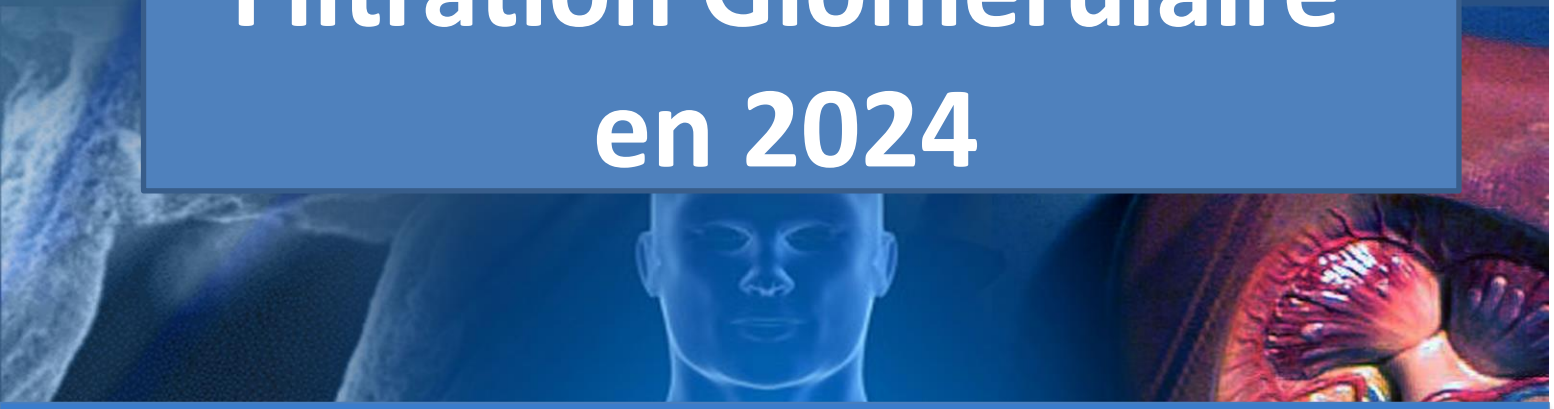
Estimation du Débit de Filtration Glomérulaire en 2024

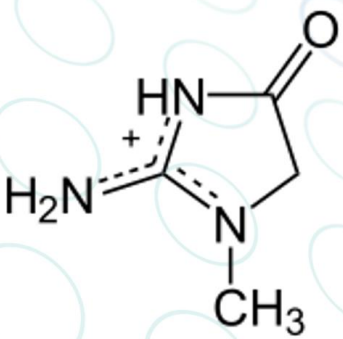


Pierre Delanaye, MD, PhD
Université de Liège
CHU Sart Tilman
BELGIQUE

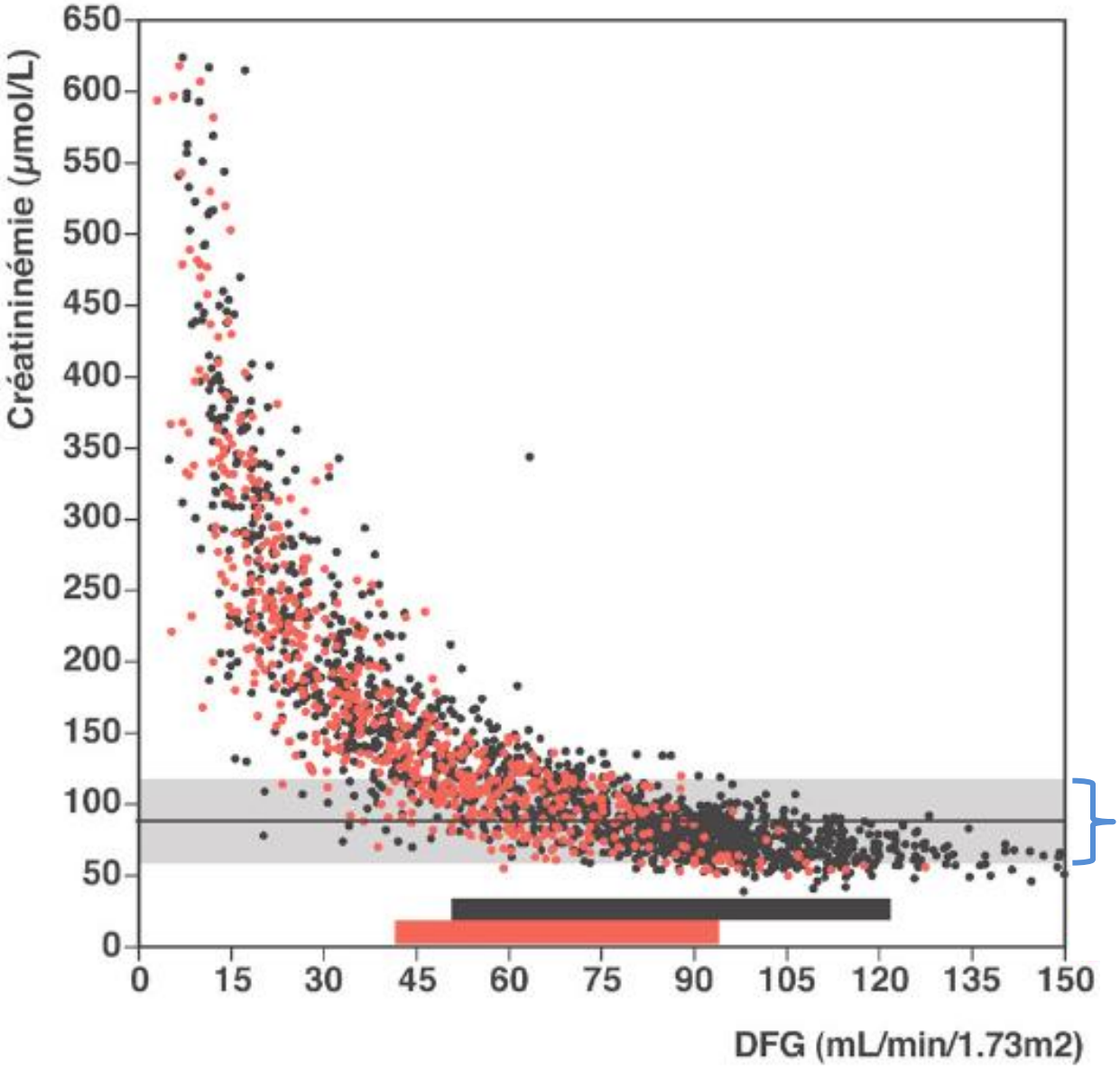
Category	Disclosure Information
Employer	Nothing to disclose.
Ownership Interest	Nothing to disclose.
Consultancy	IDS; Nephrolyx; Alentis Therapeutics; ARK Bioscience; Astellas
Research Funding	Nothing to disclose.
Honoraria	IDS; Fresenius Kabi; Fresenius Medical Care; Nephrolyx; Alentis Therapeutics; ARK Bioscience; AstraZeneca; Bayer
Patents or Royalties	Nothing to disclose.
Advisory or Leadership Role	Nothing to disclose.
Speakers Bureau	Nothing to disclose.
Other Interests or Relationships	Nothing to disclose.
Disclosure Updated Date	07/18/2023

Le DFG est le paramètre le plus utilisé pour estimer la fonction globale du rein

- Le DFG est estimé avec des biomarqueurs
- La créatinine est une des analyses les plus prescrites
- Le plus important est probablement d'en connaitre les limites…



Créatinine: « limitations mathématiques »



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

Créatinine: « limitations mathématiques »

- Relation hyperbolique entre créatinine et DFG!!!

  Pour un patient donné,

  si la créatinine augmente de 0.6 à 1.2 mg/dl
  => diminution du DFG de 50%

  si la créatinine augmente de 2.0 à 3.0 mg/dl
  => diminution du DFG de 25%

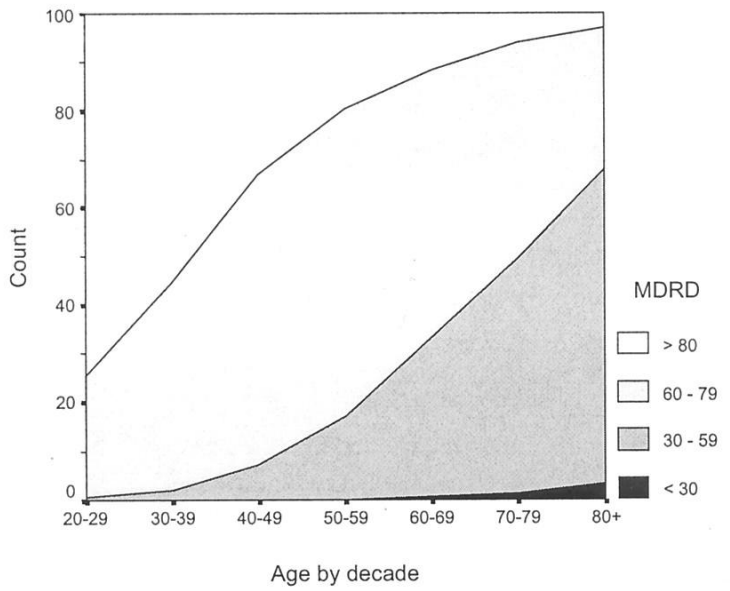
Mesure de la créatinine sérique
Limitations analytiques

- Méthodes de Jaffe (pseudochromogènes)
- Méthodes enzymatiques
- Différentes méthodes mais aussi différents « assays »
- Interférences (bilirubine)

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

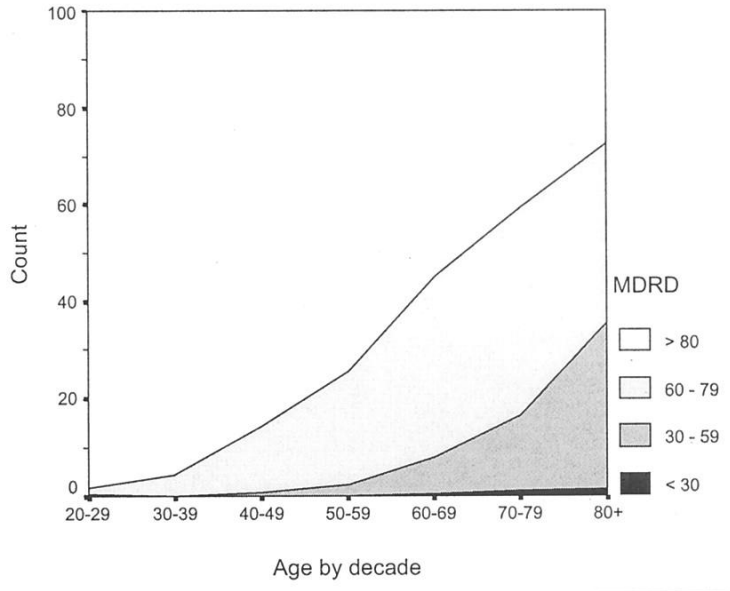
Mesure de la créatinine sérique
Limitations analytiques

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]

[a] *Biochimie Métabolique, Groupe Hospitalier Pitié-Salpêtrière, APHP, Paris, France*
[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*

STANDARDISER

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

Table 1. Summary of Targeted Cancer Therapies Known to Cause an Asymptomatic Rise in Serum Creatinine Levels Through Inhibition of Active Tubular Secretion.

Classes of targeted cancer therapies	Examples	Target cancers
CDK 4/6 inhibitors	Palbociclib, ribociclib, abemaciclib	Metastatic HR-positive and HER2-negative breast cancer
PARP inhibitors	Olaparib, niraparib, rucaparib	Ovarian cancer (BRCA1/2 +), metastatic breast cancer (BRCA1/2 +), endometrial cancer
Tyrosine kinase inhibitors		
1. ALK inhibitors	1. Crizotinib, alectinib, ceritinib	1. NSCLC
2. BCR-ABL inhibitors	2. Imatinib	2. CML, ALL, and GIST.
3. EGFR inhibitors	3. Gefitinib	3. Metastatic NSCLC
4. VEGFR inhibitors	4. Pazopanib, sunitinib, sorafenib	4. RCC, soft tissue sarcomas, GIST, HCC, and thyroid cancer
5. HER2 inhibitors	5. Tucatinib	5. Advanced or metastatic HER2-positive breast cancer
MET inhibitors	Capmatinib	NSCLC

Note. CDK = cyclin-dependent kinase; HR = hormone receptor; HER2 = human epidermal growth factor receptor 2; PARP = poly(adenosine diphosphate-ribose) polymerase; ALK = anaplastic lymphoma kinase; BCR-ABL = fusion of breakpoint cluster region and Abelson; EGFR = epidermal growth factor receptor; VEGFR = vascular endothelial growth factor receptor; NSCLC = non–small cell lung cancer; CML = chronic myelogenous leukemia; ALL = acute lymphocytic leukemia; GIST = gastrointestinal stromal tumor; RCC = renal cell carcinoma; HCC = hepatocellular carcinoma; MET = mesenchymal-epithelial transition.

Perrone RD, Clin Chem, 1992, 38, 1933
Delanaye P, Ann Biol Clin (Paris), 2010, 68, 531
Delanaye P, Nephron Clin Pract, 2011, 119, c187
Mach T, Can J Kidney Health, 2022, 9, ecollection

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

Clairance de créatinine

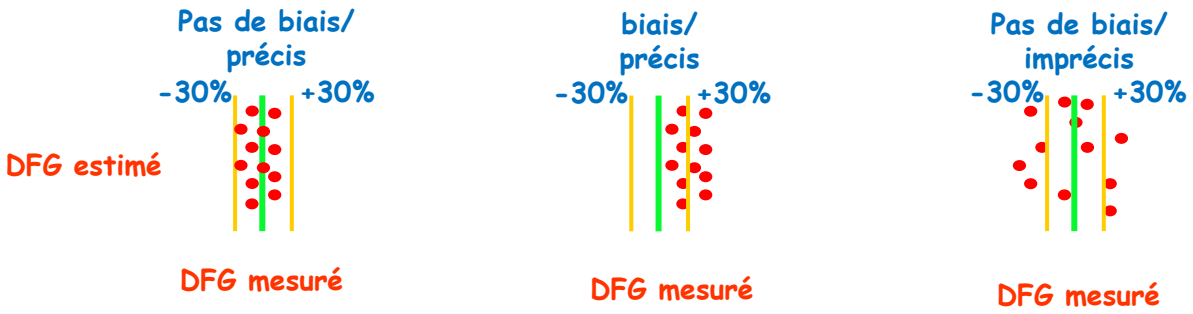
- Etude de Cockcroft
- Echantillon analysé n=236
- Echantillon de départ de 534: 2 clairances disponibles obtenues dans les services cliniques
- Exclusion de 56% (!) des sujets parce que :

1. Variabilité de la créatinine sérique > 20%: n=29
2. Excrétion de créatinine/24 h < 10 mg/j: n=31
3. « Inadequate data »(?): n=65
4. Variabilité de excrétion urinaire de créatinine > 20%: n=173 (32%)

Cockcroft DW, Nephron, 1976, 16, p31

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

Quelles équations?

- Cockcroft
- CKD-EPI
- Lund-Malmö
- EKFC

Nephron *16*: 31–41 (1976)

Prediction of Creatinine Clearance from Serum Creatinine[1]

DONALD W. COCKCROFT and M. HENRY GAULT

Departments of Medicine, Queen Mary Veterans' Hospital, Montreal, Quebec, and Memorial University, St. John's, Newfoundland

Received: 24 June 2021 | Revised: 4 October 2021 | Accepted: 19 October 2021

DOI: 10.1111/bcp.15132

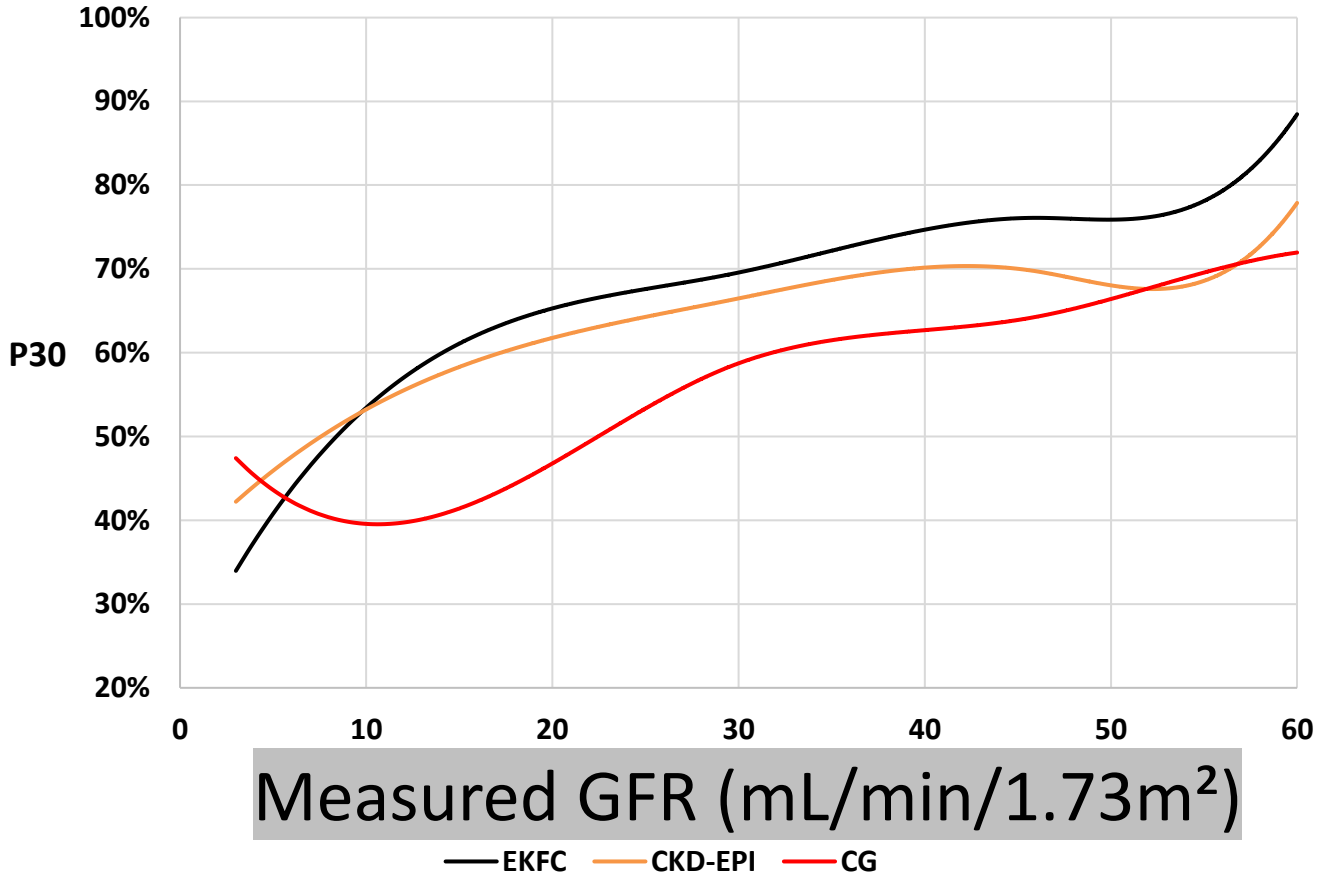
ORIGINAL ARTICLE

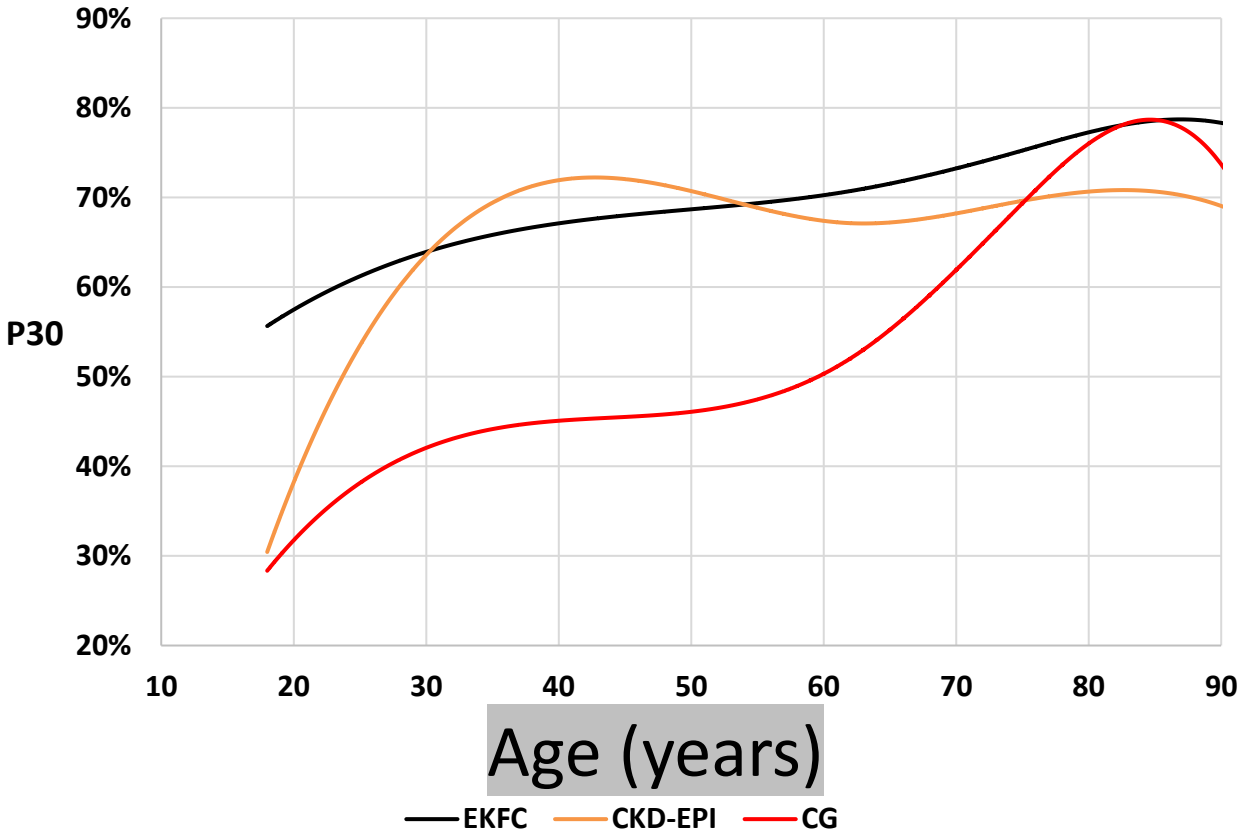
Performance of creatinine-based equations to estimate glomerular filtration rate with a methodology adapted to the context of drug dosage adjustment

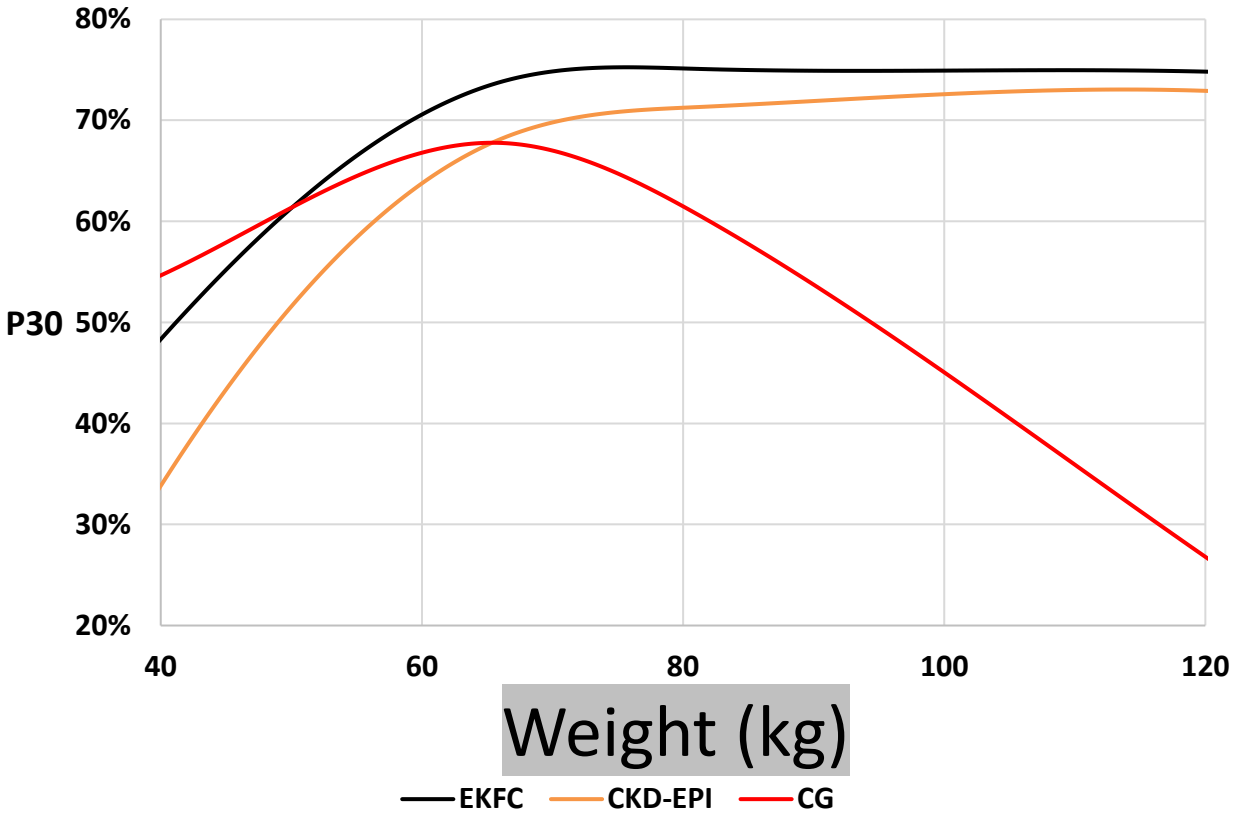
Pierre Delanaye[1,2] | Jonas Björk[3,4] | Marie Courbebaisse[5] | Lionel Couzi[6] | Natalie Ebert[7] | Björn O. Eriksen[8] | R. Neil Dalton[9] | Laurence Dubourg[10] | Francois Gaillard[11] | Cyril Garrouste[12] | Anders Grubb[13] | Lola Jacquemont[14] | Magnus Hansson[15] | Nassim Kamar[16] | Edmund 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. 2022;88:2118–2127.

- N=14,804 adults
- Cockcroft, CKD-EPI et EKFC
- De-indexed
- Focus on GFR< 60 mL/min (n=4328)


100%
90%
80%
70%
60%
50%
40%
30%
20%
P30
0
10
20
30
40
50
60
Measured GFR (mL/min/1.73m²)
EKFC
CKD-EPI
CG


90%
80%
70%
60%
50%
40%
30%
20%
P30
10
20
30
40
50
60
70
80
90
Age (years)
EKFC
CKD-EPI
CG


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

Quelles équations?

- ~~Cockcroft~~
- CKD-EPI
- EKFC

L'équation 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)*

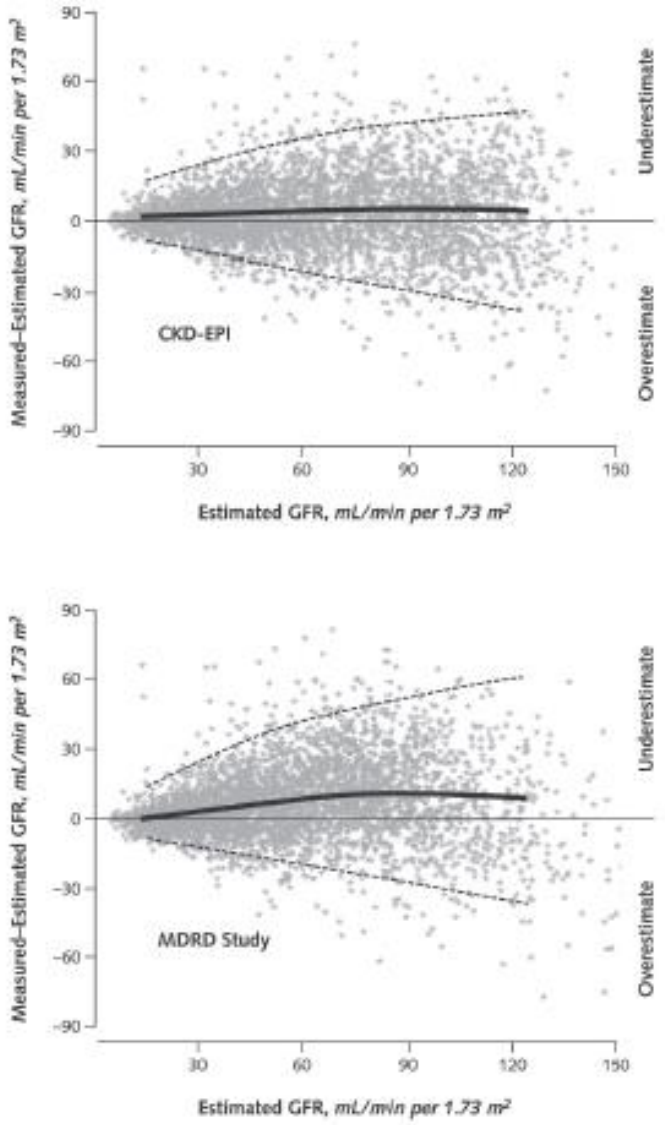
Ann Intern Med. 2009;150:604-612.

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 m²

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



Levey AS, Ann Intern Med, 2009, p604

KDIGO 2012 Clinical Practice Guideline for the Evaluation and Management of Chronic Kidney Disease

VOLUME 3 | ISSUE 1 | JANUARY 2013

http://www.kidney-international.org

Révisé in 2024

CKD-EPI: What else?

Ulf Nyman*, Anders Grubb, Anders Larsson, Lars-Olof Hansson, Mats Flodin, Gunnar Nordin, Veronica Lindström and Jonas Björk

The revised Lund-Malmö GFR estimating equation outperforms MDRD and CKD-EPI across GFR, age and BMI intervals in a large Swedish population

Clin Chem Lab Med 2014, 52(6), 815-824

Revised Lund-Malmö Study equation (LM Revised) [34]

$_{e}X-0.0158\times Age+0.438\times \ln(Age)$

Female	pCr<150 µmol/L:	$X=2.50+0.0121\times(150-pCr)$
Female	pCr≥150 µmol/L:	$X=2.50-0.926\times\ln(pCr/150)$
Male	pCr<180 µmol/L:	$X=2.56+0.00968\times(180-pCr)$
Male	pCr≥180 µmol/L:	$X=2.56-0.926\times\ln(pCr/180)$

- Lund-Malmö
- n=3495 (chez 2847 sujets), iohexol, créatinine calibrée
- DFG moyen = 60 mL/min/1,73 m²

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.

Figure 1. The new EKFC equation.

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	≥1	$107.3 \times (SCr/Q)^{-1.132} \times 0.990^{(Age - 40)}$

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>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:

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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.

DE GRUYTER Clin Chem Lab Med 2022; 60(3): 401–407

Pierre Delanaye*, François Gaillard, Jessica van der Weijden, Geir Mjøen, Ingela Ferhman-Ekholm, Laurence Dubourg, Natalie Ebert, Elke Schaeffner, Torbjörn Åkerfeldt, Karolien Goffin, Lionel Couzi, Cyril Garrouste, Lionel Rostaing, Marie Courbebaisse, Christophe Legendre, Maryvonne Hourmant, Nassim Kamar, Etienne Cavalier, Laurent Weekers, Antoine Bouquegneau, Martin H. de Borst, Christophe Mariat, Hans Pottel and Marco van Londen

Age-adapted percentiles of measured glomerular filtration in healthy individuals: extrapolation to living kidney donors over 65 years

Avant 40 ans: DFG mesuré = 107 mL/min/1.73m²
…et cela semble assez universel

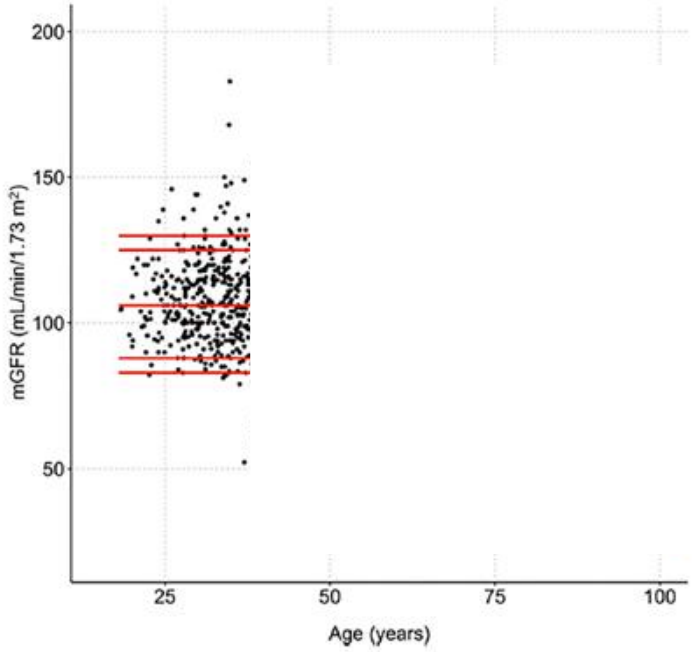


Figure 3: mGFR according to age in the development (dark dots) and external validation cohort (n=329) (gray dots). Red lines are percentiles 5, 10, 50, 90 and 95, calculated from kidney donors younger than 65 years and extrapolated for ages >65 years.

Pierre Delanaye*, François Gaillard, Jessica van der Weijden, Geir Mjøen, Ingela Ferhman-Ekholm, Laurence Dubourg, Natalie Ebert, Elke Schaeffner, Torbjörn Åkerfeldt, Karolien Goffin, Lionel Couzi, Cyril Garrouste, Lionel Rostaing, Marie Courbebaisse, Christophe Legendre, Maryvonne Hourmant, Nassim Kamar, Etienne Cavalier, Laurent Weekers, Antoine Bouquegneau, Martin H. de Borst, Christophe Mariat, Hans Pottel and Marco van Londen

Age-adapted percentiles of measured glomerular filtration in healthy individuals: extrapolation to living kidney donors over 65 years

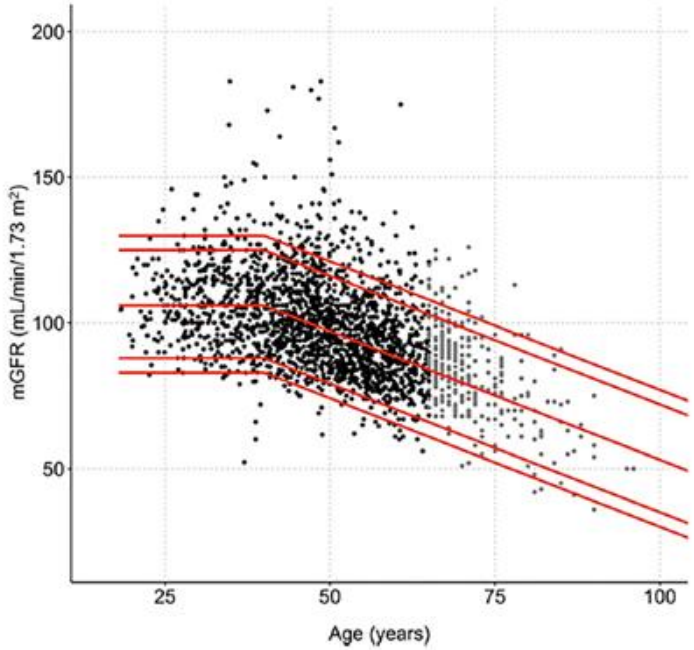
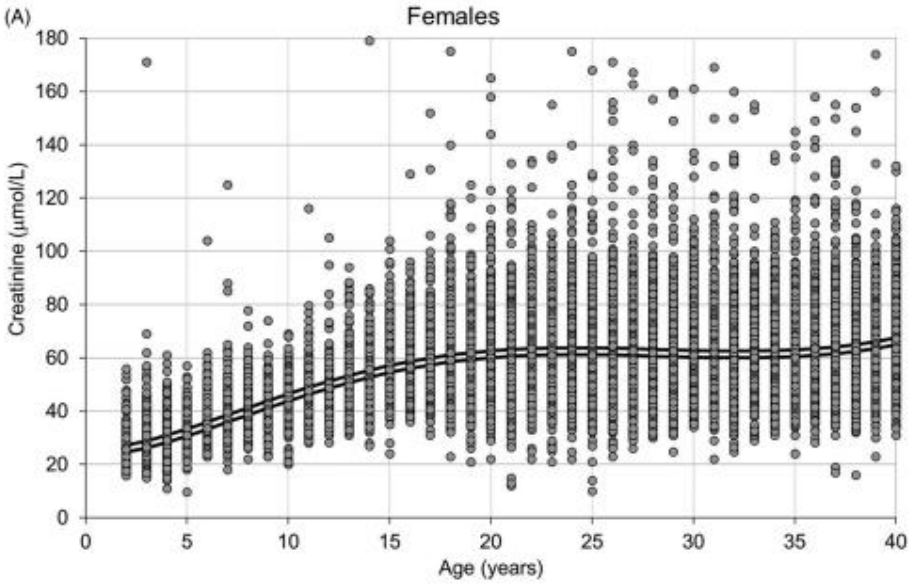
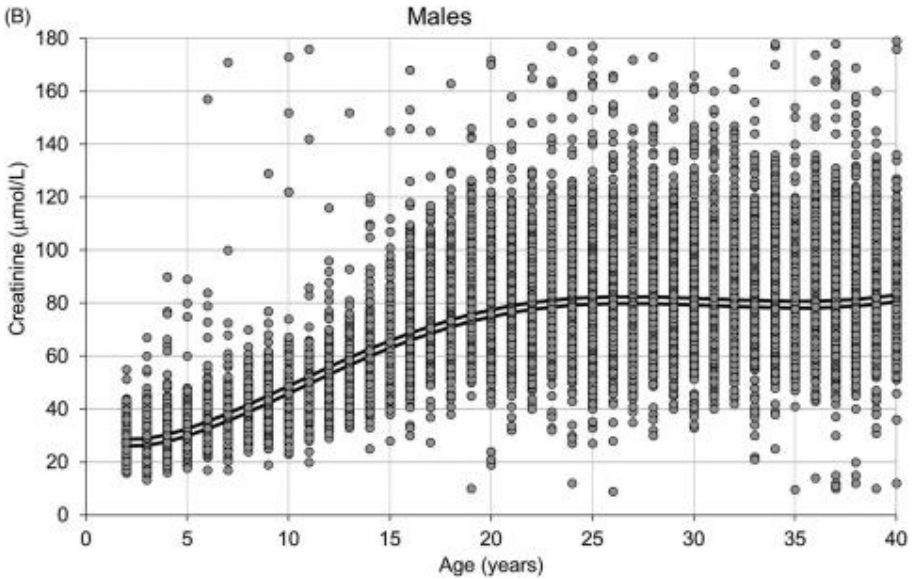


Figure 3: mGFR according to age in the development (dark dots) and external validation cohort (n=329) (gray dots). Red lines are percentiles 5, 10, 50, 90 and 95, calculated from kidney donors younger than 65 years and extrapolated for ages >65 years.



N=83,257 de 3 laboratoires (Suède, Belgique)

62 µmol/L= 0,70 mg/dL



80 µmol/L= 0,90 mg/dL

Björk J, Scand J Clin Lab Invest, 2020, 80, p456

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.

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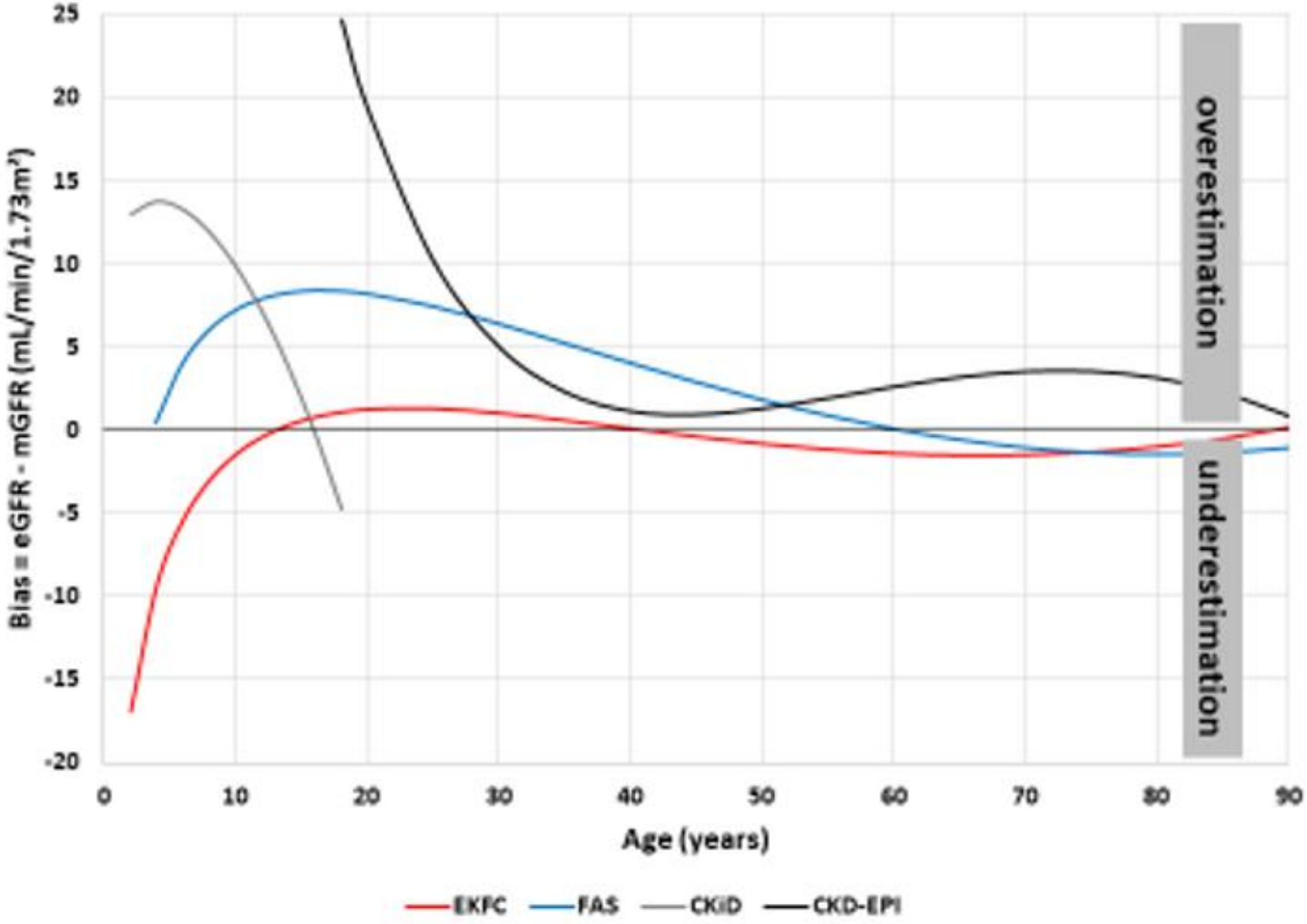
Q values (in µmol/L or mg/dL) correspond to the median SCr values for the age- and sex-specific populations. EKFC = European Kidney Function Consortium; SCr = serum creatinine.


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

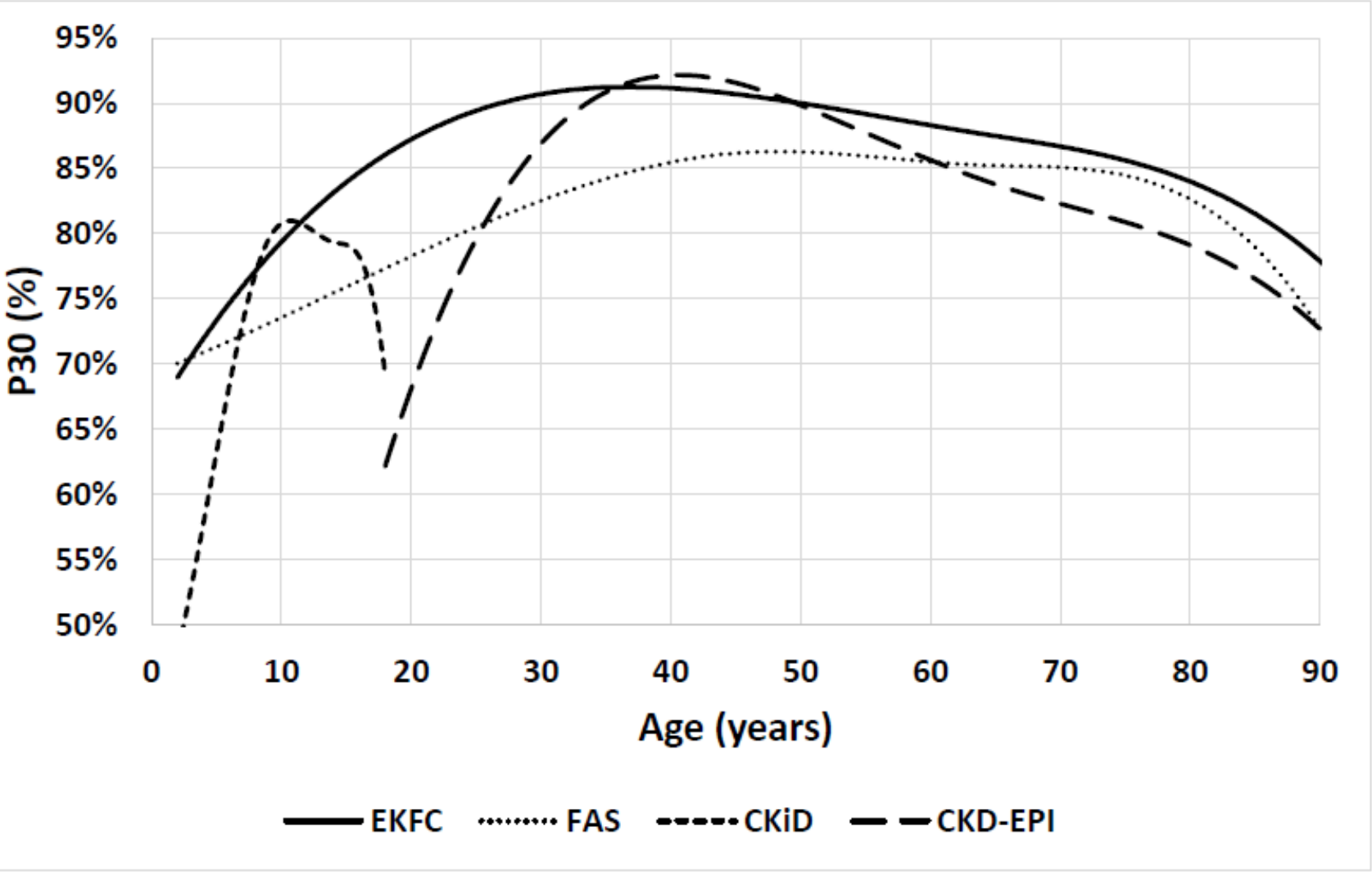


Figure S8. P30-accuracy against age for the EKFC, FAS, CKiD and CKD-EPI equation in the external validation dataset. P30 (%) was graphically presented across the age spectrum using cubic splines with two free knots and using 3rd degree polynomials.

clinical investigation www.kidney-international.org

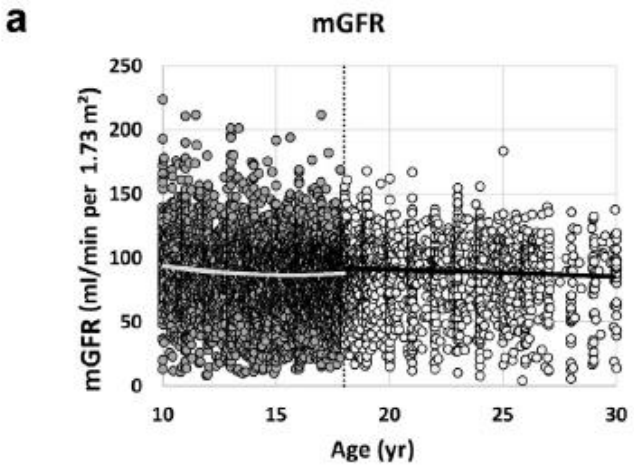
Estimating glomerular filtration rate at the transition from pediatric to adult care

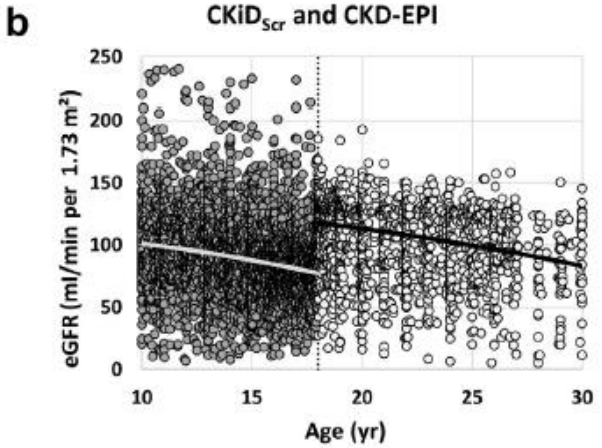
Hans Pottel[1,13], Jonas Björk[2,3,13], Arend Bökenkamp[4,13], Ulla Berg[5], Kajsa Åsling-Monemi[5], Luciano Selistre[6], Laurence Dubourg[7,13], Magnus Hansson[8], Karin Littmann[8], Ian Jones[9], Per Sjöström[9], Ulf Nyman[10,12,13] and Pierre Delanaye[11,12,13]

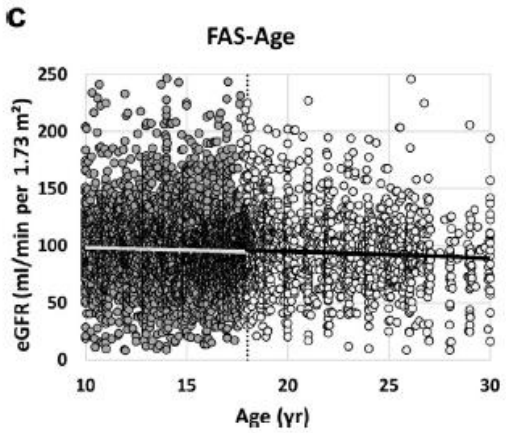
[1]Department of Public Health and Primary Care, Katholieke Universiteit Leuven Campus Kulak Kortrijk, Kortrijk, Belgium; [2]Division of Occupational and Environmental Medicine, Lund University, Lund, Sweden; [3]Clinical Studies Sweden, Forum South, Skåne University Hospital, Lund, Sweden; [4]Emma Children's Hospital, Amsterdam University Medical Center, Vrije Universiteit Amsterdam, Amsterdam, the Netherlands; [5]Department of Clinical Science, Intervention, and Technology, Division of Pediatrics, Karolinska Institutet, Karolinska University Hospital Huddinge, Stockholm, Sweden; [6]Mestrado em Ciências da Saúde—Universidade Caxias do Sul Foundation, Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, Brazil; [7]Exploration Fonctionnelle Rénale, Groupement Hospitalier Edouard Herriot, Hospices Civils de Lyon, Lyon, France; [8]Department of Laboratory Medicine, Division of Clinical Chemistry, Karolinska Institutet, Karolinska University Hospital Huddinge, Stockholm, Sweden; [9]Department of Laboratory Medicine, Örebro University Hospital, Örebro, Sweden; [10]Department of Translational Medicine, Division of Medical Radiology, Lund University, Malmö, Sweden; and [11]Nephrology-Dialysis-Transplantation, University of Liège, Centre Hospitalier Universitaire du Sart Tilman, Liège, Belgium

Kidney International (2019) **95,** 1234–1243;

- 5764 children, adolescents et young adults
- Results in « median»


a
mGFR
mGFR (ml/min per 1.73 m²)
250
200
150
100
50
0
10
15
20
25
30
Age (yr)


b
CKiD$_{Scr}$ and CKD-EPI
eGFR (ml/min per 1.73 m²)
250
200
150
100
50
0
10
15
20
25
30
Age (yr)


c
FAS-Age
eGFR (ml/min per 1.73 m²)
250
200
150
100
50
0
10
15
20
25
30
Age (yr)

Avantages de EKFC

- Meilleures performances (pas plus cher)
- Plus « physiologique »: correction au niveau de la créatinine (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)

Débat sur la « race » aux USA

Remarque sémantique

La créatinine sérique est différente entre Noir et Blancs aux USA (on ne sait pas pourquoi!)

Le DFGm (normal) n'est pas différent

La correction pour le facteur racial dans CKD-EPI$_{2009}$ a été considéré comme discriminant

Eneanya N, Nat Rev Nephrol, 2022, 18, p84
Hsu CY, N Engl J med, 2021, p

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)

NKF and ASN Release New Way to Diagnose Kidney Diseases

Both Organizations Recommend Race-Free Approach to Estimate GFR

Sept. 23, 2021, New York, NY - Today, the National Kidney Foundation (NKF) and the American Society of Nephrology (ASN) Task Force on Reassessing the Inclusion of Race in Diagnosing Kidney Diseases has released its final report, which outlines a new race-free approach to diagnose kidney disease. In the report, the NKF-ASN Task Force recommends the adoption of the new **eGFR 2021 CKD EPI creatinine equation that estimates kidney function without a race variable. The task force also recommended increased use of cystatin C combined with serum (blood) creatinine, as a confirmatory assessment of GFR or kidney function.**

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

Hindawi
International Journal of Nephrology
Volume 2020, Article ID 2141030, 9 pages
https://doi.org/10.1155/2020/2141030

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]

[1]*Postgraduation Program in Medical Sciences, Fluminense Federal University (UFF), Niterói, Rio de Janeiro, Brazil*
[2]*Postgraduation Program in Cardiovascular Sciences, Fluminense Federal University (UFF), Niterói, Rio de Janeiro, Brazil*
[3]*Nephrology Division, Department of Medicine, Fluminense Federal University (UFF), Niterói, Rio de Janeiro, Brazil*
[4]*Nuclear Medicine Division, EBESERH/Hospital Antonio Pedro, Fluminense Federal University (UFF), Niterói, Rio de Janeiro, Brazil*

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]

1 Renal Unit, Department of Internal medicine, Kinshasa University Hospital, University of Kinshasa, Kinshasa, Democratic Republic of the Congo, 2 Division of Clinical Chemistry, CHU Sart Tilman (ULg CHU), University of Liège, Liège, Belgium, 3 Division of Public Health and Primary Care, KU Leuven Campus Kulak Kortrijk, Kortrijk, Belgium, 4 Division of Nephrology-Dialysis-Transplantation, CHU Sart Tilman (ULg CHU), University of Liège, Liège, Belgium

* justinebuk@yahoo.fr

Check for updates

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

Americentrism in estimation of glomerular filtration rate equations

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

KEYWORDS: glomerular filtration rate; race; serum creatinine

Pierre Delanaye[1,2], Hans Pottel[3] and Richard J. Glassock[4]

[1]*Department of Nephrology-Dialysis-Transplantation, University of Liège, Centre Hospitalier Universitaire Sart Tilman, Liège, Belgium;* [2]*Department of Nephrology-Dialysis-Apheresis, Hôpital Universitaire Carémeau, Nîmes, France;* [3]*Department of Public Health and Primary Care, Katholieke Universiteit Leuven Campus Kulak Kortrijk, Kortrijk, Belgium; and* [4]*Department of Medicine, Geffen School of Medicine, University of California, Los Angeles, California, USA*

Correspondence: *Pierre Delanaye, Service de Dialyse, Centre Hospitalier Universitaire Sart Tilman, 4000 Liège, Belgium. E-mail: pierre_delanaye@yahoo.fr*

Nephrology Dialysis Transplantation (2023) 38: 106–118
https://doi.org/10.1093/ndt/gfac241
Advance Access publication date 24 August 2022

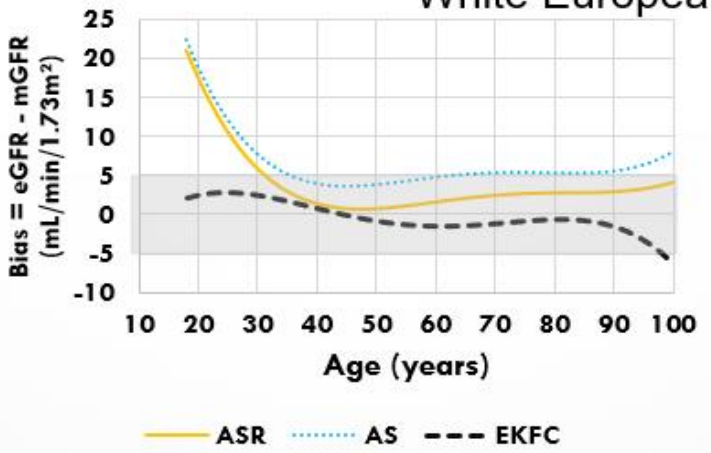
Performance of creatinine-based equations to estimate glomerular filtration rate in White and Black populations in Europe, Brazil and Africa

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], Karin Littmann[11], Christophe Mariat[12], Toralf Melsom[7], Elke Schaeffner[6], Per-Ola Sundin[13], Arend Bökenkamp[14], Ulla B. Berg[15], Kajsa Åsling-Monemi[15], Anna Åkesson[4,5], Anders Larsson[16], Etienne Cavalier[17], R. Neil Dalton[18], Marie Courbebaisse[19], Lionel Couzi[20], Francois Gaillard[21], Cyril Garrouste[22], Lola Jacquemont[23], Nassim Kamar[24], Christophe Legendre[25], Lionel Rostaing[26], Thomas Stehlé[27,28], Jean-Philippe Haymann[29], Luciano da Silva Selistre[30], Jorge P. Strogoff-de-Matos[31], Justine B. Bukabau[32], Ernest K. Sumaili[32], Eric Yayo[33], Dagui Monnet[33], Ulf Nyman[34], Hans Pottel[35,†] and Martin Flamant[36,†]

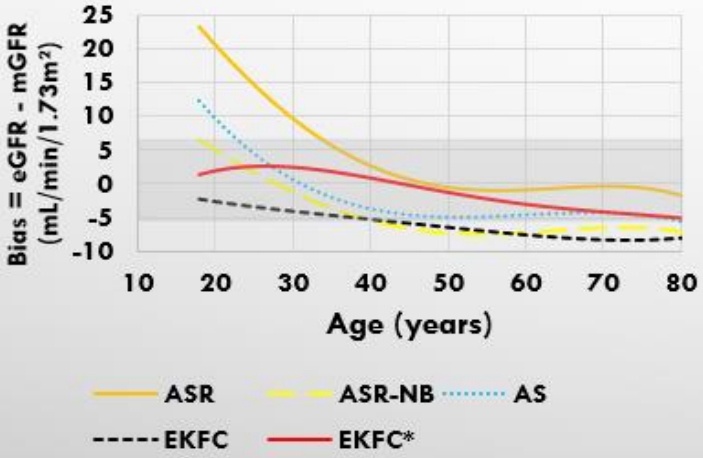
Méthodes

- Sujets de plus de 18 ans, DFG mesuré, créatinine sérique “IDMS traceable”
- EKFC consortium: 11 cohortes d’Europe (n=17,321)
- Données de Paris (n=4,429, parmi lesquels 964 européens noirs)
- Données d’Afrique (RDC et Côte d’Ivoire, n=508)

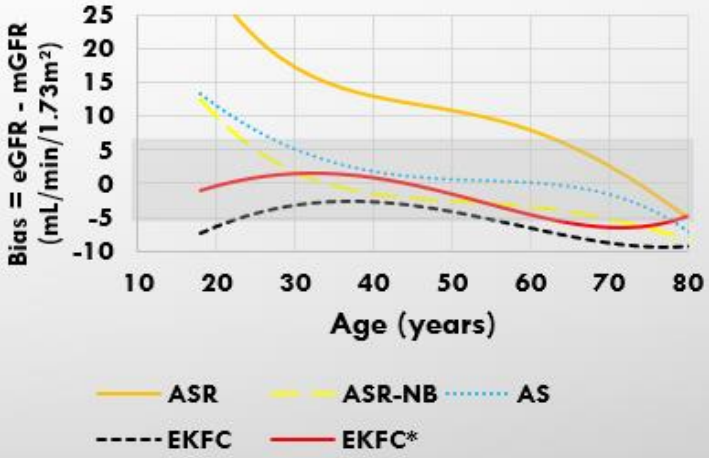
White Europeans (n=17,321)



Black Europeans (n=964)



Black Africans (n=508)



EFLM Paper

Pierre Delanaye, Elke Schaeffner, Mario Cozzolino, Michel Langlois, Mario Plebani, Tomris Ozben and Etienne Cavalier*, on behalf of the Board members of the EFLM Task Group Chronic Kidney Diseases

The new, race-free, Chronic Kidney Disease Epidemiology Consortium (CKD-EPI) equation to estimate glomerular filtration rate: is it applicable in Europe? A position statement by the European Federation of Clinical Chemistry and Laboratory Medicine (EFLM)

Nephrol Dial Transplant (2023) 38: 1–6
https://doi.org/10.1093/ndt/gfac254
Advance Access publication date 7 September 2022

What should European nephrology do with the new CKD-EPI equation?

Ron T. Gansevoort[1], Hans-Joachim Anders[2], Mario Cozzolino[3], Danilo Fliser[4], Denis Fouque[5], Alberto Ortiz[6,7], Maria José Soler[8] and Christoph Wanner[9]

[1]Department of Nephrology, University Medical Center Groningen, University of Groningen, Groningen, The Netherlands, [2]Renal Division, Hospital of the Ludwig Maximilans University, Munich, Germany, [3]Department of Health Sciences, University of Milan, Renal Division, ASST Santi Paolo e Carlo, Milan, Italy, [4]Department of Internal Medicine IV, Renal and Hypertensive Disease, University Medical Center, Homburg, Saar, Germany, [5]Department of Nephrology, Hospices Civils de Lyon, Centre Hospitalier Lyon-Sud, Pierre-Benite, University of Lyon, France, [6]Department of Nephrology, IIS-Fundacion Jimenez Diaz- UAM, Madrid, Spain, [7]Department of Medicine, Universidad Autonoma de Madrid, Madrid, Spain, [8]Department of Nephrology, Hospital Vall d'Hebron, Barcelona, Vall d'Hebron Research Institute (VHIR), Barcelona, Spain and [9]Department of Internal Medicine I and Comprehensive Heart Failure Center, University Hospital Würzburg, Würzburg, Germany

Correspondence to: Ron T. Gansevoort; E-mail: r.t.gansevoort@umcg.nl

Le principal avantage de EKFC est sa flexibilité

Performance of the European Kidney Function Consortium (EKFC) creatinine-based equation in United States cohorts

see commentary on page 445

Pierre Delanaye[1,2,16], Andrew D. Rule[3,16], Elke Schaeffner[4,16], Etienne Cavalier[5,16], Junyan Shi[6,7], Andrew N. Hoofnagle[7,8,9,10], Ulf Nyman[11,16], Jonas Björk[12,13,15,16] and Hans Pottel[14,15,16]

[1]Department of Nephrology-Dialysis-Transplantation, University of Liège, CHU Sart Tilman, Liège, Belgium; [2]Department of Nephrology-Dialysis-Apheresis, Hôpital Universitaire Carémeau, Nîmes, France; [3]Division of Nephrology and Hypertension, Mayo Clinic, Rochester, Minnesota, USA; [4]Institute of Public Health, Charité – Universitätsmedizin Berlin, Berlin, Germany; [5]Department of Clinical Chemistry, University of Liège, CHU Sart Tilman, Liège, Belgium; [6]Department of Pathology and Laboratory Medicine, University of British Columbia, Vancouver, British Columbia, Canada; [7]Department of Laboratory Medicine and Pathology, University of Washington, Seattle, Washington, USA; [8]Kidney Research Institute, Department of Medicine, University of Washington, Seattle, Washington, USA; [9]Division of Metabolism, Endocrinology, and Nutrition, University of Washington, Seattle, Washington, USA; [10]Department of Medicine, University of Washington, Seattle, Washington, USA; [11]Department of Translational Medicine, Division of Medical Radiology, Lund University, Malmö, Sweden; [12]Division of Occupational and Environmental Medicine, Lund University, Lund, Sweden; [13]Clinical Studies Sweden, Forum South, Skåne University Hospital, Lund, Sweden; and [14]Department of Public Health and Primary Care, KU Leuven Campus Kulak Kortrijk, Kortrijk, Belgium

Kidney International (2024) **105,** 629–637;

Validation de EKFC aux USA

Cohorts	Sample Size	Age (years)	Measured GFR (mL/min/1.73m²)	% of women	% of Black subjects	Proportion of individuals with urinary clearance data available
All	*12,854*	*56.0 [22.1]*	*57 [46]*	*44.3*	*21.7*	*93.2*
AASK	1,844	54.5 [16.0]	57 [35]	35.9	100	100
ALTOLD	381	43.3 [19.0]	97 [18]	65.1	1.8	0
CRIC	1,194	59.0 [17.7]	48 [28]	44.4	44.7	100
CRISP	217	34.0 [13.0]	93 [34]	59.0	11.1	100
DCCT/EDIC	809	31.0 [9.0]	119 [25]	47.8	1.4	100
GENOA/ECAC	1,093	66.1 [12.1]	80 [27]	56.6	0	100
Mayo Clinic	5,069	59.0 [21.0]	50 [40]	44.6	2.0	100
MDRD	1,756	51.0 [21.0]	36 [29]	39.5	12.4	100
PERL	491	52.0 [15.0]	70 [25]	33.6	10.8	0

Results are expressed in % or Median [interquartile range].
GFR: glomerular filtration rate

Delanaye P, 2024, Kidney Int, p629

Les valeurs de Q sont adaptées aux populations

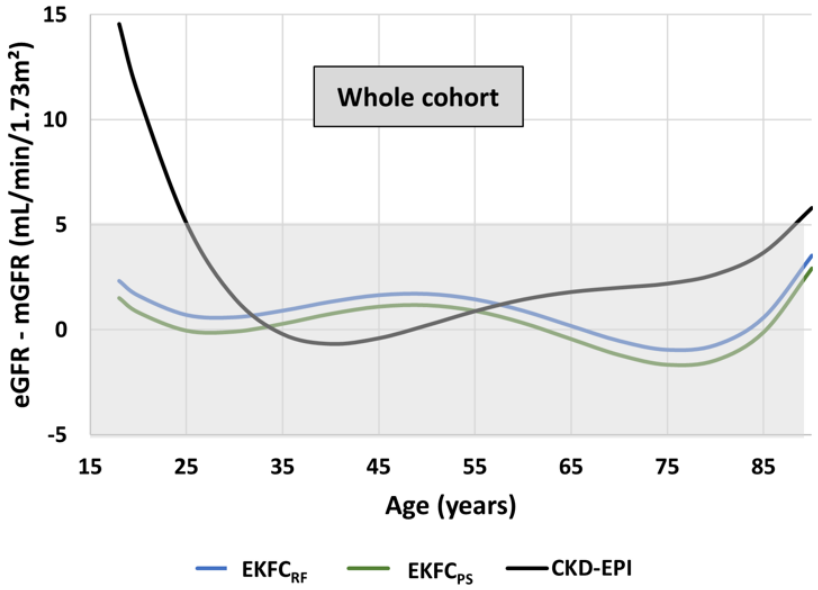
Q-values determined in different populations

	Q value in women	Q value in men	Origine
White European	0.70	0.90	Large data from laboratories in Sweden and Belgium
Black European	0.74	1.02	Living kidney donors in Paris
Black Africans (Central Africa)	0.72	0.96	Healthy people in Congo
White US population-specific	0.73	0.93	Large data from laboratories from University of Washington Medicine System
Black US population-specific	0.73	1.00	Large data from laboratories from University of Washington Medicine System
White US population-specific	0.70	0.94	National Health and Nutrition Examination Survey
Black US population-specific	0.72	1.03	National Health and Nutrition Examination Survey
US race-free	0.73	0.97	Large data from laboratories from University of Washington Medicine System
China	0.62	0.88	27,830 healthy people

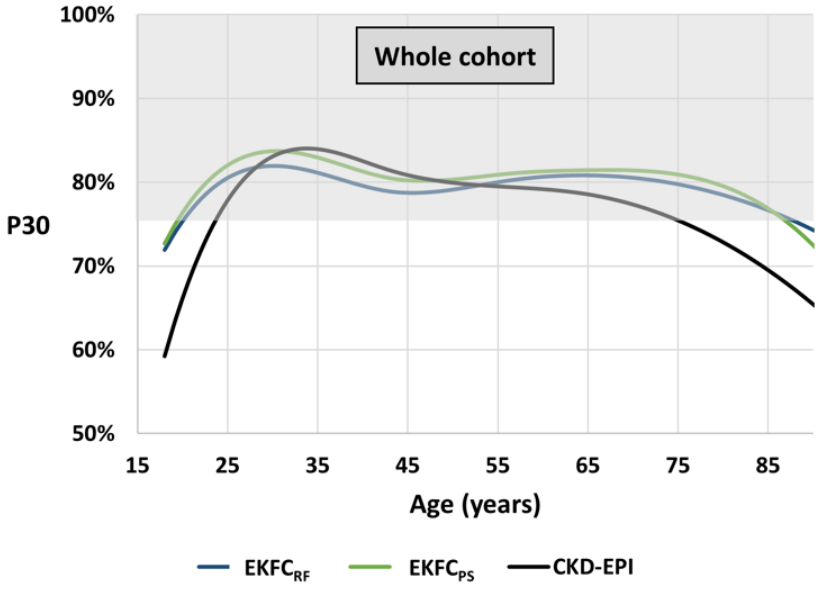
All results are expressed in mg/dL

Shi J, Clin Chim Acta, 2021, 520, p16

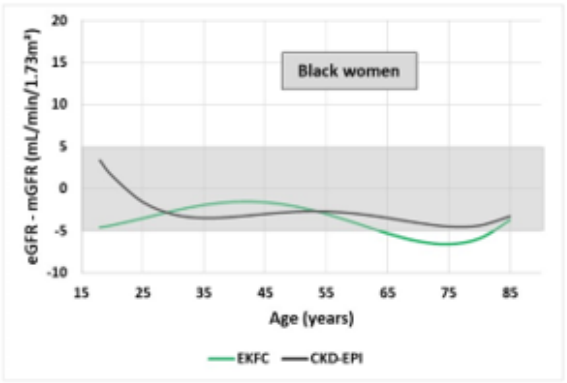
A

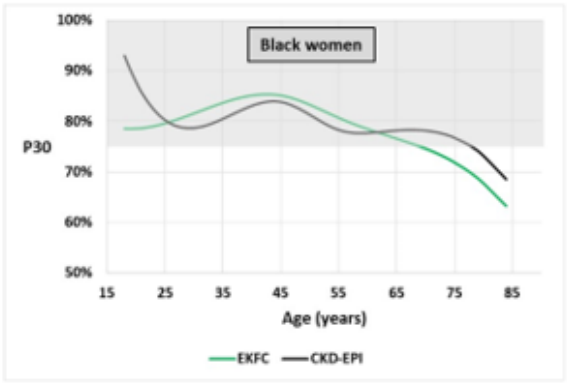

15
10
5
0
-5
eGFR - mGFR (mL/min/1.73m²)
Whole cohort
15
25
35
45
55
65
75
85
Age (years)
EKFC$_{RF}$
EKFC$_{PS}$
CKD-EPI

B


100%
90%
80%
70%
60%
50%
P30
Whole cohort
15
25
35
45
55
65
75
85
Age (years)
EKFC$_{RF}$
EKFC$_{PS}$
CKD-EPI

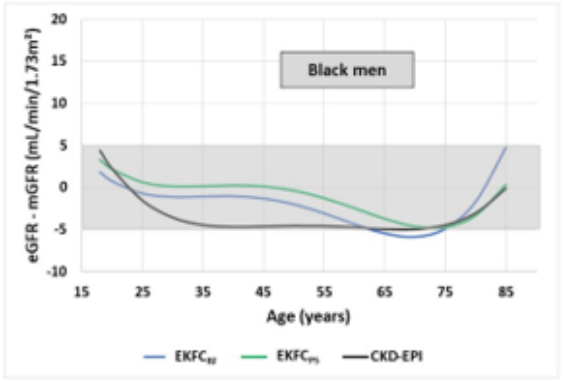
Bias (A) and accuracy within 30% (P30) (B) for the CKD-EPI$_{2021}$ and the EKFC in Black women (n=1,087) according to age.

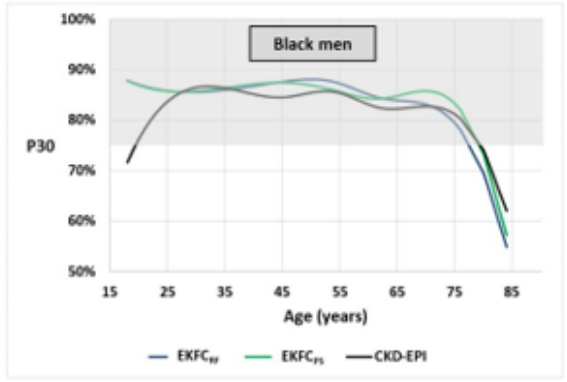




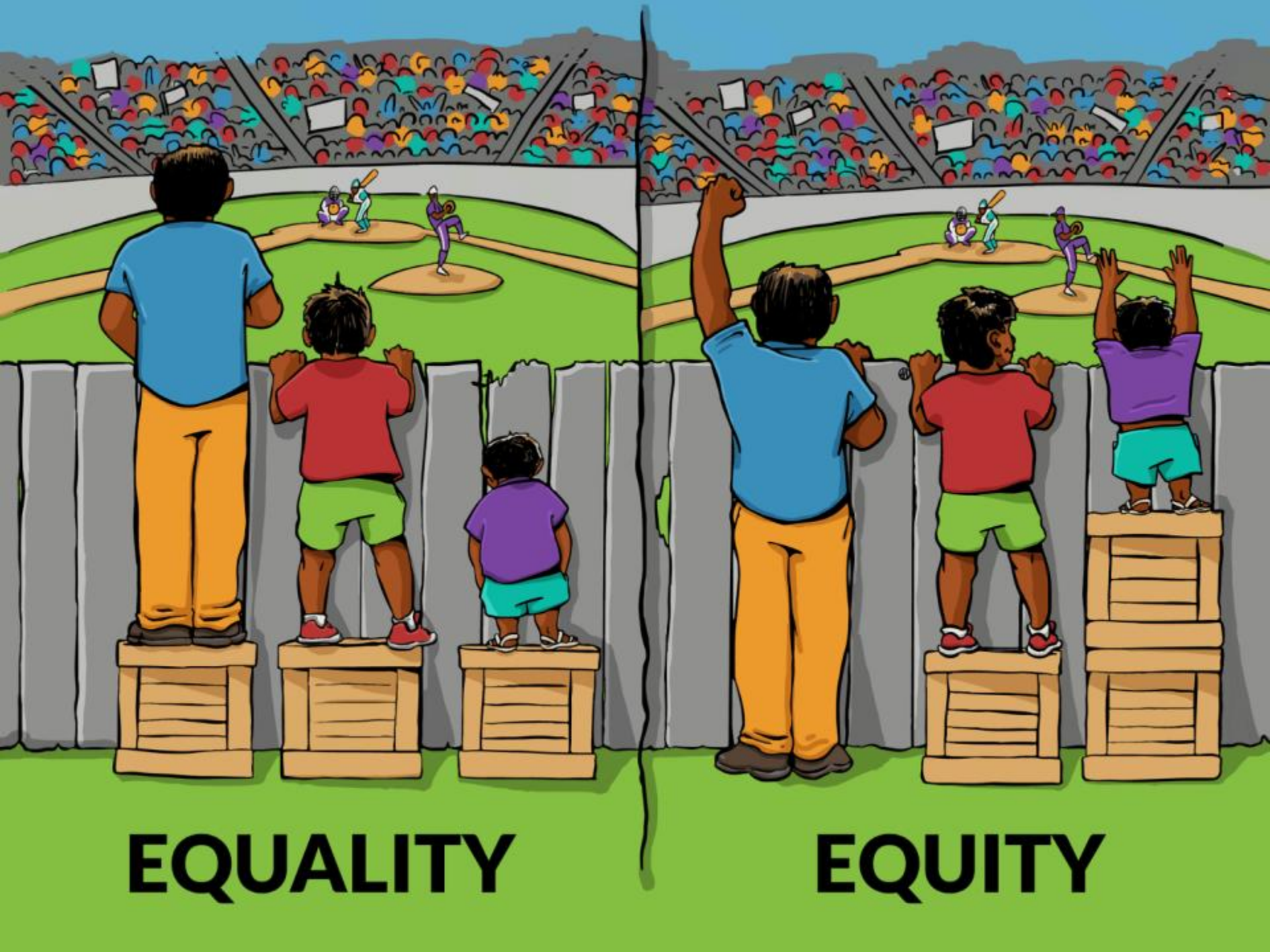
Legend: CKD-EPI$_{2021}$: race-free Chronic Kidney Disease Epidemiology, EKFC$_{RF}$: European Kidney Function Consortium with race-free Q-values. EKFC$_{PS}$: European Kidney Function with population specific Q-values

Bias (A) and accuracy within 30% (P30) (B) for the CKD-EPI$_{2021}$, the EKFC$_{RF}$ and EKFC$_{PS}$ in Black men (n=1,703) according to age.





Legend: CKD-EPI$_{2021}$: race-free Chronic Kidney Disease Epidemiology, EKFC$_{RF}$: European Kidney Function Consortium with race-free Q-values. EKFC$_{PS}$: European Kidney Function with population specific Q-values


EQUALITY
EQUITY

Nephron

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Glomerular Filtration Rate Estimation in Adults: Myths and Promises

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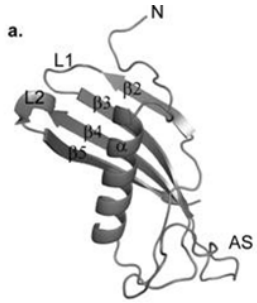
- Le principal avantage de EKFC est sa flexibilité
- Q peut être adapté à chaque population
- Y compris une population “mixée” ou un concept “race-free”
- Q peut être obtenu à partir de grandes cohortes ou de données spécifiques
- Q peut être obtenu dans chaque hôpital (vrai Q “local”)

Cystatine C



- 1982, Anders Grubb, Sweden
- Petit peptide produit par toutes les cellules nuclées (cysteine-protease inhibitor)
- Filtrée librement, non-sécrétée, réabsorbée totalement au niveau tubulaire et catabolisée dans les tubules

- Pas (moins) de variation selon genre et ethnie
- Inflammation, obésité, function thyroidienne

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 m² 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)

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Cystatin C–Based Equation to Estimate GFR without the Inclusion of Race and Sex

H. Pottel, J. Björk, A.D. Rule, N. Ebert, B.O. Eriksen, L. Dubourg, E. Vidal-Petiot, A. Grubb, M. Hansson, E.J. Lamb, K. Littmann, C. Mariat, T. Melsom, E. Schaeffner, P.-O. Sundin, A. Åkesson, A. Larsson, E. Cavalier, J.B. Bukabau, E.K. Sumaili, E. Yayo, D. Monnet, M. Flamant, U. Nyman, and P. Delanaye

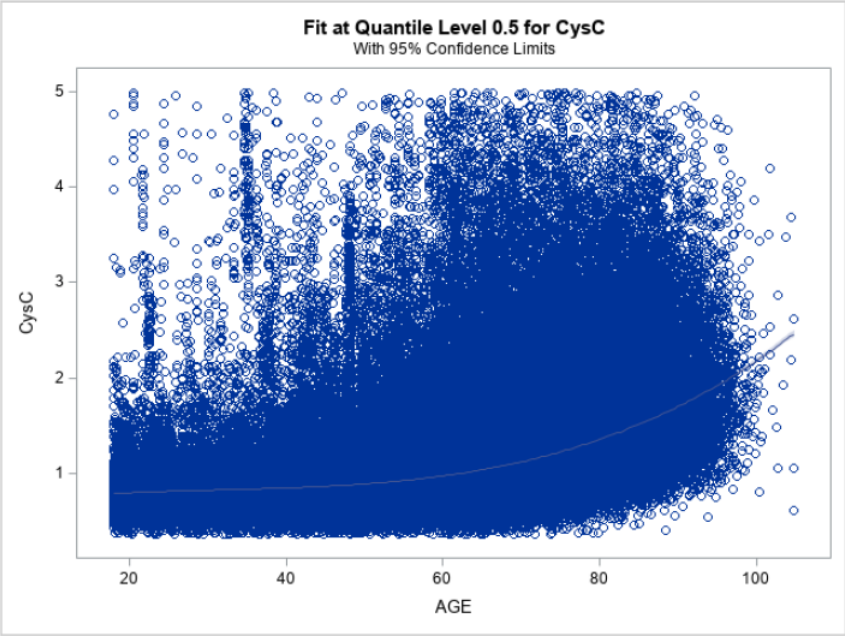
ABSTRACT

N Engl J Med 2023;388:333-43.

1er étape: cystatine C et âge

Données de labo de Suède
N=227,643
♀ 95,469
♂ 132,174

Figure S3. Cystatin C versus age and the median quantile line for the 227,643 included subjects.

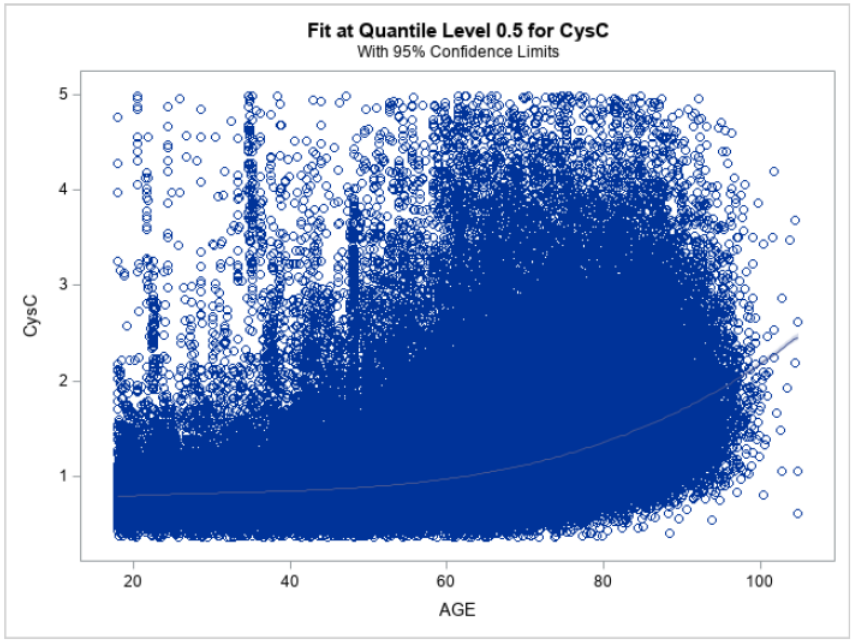


♀ Q' = 0.79 mg/L jusqu'à 50 ans,
Q' = 0.79 + 0.005 x (Age – 50)
♂ Q' = 0.86 mg/L jusqu'à 50 ans
Q' = 0.86 + 0.005 x (Age – 50)

1er étape: cystatine C et sexe

Données de labo de Suède
N=227,643
♀ 95,469
♂ 132,174

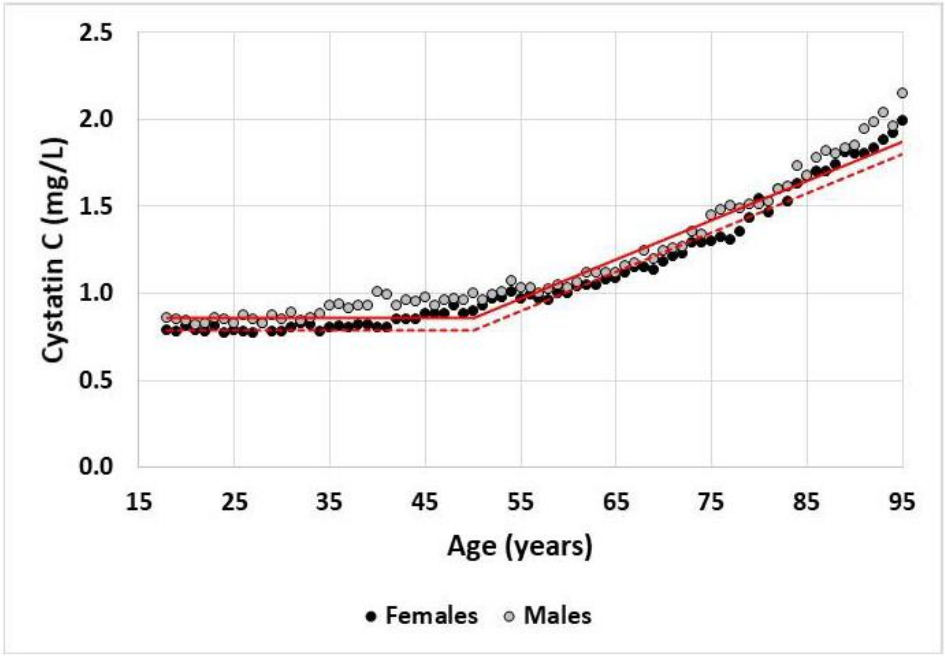
Figure S3. Cystatin C versus age and the median quantile line for the 227,643 included subjects.



♀ Q' = 0.79 mg/L jusqu'à 50 ans,
Q' = 0.79 + 0.005 x (Age – 50)
♂ Q' = 0.86 mg/L jusqu'à 50 ans
Q' = 0.86 + 0.005 x (Age – 50)

2ème étape: cystatine C et sexe

Figure S4. Median plasma cystatin C in one-year intervals against age for men and women. A mathematical model to define Q'-values is proposed (red solid line): for adults Q' = 0.79 mg/L (women, dashed line) and 0.86 mg/L (men, solid line) until 50 years and a linear increasing model thereafter.



Q' = 0.83 mg/L jusqu'à 50 ans
Q' = 0.83 + 0.005 x (Age – 50)

3ème étape: Cystatine C et “race”

- Données du même centre en France
- Même DFG de référence (Cr-EDTA)
- Même dosage de créatinine et de cystatine C

Table S3. Patient characteristics of the entire cohorts used for the matching analysis (mean ± SD)

Ethnicity/Sex	N	Age (years)	BMI (kg/m²)	mGFR (mL/min/1.73m²)	SCr (mg/dL)	CysC (mg/L)
White Men	1296 (57%)	53.0 ± 14.6	26.2 ± 4.9	61.8 ± 26.0	1.52 ± 0.73	1.52 ± 0.68
Black Men	436 (63%)	50.7 ± 13.1	26.3 ± 4.5	62.0 ± 22.1	1.73 ± 0.81	1.41 ± 0.61
White Women	966 (43%)	52.5 ± 15.2	25.8 ± 6.2	62.8 ± 26.8	1.16 ± 0.61	1.38 ± 0.73
Black Women	261 (37%)	51.9 ± 15.2	27.4 ± 5.8	59.1 ± 25.6	1.40 ± 0.79	1.46 ± 0.76

3ème étape: Cystatin C et “race”

Analyse matchée 1:1

- Pour le sexe
- IMC (±2,5 kg/m²)
- DFG mesuré (±3 mL/min/1.73m²)
- âge (± 3 ans)

Table S4. Demographic and renal characteristics of the matched White and Black subjects (mean ± SD)

Sex	N	Age (years)	BMI (kg/m²)	mGFR (mL/min/1.73m²)	SCr (mg/dL)	CysC (mg/L)
White Men	377	51.1 ± 12.2	25.7 ± 3.4	63.8 ± 21.0	1.43 ± 0.62	1.41 ± 0.56
Black Men	377	50.8 ± 12.3	25.8 ± 3.5	63.6 ± 21.0	1.65 ± 0.64	1.37 ± 0.59
White Women	200	53.4 ± 11.9	26.1 ± 4.6	59.7 ± 23.2	1.16 ± 0.53	1.40 ± 0.69
Black Women	200	53.3 ± 11.9	26.2 ± 4.6	59.8 ± 23.1	1.33 ± 0.61	1.41 ± 0.64

4ème étape:
Validation de la nouvelle équation

$$\text{EKFC} - \text{eGFR} = 107.3/[\text{Biomarker}/Q]^{\alpha} \times [0.990^{(\text{Age}-40)} \text{ if age } >40 \text{ years}],$$

with $\alpha = 0.322$ when biomarker/Q is less than 1
and $\alpha = 1.132$ when biomarker/Q is 1 or more.

Adultes
DFGm, creatinine et cystatine C calibrées
N=12,832

11 cohortes
Européens blancs: n=7,727
Européens blancs de Paris: n=2,646
US blancs: n=1,093
Européens noirs de Paris: n=858
Africains noirs: n=508

Table 1. Performance of Single Biomarker (Serum Creatinine or Cystatin C)–Based Equations to Estimate the Glomerular Filtration Rate.*

Variable	Serum Creatinine–Based Equations		
	CKD-EPI eGFRcr(ASR)	CKD-EPI eGFRcr(AS)	EKFC eGFRcr
EKFC cohort, 7727 White patients			
Median bias (95% CI) — ml/min/1.73 m²†	3.96 (3.67 to 4.32)	7.40 (7.02 to 7.76)	0.58 (0.32 to 0.86)
IQR of estimated GFR– measured GFR— ml/min/1.73 m²‡	15.5 (–3.0 to 12.5)	16.3 (0.0 to 16.3)	14.5 (–6.5 to 8.0)
Root-mean-square error (95% CI) — ml/min/1.73 m²§	14.8 (14.4 to 15.2)	16.3 (15.9 to 16.6)	13.1 (12.8 to 13.4)
P_{10} — % (95% CI)¶	40.3 (39.2 to 41.4)	34.7 (33.6 to 35.8)	43.3 (42.2 to 44.4)
P_{30} — % (95% CI)‖	81.6 (80.8 to 82.5)	75.7 (74.8 to 76.7)	85.8 (85.0 to 86.5)

7.40 (7.02 to 7.76) 0.58 (0.32 to 0.86)
16.3 (0.0 to 16.3) 14.5 (–6.5 to 8.0)
16.3 (15.9 to 16.6) 13.1 (12.8 to 13.4)
34.7 (33.6 to 35.8) 43.3 (42.2 to 44.4)
75.7 (74.8 to 76.7) 85.8 (85.0 to 86.5)

Table 1. Performance of Single Biomarker (Serum Creatinine or Cystatin C)–Based Equations to Estimate the Glomerular Filtration Rate.*

Variable	Cystatin C–Based Equations	
	CKD-EPI eGFRcys	EKFC eGFRcys without Sex
EKFC cohort, 7727 White patients		
Median bias (95% CI) — ml/min/1.73 m²†	0.28 (−0.02 to 0.64)	0.00 (−0.37 to 0.27)
IQR of estimated GFR− measured GFR— ml/min/1.73 m²‡	19.1 (−7.9 to 11.2)	14.4 (−7.9 to 6.5)
Root-mean-square error (95% CI) — ml/min/1.73 m²§	15.8 (15.5 to 16.1)	13.5 (12.9 to 14.1)
P_{10} — % (95% CI)¶	32.0 (31.0 to 33.0)	41.7 (40.6 to 42.8)
P_{30} — % (95% CI)‖	80.8 (79.9 to 81.7)	86.2 (85.4 to 87.0)

Cystatin C–Based Equations

CKD-EPI eGFRcys	EKFC eGFRcys without Sex
0.28 (−0.02 to 0.64)	0.00 (−0.37 to 0.27)
19.1 (−7.9 to 11.2)	14.4 (−7.9 to 6.5)
15.8 (15.5 to 16.1)	13.5 (12.9 to 14.1)
32.0 (31.0 to 33.0)	41.7 (40.6 to 42.8)
80.8 (79.9 to 81.7)	86.2 (85.4 to 87.0)

Table 1. Performance of Single Biomarker (Serum Creatinine or Cystatin C)–Based Equations to Estimate the Glomerular Filtration Rate.*

Variable	Serum Creatinine–Based Equations			Cystatin C–Based Equations	
	CKD-EPI eGFRcr(ASR)	CKD-EPI eGFRcr(AS)	EKFC eGFRcr	CKD-EPI eGFRcys	EKFC eGFRcys without Sex
EKFC cohort, 7727 White patients					
Median bias (95% CI) — ml/min/1.73 m²†	3.96 (3.67 to 4.32)	7.40 (7.02 to 7.76)	0.58 (0.32 to 0.86)	0.28 (–0.02 to 0.64)	0.00 (–0.37 to 0.27)
IQR of estimated GFR– measured GFR— ml/min/1.73 m²‡	15.5 (–3.0 to 12.5)	16.3 (0.0 to 16.3)	14.5 (–6.5 to 8.0)	19.1 (–7.9 to 11.2)	14.4 (–7.9 to 6.5)
Root-mean-square error (95% CI) — ml/min/1.73 m²§	14.8 (14.4 to 15.2)	16.3 (15.9 to 16.6)	13.1 (12.8 to 13.4)	15.8 (15.5 to 16.1)	13.5 (12.9 to 14.1)
P_{10} — % (95% CI)¶	40.3 (39.2 to 41.4)	34.7 (33.6 to 35.8)	43.3 (42.2 to 44.4)	32.0 (31.0 to 33.0)	41.7 (40.6 to 42.8)
P_{30} — % (95% CI)‖	81.6 (80.8 to 82.5)	75.7 (74.8 to 76.7)	85.8 (85.0 to 86.5)	80.8 (79.9 to 81.7)	86.2 (85.4 to 87.0)

Table 2. Performance of Combined Serum Creatinine– and Cystatin C–Based Equations to Estimate GFR.*

Variable	CKD-EPI eGFRcr-cys(ASR)	CKD-EPI eGFRcr-cys(AS)	EKFC eGFRcr-cys without Sex
EKFC cohort, 7727 White patients			
Median bias (95% CI) — ml/min/1.73 m²†	2.50 (2.17 to 2.76)	5.04 (4.69 to 5.36)	0.37 (0.14 to 0.66)
IQR of estimated GFR – measured GFR — ml/min/1.73 m²‡	14.8 (–3.6 to 11.2)	16.7 (–1.8 to 14.9)	12.0 (–5.9 to 6.1)
Root-mean-square error (95% CI) — ml/min/1.73 m²§	13.1 (12.8 to 13.4)	14.7 (14.4 to 15.0)	11.3 (11.0 to 11.6)
P_{10} — % (95% CI)¶	41.5 (40.4 to 42.6)	37.2 (36.2 to 38.3)	48.9 (47.8 to 50.0)
P_{30} — % (95% CI)‖	88.3 (87.6 to 89.0)	84.2 (83.4 to 85.0)	90.4 (89.8 to 91.1)
Paris cohort, 2646 White patients			
Median bias (95% CI) — ml/min/1.73 m²†	–1.35 (–1.82 to –0.97)	0.64 (0.16 to 1.15)	–0.65 (–1.06 to –0.23)
IQR of estimated GFR – measured GFR — ml/min/1.73 m²‡	13.4 (–7.5 to 5.8)	14.1 (–5.8 to 8.3)	12.4 (–6.8 to 5.6)
Root-mean-square error (95% CI) — ml/min/1.73 m²§	12.1 (11.6 to 12.7)	12.6 (12.0 to 13.1)	11.8 (11.2 to 12.4)
P_{10} — % (95% CI)¶	43.9 (42.0 to 45.8)	42.3 (40.4 to 44.1)	45.8 (43.9 to 47.7)
P_{30} — % (95% CI)‖	89.7 (88.5 to 90.8)	89.2 (88.0 to 90.4)	92.1 (91.1 to 93.1)
U.S. cohort, 1093 White patients			
Median bias (95% CI) — ml/min/1.73 m²†	9.23 (8.45 to 10.10)	13.9 (13.1 to 14.9)	0.97 (0.01 to 2.12)
IQR of estimated GFR – measured GFR — ml/min/1.73 m²‡	18.4 (0.5 to 18.8)	18.1 (5.1 to 23.3)	17.4 (–8.2 to 9.2)
Root-mean-square error (95% CI) — ml/min/1.73 m²§	18.1 (17.1 to 19.1)	21.0 (20.1 to 22.0)	15.5 (14.3 to 16.7)
P_{10} — % (95% CI)¶	37.1 (34.3 to 40.0)	28.1 (25.4 to 30.8)	45.7 (42.7 to 48.6)
P_{30} — % (95% CI)‖	79.5 (77.1 to 81.9)	72.1 (69.4 to 74.8)	88.7 (86.9 to 90.6)
Paris cohort, 858 Black patients			
Median bias (95% CI) — ml/min/1.73 m²†	–0.37 (–1.06 to 0.57)	–2.08 (–2.71 to –1.32)	–0.65 (–1.23 to 0.11)
IQR of estimated GFR – measured GFR — ml/min/1.73 m²‡	15.2 (–6.4 to 8.8)	14.0 (–7.9 to 6.1)	12.4 (–6.2 to 6.2)
Root-mean-square error (95% CI) — ml/min/1.73 m²§	13.3 (11.9 to 14.6)	12.6 (11.2 to 13.9)	11.6 (10.0 to 13.0)
P_{10} — % (95% CI)¶	38.7 (35.4 to 42.0)	38.9 (35.7 to 42.2)	48.3 (44.9 to 51.6)
P_{30} — % (95% CI)‖	87.9 (85.7 to 90.1)	89.0 (87.0 to 91.1)	92.0 (90.1 to 93.8)
African cohort, 508 Black patients			
Median bias (95% CI) — ml/min/1.73 m²†	8.55 (6.87 to 10.30)	4.08 (2.37 to 5.78)	0.42 (–1.03 to 1.51)
IQR of estimated GFR – measured GFR — ml/min/1.73 m²‡	24.7 (–4.5 to 20.1)	22.0 (–7.4 to 14.7)	17.1 (–7.2 to 10.0)
Root-mean-square error (95% CI) — ml/min/1.73 m²§	19.7 (18.2 to 21.1)	17.2 (15.8 to 18.5)	14.7 (13.3 to 16.0)
P_{10} — % (95% CI)¶	28.7 (24.8 to 32.7)	34.3 (30.1 to 38.4)	43.5 (39.2 to 47.8)
P_{30} — % (95% CI)‖	75.0 (71.2 to 78.8)	77.6 (73.9 to 81.2)	84.3 (81.1 to 87.4)

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ORIGINAL ARTICLE

Extending the cystatin C based EKFC-equation to children – validation results from Europe

Hans Pottel[1] · Ulf Nyman[2] · Jonas Björk[3,4] · Ulla Berg[5] · Arend Bökenkamp[6] · Laurence Derain Dubourg[7] · Sandrine Lemoine[7] · Karollen Goffin[8] · Anders Grubb[9] · Magnus Hansson[10] · Anders Larsson[11] · Karin Littmann[12] · Kajsa Åsling-Monemi[5] · Khosrow Adeli[13] · Etienne Cavalier[14] · Pierre Delanaye[15,16]

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Cystatine C

- La cystatine C permet une estimation du DFG sans les variables “âge” ni “sexe”
- L’équation EKFC est mathématiquement la même pour la créatinine et le cystatine C, seul Q change
- Continuum entre enfants et adultes pour $EKFC_{crea}$ et $EKFC_{CC}$
- Les équations EKFC sont un peu meilleures que les équations CKD-EPI correspondantes => alternative valable en Europe et en Afrique
- Les équations basées sur la cystatine C ne sont pas meilleures que les équations basées sur la créatinine
- Les équations combinées sont meilleures (exactitude +5-10%)
- Meilleure association avec le pronostic cardiovasculaire
- Standardisation
- Plus cher
- Comment gérer les résultats différents entre créatinine et cystatine C?

https://ekfccalculator.pages.dev/

KDIGO 2024 CLINICAL PRACTICE GUIDELINE FOR THE EVALUATION AND MANAGEMENT OF CHRONIC KIDNEY DISEASE

1.2.4 Selection of GFR estimating equations

Recommendation 1.2.4.1: We recommend using a validated GFR estimating equation to derive GFR from serum filtration markers (eGFR) rather than relying on the serum filtration markers alone (*1D*).

Practice Point 1.2.4.1: Use the same equation within geographical regions (as defined locally [e.g., continent, country, and region] and as large as possible). Within such regions, equations may differ for adults and children.

Practice Point 1.2.4.2: Use of race in the computation of eGFR should be avoided.

Special considerations

Pediatric considerations

Practice Point 1.2.4.3: Estimate GFR in children using validated equations that have been developed or validated in comparable populations.

Table 14 | Validated GFR estimating equations

Marker	Equation name and year	Age	Variables	Development populations
Creatinine	CKD-EPI 2009[238]	≥18; modification CKD-EPI 40 for pediatric available	Developed using A, S, R but reported not using the Black race coefficient, A, S, R (NB)	8254 Black and NB individuals from 10 studies in the United States and Europe[a]
	CKiD U25 2021[239]	1–25	A, S, height	928 children with CKD in the United States and Canada
	CKD-EPI 2021[147]	≥18	A, S	8254 Black and NB individuals from 10 studies in the United States and Europe[a]
	EKFC 2021[240]	2–100	A, S, European Black and NB specific Q-value; separate Q-values for Africa vs. Europe	mGFR vs. SCr (11,251 participants in 7 studies in Europe and 1 study from the United States) Normal GFR from 5482 participants in 12 studies of kidney donor candidates (100% Caucasian) European NB Q from 83,157 laboratory samples (age 2–40 years) in 3 European hospital clinical laboratories; European Black Q-value (N = 90 living kidney donors from Paris); African Black Q-value (N = 470 healthy individuals from République Démocratique de Congo); All Q-values developed in cohorts independent for EKFC development and validation
Cystatin C	CKD-EPI 2012[148]	≥18	A, S	5352 Black and NB individuals from 13 studies in the United States and Europe
	EKFC 2023[91]	18–100	A	mGFR vs. SCys (assumed to be the same as mGFR vs. SCr) Normal GFR (same as for the SCr equation) Q from laboratory samples from 227,643 (42% female) laboratory samples from Uppsala University Hospital, Sweden

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)

Ne pas sur-interpreter un DFG estimé…

Toutes les équations restent des estimations

OK au niveau populationnel

Manque de précision au niveau individuel

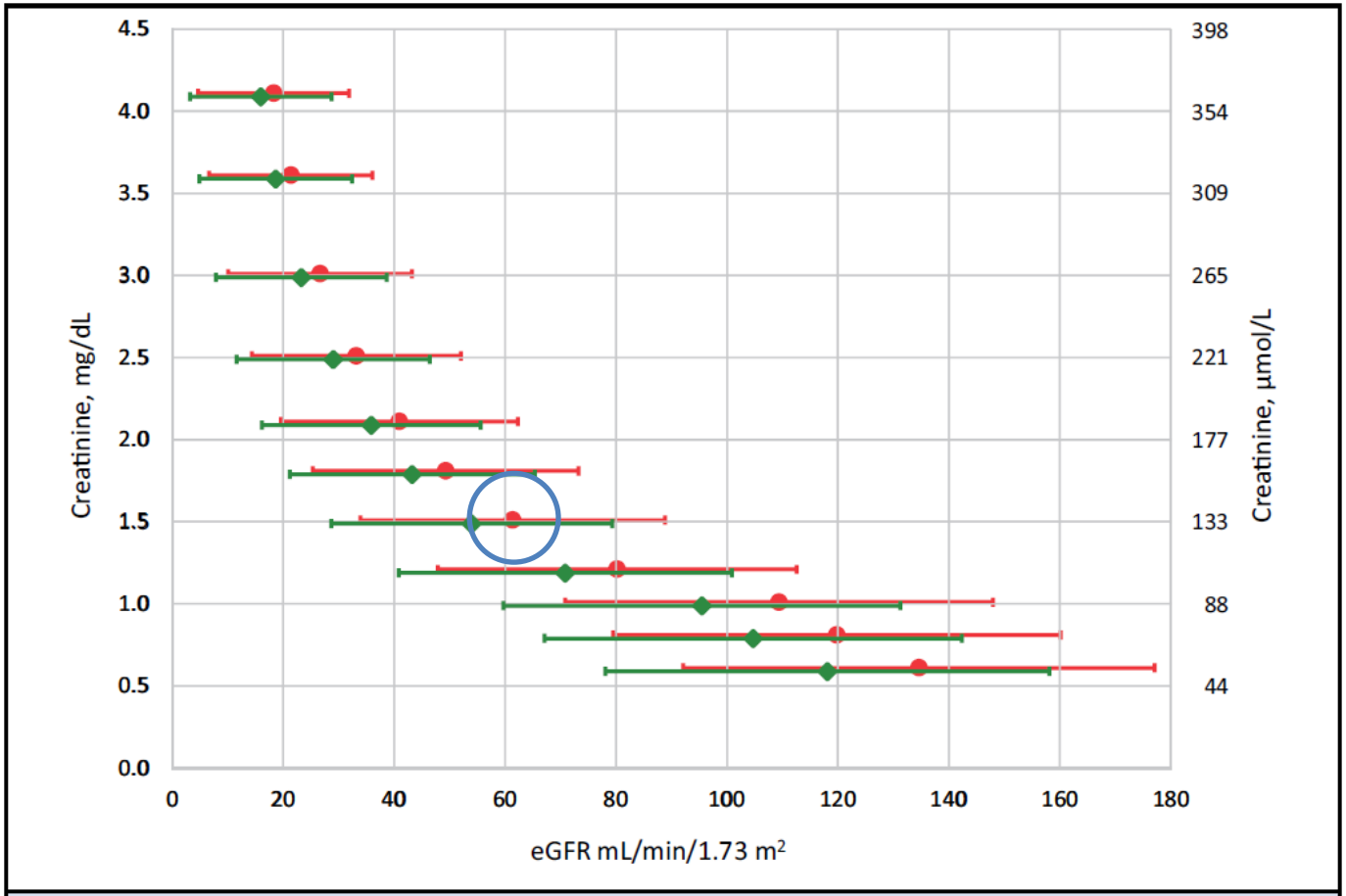

Fig. 1. Uncertainty of eGFR calculated using the CKD-EPI equations for African-Americans and non-African-Americans at various creatinine concentrations for a 50-year-old male. Circles (red, larger values) indicate African-American and diamonds (green, lower values) indicate non-African-American equations.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

DFGe = 60,25 ml/min/1.73m²

Miller WG, Clin Chem, 2021, p693 and p820

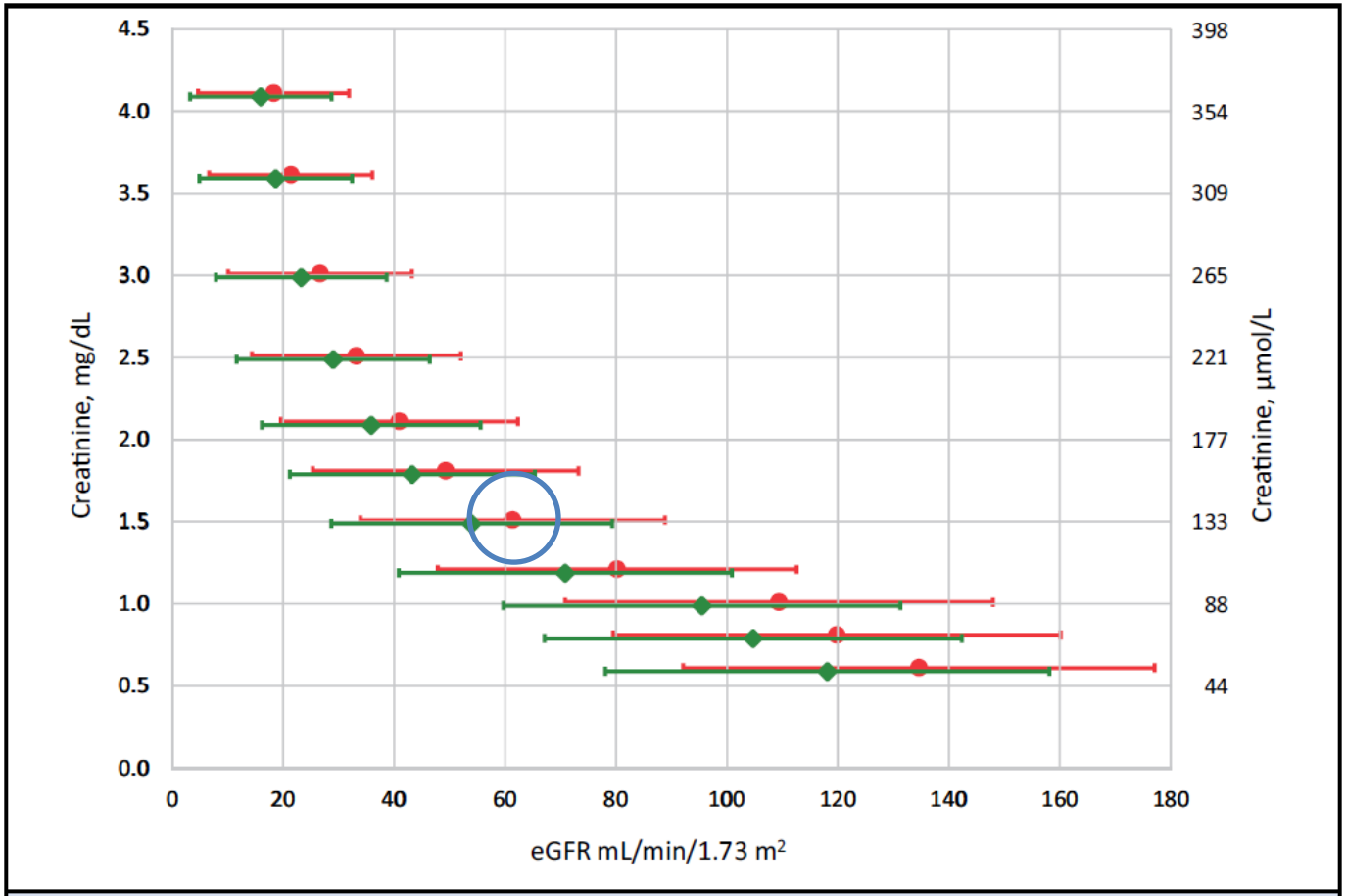

Fig. 1. Uncertainty of eGFR calculated using the CKD-EPI equations for African-Americans and non-African-Americans at various creatinine concentrations for a 50-year-old male. Circles (red, larger values) indicate African-American and diamonds (green, lower values) indicate non-African-American equations.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

DFGe ~~= 60,25 ml/min/1.73m²~~

= 60 ml/min/1.73m² (CI 95%: 33-87)

Miller WG, Clin Chem, 2021, p693 and p820

Variable	CKD-EPI eGFRcr-cys(ASR)	CKD-EPI eGFRcr-cys(AS)	EKFC eGFRcr-cys without Sex
EKFC cohort, 7727 White patients			
Median bias (95% CI) — ml/min/1.73 m²†	2.50 (2.17 to 2.76)	5.04 (4.69 to 5.36)	0.37 (0.14 to 0.66)
IQR of estimated GFR – measured GFR — ml/min/1.73 m²‡	14.8 (–3.6 to 11.2)	16.7 (–1.8 to 14.9)	12.0 (–5.9 to 6.1)
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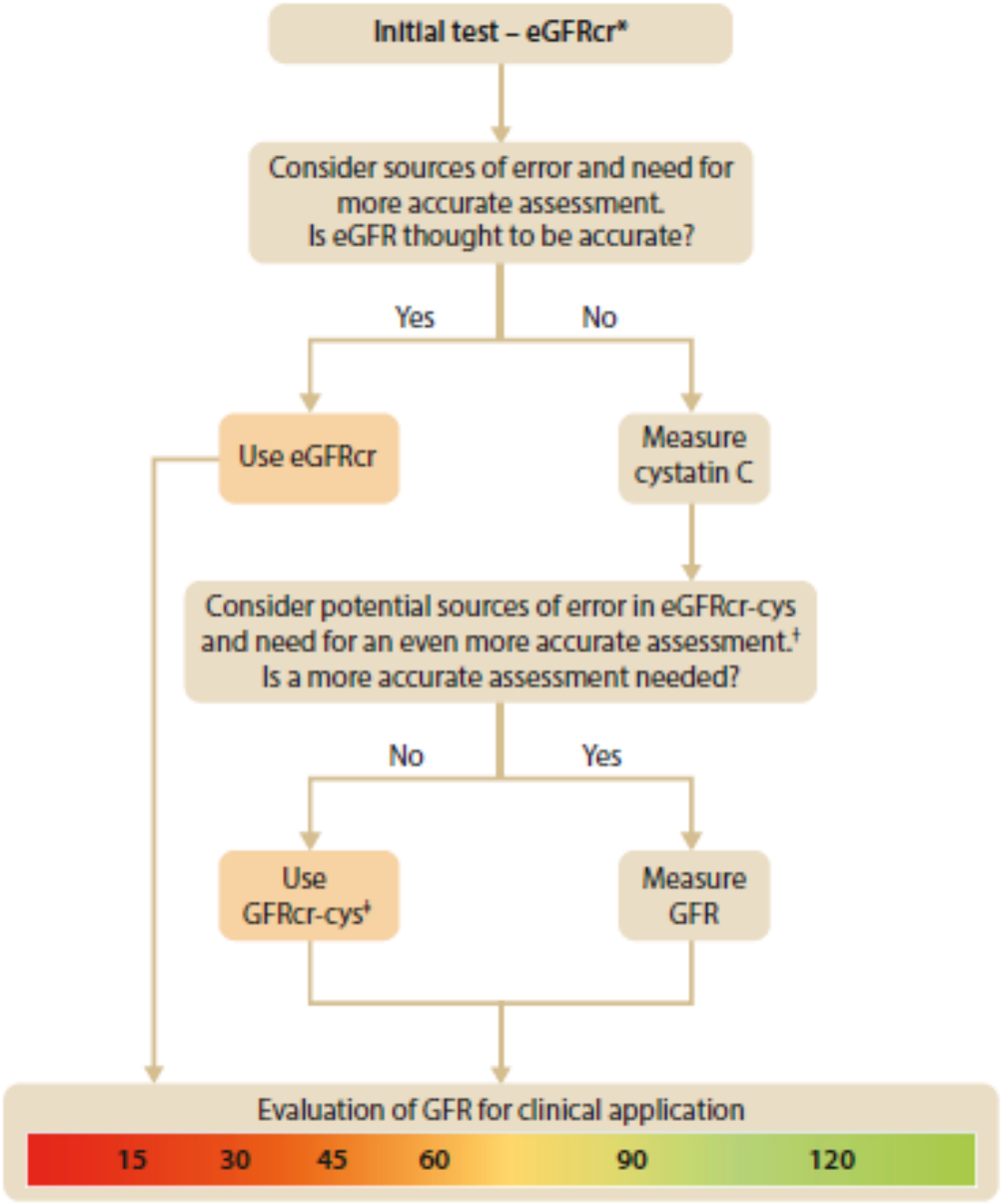
P_{10} — % (95% CI)¶	41.5 (40.4 to 42.6)	37.2 (36.2 to 38.3)	48.9 (47.8 to 50.0)
P_{30} — % (95% CI)‖	88.3 (87.6 to 89.0)	84.2 (83.4 to 85.0)	90.4 (89.8 to 91.1)


Initial test – eGFRcr*
Consider sources of error and need for more accurate assessment. Is eGFR thought to be accurate?
Yes
No
Use eGFRcr
Measure cystatin C
Consider potential sources of error in eGFRcr-cys and need for an even more accurate assessment.† Is a more accurate assessment needed?
No
Yes
Use GFRcr-cys‡
Measure GFR
Evaluation of GFR for clinical application
15
30
45
60
90
120

Kidney Medicine

Cystatin C as a GFR Estimation Marker in Acute and Chronic Illness: A Systematic Review

Ogechi M. Adingwupu, Ernesto Rodolpho Barbosa, Paul M. Palevsky, Joseph A. Vassalotti, Andrew S. Levey, and Lesley A. Inker

2023 Sep 19;5(12):100727.

Conclusions: eGFRcr-cys improves GFR estimation in populations with a variety of acute and chronic illnesses, providing indications for cystatin C measurement. Performance was poor in many studies, suggesting the need for more frequent mGFR.

Study, year	Country	N	Age	Creatinine		Cystatin C		Creatinine-Cystatin C	
				Equations	Accuracy, P_{30}	Equations	Accuracy, P_{30}	Equations	Accuracy, P_{30}
Cancer									
Shibata, 2015[24] hematological cancer	Japan	41	A	*Matsuo*	–	*Horio*	–	–	–
Hingorani, 2015[25] hematological cancer	Japan	50	A	*CKD-EPI 2009*	79	*CKD-EPI 2012*	76	*CKD-EPI 2012*	89
Hingorani, 2015[25] HSC	Japan	50	A	*CKD-EPI 2009*	82	*CKD-EPI 2012*	72	*CKD-EPI 2012*	84
Matsuoka, 2020[26] HSC	Japan	17	P	*Bedside CKiD*	23	*CKiD*	81	*CKiD*	81
				Uemura	55	*Uemura*	61	–	–
Costa e Silva, 2021[27] solid organ cancer	Brazil	1200	A	*CKD-EPI 2009*	81 (79, 83)	*CKD-EPI 2012*	88 (86, 90)	*CKD-EPI 2012*	92 (91, 94)
HIV									
Inker, 2012[28]	USA	200	A	*CKD-EPI 2009*	85 (80, 90)	*CKD-EPI 2012*	83 (77, 88)	*CKD-EPI 2012*	90 (86, 94)
Bhasin, 2013[29]	USA	187	A	*CKD-EPI 2009*	89 (83, 93)	*CKD-EPI 2012*	79 (72, 85)	*CKD-EPI 2012*	91 (85, 94)
Gagneuax-Brunon, 2013[30]	France	203	A	*CKD-EPI 2009*	82	*CKD-EPI 2012*	80	*CKD-EPI 2012*	81
Yukawa, 2018[31]	Japan	15	A	*Matsuo*	40 (12, 68)	*Horio*	93 (79, 100)	–	–
Lucas, 2020[32]	USA	222	A	*CKD-EPI 2009*	79 (76, 82)	*CKD-EPI 2012*	83 (80, 85)	*CKD-EPI 2012*	88 (86, 91)
Cirrhosis									
De Souza, 2014[33]	France	202	A	*CKD-EPI 2009*	56	*CKD-EPI 2012*	83	*CKD-EPI 2012*	78
Torre, 2016[34]	Mexico	91	A	*CKD-EPI 2009*	41 (30, 51)	*CKD-EPI 2012*	63 (52, 73)	CKD-EPI 2012	60 (50, 71)
Stammler, 2023[35]	USA & France	203	A	*CKD-EPI 2009*	75 (69, 81)	–	–	*CKD-EPI 2012*	86 (81, 91)
				CKD-EPI 2021	74 (68, 80)	–	–	*CKD-EPI 2021*	86 (81, 90)
Liver Transplant									
Wagner, 2012[36]	Austria	49	A	*CKD-EPI 2009*	52	*CKD-EPI 2012*	42	–	–
Allen, 2015[37]	USA	401	A	*CKD-EPI 2009*	76 (72, 79)	*CKD-EPI 2012*	60 (56, 64)	*CKD-EPI 2012*	84 (82, 87)
Bluhme, 2021[38]	Sweden	91	P	*CKiD/MDRD*	68 (61, 75)	*CKD-EPI 2012*	86 (82, 91)	–	–
				Lyon	84 (79, 89)	*CAPA*	88 (83, 92)	–	–
				FAS	68 (60, 77)	–	–	–	–
Heart Failure									
Kervella, 2017[39]	France	66	A	*CKD-EPI 2009*	33 (23, 45)	*CKD-EPI 2012*	65 (53, 76)	*CKD-EPI 2012*	52 (40, 63)
Swolinsky, 2021[40]	Germany	38	A	*CKD-EPI 2009*	66	*CKD-EPI 2012*	56	*CKD-EPI 2012*	74
Neuromuscular Disease									
Aldenbratt, 2022[41]	Sweden	145	A	*CKD-EPI2009*	37 (30, 46)	*CAPA*	49 (41, 57)	*CAPA+ CKD-EPI2009*	44 (35, 51)
Critical Illness									
Delanaye, 2014[42]	Belgium& France	47	A	*CKD-EPI 2009*	60	*CKD-EPI 2012*	53	*CKD-EPI 2012*	62
Carlier, 2015[43]	Belgium	68	A	*CKD-EPI 2009*	40 (29, 52)	*CKD-EPI 2012*	45 (33, 57)	*CKD-EPI 2012*	54 (11, 65)
Ravn, 2019[44]	Sweden	30	A	*LM-REV*	67 (49, 81)	*CAPA*	47 (30, 64)	*CKD-EPI2012*	80 (63, 91)
				CKD-EPI2009	63 (46, 78)	*CKD-EPI2012*	43 (27, 61)	*CAPA+LM-REV*	87 (70, 95)
Sangla, 2020[45]	Switzerland	63	A	*CKD-EPI 2009*	44	*CKD-EPI 2012*	46	*CKD-EPI 2012*	56
Haines, 2023[46]	United Kingdom	27	A	*CKD-EPI 2021*	–	*CKD-EPI 2012*	–	–	–
Obesity									
Chang, 2020[47] Pre-bariatric	USA	27	A	*CKD-EPI 2009*	85 (70, 96)	*CKD-EPI 2012*	78 (59, 93)	*CKD-EPI 2012*	93 (81, 100)
Chang, 2020[47] Post-bariatric	USA	27	A	*CKD-EPI 2009*	85 (70, 96)	*CKD-EPI 2012*	93 (81, 100)	*CKD-EPI 2012*	93 (81, 100)

Figure 2. Accuracy of creatinine and cystatin C estimating GFR equations by clinical population. Accuracy was defined as the proportion of eGFR within 30% of mGFR (P_{30}). Where defined as 1-P_{30}, we converted it to P_{30} for consistency. Units are percent for P_{30}. Green box indicates high accuracy with P_{30} of magnitude > 90%. Yellow box indicates moderate accuracy with P_{30} of magnitude 80%-90 %; (red box) indicates low accuracy with P_{30} of magnitude less than 80%. GFR, glomerular filtration rate; mGFR, measured GFR; eGFR, estimated GFR.

Nephrol Dial Transplant, 2024, 39, 1088–1096
https://doi.org/10.1093/ndt/gfad241
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Diagnostic standard: assessing glomerular filtration rate

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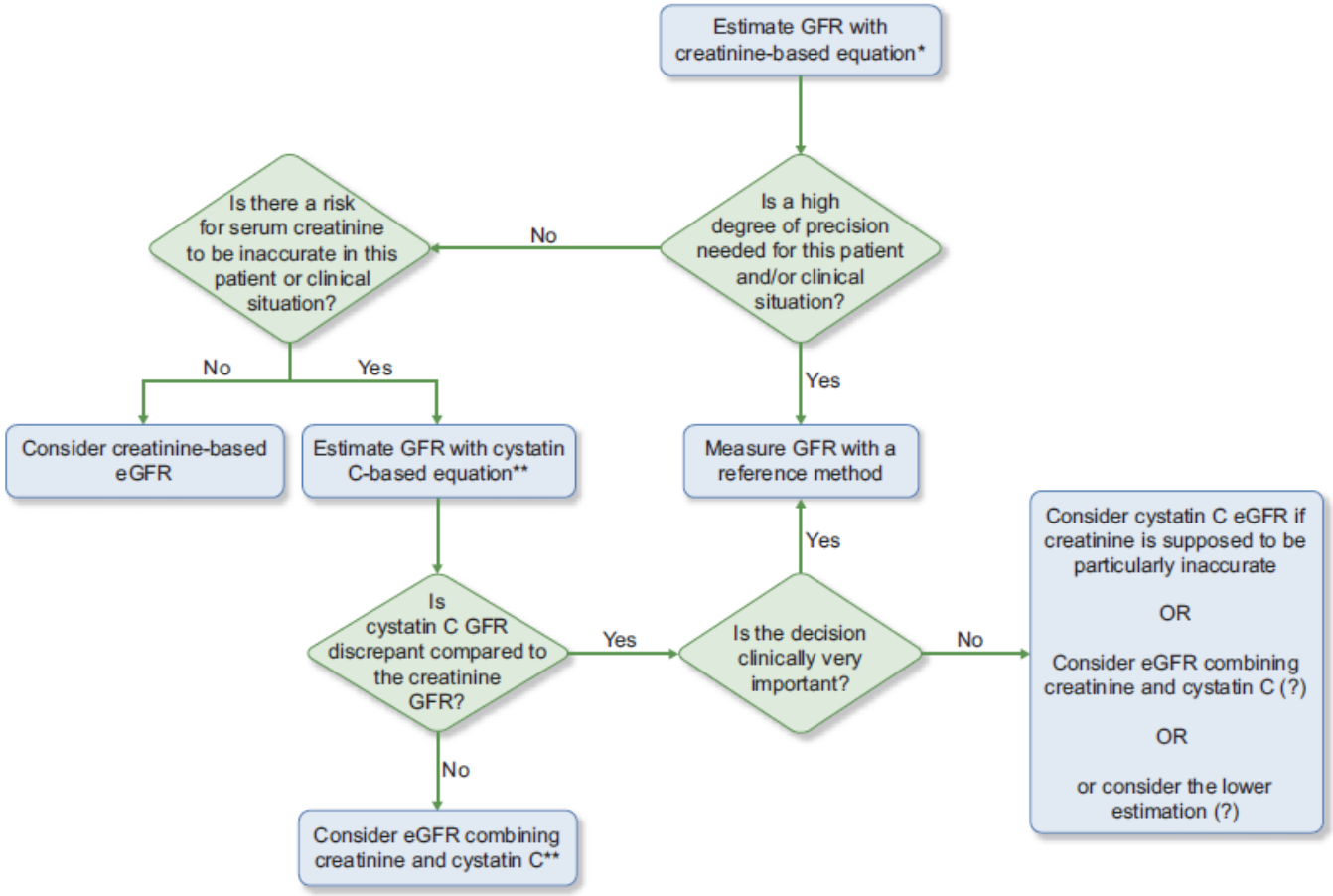

Figure 1: Estimation of GFR in Nephrology, in clinical practice and at the individual level. *Using the best validated equation in your region and/or population. **Using the cystatin C or combined equation corresponding to the creatinine-based equation used at the first step.

The applicability of eGFR equations to different populations

Pierre Delanaye and Christophe Mariat

RETOUR à une mesure du DFG

Delanaye P, Nature Rev Nephrol, 2013, 9, p513
Ebert N, Clin Kidney J, 2021, 14, p1861
Agarwal R, Nephrol Dial Transplant, 2019, 34, p2001
Shafi T, Ann Intern Med, 2022, 175, p1073

Practice Point 1.2.2.2: Where more accurate ascertainment of GFR will impact treatment decisions, measure GFR using plasma or urinary clearance of an exogenous filtration marker (Table 9).

Clairance plasmatique d'iohexol

Pas si difficile
Pas si cher
Remboursé
"Kidney Day"

Iohexol plasma clearance measurement protocol standardization for adults: a consensus paper of the European Kidney Function Consortium

Check for updates

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Merci