

Diabetic Kidney Disease: Improving Outcomes and Reducing Costs

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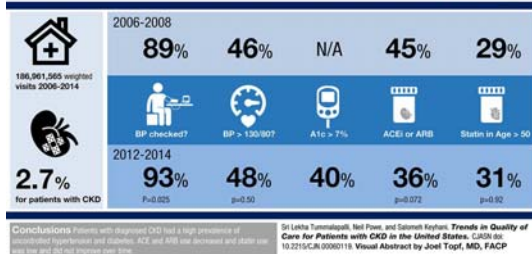
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So how's CKD care in America?

CJASN
Clinical Journal of the American Society of Nephrology

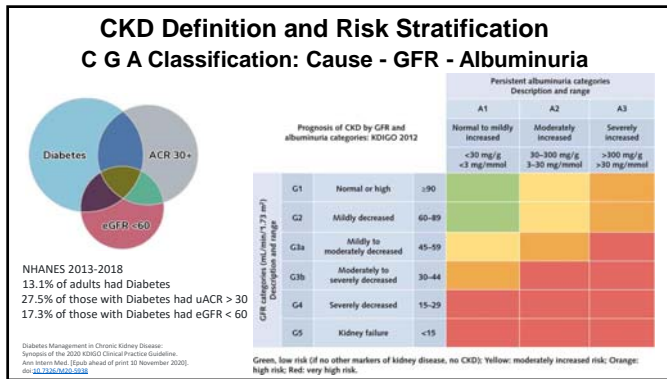


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Learning Objectives

- Define applications of eGFR and urine albumin-creatinine ratio (uACR) tests in individuals with T2DM for detection and risk stratification of CKD as defined by the kidney health evaluation for patients with diabetes Healthcare Effectiveness Data and Information Set (HEDIS) measure
- Describe how CKD risk stratification informs interventions to reduce kidney failure, decrease cardiovascular risk and limit hospitalizations
- Cite recent studies of the kidney and cardiovascular protective effects of specific treatment regimens, and their indications for management in individuals with T2DM and CKD
- Examine interventions to decrease the risks for cardiovascular disease and dialysis in individuals with T2DM and CKD, based on an understanding of the pathophysiology of progression to these disorders

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Different Categories for Albuminuria

Albuminuria+ Terminology	Dipstick Proteinuria	Albumin+ Excretion mg/day	uACR+ mg/g	uPCR+ mg/g
Normal – mildly increased (A1)	negative	< 30	< 30	< 142
Moderately increased (A2)	+1	30 to 300	30 to 300	142 to 660
Severely Increased (A3)	+2 or greater	> 300	> 300	> 660

Required for KED Measure

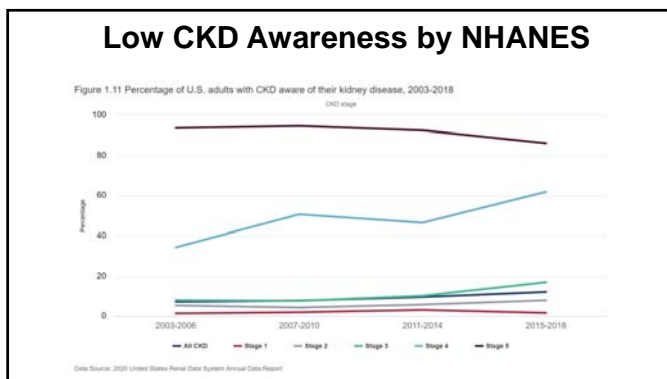
These categories incorporate approximations and inaccuracies depending on gender, age and other factors, but is useful as a pragmatic approach when ACR is not available.

These categories are adapted from KDIGO; Kidney Disease Improving Global Outcomes. +

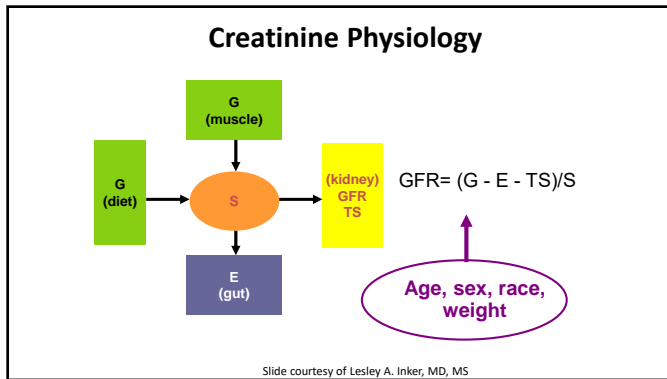
These categories are from a meta-analysis of uPCR to uACR conversion.

Ann Intern Med. 2020;173(6):426-435

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Serum Creatinine

Age	Gender	Race	SCr (mg/dL)	Estimated GFR* (mL/min/1.73 m ²)
20	M	B	1.30	91
20	M	W	1.30	79
20	F	B	1.30	69
55	M	W	1.30	61
55	F	B	1.30	54
55	F	W	1.30	46

B = black; W = all ethnic groups other than black;
*CKD-EPI creatinine Equation

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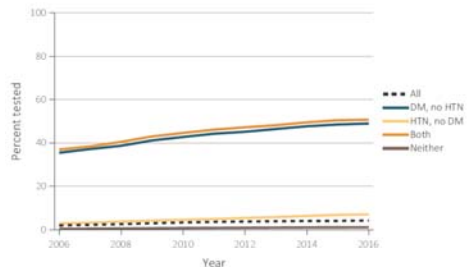
Factors Affecting Creatinine Generation*

Factor	Affect on serum creatinine
✓ Age	Decrease
✓ Female Sex	Decrease
✓ Race	
African American	Increase
Hispanics	Decrease
Asian	Decrease
Body Habitus	
Muscular	Increase
Amputation	Decrease
Obesity	No change
Chronic Illness	
Malnutrition, inflammation, de-conditioning	Decrease
Neuromuscular diseases	Decrease
Diet	
Vegetarian Diet	Decrease
Ingestion of Cooked Meats	Increase

*The use of race in estimating GFR is controversial but is currently being addressed by NKF and ASN Task Force

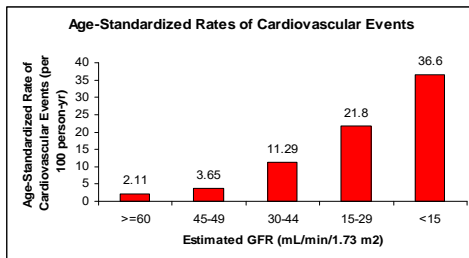
8

Low Albuminuria Testing in Americans With Diabetes



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CKD Severity Predicts CVD Risk: Cardiovascular events by eGFR

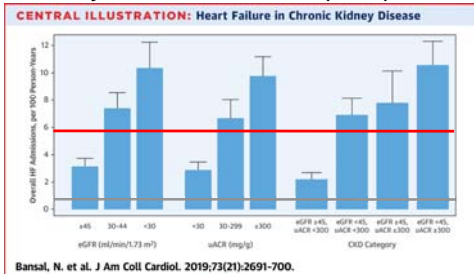


Kaiser outpatients with at least one serum creatinine - eGFR
n = 1,120,295

Go AS, et al: NEJM. 2004; 351:1296-1305

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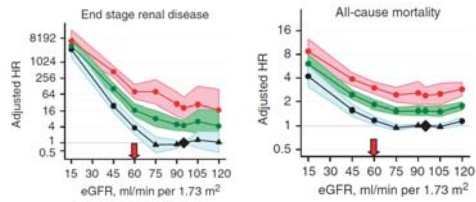
Heart Failure Hospitalization by eGFR and Albuminuria (uACR)



CRIC cohort n = 3,791. Unadjusted rates shown, & Figure adapted
Crude CRIC (CKD) cohort rate 5.8
Crude general population rate 0.5

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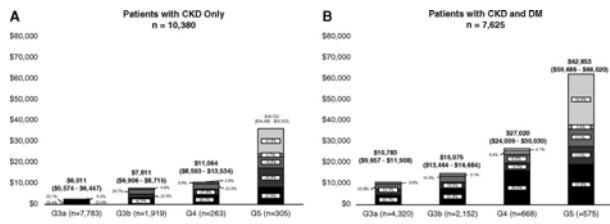
Low eGFR and Albuminuria Predict Kidney Failure and Mortality



Kidney Int. Suppl. 2013; 3: 1-150.

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As eGFR Falls, Costs Multiply: Population Medical Costs by CKD G stage

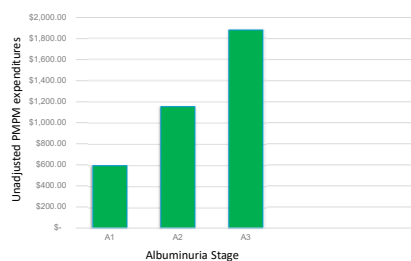


Annualized mean medical costs in total (95% CIs) and by resource adjusted for age, sex, and race/ethnicity for patients with CKD and (A) no comorbidities and (B) diabetes dramatically with declining kidney function. Similar patterns for (C) cardiovascular disease and heart failure (D) are not shown. The comorbidity groups are not mutually exclusive.

Gregory A. Nichols et al. JASN 2020;31:1594-1601

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As Albuminuria Rises, Costs Multiply: Population Medical Costs by CKD A stage



Am J Managed Care 2019; 25(11):e326-e333

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Kidney Health Evaluation for Patients with Diabetes (KED) HEDIS® Measure

Measure - Patients who received a kidney profile evaluation defined by an estimated Glomerular Filtration Rate (eGFR) AND urine Albumin-Creatinine Ratio (uACR) within a 12-month period

Patients aged 18-85 years with a diagnosis of diabetes with at least one in person or telehealth visit within a 12-month period

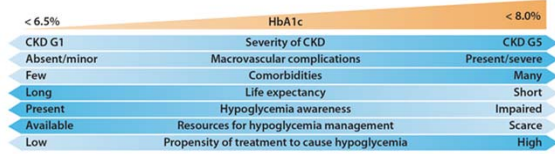
Exclusions: Diagnosis of CKD stage G5 or ESRD, palliative care services and hospice enrollment

National Committee for Quality Assurance. HEDIS 2020 Technical Specifications. Vol 2; 2020.
<https://www.ncqa.org/hedis/>

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GLYCEMIC MONITORING AND TARGETS IN PATIENTS WITH DIABETES AND CKD

Recommendation 2.2.1. We recommend an individualized HbA1c target ranging from <6.5% to <8.0% in patients with diabetes and CKD not treated with dialysis (Figure 9) (1C).



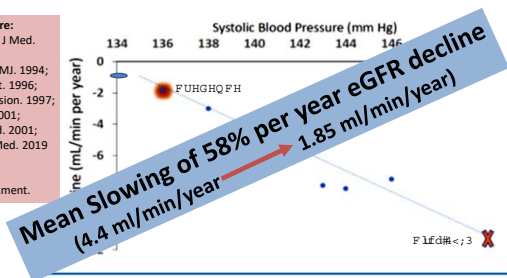
Kidney Int. 2020; 98(4S):S1-S115

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Rate of decline in kidney function by blood pressure from clinical trials in diabetic kidney disease

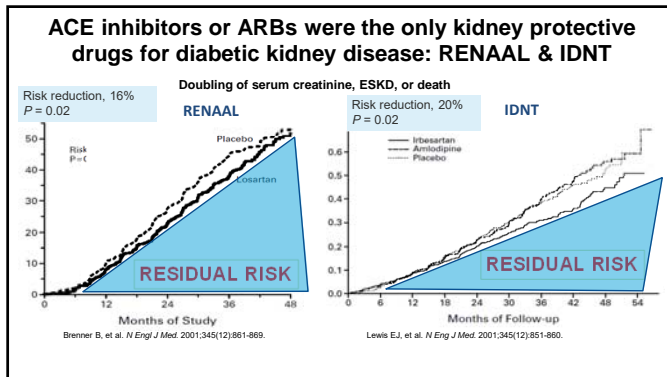
Trials included in figure:
Captopril Trial, N Engl J Med. 1993;
Hannadouché et al, BMJ. 1994;
Bakris et al, Kidney Int. 1996;
Bakris et al, Hypertension. 1997;
IDNT, N Engl J Med. 2001;
RENAAL, N Engl J Med. 2001;
CREDESCENCE, N Engl J Med. 2019 (orange glow).

X represents -no treatment.

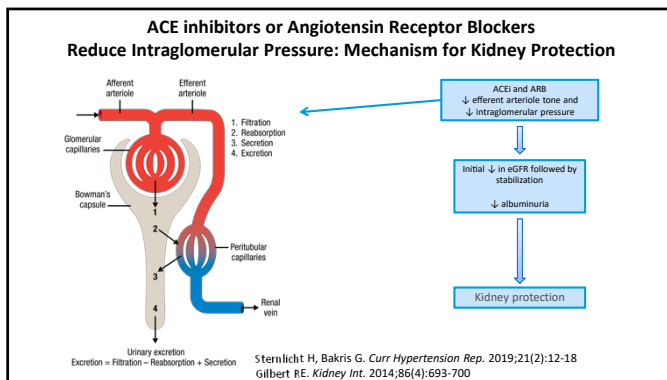


Bakris GL. Am J Kidney Dis 2019;74:573-575

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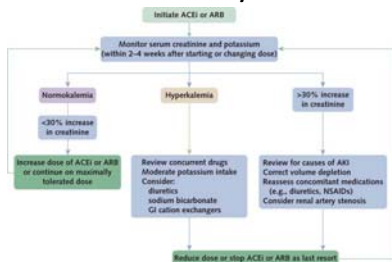
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In my practice, I stop lisinopril 2.5 mg daily if the serum creatinine rises from 1.6 to 1.9 mg/dL?

- A. Yes
B. No

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Use of ACE inhibitors or Angiotensin Receptor Blockers in Diabetic Kidney Disease



ACEi = angiotensin-converting enzyme inhibitor; ARB = angiotensin II receptor blocker; AKI = acute kidney injury; NSAID = nonsteroidal anti-inflammatory drug. (Reproduced from reference 4.)

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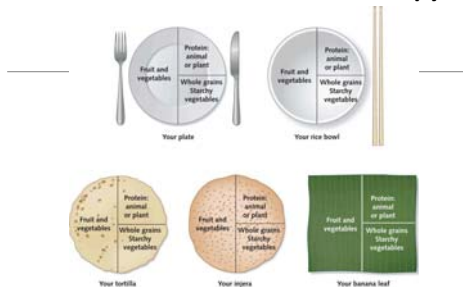


Pete Quaife

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Consider Medical Nutrition Therapy



Ann Intern Med. Published online 10 November 2008;doi:10.7326/0000-0008

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Predictors of Hyperkalemia before Starting ACEi or ARB Therapy Derived from Trials^{1,2}

- eGFR <45 mL/min/1.73m²
- Serum potassium >4.5 mEq/L
- eGFR <45 mL/min/1.73m² + serum K >4.5 mEq/L
(**Strongest Predictor**)
- eGFR <30 mL/min/1.73m² obviously high risk
- **Avoid ACEi and ARB in combination³⁻⁵**
— Risk of adverse events (hemodynamic AKI, hyperkalemia)

1. Lazich J, et al. *Semin Nephrol* 2014; 22(2):123-32
2. Khosla N, et al. *Am J Nephrol* 2009; 30(5):418-424

3. Kunz R, et al. *Ann Intern Med*. 2008;148:30-48
4. Mann J, et al. ONTARGET study. *Lancet*. 2008;372:547-553
5. Fried LF, et al. VA Nephron D Study. *N Engl J Med*. 2013;369:1892-1903

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Agents Used for Chronic Hyperkalemia¹

	SPS ²	Patiromer ³	SZC ⁴
Dose	15g 1–4 times daily Maintenance: once daily	8.4–25.2g daily Titrate by 8.4 g increments	Initial (for up to 48 hours): 10g 3 times daily Maintenance: 10g once daily
Electrolyte disturbances	Hypocalcemia, Hypomagnesemia	Hypomagnesemia (5.3%)- reduction 0.15-0.2 mg	None
Drug interactions	Cation-donating antacids/laxatives, avoid sorbitol, lithium, thyroxine	Binds oral 3 medications (cipro, metformin, levothyroxine) Administer 3 hours apart	Not formally tested—label says oral meds should be spaced by 2 hours

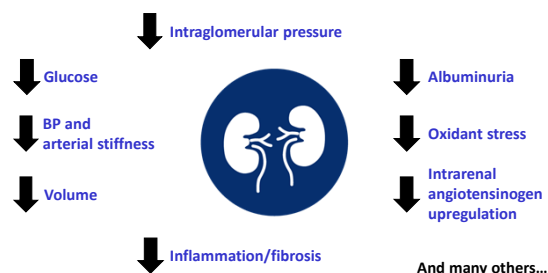
Adverse Effects

- SPS = Sodium polystyrene sulfonate - constipation, diarrhea, nausea, intestinal necrosis (sorbitol formulation - published post-marketing reports)
- Patiromer—constipation, diarrhea, nausea, abdominal discomfort/flatulence, hypomagnesemia
- SZC= Sodium Zirconium Cyclosilicate - edema 16.1% with 10 g dosing, constipation, diarrhea, nausea

1. Initial interventions to consider are diet, diuretics, & sodium bicarbonate
2. FDA Prescribing Information; Lesage L, et al. *Clin J Am Soc Nephrol*. 2015;10: 2136–2142
3. Weir MR, et al. *N Engl J Med*. 2015;372(3):211-21
4. Packham DK, et al. *N Engl J Med*. 2015; 372(3):222-231

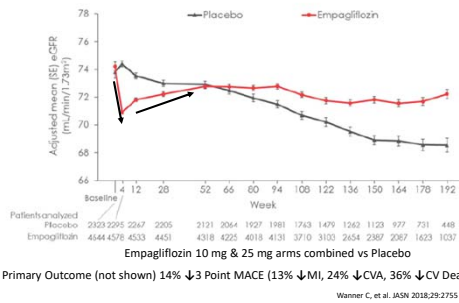
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Many Kidney Effects of SGLT2 Inhibition



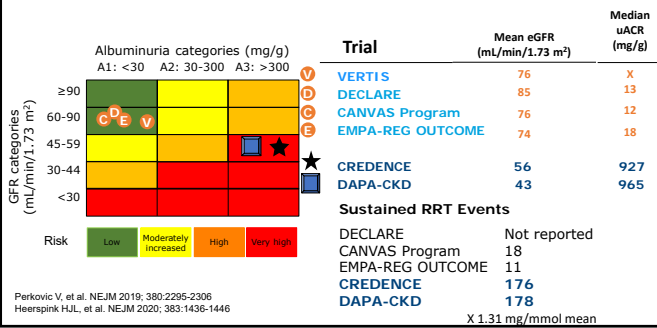
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EMPA-REG OUTCOME Trial: Kidney Function Over Time



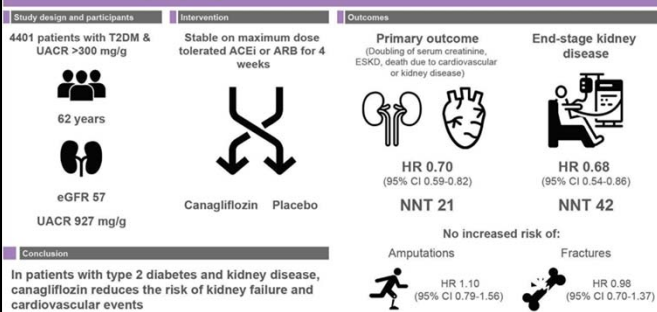
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Kidney Risk in Cohorts Studied with SGLT2 inhibitors

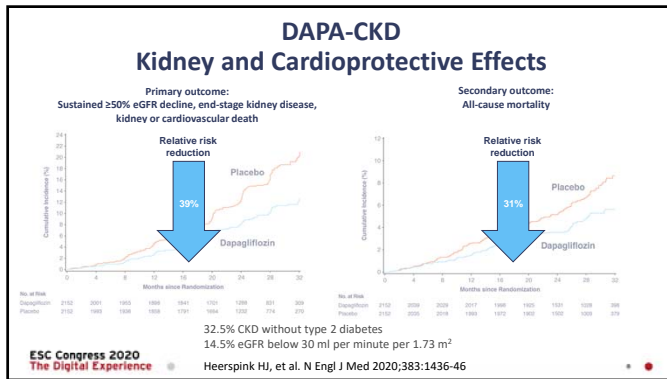


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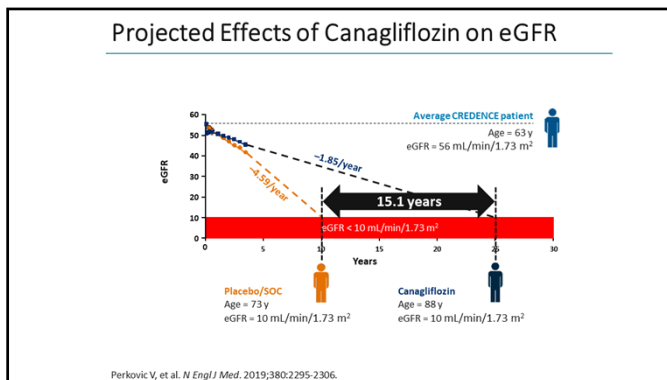
CREDENCE: Canagliflozin and renal outcomes in type 2 diabetes and nephropathy



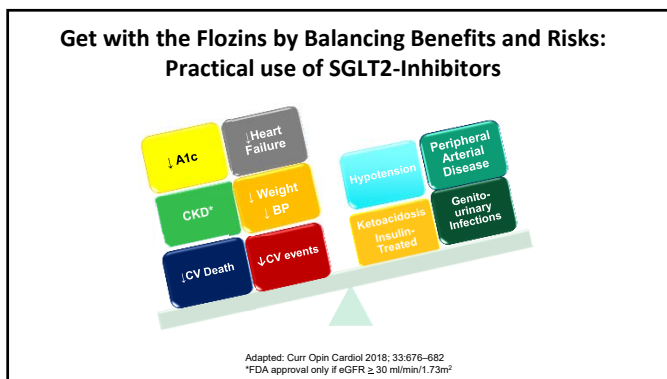
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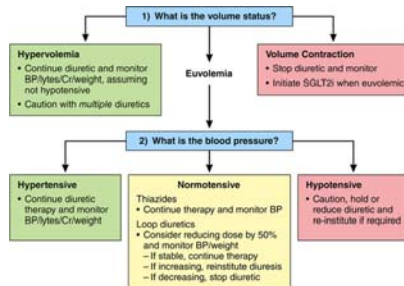


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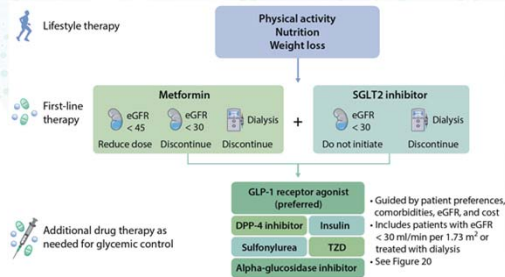
An Approach to Diuretic Use With SGLT-2i



Use of SGLT-2i in the Hands of Cardiologists.
Circulation 2016; 134(24):915-1917

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TREATMENT ALGORITHM FOR SELECTING ANTIHYPERGLYCEMIC DRUGS FOR PATIENTS WITH T2D AND CKD



Kidney Int. 2020; 98(4S):S1-S115

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In my practice, I use a conceptual list of indications for nephrology consultation?

- A. Yes
B. No

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Indications for Nephrology Referral for People with CKD

				Persistent albuminuria categories Description and range		
				A1	A2	A3
				Normal to mildly increased <30 mg/g <3 mg/mmol	Moderately increased 30–300 mg/g 3–30 mg/mmol	Severely increased >300 mg/g >30 mg/mmol
GFR categories (eGFR, L/min/1.73 m ²) Description and range	G1	Normal or high	≥90		Monitor	Refer*
	G2	Mildly decreased	60–89		Monitor	Refer*
	G3a	Mildly to moderately decreased	45–59	Monitor	Monitor	Refer
	G3b	Moderately to severely decreased	30–44	Monitor	Monitor	Refer
	G4	Severely decreased	15–29	Refer*	Refer*	Refer
	G5	Kidney failure	<15	Refer	Refer	Refer

KDOQI US Commentary on the 2012 KDIGO Evaluation and Management of CKD

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Why Refer to Nephrology

- Identify Cause – Kidney biopsy in selected cases
- Slow Progression of CKD
- CKD Complications management
 - CKD Anemia
 - CKD Hyperkalemia
 - CKD Mineral and Bone Disease
 - CKD Metabolic Acidosis
 - CKD Malnutrition
- Medication management
- Kidney Replacement Therapy (KRT) decision making and planning

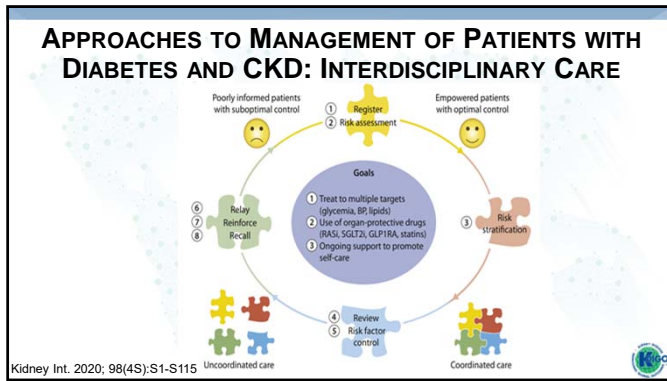
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Observational Studies of Early versus Late Nephrology Consultation

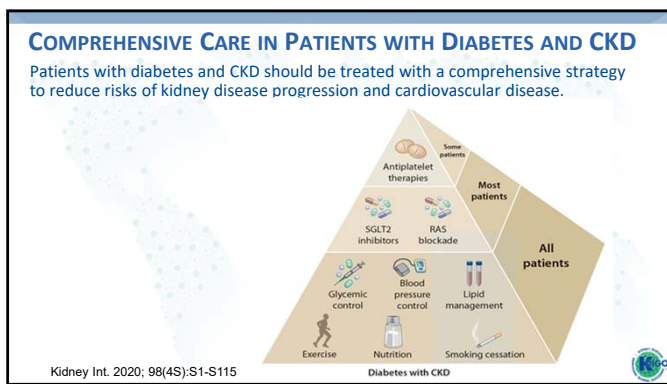
Variable	Early referral Mean (SD)	Late referral mean (SD)	P value
Overall mortality %	11 (3)	23 (4)	<0.0001
1-year mortality %	13 (4)	29 (5)	0.028
Hospital stay, days	13.5 (2.2)	25.3 (3.8)	0.0007
KRT serum albumin (mg/dL)	3.62 (0.05)	3.40 (0.03)	0.001
KRT hematocrit %	30.54 (0.18)	29.71 (0.10)	0.013

Chan M, et al. Am J Med. 2007;120:1063-1070.
KDIGO CKD Work Group. Kidney Int Suppl. 2013;3:1-150.

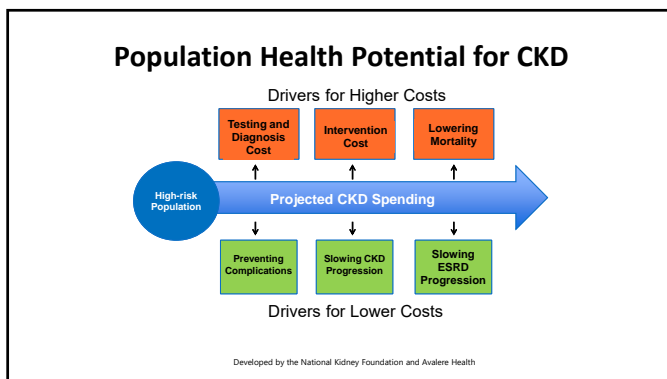
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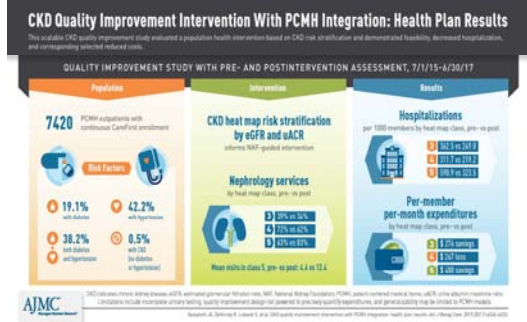
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CKD Population Health Impact: Reduce Hospitalizations and Costs



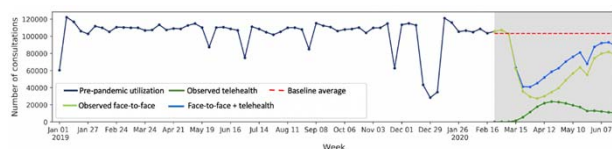
**The Impact of the COVID-19 Pandemic on Outpatient Visits:
Think about how to engage your missing patients.**



Source: Aleev Mehrotra et al. The Impact of the COVID-19 Pandemic on Outpatient Visits: Changing Patterns of Care in the Newest COVID-19 Hot Spots (Commonwealth Fund, Aug.13, 2020). <https://doi.org/10.26099/nyag-q550>

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Who are your Missing Patients?
Telehealth use only partially compensated for missing clinician visits



> 10 million healthcare encounters from the UHG Medicare Advantage population
CKD Stages G3-4 in 2018. Care during the pre-pandemic period (Jan 1, 2019 to Feb 29, 2020) was
used to predict visits for the pandemic period (March 1 to June 30, 2020).

Diamantidis C, Cook D, Westman J et al.:
Missing Care: The Impact of the COVID-19 Pandemic on CKD Care Delivery.
National Kidney Foundation. Abstract Spring Clinical Meeting 2021 (in press).

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CKD Population Health Impact: Summary for Comments and Questions

- Kidney Health Evaluation for Patients with Diabetes (KED)
- Testing with kidney function (eGFR) and albuminuria (uACR)
- Diagnosis
- Risk stratification or heat map
- Interventions
- Patient engagement
- Interdisciplinary care
- Reduce transitions between stages and prevent or delay kidney failure
- Reduce cardiovascular complications
- Contain costs
- Repeat testing at least annually

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Extra Slides for Questions

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eGFR Estimating Equations and Race Coefficients

- MDRD Equation

$$eGFR = 175 \times (S_{Cr})^{-1.154} \times (Age)^{-0.203} \times 0.742[\text{if female}] \times 1.212[\text{if black}]$$
- CKD-EPI Creatinine Equation (2009)

$$eGFR = 141 \times \min(S_{Cr}/\kappa, 1)^{\alpha} \times \max(S_{Cr}/\kappa, 1)^{-1.209} \times 0.993^{\beta_{age}} \times 1.018[\text{if female}] \times 1.159[\text{if black}]$$

$$\kappa = 0.7 \text{ (if female) or } 0.9 \text{ (if male); } \alpha = -0.329 \text{ (if female) or } -0.411 \text{ (if male)}$$
- CKD-EPI Creatinine-Cystatin Equation (2012)

$$eGFR = 135 \times \min(S_{Cr}/\kappa, 1)^{\alpha} \times \max(S_{Cr}/\kappa, 1)^{-0.601} \times \min(S_{Cys}/0.8, 1)^{-0.375} \times \max(S_{Cys}/0.8, 1)^{-0.711} \times 0.993^{\beta_{age}} \times 0.969[\text{if female}] \times 1.08[\text{if black}]$$

$$\kappa = 0.7 \text{ (if female) or } 0.9 \text{ (if male); } \alpha = -0.248 \text{ (if female) or } -0.207 \text{ (if male)}$$
- CKD-EPI Cystatin C Equation (2012)

$$eGFR = 133 \times \min(S_{Cys}/0.8, 1)^{-0.499} \times \max(S_{Cys}/0.8, 1)^{-1.328} \times 0.996^{\beta_{age}} \times 0.932[\text{if female}]$$

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Implications of Removing Race from eGFR Equations

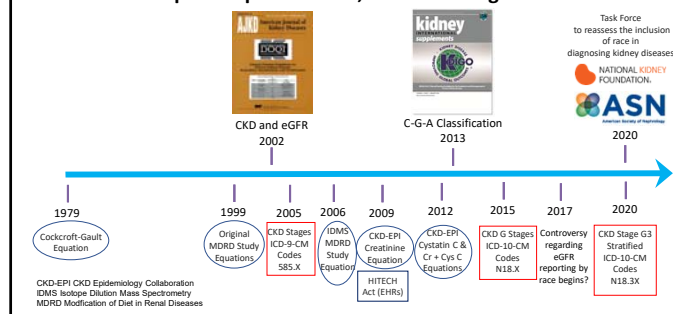
Table. Potential Implications for Black Adults in the US Following Removal of Race from eGFR^a

Implication ^a	eGFR range, mL/min/1.73 m ²	No. in NHANES (weighted %)		Absolute change, weighted % (95% CI)
		Including race	Removing race	
CKD diagnosis	<60	1646 (14.9)	2051 (18.4)	3.5 (1.2-5.9)
Ineligible to donate kidney	<60	3848 (38.5)	4088 (40.6)	2.1 (1.8-2.4)
Reclassification: CKD stage 3b or higher and related drug recommendations ^b	<45	282 (2.3)	439 (3.3)	1.2 (1.0-1.5)
Medical nutrition therapy covered	13-50	724 (5.0)	789 (5.3)	0.47 (0.37-0.60)
Reclassification: CKD stage 4 or higher and related drug recommendations ^b	<30	320 (1.0)	155 (1.3)	0.29 (0.19-0.43)
Referral to nephrologist	<30	357 (3.2)	384 (3.4)	0.22 (0.13-0.35)
Kidney disease education covered	15-29	33 (0.22)	52 (0.36)	0.14 (0.07-0.23)
Eligible for kidney transplant waiting list	<20	74 (0.66)	82 (0.71)	0.051 (0.02-0.10)

Diao JA, et al. JAMA 2021; 325: 184-186

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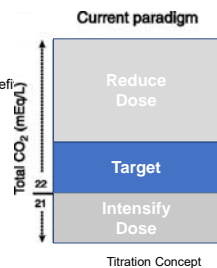
Timeline of Influencers: clinical practice guidelines, GFR equation publications, EHRs and diagnosis codes



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CKD Metabolic Acidosis: Alkali Therapy Implementation

- Patient engagement
 - Protect kidney function
 - Promote bone and muscle health
 - Dietary fruits and vegetables benefit
 - Understand the target
- Titrate to target tCO₂ 22-24 mEq/L
- Sodium load consider initiating or adjusting diuretics



Adapted: Am J Med. 2016 Feb;129(2):153-162

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**Metformin-containing Medicines FDA Labeling Revisions:
Risk of Lactic Acidosis, 4/08/16**

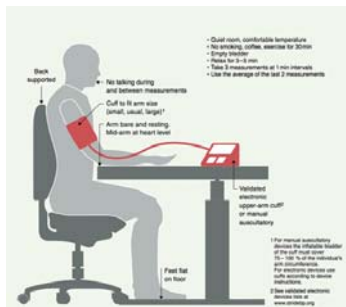
**Metformin is contraindicated in patients with an
eGFR below 30 mL/minute/1.73 m².**

Starting metformin in patients with an eGFR between
30-45 mL/minute/1.73 m² is not recommended

<http://www.fda.gov/downloads/Drugs/DrugSafety/UCM494140.pdf>

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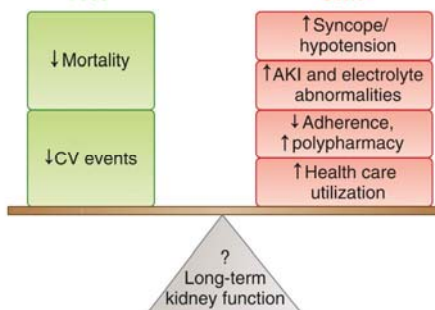
How to Measure Blood Pressure



Thomas Unger. Hypertension. 2020 International Society of Hypertension Global Hypertension Practice Guidelines, 75(6): 1334-1357

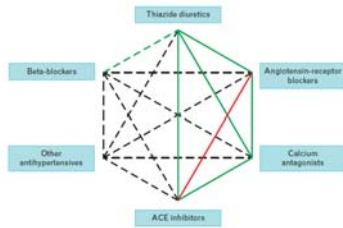
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Pros < 130/80 mm Hg? Cons



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BP Medication Combinations: Conceptual Diagram



Abbreviations:

Green lines = preferred
Green dashes = useful
Black dashes = possible
Red line = not recommended

2013 ESH/ESC Guidelines
J Hypertens 2013

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Prescribing Steps in CKD: One Approach¹

1. ACEi or ARB if albuminuria or proteinuria
2. Diuretic or CCB
3. CCB or Diuretic
4. Mineralocorticoid Receptor Blocker (MRB)*

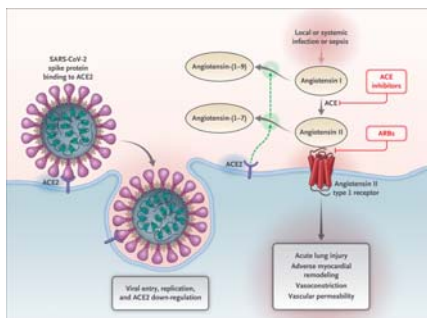
*MRB effective in Resistant HTN based the PATHWAY-2 trial that excluded eGFR <45
AMBER trial² RCT spironolactone vs spironolactone vs patiromer with eGFR 25-45

ACEi = Angiotensin Converting Enzyme Inhibitor
ARB = Angiotensin II Receptor Blocker
CCB = Calcium Channel Blocker

1. Sinha AD, Agarwal R, C. JASN 2019;14(5):757-764
2. Agarwal R, et al. Lancet 2019 394(10208):1540-1550

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ACEi or ARB and SARS-CoV-2



NEJM 2020 Mar 30. doi: 10.1056/NEJMs2005760. [Epub ahead of print]

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ACE inhibitors or ARBs do not increase SARS-CoV-2 Risk: Observational Data*

Over 12 thousand NYC patients with SARS-CoV-2 testing
59.1% + test and 24.6% severe illness

No significant difference in SARS-CoV-2 positive testing
No significant difference in severe illness (data not shown)

Blood Pressure (BP) Medication	Matched Patients Treated with BP Medication +SARS-CoV-2/Total	Matched Patients not Treated with BP Medication +SARS-CoV-2/Total	% Median Difference (95% Confidence Interval)
ACE inhibitor	627/1044 (60.1%)	653/1044 (62.5%)	-2.5 (-6.7 to 1.6)
ARB	664/1137 (58.4%)	639/1137 (56.2%)	2.2 (-1.9 to 6.3)
ACE inhibitor or ARB	1110/1909 (58.1%)	1101/1909 (57.7%)	0.5 (-2.6 to 3.6)
Beta-blocker	912/1686 (54.1%)	976/1686 (57.9%)	-3.8 (-7.2 to -0.4)
Calcium-channel blocker	992/1672 (59.3%)	976/1672 (58.4%)	0.9 (-2.3 to 4.3)
Thiazide diuretic	549/986 (55.7%)	590/986 (59.8%)	-4.2 (-8.5 to 0.2)

*Reynolds HR et al. N Engl J Med 2020;382:2441-2448
BRACE Corona Trial presented at European Society of Cardiology 9/01/20 (unpublished data not shown)
