Medication Dosing for Renal Patients
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July 20, 2017
I, Rebecca Maxson, have no actual or potential conflict of interest in relation to this program.
OBJECTIVES

- Determine the most efficacious and safest dose for a patient
- Estimate any patient’s renal function using both Cockcroft-Gault and Modification of Diet in Renal Disease equations
- Understand the risk versus benefit of different medication doses for patients with kidney disease
- Apply pharmacokinetic and drug database information for drug dosing in kidney dysfunction for key medication classes.
**Problem Scope**

- Approximately 30 million Americans have CKD (14.8%)
- Alabama ranks 5th in the nation for kidney disease
- Hospitalization for acute kidney injury (AKI)
  - ~53,000 Medicare patients age 66+
  - ~20,000 Clinformatics™ patients age 22+
  - ~77,000 Veterans Affairs patients age 22+

## Problem Scope – Medication Dosing

<table>
<thead>
<tr>
<th>Study (year)</th>
<th>Population</th>
<th>Inappropriate (%)</th>
<th>Drugs studied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long et al (2004)</td>
<td>Review of published studies</td>
<td>19% in inpatient 69% in outpatient</td>
<td>various</td>
</tr>
<tr>
<td>ÇERRENE study group (2016)</td>
<td>301 CKD patients at French nephrology centers</td>
<td>38.2 to 53.5%</td>
<td>Oral antidiabetics</td>
</tr>
<tr>
<td>Chang et al (2015)</td>
<td>VA outpatient 73,000 CrCl 30-49 ml/min 11,000 CrCl 15-29 ml/min</td>
<td>CrCl 30-49: 13% CrCl 15-29: 39%</td>
<td>Selected drugs</td>
</tr>
<tr>
<td>Farag et al (2014)</td>
<td>667 pts/mnth, 1,464 scripts/mnth outpatient southwest Ontario</td>
<td>66.3% dose too high 11.5% - nitrofurantoin (CI)</td>
<td>Selected antibiotics</td>
</tr>
</tbody>
</table>

## Problem Scope – Medication Dosing

<table>
<thead>
<tr>
<th>Study (year)</th>
<th>Population</th>
<th>Inappropriate(%)</th>
<th>Drugs studied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Papaioannou et al (2000)</td>
<td>456 pts from 4 LTCF in Southern Ontario</td>
<td>42.3% all pts CrCl &gt; 50: 0.55% CrCl 10-50: 44% CrCl &lt; 10: 100%</td>
<td>Selected drugs</td>
</tr>
<tr>
<td>Hanion et al (2011)</td>
<td>1,304 pts from 133 VA nursing homes</td>
<td>11.9%</td>
<td>Any renally cleared med</td>
</tr>
</tbody>
</table>

In your opinion, what information is most necessary in determining most efficacious and safest dose for a renal patient?

A. Estimated CrCl
B. Estimated GFR
C. Pharmacokinetics of drug
D. Patient’s clinical status
POLL ANYWHERE 1
In your opinion, what information is most necessary in determining most efficacious and safest dose for a renal patient?

A. Estimated CrCl
B. Estimated GFR
C. Pharmacokinetics of drug
D. Patient’s clinical status
Estimating kidney function
WHAT INFORMATION DO YOU USE IN ESTIMATING KIDNEY FUNCTION?

- PollAnywhere text thing
# Markers of Kidney Function

<table>
<thead>
<tr>
<th></th>
<th>Benefits</th>
<th>Pitfalls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inulin</td>
<td>Most accurate</td>
<td>Very expensive, exogenous</td>
</tr>
<tr>
<td>SCr</td>
<td>Easy, inexpensive, ubiquitous lab value</td>
<td>Affected by production</td>
</tr>
<tr>
<td></td>
<td>Filtered AND secreted</td>
<td>Changes lag damage/recovery</td>
</tr>
<tr>
<td>BUN</td>
<td>Easy, inexpensive, ubiquitous lab value</td>
<td>Non-specific for kidney damage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Benign molecule that is a marker for uremic toxins</td>
</tr>
<tr>
<td>Cystatin C</td>
<td>Similar specificity to SCr</td>
<td>More expensive</td>
</tr>
</tbody>
</table>

Pharmacotherapy 2011;31:1130-1144.  
# Markers of Kidney Function

<table>
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<tr>
<th>Benefits</th>
<th>Pitfalls</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UOP</strong></td>
<td>Specific to kidneys</td>
</tr>
<tr>
<td></td>
<td>Hard to measure/quantify</td>
</tr>
<tr>
<td></td>
<td>Difficult to determine quality</td>
</tr>
<tr>
<td><strong>Albuminuria/Proteinuria</strong></td>
<td>Higher risk if present</td>
</tr>
<tr>
<td></td>
<td>Does not quantify kidney function</td>
</tr>
<tr>
<td><strong>Urinalysis</strong></td>
<td>Easy, inexpensive</td>
</tr>
<tr>
<td></td>
<td>Does not quantify kidney function</td>
</tr>
</tbody>
</table>

WHAT ESTIMATING EQUATION IS BEST?

- Poll anywhere text thing...
**COCKCROFT-GAULT (CG)**

- Estimate of creatinine clearance (CrCl) in ml/min
- 249 men with average measured CrCl of 73 ml/min
- Endorsed by FDA for drug development pharmacokinetic studies
- What weight?
  - BMI between 30 and 40: total or actual
  - BMI ≥ 40: lean body weight reduces bias
- Least biased equation in elderly
- EMR systems often report result in pharmacy workflow
  - Know what assumptions are made regarding weight and SCr

\[(140 - \text{age})(\text{wt kg}) \times 0.85 \text{ female} \times \text{SCr} \times 72\]

You see an 85 year old female patient in your LTCF. She has all meals delivered to her room. She lies in bed or sits in her chair in her room most days.

Height 62 in, Weight 53 kg, SCr 0.6

What SCr do you use in estimating her kidney function?
SCr ROUNDING

- Poll anywhere with just text??
BALTIMORE LONGITUDINAL STUDY OF AGING COHORT

- 269 randomly selected pts from 1/1/2005 – 12/31/2010
  - At least 70 yoa, measured CrCl < 70 ml/min, no dialysis, no signs of renal failure
- 103 with SCr < 1 mg/dL
  - mCrCl: 56.2±11.5
  - No rounding: 55.8±15
  - Round to 1: 44.1±10.2
  - P < 0.001 for both comparisons
- Rounding SCr to 1 “leads to an underestimation of renal function and can lead to subtherapeutic doses of critical medications.”

Figure S2

MODIFICATION OF DIET IN RENAL DISEASE (MDRD)

175 x (SCr)^{-1.154} x (age in yrs)^{-0.203} x (0.742 if female) x (1.212 if AA)

- Estimates GFR in ml/min/1.73m^2
- 1,628 patients with average measured GFR of 40 ml/min/1.73m^2
- All patients had CKD
- Average age 51 yo, 6%-male, 88% caucasian
- To individualize (so similar to CG), multiply by BSA
- EMR systems use to report GFR with chem7 labs
- Not accurate >60 ml/min/1.73m^2

CHRONIC KIDNEY DISEASE EPIDEMIOLOGY COLLABORATION (CKD-EPI)

177.6 x (Scr)$^{-0.65}$ x (CysC)$^{-0.57}$ x (age)$^{-0.2}$ x (0.82 female) x (1.11 AA)

- Estimates GFR in ml/min/1.73m²
- Pooled study of 5,500 patients with mean GFR of 68±40 ml/min/1.73m²
- Most appropriate for patients with eGFR of 60-199 ml/min/1.73m²
- To individualize (so similar to CG), multiply by BSA

Are they all the same? Are they interchangeable?

A. Yes
B. No
Are they all the same? Are they interchangeable?

A. Pollanywhere slide
### MDRD vs CG

<table>
<thead>
<tr>
<th>Study (year)</th>
<th>Population</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemsen et al (2009)</td>
<td>372 pts, Nebraska Med Ctr antimicrobials</td>
<td>• Mean MDRD:CG 1.41 (0.84-1.98)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 35.7% with different dose</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 99% need higher dose with MDRD</td>
</tr>
<tr>
<td>Golik and Lawrence (2008)</td>
<td>207 pts, Tufts Med Ctr Boston antimicrobials Multiple versions CG/MDRD</td>
<td>• Best correlation: unadjusted MDRD and CG with IBW and adjusted SCR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Mean discordance 16.5 ml/min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 22.8-36.3% discordant dose</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• MDRD had higher doses</td>
</tr>
<tr>
<td>Wargo et al (2006)</td>
<td>409 pts, Huntsville hospital Antimicrobials Multiple versions CG/MDRD</td>
<td>• Mean MDRD/CG: 40.2 vs 34.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 20-36% discordant rate (p &lt; 0.001)</td>
</tr>
</tbody>
</table>

# CKD-EPI vs CG

<table>
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</thead>
<tbody>
<tr>
<td>Wargo and English (2010)</td>
<td>409 pts, Huntsville hospital Antimicrobials</td>
<td>• For 95% of cases, CKD-EPI may be 15.3 ml/min above or 5.1 ml/min below CG</td>
</tr>
<tr>
<td></td>
<td>Multiple versions CG</td>
<td>• 15-25% discordant rate</td>
</tr>
</tbody>
</table>

Ann Pharmacother 2010;44:439-446.
WHICH EQUATION???

- Cerrene study group, 2016
  - 301 CKD pts in France, oral antidiabetics
  - Inappropriate dose
    - CKD-EPI 53.5%
    - CKD-EPI individualized 45.9%
    - CG 38.2%

- Hanion et al, 2011
  - 1.304 VA nursing home pts, renally cleared medications
  - Inappropriate dose
    - MDRD 5.9%
    - CG 11.9%

Park et al, 2012

- FDA data on all new molecular entities approved between 1998 and 2010 - \(26\)
- Looked at recommended renal dose adjustments if MDRD, MDRD individualized (BSA) or CG was used
- \(8\%\) required dose change between CG and MDRD individualized
- \(16\%\) required dose change between CG and MDRD
- After looking at many variables, authors concluded:

“For patients with advanced age, low weight, and modestly elevated serum creatinine concentration values, further work is needed before the MDRD equations can replace the CG equation for dose adjustment in approved product information labeling”

What do we do????

- Do not exclusively use the values reported in EMR for drug adjustments.
- Calculate a quick CrCl using CG (with weight and without).
- Compare it to the value reported by the lab EMR (usually MDRD).
- Consult the FDA recommendations for renal dose adjustments using the prescribing information or a trusted drug database.
- Think about the risk/benefit for the patient for the given medication.
- Choose the best dose for your individual patient.

Pharmacotherapy 2011;31:1130-1144.
WAIT… YOU WANT ME TO DO ALL THIS MATH?????

Remember – GFR by MDRD is with labs and CrCl by CG is in pharmacy workflow

But these use one specific formula – only one weight or no weight, etc
Application Case
UTI/SEPSIS IN 85 YEAR OLD MALE

85 YOAAM, NHR, admitted with altered mental status. Urinalysis indicates a UTI. WBC elevated, hypotensive, tachycardic, temp 101 deg F. Admitted to ICU with possible sepsis. All other medical treatment is correct and cultures later show a levofloxacin-sensitive E. coli as the causative agent for UTI and bacteremia. On admission to ICU, you are asked to recommend a dose for levofloxacin (other antibiotics are also ordered empirically but we are focusing on levofloxacin).

Ht: 65 in  
Wt: 150 lbs (68 kg)  
IBW: 61.5 kg  
BSA: 1.75 m²

SCr: 1.8 mg/dL (baseline)

CrCl: 28.86 (actual wt)  
26.1 (IBW)

MDRD: 44
WHAT DOSE OF LEVOFLOXACIN DO YOU RECOMMEND?

A. 750 mg IV daily
B. 500 mg IV daily
C. 750 mg IV q48h
D. 750 mg x 1 then 500 mg IV q48h
WHAT IF CRCL RANGED FROM 18 TO 22 ML/MIN DEPENDING ON PATIENT'S WEIGHT AND MDRD WAS 20?

A. 750 mg IV daily
B. 500 mg IV daily
C. 750 mg IV q48h
D. 750 mg x 1 then 500 mg IV q48h
A few examples of inappropriate renal dosing
65 yof seen in ED for ongoing pain in right middle finger. ED provider notes that end of finger is red, swollen and painful. No labs drawn in the ED.

**PMH:** HTN, hypothyroidism, DM, CKD stage 4

**Home meds:** furosemide, enalapril, calcitriol, levothyroxine, sodium bicarbonate, atorvastatin 80 mg daily

**Previous labs:**

- **K** (3.1-5) 3.9 mEq/L
- **SCr** (0.4-1.2) 3.1 mg/dL
- **CrCl** 28.27 ml/min
- **GFR** 18 ml/min/1.73m²

After opening the wound, the patient is sent home with TMP-SMX 160/800 mg BID and cephalexin 500 mg QID x 10 days.
Based on previous scenario, which of the following outcomes would you expect?

A. No changes, appropriate antimicrobial coverage and dose
B. SCr and K will increase
C. SCr and K will decrease
D. SCr will stay the same and K will increase
E. SCr will stay the same and K will decrease
NP in my clinic saw the ED note. Pt was called and instructed to stop TMP-SMX. The pt stopped this medication after 4 days.

Pt’s finger was worse when seen in CKD clinic. Why? No MRSA coverage with cephalexin (which was also dosed inappropriately and put pt at risk for CNS ADRs). Sent back to the ED. This time home on clindamycin and another follow up for labs.

<table>
<thead>
<tr>
<th></th>
<th>Historical</th>
<th>1 week post TMP-SMX</th>
<th>2 weeks post TMP-SMX</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>K</strong></td>
<td>(3.1-5)</td>
<td>3.9 mEq/L</td>
<td>5.5 mEq/L</td>
</tr>
<tr>
<td><strong>Scr</strong></td>
<td>(0.4-1.2)</td>
<td>3.1 mg/dL</td>
<td>5 mg/dL</td>
</tr>
<tr>
<td><strong>CrCl</strong></td>
<td>28.27 ml/min</td>
<td>17.5 ml/min</td>
<td>24.35 ml/min</td>
</tr>
<tr>
<td><strong>GFR</strong></td>
<td>18 ml/min/1.73m²</td>
<td>11 ml/min/1.73m²</td>
<td>15 ml/min/1.73m²</td>
</tr>
</tbody>
</table>
**Rebecca’s Bactrim Rant**

- PLEASE ask your patient if they have kidney disease before dispensing full dose TMP-SMX (1 DS BID).
- MOST (well 60%) of kidney patients will admit that they have kidney disease. They might even know their last GFR or stage of CKD.
- Call the prescriber and discuss renally adjusting the dose or changing to another agent (clindamycin or linezolid).
- This drug puts my patients at risk for life-threatening hyperkalemia and/or initiation of dialysis.
- In this case, prescribing and dispensing full dose TMP-SMX led to
  - Decreased renal function, hyperkalemia
  - Another visit to the clinic, another visit to the ED, a second antibiotic
Direct Oral Anticoagulants (DOACs)
58 yof (163 kg) with Afib is started on dabigatran 150 mg PO BID.

PMH: HFpEF (EF 60%), obesity, DM, COPD, hypothyroidism

Home meds: insulin glargine, levothyroxine, loratidine, losartan, paroxetine, ranitidine, albuterol, alprazolam, MVI

Baseline SCr: 1.5 mg/dL (CrCl 47 ml/min without weight, 105 ml/min with actual body weight, GFR 36 ml/min/1.73m²)

<table>
<thead>
<tr>
<th></th>
<th>Typical Dose</th>
<th>Renal Dosing (CrCl ml/min, SCr mg/dL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dabigatran</td>
<td>150 mg BID</td>
<td>CrCl 15-30: 75 mg BID, CrCl &lt;15: not recommended</td>
</tr>
</tbody>
</table>

DOACS CASE

Presented to ED after three months of dabigatran with following complaints:

- Worsening SOB
- Increasing edema
- Multiple blisters/bullae on lower legs
- Vaginal bleeding, hematuria and multiple large bruises

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>ED</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCr</td>
<td>1.5 mg/dL</td>
<td>2.6 mg/dL</td>
</tr>
<tr>
<td>CrCl</td>
<td>47-105 ml/min</td>
<td>27-61 ml/min</td>
</tr>
<tr>
<td>GFR</td>
<td>36 ml/min/1.73m²</td>
<td>19 ml/min/1.73m²</td>
</tr>
</tbody>
</table>

Patient treated with idarucizumab and hemodialysis. Renal function did not recover. Hospitalized for two months.

DOACs Take Home Points

- Need for multiple estimates of kidney function.
- Dabigatran was NOT inappropriately dosed **BUT**
  - Patient’s renal function declined without anyone knowing
  - FOLLOW-UP is critical in patient’s at risk for declining renal function
- Risk factors for renal decline in this patient
  - Pre-existing CKD
  - Diabetes mellitus
  - HFpEF
  - Obesity
  - COPD
  - Losartan

DOACs TAKE HOME POINTS

- The renal dosing recommendations in the labels for DOACS are primarily from small pharmacokinetic studies that compare anti-Xa levels in patients with and without renal disease OR extrapolated from small subsets of renal patients in the clinical trials.
  - MAJORITY of clinical trials excluded patients with CrCl < 30 ml/min
  - USE THIS DATA WITH CAUTION!
  - CONSTANT VIGILANCE AND FOLLOWUP
Gabapentin
GABAPENTIN…OLD DRUG, NEW USES

- FDA-indications: postherpetic neuralgia and adjunctive therapy for partial seizures
- Primary use: pain syndromes included migraines, phantom limb pain, cancer-related pain, spinal cord injury and neuropathic pain
- Estimate 90% of gabapentin sales are for off-label indications
- Minimal metabolism
- Elimination is exclusively renal

POLLANYWHERE

- What are signs of gabapentin toxicity?
# GABAPENTIN IN CKD

<table>
<thead>
<tr>
<th></th>
<th>Group I</th>
<th>Group II</th>
<th>Group III</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of pts</td>
<td>126</td>
<td>594</td>
<td>9</td>
</tr>
<tr>
<td>eGFR (MDRD, ml/min/1.73m²)</td>
<td>108.5±1.8</td>
<td>65.6±0.69</td>
<td>dialysis</td>
</tr>
<tr>
<td>Gabapentin dose (mg/day)</td>
<td>1922±118</td>
<td>1830±45.3</td>
<td>1254±217.2</td>
</tr>
<tr>
<td>Pts with toxicity</td>
<td>0</td>
<td>33 (5.56%)</td>
<td>7 (77.8%)</td>
</tr>
<tr>
<td>Mean gabapentin concentration (mcg/mL)</td>
<td>--</td>
<td>29.1±2.46</td>
<td>54.7±15.9</td>
</tr>
</tbody>
</table>

> “Individuals with symptomatic gabapentin toxicity were significantly older and had a higher number of clinical diagnoses.”

GABAPENTIN CASE

75 yof complains of right-sided hip pain. Initiated on gabapentin 300 mg PO TID.
PMH: congenital L hip dislocation and hemiarthroplasty, B knee OA, HTN
Home meds: diclofenac 75 mg BID, tramadol 50 mg QID, dihydrocodeine 30 mg QID, furosemide 80 mg daily, amlodipine 5 mg daily, irbesartan 300 mg daily.
Baseline SCr: 1.3 mg/dL (GFR 43 ml/min/1.73m²)

Two days after starting gabapentin, pt falls at home. She is admitted from the ED as she was drowsy, disoriented and disheveled.
# Gabapentin Case – Hospital Course

<table>
<thead>
<tr>
<th>Day</th>
<th>Symptoms/diagnosis</th>
<th>SCr mg/dL</th>
<th>Gabapentin dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admit</td>
<td>R hip pain and biliary infection, Sleepy but easily rousable, Start IV fluids, antibiotics/stop diclofenac, irbesartan</td>
<td>1.56 GFR 34</td>
<td>300 mg TID</td>
</tr>
<tr>
<td>7</td>
<td>Drowsier and increasingly hypotensive, Continue IVF/stop tramadol, dihydrocodeine</td>
<td>1.93 GFR 12</td>
<td>300 mg TID</td>
</tr>
<tr>
<td>10</td>
<td>Unconscious with minimal respiratory effort, Move to ICU, IVF, IV norepinephrine, meropenem</td>
<td></td>
<td>300 mg TID</td>
</tr>
<tr>
<td>10 PM</td>
<td>Persistently drowsy, occasional myoclonic jerks, ruled out hypotension as cause, 800 mcg naloxone – no change, Start CRRT for gabapentin removal, support kidneys</td>
<td></td>
<td>Stopped</td>
</tr>
<tr>
<td>11</td>
<td>Noticeably more lucid, able to cooperate</td>
<td></td>
<td>Not restarted</td>
</tr>
<tr>
<td>D/C</td>
<td>No growth in all cultures</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The “Triple Whammy”
TRIPLE WHAMMY

- Trends of AKI with the combination of NSAIDs, ACEI/ARBs and diuretics
- Why?
  - Diuretics and NSAIDs decrease blood flow to kidneys
  - ACEI/ARBs block RAAS
  - Kidneys can’t adequately adjust to decreased blood flow because of RAAS blockade

Renal Failure 2014;36:1166-1168.
**TRIPLE WHAMMY**

<table>
<thead>
<tr>
<th>Study (year)</th>
<th>Population</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lapi et al (2013)</td>
<td>Cohort of pts on antiHTN agents 1/1/97 – 12/31/08</td>
<td>• 31% higher rate of AKI with triple therapy (RR 1.31, 1.12-1.53)</td>
</tr>
</tbody>
</table>
| Muriithi et al (2014) | 133 pts with biopsy-proven acute interstitial nephritis (AIN), Mayo clinic | • 71% drug-related  
  • 35% antibiotics  
  • 10% PPIs  
  • 7% NSAIDs  
  • 20% other causes – autoimmune, infections, etc |
CASE EXAMPLE

79 yof discharged home after treatment with omeprazole for abdominal pain.

PMH: HTN, depression, arthritis

D/C meds: furosemide, aspirin, carvedilol, omeprazole, ramipril

At a home visit, pt was noted to have worsening depression, R shoulder pain and cystitis.

Meds added: ketoprofen, ciprofloxac in
CASE EXAMPLE

79 yof on triple whammy.

One week later: presents to ED with anorexia, asthenia and facial swelling

New diagnosis of heart failure (previous EF 68%), pleural effusion, metabolic acidosis (pH 6.4) and AKI (SCr 5.6 mg/dL from 0.82 mg/dL).

Treated with bicarbonate infusion and hemodialysis without success

Pt died 13 days after admission
CASE EXAMPLE – AUTHOR’S CONCLUSIONS

- “NSAIDs are very dangerous and potentially harmful when co-administered with ACEIs or diuretics”
- This pt developed AKI one week after starting NSAID
- Ciprofloxacin might also be implicated – some reports of nephrotoxicity
- Also possible that change in clinical status induced cardiorenal syndrome which lead to HF and death
SUMMARY

- Choosing a medication dose for a kidney patient REQUIRES clinical assessment.
- Choosing one estimating equation based on one SCr value and the information in a drug database is NOT ideal care.
- Need a range of CrCl and GFR values to truly assess renal function.
- Choose dose based on RISK vs BENEFIT.
- Inappropriate dosing leads to poor patient outcomes.
- Clinical FOLLOWUP!
- Kidney practitioners HATE TMP-SMX and NSAIDs in our patients.
Medication Dosing for Renal Patients

Rebecca Maxson, PharmD, BCPS
Assistant Clinical Professor, Harrison School of Pharmacy
CKD clinic at UAB’s The Kirklin Clinic
July 20, 2017