55.3±20.5	52.0
Leuven	Belgium	Referrals	21	Plasma clearance	^{51}Cr-EDTA	19.1±1.2	78.2±23.1	47.6
Lund	Sweden	CAPA-study[5]	2,847	Plasma clearance	Iohexol	60.1±16.5	62.5±34.1	48.5
Lyon	France	Referrals	2,435	Plasma/renal clearance	Iohexol/inulin	31.3±16.7	84.5±32.7	46.8
Örebro	Sweden	Referrals	2,051	Plasma clearance	Iohexol	56.5±16.3	64.3±36.0	41.7
Saint-Etienne	France	HIV-study[9]	203	Plasma clearance	Iohexol	48.7±10.3	100.3±27.3	48.7
Stockholm	Sweden	Referrals	856	Plasma clearance	Iohexol	72.9±14.1	48.7±27.6	44.2
Tromsø	Norway	RENIS-T6 study[10]	1,627	Plasma clearance	Iohexol	58.1±3.8	101.5±19.9	50.8
Kinshasa/ Abidjan	DRC/Côte d'Ivoire	African Study[11]	508	Plasma clearance	Iohexol	41.8±14.3	80.5±28.9	46.7
Rio de Janeiro	Brazil	Brazilian study[12]	39	Plasma clearance	^{51}Cr-EDTA	60.0±13.5	41.9±23.4	59.0
Paris	France	Referrals	4429	Plasma clearance	^{51}Cr-EDTA	52.4±14.8	61.3±26.6	41.1
Black population								
Kinshasa/ Abidjan	DRC/Côte d'Ivoire	African Study[11]	508	Plasma clearance	Iohexol	41.8±14.3	80.5±28.9	46.7
Rio de Janeiro	Brazil	Brazilian study[12]	61	Plasma clearance	^{51}Cr-EDTA	55.9±13.8	49.8±32.2	50.8
Paris	France	Referrals	964	Plasma clearance	^{51}Cr-EDTA	50.4±13.8	61.1±24.6	41.1

*Referrals = referred for plasma or renal clearance measurement on clinical grounds. Results mean±SD.

EKFC

17321

White Europeans (Paris)

4429

Black Europeans (Paris)

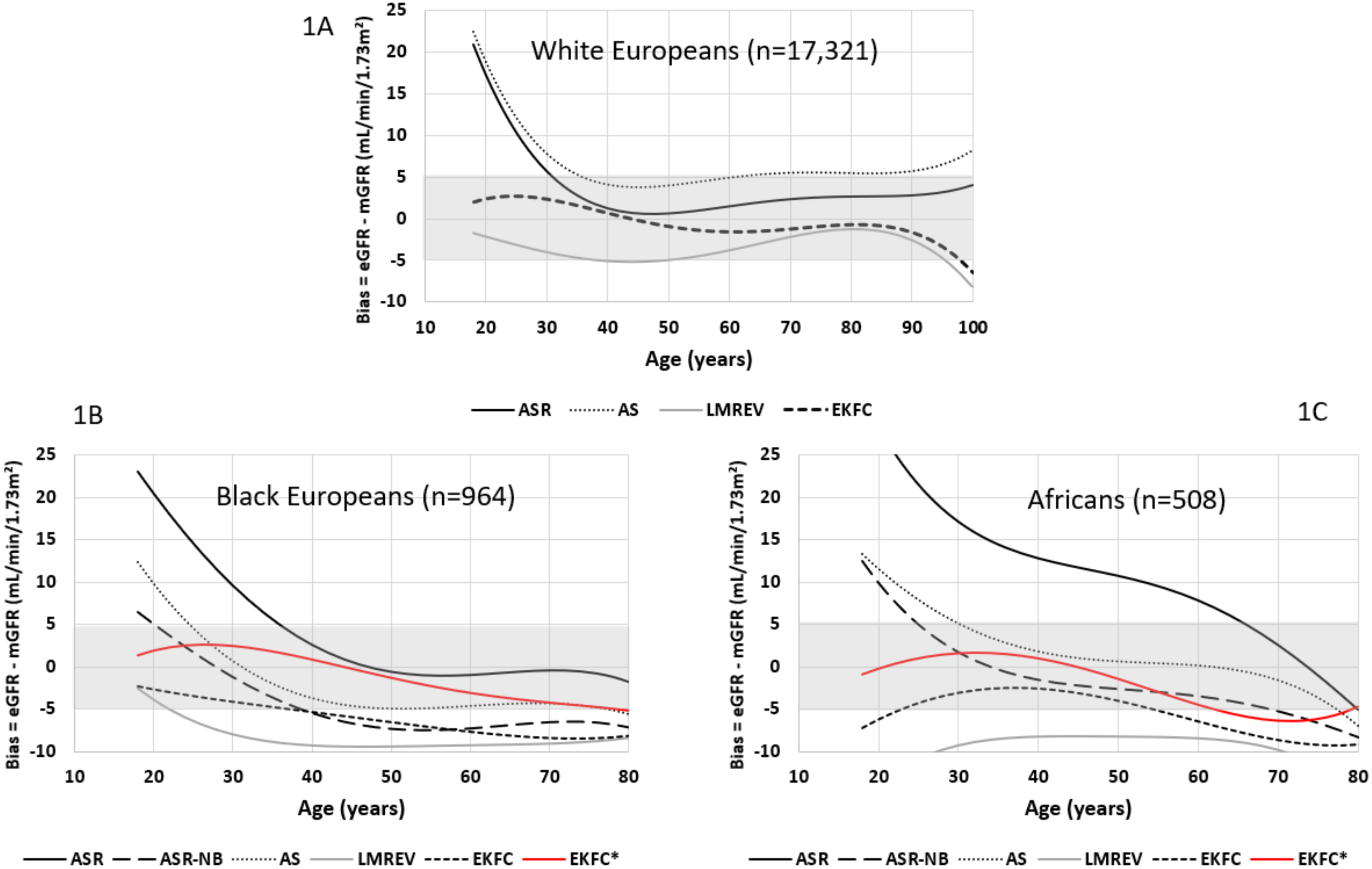
964

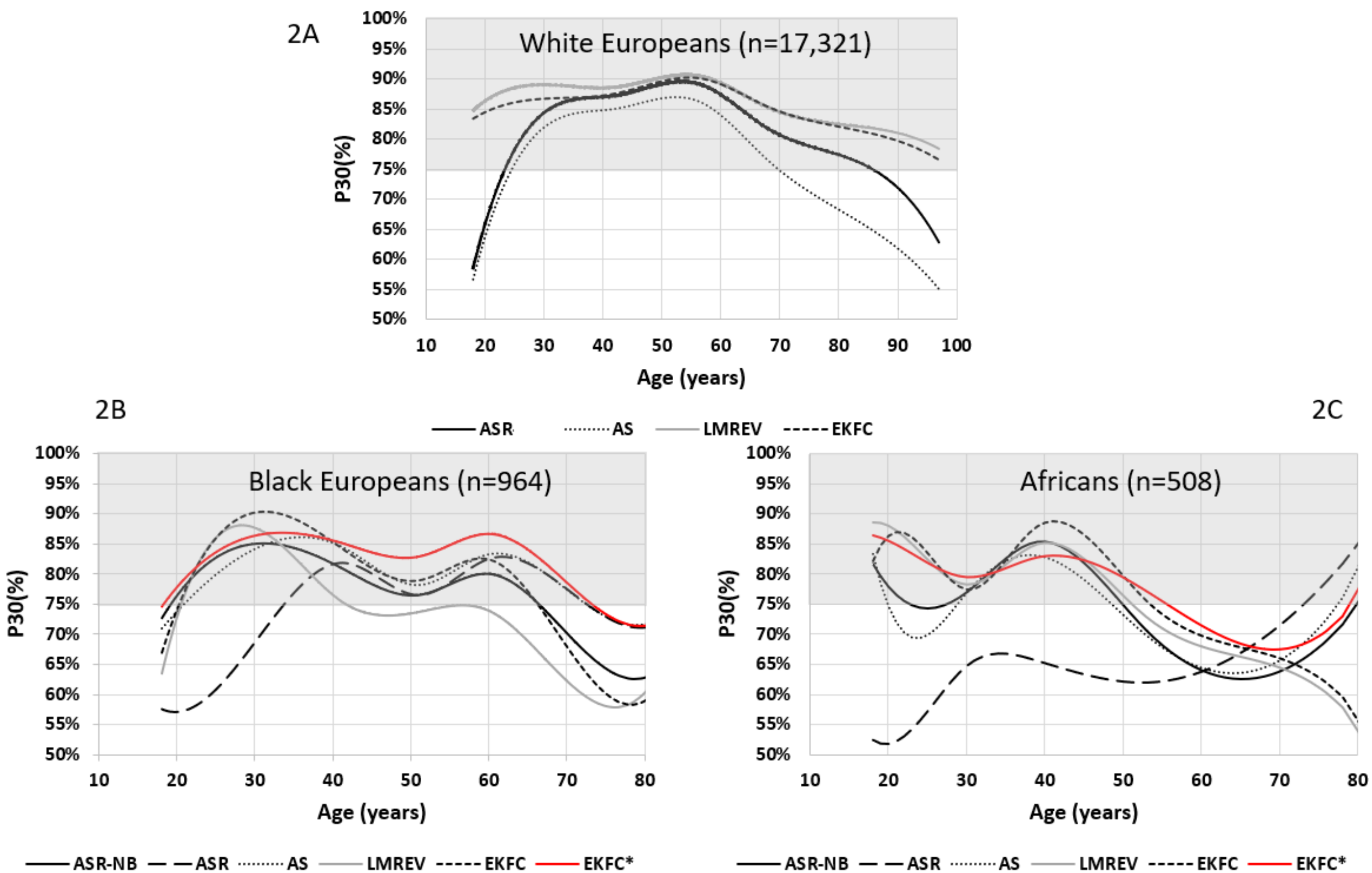
Africans

508

EKFC	Q Female/male
European cohort	0.70/0.90
European cohort	0.74/1.02
African cohort	0.72/0.96

Q specifically developed for Black populations
(not a correction from White data!)


1A
White Europeans (n=17,321)
Bias = eGFR - mGFR (mL/min/1.73m²)
Age (years)
ASR
AS
LMREV
EKFC
1B
Black Europeans (n=964)
Bias = eGFR - mGFR (mL/min/1.73m²)
Age (years)
ASR
ASR-NB
AS
LMREV
EKFC
EKFC*
1C
Africans (n=508)
Bias = eGFR - mGFR (mL/min/1.73m²)
Age (years)
ASR
ASR-NB
AS
LMREV
EKFC
EKFC*


2A
White Europeans (n=17,321)
P30(%)
Age (years)
ASR
AS
LMREV
EKFC
2B
Black Europeans (n=964)
P30(%)
Age (years)
ASR-NB
ASR
AS
LMREV
EKFC
EKFC*
2C
Africans (n=508)
P30(%)
Age (years)
ASR-NB
ASR
AS
LMREV
EKFC
EKFC*

Americentrism in estimation of glomerular filtration rate equations

Check for updates

Kidney International (2022) **101**, 856–858; https://doi.org/10.1016/j.kint.2022.02.022

KEYWORDS: glomerular filtration rate; race; serum creatinine

- Arguments can be posited in favor of using the previous CKD-EPI creatinine equation in Europe, Africa, Brazil, and elsewhere without any race correction
- Should these countries, and others, use a new equation, developed in America to remedy a specific issue of structural racism relating to the Black American~~s~~ population, for a problem that may not be relevant in their own country?
- Especially if the performance characteristics of the new equation are poorer than the current equation when used without any race variable?

THE WORLD ACCORDING TO AMERICANS

Un expert, c'est une opinion. Deux experts, c'est la contradiction. Trois experts, c'est la confusion.

Anonyme [redacted]

Limitations des formules = créatinine

Populations spécifiques:
Les équations ne sont pas magiques!!
Gardons notre sens clinique!!

Anorexie nerveuse (Delanaye P, Clin Nephrol, 2009, 71, 482)

Cirrhose (Skluzacek PA, Am J Kidney Dis, 2003, 42, 1169)

USI (Delanaye P, BMC Nephrology, 2014, 15, 9)

Hospitalisés (Poggio ED, Am J Kidney Dis, 2005, 46, 242)

Greffés cœur (Delanaye P, Clin Transplant, 2006, 20, 596)

Greffés rein (Masson I, Transplantation, 2013, 95, 1211)

Obèse (Bouquegneau A, NDT, 2013, 28, iv122)

Table 2. Classification of patients in CKD stages by a representative group of nine creatinine and/or cystatin C–based formulas

Creatinine

Stage	Cockcroft-Gault GFR	N	True positive	False positive	Missing	aMDRD GFR	N	True positive	False positive	Missing	CKD-EPI GFR	N	True positive	False positive	Missing
1	178	242	142 (80%)	100 *(41%)*[a]	36 (20%)	178	175	115 (65%)	60 *(34%)*	63 (35%)	178	222	136 (76%)	86 *(39%)*	42 (24%)
2	252	254	136 (54%)	118 *(46%)*	116 (46%)	252	259	145 (58%)	114 *(44%)*	107 (42%)	252	241	138 (55%)	103 *(43%)*	114 (45%)
3	251	248	151 (60%)	97 *(39%)*	100 (40%)	251	257	166 (66%)	91 *(35%)*	85 (34%)	251	226	155 (62%)	71 *(31%)*	96 (38%)
4	176	124	99 (56%)	25 *(20%)*	77 (44%)	176	157	121 (69%)	36 *(23%)*	55 (31%)	176	156	121 (69%)	35 *(22%)*	55 (31%)
5	25	14	6 (24%)	8 *(57%)*	19 (76%)	25	34	13 (52%)	21 *(62%)*	12 (48%)	25	37	13 (52%)	24 *(65%)*	12 (48%)

Cystatin-C

Stage	Le Bricon GFR	N	True positive	False positive	Missing	MCQ GFR	N	True positive	False positive	Missing	CKD-EPI GFR	N	True positive	False positive	Missing
1	178	259	162 (91%)	97 *(37%)*	16 (9%)	178	146	114 (64%)	32 *(22%)*	64 (36%)	178	229	155 (87%)	74 *(32%)*	23 (13%)
2	252	243	148 (59%)	95 *(39%)*	104 (41%)	252	205	127 (50%)	78 *(38%)*	125 (50%)	252	182	128 (51%)	54 *(30%)*	124 (49%)
3	251	329	170 (68%)	159 *(48%)*	81 (32%)	251	274	166 (66%)	108 *(39%)*	85 (34%)	251	246	177 (71%)	69 *(28%)*	74 (29%)
4	176	50	32 (1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2 *(27%)*	36 (20%)
5	25	1	1 (4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9 *(58%)*	11 (44%)

Creatinine + Cystatin-C

Stage	GFR	N	True positive	[illegible]	False positive	Missing
1	178	288	168 (9	[illegible]	5 *(29%)*	20 (11%)
2	252	207	127 (5	[illegible]	0 *(28%)*	98 (39%)
3	251	227	172 (6	[illegible]	3 *(23%)*	78 (31%)
4	176	149	130 (7	[illegible]	2 *(24%)*	40 (23%)
5	25	11	8 (3	[illegible]	2 *(54%)*	6 (24%)

Results. Misclassification was a constant for all 61 formulas evaluated and averaged 50% for creatinine-based and 35% for cystatin C–based equations. Most of the cases were misclassified as one stage higher or lower. However, in 10% of the subjects, one stage was skipped and patients were classified two stages above or below their real stage. No clinically relevant improvement was observed with cystatin C–based formulas compared with those based on creatinine.

'True positives cases' represent the subjects that were corretly classified in each CKD stage by eGFR. 'False positives cases' represent the patients who were classified in one CKD stage based on eGFR when actually belonging to a different stage. 'Missing cases' represent the cases that were not classified in the corresponding CKD stage.

[a]The percentage of false positive cases refers to the number of cases defined in each CKD stage by mGFR (grey column). The percentage of true positive and missing cases refers to the number of cases defined in each CKD stage by eGFR.

Received: 24 June 2021 | Revised: 4 October 2021 | Accepted: 19 October 2021
DOI: 10.1111/bcp.15132

ORIGINAL ARTICLE

Performance of creatinine-based equations to estimate glomerular filtration rate with a methodology adapted to the context of drug dosage adjustment

Pierre Delanaye[1,2] | Jonas Björk[3,4] | Marie Courbebaisse[5] | Lionel Couzi[6] | Natalie Ebert[7] | Björn O. Eriksen[8] | R. Neil Dalton[9] | Laurence Dubourg[10] | Francois Gaillard[11] | Cyril Garrouste[12] | Anders Grubb[13] | Lola Jacquemont[14] | Magnus Hansson[15] | Nassim Kamar[16] | Edmund J. Lamb[17] | Christophe Legendre[18] | Karin Littmann[19] | Christophe Mariat[20] | Toralf Melsom[8] | Lionel Rostaing[21] | Andrew D. Rule[22] | Elke Schaeffner[7] | Per-Ola Sundin[23] | Ulla B. Berg[24] | Kajsa Åsling-Monemi[24] | Luciano Selistre[25] | Anna Åkesson[3,4] | Anders Larsson[26] | Arend Bökenkamp[27] | Hans Pottel[28] | Ulf Nyman[29]

Br J Clin Pharmacol. 2021;1–10.

- 14,804 participants (adultes)
- Cockcroft, CKD-EPI et EKFC
- De-indexé
- Focus sur DFG< 60 mL/min (n=4328)

Classification

- Erreur de 1 classe:

Cockcroft: 46.1%

CKDEPI: 43.7%

EKFC: 41.1%

- Erreur de 2 classes:

Cockcroft: 9,3%

CKDEPI: 7,2%

EKFC: 5,4%

Ne pas sur-interpreter un résultat…

Toutes les équations restent des estimations

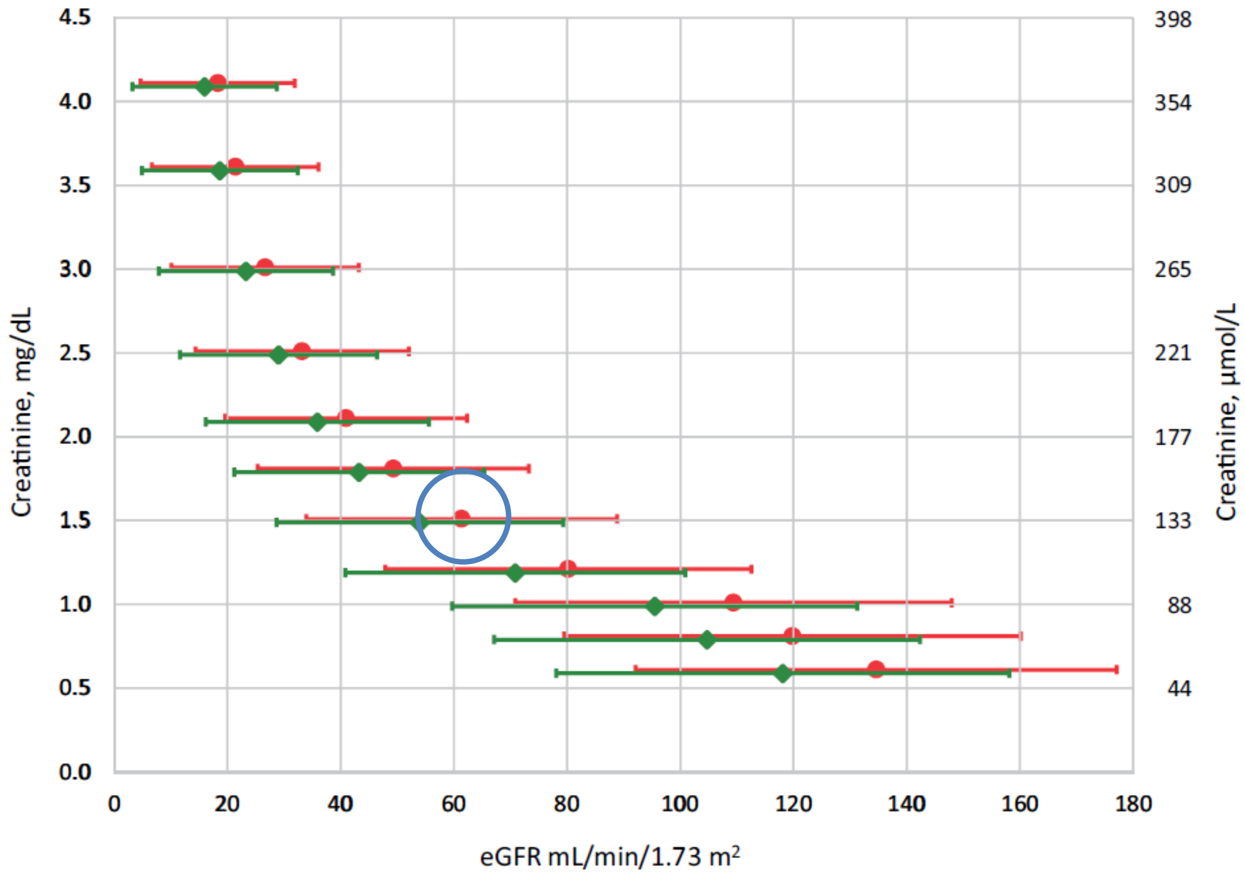


Fig. 1. Uncertainty of eGFR calculated using the CKD-EPI equations for African-Americans and non-African-Americans at various creatinine concentrations for a 50-year-old male. Circles (red, larger values) indicate African-American and diamonds (green, lower values) indicate non-African-American equations. Plot symbols are the eGFR values and error bars represent the 95% CI for each eGFR value.

eGFR = 60,25 ml/min/1.73m²

Miller WG, Clin Chem, 2021, p693 and p820

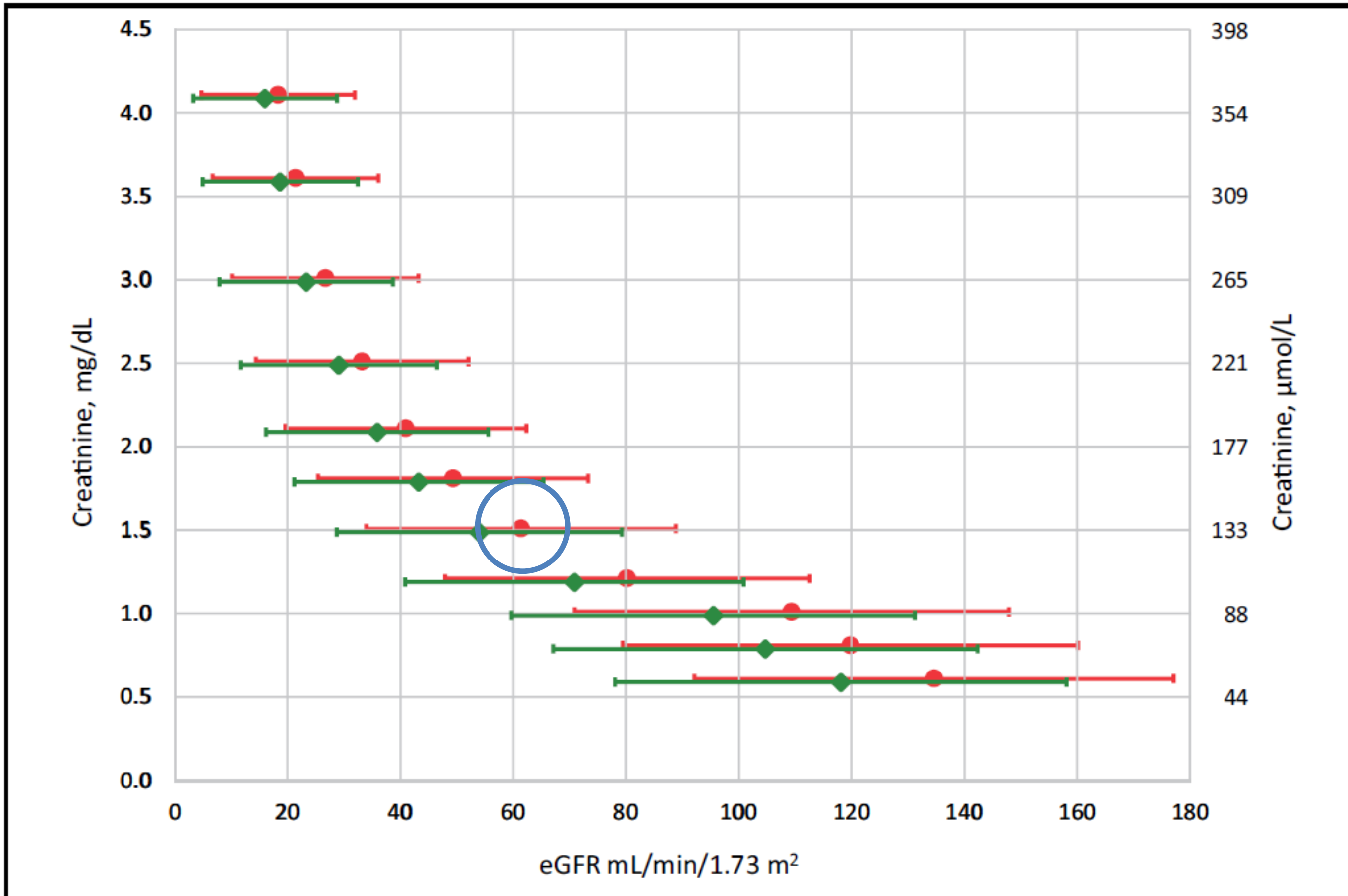


Fig. 1. Uncertainty of eGFR calculated using the CKD-EPI equations for African-Americans and non-African-Americans at various creatinine concentrations for a 50-year-old male. Circles (red, larger values) indicate African-American and diamonds (green, lower values) indicate non-African-American equations. Plot symbols are the eGFR values and error bars represent the 95% CI for each eGFR value.

eGFR ~~= 60,25 ml/min/1.73m²~~

= 60 ml/min/1.73m² (CI 95%: 33-87)

Miller WG, Clin Chem, 2021, p693 and p820

REVIEWS

The applicability of eGFR equations to different populations

Pierre Delanaye and Christophe Mariat

Delanaye P, Nature Rev Nephrol, 2013, 9, 513

Et si on mesurait le DFG…

Mesurer le DFG: Pourquoi? Une question de précision!

- Décision d'initier la dialyse
- Individus sarcopéniques
- Gabarit extrême
- Cirrhose, USI, Hyperfiltration
- Donneur vivant

Agarwal R, Nephrol Dial Transplant, 2019, 34, p2001
Ebert N, Clin Kidney J, 2021, p1861

Impact of estimation versus direct measurement of predonation glomerular filtration rate on the eligibility of potential living kidney donors

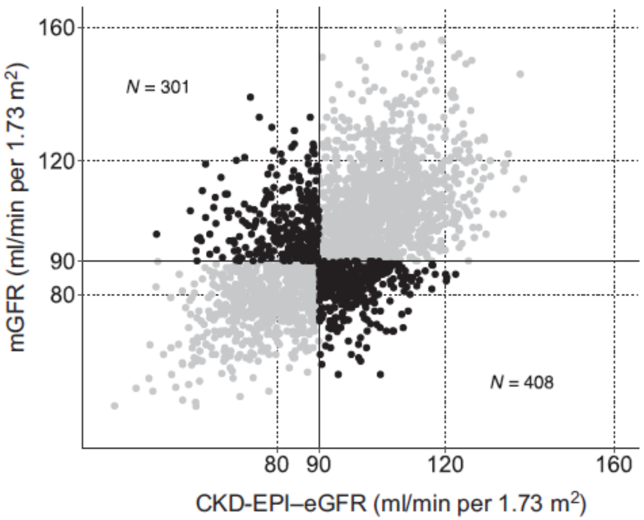
Check for updates

see commentary on page 738

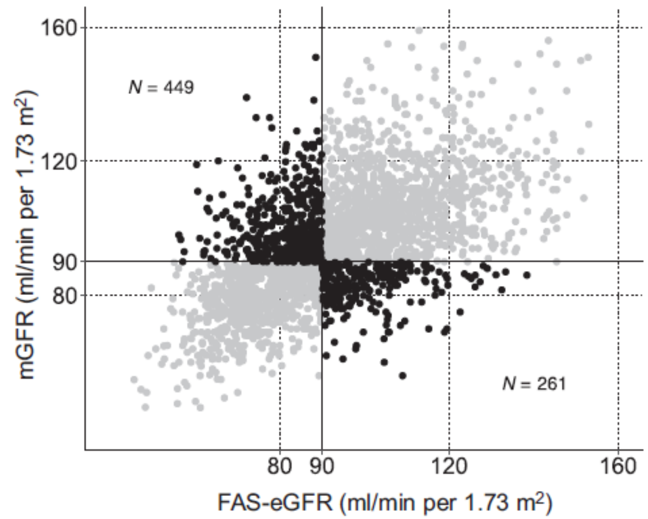
François Gaillard[1,2], Marie Courbebaisse[2,3], Nassim Kamar[4,5,18], Lionel Rostaing[6,18], Lola Jacquemont[7,8], Maryvonne Hourmant[7,8], Arnaud Del Bello[4], Lionel Couzi[9,10], Pierre Merville[9,10], Paolo Malvezzi[6], Benedicte Janbon[6], Bruno Moulin[11], Nicolas Maillard[12], Laurence Dubourg[13,14], Sandrine Lemoine[13], Cyril Garrouste[15], Hans Pottel[16], Christophe Legendre[1,2], Pierre Delanaye[17,19] and Christophe Mariat[12,19]

Kidney International (2019) **95,** 896–904;

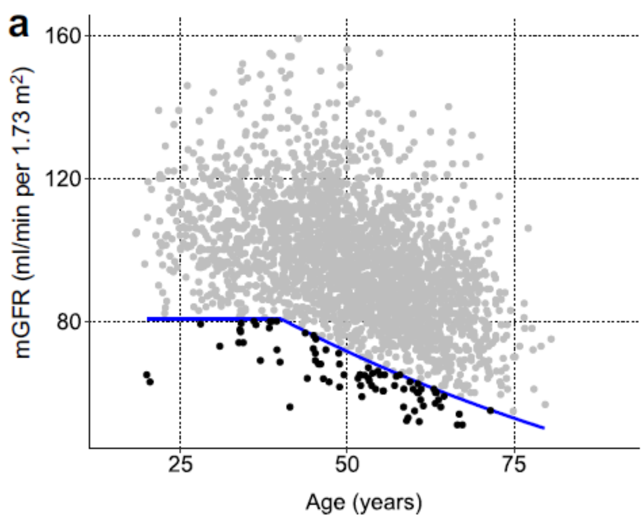
- N=2,733 donneurs potentiels
- DFG mesuré, créatinine calibrée



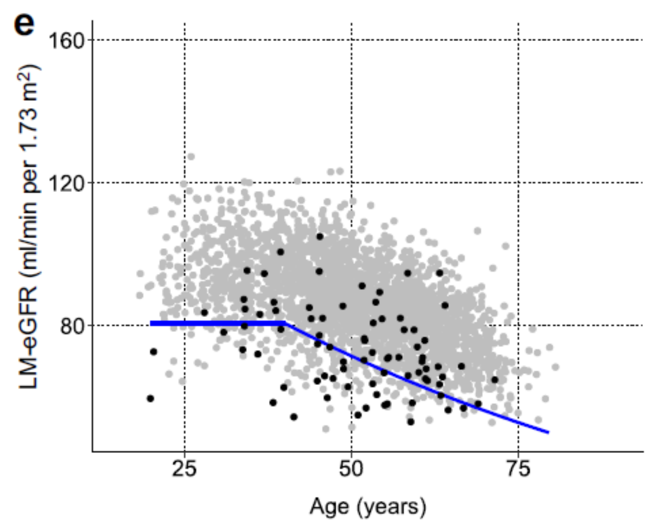
N = 301
N = 408
mGFR (ml/min per 1.73 m2)
CKD-EPI–eGFR (ml/min per 1.73 m2)



N = 449
N = 261
mGFR (ml/min per 1.73 m2)
FAS-eGFR (ml/min per 1.73 m2)



a
mGFR (ml/min per 1.73 m2)
Age (years)



e
LM-eGFR (ml/min per 1.73 m2)
Age (years)

Mesurer le DFG: Pourquoi? Une question de précision!

- Décision d'initier la dialyse
- Individus sarcopéniques
- Gabarit extrême
- Cirrhose, USI, Hyperfiltration
- Donneur vivant
- Recherche Clinique, EMA
- Dosage d'un médicament potentiellement néphrotoxique (=>2)
- Pas de preuve définitive…

Agarwal R, Nephrol Dial Transplant, 2019, 34, p2001
Ebert N, Clin Kidney J, 2021, p1861

Disponibles sur le marché…

Marqueurs	Forces	Limites
Inuline	"Gold standard" (ou historique)	Coûteux Dosage ni facile ni standardisé Impossible en clairance plasmatique
Iothalamate	Le plus populaire aux USA Isotopique ou "froide"	Sécrétion tubulaire Allergie Iode
Iohexol	Populaire en Europe Froide	Allergie Iode
EDTA	Facile à mesurer	Seulement isotopique Pas disponible aux USA…et plus en Europe!!
DTPA	Facile à mesurer	Seulement isotopique Liaison aux protéines

Stevens LA, J Am Soc Nephrol, 2009, 20, 2305
Cavalier E, Clin Chim Acta, 2008, 396, 80
Delanaye P, Clin Kidney J, 2016, 9, 700

Comment mesurer le DFG?

Table 4. Available procedures to perform iohexol clearance

Methodology	Indication in clinical practice	Indication in clinical research	Bibliographic examples where the procedure is described into details
Urinary clearance	Increased extracellular volume (oedema, ascites, intensive care units, etc.)	Basic (physiologic) studies Specific populations (cirrhotic, intensive care, nephrotic syndrome, oedema, etc.)	[36, 77, 125, 170]
Plasma clearance			
Multiple samples (first or fast, second or slow exponential curves and calculation of area under the curve)	High GFR values ('hyperfiltrating') subjects	Development of equations to estimate GFR Studies in hyperfiltrating patients	[52, 93, 171]
Multiple samples only for second and slow component (2 h after injection, 4 samples over 5 or 6 h, 1 sample/h) + BM correction	High precision determination (see text)	Development of equations to estimate GFR Clinical research with GFR as main endpoint	[126, 172]
Idem + late sample (8 h or 24 h)	Pre-dialysis subjects	Research in pre-dialysis subjects	[52, 77]
Simplified two or three sample method (2 samples: first at 2 or 3 h and second at 4 or 5 h) + BM correction	CKD or healthy population	Development of equations to estimate GFR Clinical research with GFR as a secondary endpoint	[69, 116]
Simplified single-sample method + Jacobsson correction [110]	CKD or healthy population	Development of equations to estimate GFR Clinical research with GFR as a secondary endpoint Epidemiological research	[14, 173]

Suggestions (expert opinion-based) according to the clinical or experimental context.
GFR, glomerular filtration rate; CKD, chronic kidney disease; BM, Brochner-Mortensen correction [116].

Delanaye P, Clin Kidney J, 2016, 9, 700

EKFC

Nephrol Dial Transplant (2018) 33: 1778–1785
doi: 10.1093/ndt/gfx345
Advance Access publication 8 January 2018

Single- versus multiple-sample method to measure glomerular filtration rate

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*These authors equally contributed as first author.
**These authors equally contributed as last senior author.

Original Investigation AJKD

Comparability of Plasma Iohexol Clearance Across Population-Based Cohorts

Bjørn O. Eriksen, Elke Schaeffner, Toralf Melsom, Natalie Ebert, Markus van der Giet, Vilmundur Gudnason, Olafur S. Indridasson, Amy B. Karger, Andrew S. Levey, Mirjam Schuchardt, Liv K. Sørensen, and Runolfur Palsson

Rationale & Objective: Glomerular filtration rate (GFR) estimation based on creatinine or cystatin C level is currently the standard method for assessing GFR in epidemiologic research and clinical trials despite several important and well-known limitations. Plasma iohexol clearance has been proposed as an inexpensive method for measuring GFR that could replace estimated GFR in many research projects. However, lack of standardization for iohexol assays and the use of different protocols such as single- and multiple-sample methods could potentially hamper comparisons across studies. We compared iohexol assays and GFR measurement protocols in 3 population-based European cohorts.

Study Design: Cross-sectional investigation.

Setting & Participants: Participants in the Age...

Results: Frozen samples from the 3 studies were obtained and iohexol concentrations were remeasured in the laboratory at the University Hospital of North Norway. Lin's concordance correlation coefficient ρ was >0.96 and C_b (accuracy) was >0.99 for remeasured versus original serum iohexol concentrations in all 3 cohorts, and Passing-Bablok regression did not find differences between measurements, except for a slope of 1.025 (95% CI, 1.006-1.046) for the log-transformed AGES-Kidney measurements. The multiple-sample iohexol clearance measurements in AGES-Kidney and BIS were compared with single-sample GFRs derived from the same iohexol measurements. Mean bias for multiple-sample relative to single-sample GFRs in AGES-Kidney and BIS were −0.25 and −0.15 ml/min and 99% and 97% of

Complete author and article information provided before references.

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doi: 10.1053/j.ajkd.2019.10.008

ARTICLE IN PRESS
KI REPORTS KIReports.org CLINICAL RESEARCH

Comparison of Plasma Clearance With Early-Compartment Correction Equations and Urinary Clearance in High GFR Ranges

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KI REPORTS KIReports.org RESEARCH LETTERS

Comparison of Early-Compartment Correction Equations for GFR Measurements

Check for updates

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AJKD

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RESEARCH LETTER

Concordance ... Iohexol Plasma Clearance

To the Editor:

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Pottel et al. BMC Nephrology (2021) 22:166
https://doi.org/10.1186/s12882-021-02376-0

BMC Nephrology

RESEARCH Open Access

Iohexol plasma clearance for measuring glomerular filtration rate: effect of different ways to calculate the area under the curve

Check for updates

Hans Pottel[1*], Elke Schaeffner[2], Natalie Ebert[2], Markus van der Giet[3] and Pierre Delanaye[4,5]

KI REPORTS KIReports.org RESEARCH LETTER

Iohexol Plasma Clearance: Impact of Weighing the Syringe

Check for updates

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Kidney Int Rep (2021) **6**, 2478–2480; https://doi.org/10.1016/j.ekir.2021.05.038

Conclusions

- Limitations de la créatinine
- Plusieurs formules
- Avantages de la formule EKFC
- Cystatine C
- Mesure du DFG est possible (iohexol)

Merci de votre attention

Merci de votre attention

Merci Pr Nseka

Questions?