Medication Management and Mismanagement in Chronic Kidney Disease

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ACOI Hospital Medicine Course
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Disclosures

• None, just working for The Man
Scope of the Problem

- Increasing incidence of Acute Kidney Injury (AKI) and Chronic Kidney Disease (CKD)
- With a change in renal function there is a corresponding alteration in pharmacokinetic and pharmacodynamics of drugs
- Markers of renal function may not accurately represent true function
The person who takes medicine must recover twice, once from the disease and once from the medicine

Sir William Osler
Definitions

- **Acute Kidney Injury (AKI):** a 50% decrease in renal function, roughly a doubling of the serum creatinine.

- **Chronic Kidney Disease (CKD):** a GFR < 60 ml/min. per 1.73 m² (Stage 3) CKD, this is when drug dosages need to be evaluated.
### KDIGO Staging of CKD 2012

#### Guide to Frequency of Monitoring (number of times per year) by GFR and Albuminuria Category

<table>
<thead>
<tr>
<th>GFR categories \ Description and range</th>
<th>Persistent albuminuria categories</th>
<th>Description and range</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1 Normal or high \ \ \ \ \ \ ≥90</td>
<td>A1 Normal to mildly increased</td>
<td>&lt;30 mg/g &lt;3 mg/mmol</td>
</tr>
<tr>
<td>G2 Mildly decreased \ \ 60–89</td>
<td>A2 Moderately increased</td>
<td>30–300 mg/g 3–30 mg/mmol</td>
</tr>
<tr>
<td>G3a Mildly to moderately decreased \ 45–59</td>
<td>A3 Severely increased</td>
<td>&gt;300 mg/g &gt;30 mg/mmol</td>
</tr>
<tr>
<td>G3b Moderately to severely decreased \ 30–44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G4 Severely decreased \ 15–29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G5 Kidney failure \ &lt;15</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Persistent albuminuria categories

- **A1 Normal to mildly increased**
  - <30 mg/g <3 mg/mmol
- **A2 Moderately increased**
  - 30–300 mg/g 3–30 mg/mmol
- **A3 Severely increased**
  - >300 mg/g >30 mg/mmol
# CKD Staging

Table 1. Definition of CKD Stages Based on GFR*

<table>
<thead>
<tr>
<th>CKD Stage</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kidney damage with GFR $\geq$ 90 mL/min/1.73 m²</td>
</tr>
<tr>
<td>2</td>
<td>Kidney damage with GFR of 60–89 mL/min/1.73 m²</td>
</tr>
<tr>
<td>3</td>
<td>GFR of 30–59 mL/min/1.73 m²</td>
</tr>
<tr>
<td>4</td>
<td>GFR of 15–29 mL/min/1.73 m²</td>
</tr>
<tr>
<td>5</td>
<td>GFR $&lt;$ 15 mL/min/1.73 m², or kidney failure treated by dialysis or transplantation</td>
</tr>
</tbody>
</table>

CKD = chronic kidney disease; GFR = glomerular filtration rate.  
* Adapted from reference 3. The Kidney Disease: Improving Global Outcomes Work Group recently updated its definition of CKD progression to include consideration of both GFR and albuminuria stages (2).
Assessment of Renal Function

The patient must be at a steady metabolic state (good or poor but steady)

Urine based: 24 urine collection for creatinine clearance

Serum Creatinine based: other factors taken into consideration

Cystatin C: not available yet
24 hour urine collection

• Considered the “gold standard” but fraught with errors.

Creatinine Clearance = \( \frac{U_{\text{creat.}} \times Vol. \text{ urine}}{\text{Screat.}} \) m\(^2\)/min per m\(^2\)

- Erroneous collection: under or over collected
- Takes >24 hours for results
- Inaccurate in AKI
Serum Creatinine based

**Advantages:**
- Cr is freely filtered, not protein bound or reabsorbed
- Small amt. secreted DT
- Easily measured
- Consistent excretion over a wide range of GFRs (steady state)

**Disadvantages:**
- Not accurate in AKI
- Level varies with analytical method
- Not all creatinine levels are created equal
Serum creatinine

- The balance between muscle metabolism (anabolism and catabolism) and renal excretion
Commonly Utilized Equations to Estimate GFR

<table>
<thead>
<tr>
<th>Table 3 – Formulas for estimating glomerular filtration rate*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cockcroft-Gault</strong>&lt;sup&gt;5&lt;/sup&gt;</td>
</tr>
</tbody>
</table>
| \[
\frac{(140 - \text{age}) \times (\text{IBW})}{\text{SCr} \times 72}
\] |
| **Modified MDRD**<sup>6†</sup> (female)                     |
| \[
186.3 \times \text{SCr}^{-1.154} \times \text{age}^{-0.203} \times 0.742 \times 1.210
\] |

IBW, ideal body weight; SCr, serum creatinine; MDRD, Modification of Diet in Renal Disease.

*Age, years; IBW, kg; SCr, mg/dL.
†An online calculator based on the modified MDRD equation can be found at:
Factors that Increase Creatinine Levels

- Decreased renal function acute or chronic
- Male
- African American (compared to whites)
- Muscle damage/trauma (rhabdomyolysis, necrotizing infection, seizure, restraints, exercise)
- Cooked meat
- Creatine

http://www.clevelandclinicmeded.com/medicalpubs/diseasemanagement/nephrology/kidney-function/ accessed 01/14/16
Factors leading to a low creatinine

- Decreased muscle mass
- Liver disease
- Malnutrition/Vegetarians
- Over hydration
- Low albumin (cirrhosis, NS, SIRS)

All Creatinine Levels are Not Created Equal

- A 28 year old male, 73 kg., serum creatinine (Scr) 1.1 mg/dl, GFR 102 ml/min.

- A 77 year old female, 37 kg., Scr 0.6 mg/dl, GFR 46 ml/min.

- After several days in the hospital her Scr is now 1.1 mg/dl, GFR 25 ml/min.

- While still in the “normal range, her creatinine has doubled = AKI
A Tale of Two Creatinines

- 28 year old male, 73 kg, Scr 1.1 mg/dl, GFR 102 ml/min.
- Both kidneys are removed, 24 hours later Scr is 2.0 mg/dl, calculated GFR 57 ml/min.
- What is the GFR?

- All calculations used the Cockcroft-Gault Equation.
Drug Dosage in AKI

• Limited research data
• Creatinine does not reflect renal function; can use GFR for loading doses
• Rate of change of GFR or creatinine may help
• Other factors: Intake and output, BUN, serum \( \text{HCO}_3^- \), phosphorus, influence of dialysis
Best resources for drug dosing in AKI or CKD

- Clinical pharmacist
- Nephrologist
- Both can keep the patient (and you) out of trouble
- As renal function changes so do many drug dosages
Drug Resources

- Available as a book and app
- [http://renalpharmacyconsultants.com/](http://renalpharmacyconsultants.com/)
- A number of sites available
Common sequence in MSOF

Respiratory dysfunction

Cardiac dysfunction: vasodilatation, low BP

Hepatic dysfunction/congestion

Renal dysfunction: pre-renal to renal
Factors in AKI

- Hydration status (ongoing)
- Hemodynamic: BP C.O.
- Leaky capillaries

- Hypoalbuminemia
- Decreased nutrition
- Decreased hepatic perfusion and function
- Decreased protein synthesis
- Competitive inhibition from other drugs
Best resources for drug dosing in AKI or CKD

- Clinical pharmacist
- Nephrologist
- Both can keep the patient (and you) out of trouble
- As renal function changes so do many drug dosages
Drug dosage in AKI

Loading dose: Increased Volume of distribution ($V_D$) esp. hydrophilic meds (b-lactams, cephalosporins, penems) consider increasing LD by 25-50% of normal

Maintenance dose: non renal clearance of vanco, imipenem and ceftizoxime

Monitor: drug levels if possible
Hemodialysis

• Nephrology* should assist with timing and dosage consideration of certain meds e.g. aminoglycosides, vancomycin

• p.s. Please do not order post dialysis labs unless requested by nephrology

*when available
Hemodialysis Drug Dosage Factors

• Molecular weight: lower easier to remove w/ HD (Lithium, ASA)
• Protein binding
• Volume of distribution
• Dialyzer factor: fiber type, pore size
• Blood flow and dialysate flow rates
• Ultrafiltration rate
CRRT

- Very limited data
- CVVHD and SLED
- Diffusion or convection or both
- Replacement fluid use
- Ultrafiltration rate
- Follow levels if possible
Vancomycin

• Glycopeptide
• Early preparations had higher incidence of AKI
• AKI 5-15% today, esp. w/ beta lactam-Zosyn
• Used in more critically ill patients or with underlying disease risk factors
• Sometimes used w/ aminoglycosides
• AKI associated with elevated trough levels
Vancomycin dosage

Dose based on 15-20 mg/kg of actual weight*
Do not exceed 2.0 gm per dose
Do not exceed 4 gm/day total dosage
Possible benefit with continuous infusion but soft data
Keep trough >10 mcg/ml (15-20 mcg/ml)
Draw trough 30 min. prior to next dose
Draw pre-dialysis for re-dosing

*YMMV at your institution
Aminoglycosides

- Drug is reabsorbed in the proximal tubule, enhanced with volume depletion
- Can lead to a Fanconi’s syndrome: hypokalemia, hypomagnesemia, hypocalcemia, hypophosphatemia
Aminoglycosides

• In AKI or CKD cost to benefit ratio
• Do not use alone, but increased risk of toxicity with other nephrotoxins
• Order of toxicity: gentamicin > tobramycin > amikacin
Mechanism of toxicity in proximal tubule
Risk Factors Aminoglycoside AKI

Dosage, frequency and duration of therapy
Age
Hypoperfusion (CHF, sepsis, dehydration, hypotension)
Concomitant medications (vancomycin)
Comorbid conditions (sepsis, diabetes, leukemia)
Elevated trough levels
Decreased renal function
Choice of aminoglycoside
Initial dosage*

- Use current weight unless obese and >125% of IBW
- Obese weight in kg = IBW + [0.4 × TBW - IBW]
- Males IBW kg = 50 + (2.3 × inches above 60)
- Female IBW kg = 45 + (2.3 × inches above 60)

*YMMV at your institution
**Dosage frequency**

<table>
<thead>
<tr>
<th>Drug</th>
<th>Dosage (mg/kg)</th>
<th>CcrI &gt; 60 (ml/min)</th>
<th>CcrI 40-59 (ml/min)</th>
<th>CcrI 20-39 (ml/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amikacin</td>
<td>15</td>
<td>Every 24 hrs</td>
<td>36 hrs</td>
<td>48 hrs</td>
</tr>
<tr>
<td>Gentamicin</td>
<td>5-7</td>
<td>Every 24 hrs</td>
<td>36 hrs</td>
<td>48 hrs</td>
</tr>
<tr>
<td>Netilmicin</td>
<td>5-7</td>
<td>Every 24 hrs</td>
<td>36 hrs</td>
<td>48 hrs</td>
</tr>
<tr>
<td>Tobramycin</td>
<td>5-7</td>
<td>Every 24 hrs</td>
<td>36 hrs</td>
<td>48 hrs</td>
</tr>
</tbody>
</table>

*YMMV at your institution*
Gentamicin and Tobramycin
AKI/CKD

- Correct hypokalemia and hypomagnesemia which can aggravate toxicity
- Measure level before dialysis and give after treatment
### Extended interval aminoglycoside dose and dosing interval in adults by renal function

<table>
<thead>
<tr>
<th>Creatinine clearance* (mL/min/70 kg)</th>
<th>Initial and maintenance dose †</th>
<th>Initial dosing interval (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥120</td>
<td>Use traditional intermittent dosing</td>
<td></td>
</tr>
<tr>
<td>60 to 119</td>
<td>Infuse over 1 hour:</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>7 mg/kg for gentamicin or tobramycin</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15 mg/kg for amikacin</td>
<td></td>
</tr>
<tr>
<td>40 to 59</td>
<td>Infuse over 1 hour:</td>
<td>36 (or use traditional intermittent dosing)</td>
</tr>
<tr>
<td></td>
<td>7 mg/kg for gentamicin or tobramycin</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15 mg/kg for amikacin</td>
<td></td>
</tr>
<tr>
<td>&lt;40†</td>
<td>Use traditional intermittent dosing</td>
<td></td>
</tr>
</tbody>
</table>

The maintenance dose and dosing intervals may need to be adjusted based on results of serum drug concentration monitoring. This is discussed in the topic review of aminoglycoside dosing, section on drug concentration monitoring. Extended interval aminoglycoside dosing is not recommended for particular indications and populations. As an example, the doses listed in this table do NOT apply to aminoglycosides being used as synergistic therapy for gram positive infections or aminoglycoside use in cystic fibrosis patients. Such exclusions are discussed in more detail in the topic on aminoglycoside dosing.

* Creatinine clearance may be estimated by use of Cockcroft-Gault equation. Calculators for estimation of creatinine clearance are available in UpToDate.
† The appropriate dosing weight to use for dose calculation is discussed in the topic on aminoglycoside dosing.
△ Some institutions use a lower threshold of 20 to 30 mL/min for using traditional intermittent instead of extended interval dosing. In such cases, for patients who have a creatinine clearance between this lower limit and 40 mL/min, the calculated aminoglycoside dose is administered at a 48-hour interval.
## Recommended loading dose for traditional, intermittent dosing of gentamicin or tobramycin in adults

<table>
<thead>
<tr>
<th>Site of Infection or Indication</th>
<th>Desired peak concentration</th>
<th>Loading dose, mg/kg* † Δ</th>
<th>Loading dose, mg/kg* † Δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gentamicin synergy with beta-lactams for treatment of serious gram-positive infections</td>
<td>3 to 4 mcg/mL</td>
<td>1 (initial dose, not a loading dose)</td>
<td></td>
</tr>
<tr>
<td>Uncomplicated lower urinary tract infection</td>
<td>2 to 4 mcg/mL</td>
<td>1 (initial dose, not a loading dose)</td>
<td></td>
</tr>
<tr>
<td>Gram-negative sepsis or other serious gram-negative infections, including pseudomonal infection, gram-negative pneumonia, and acute life-threatening gram-negative infection in a critically ill patient*</td>
<td>7 to 10 mcg/mL</td>
<td>2.5 to 3</td>
<td></td>
</tr>
</tbody>
</table>

These loading doses are used when a traditional, intermittent dosing strategy is being employed. For many patients, the preferred dosing strategy is extended-interval. Refer to aminoglycosides topic discussion of selection of dosing strategy.

* The loading dose is not adjusted for renal impairment.
† For overweight or obese patients, ideal body weight or dosing weight (respectively) should be used for scaling dose. A calculator to determine ideal body weight and dosing weight is available in UpToDate.
Δ These loading dose recommendations do not apply to special populations (ie, pregnant women, patients with ascites, severe burns, critical illness, fluid overload, cystic fibrosis) who may have altered aminoglycoside pharmacokinetics. A modified loading dose and approach to dose adjustment may be needed. Refer to topic discussion.
° Aminoglycosides should generally not be used as single agent therapy for serious infections due to typical gram-negative rods. Exceptions include uncomplicated lower urinary tract infections, tularemia, and plague.

*This table lists doses recommended by UpToDate contributors based on pharmacokinetic data and institutional experience.*
**Maintenance dose nomogram for traditional, intermittent dosing of gentamicin and tobramycin in adults**

<table>
<thead>
<tr>
<th>Creatinine clearance ‡ conventional unit (mL/minute)</th>
<th>Creatinine clearance ‡ SI unit (mL/second)</th>
<th>Maintenance dose (percent of loading dose △)</th>
<th>Dose interval (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;90</td>
<td>&gt;1.5</td>
<td>84</td>
<td>8</td>
</tr>
<tr>
<td>80 to 90</td>
<td>1.3 to 1.5</td>
<td>80</td>
<td>8</td>
</tr>
<tr>
<td>70 to 79</td>
<td>1.2 to &lt;1.3</td>
<td>76</td>
<td>8</td>
</tr>
<tr>
<td>60 to 69</td>
<td>1 to &lt;1.2</td>
<td>84</td>
<td>12</td>
</tr>
<tr>
<td>50 to 59</td>
<td>0.8 to &lt;1</td>
<td>79</td>
<td>12</td>
</tr>
<tr>
<td>40 to 49</td>
<td>0.7 to &lt;0.8</td>
<td>72</td>
<td>12</td>
</tr>
<tr>
<td>30 to 39</td>
<td>0.5 to &lt;0.7</td>
<td>86</td>
<td>24</td>
</tr>
<tr>
<td>20 to 29</td>
<td>0.33 to &lt;0.5</td>
<td>75</td>
<td>24 to 36</td>
</tr>
<tr>
<td>&lt;20 †</td>
<td>&lt;0.33 †</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For many patients, the preferred dosing strategy is extended-interval. Refer to aminoglycosides topic discussion of selection of dosing strategy. Although the dosing adjustments listed in this table should be applicable for amikacin dosing, they have not been validated for use with that agent. ‡ Creatinine clearance may be estimated using the Cockcroft-Gault equation. Calculators for estimation of creatinine clearance are available in UpToDate.

△ Loading dose recommendations are provided for in a separate table.

◊ When the creatinine clearance is below 20 mL/min, a loading dose is recommended with subsequent doses guided by monitoring of the serum aminoglycoside concentration.

*This table lists dosing adjustments recommended by UpToDate contributors based on pharmacokinetic data and institutional experience.*
Beta Lactams and Cephalosporins

- Can lead to acute interstitial nephritis or acute GN
- Can potentiate nephrotoxicity when used with aminoglycosides
- Zosyn + Vancomycin + sick patient = AKI

Sulfas

- Avoid if possible
- In AKI/CKD can be easily toxic
- Trimethoprim competitively blocks the secretion of creatinine, falsely elevating the creatinine by ~0.5 mg/dl and acts like a K sparing diuretic.
- Sulfanilamide crystal can form in the urine
- Common cause of acute interstitial nephritis
- Do not use nitrofurantoin in AKI/CKD
Antivirals

• Direct toxicity to tubular cells: cidofovir, adefovir, dipivoxil, tenofovir, and acyclovir
• Crystal formation: acyclovir, indinavir

Risk factors for AKI from contrast

- CKD/AKI
- Diabetes mellitus
- Age>70
- Dehydration
- Concurrent nephrotoxins
- Myeloma
- HIV
- Transplant

- Cardiovascular disease
- Cirrhosis
- Repeat studies
- Volume of contrast
- High osmolar contrast
- Intra-arterial>intravenous route
- Metformin

Mechanism of injury

- Osmolarity of contrast 1200-1600 mosm
- Causes intense microvascular vasoconstriction and subsequent ischemia
Contrast Studies

- Iodinated (CT, cath, angio) and gadolinium (MRI)
- A multitude of studies since landmark *NEJM* study of 1994 demonstrating benefit of pre and post procedure I.V. hydration in at risk patients
- Bicarbonate, ANP, acetylcysteine, CCBs, statins, ascorbic acid, trimetizadine, diuretics have been tried with conflicting results
- Cannot replace hydration
IVF Hydration to Prevent AKI from Contrast

- 78 patients, 51%DM, Scr ~2.1 mg/dl, scheduled to undo go cath. or other angiography, randomized into 3 groups.
- Each group received 0.45% saline dosed at 1 ml/kg I.V. for 12 hours before and after procedure.
- One group received just I.V.F,
- One group received I.V.F. + 25 gm mannitol
- One group received I.V.F plus 80 mg furosemide

Results

- 20 of the 78 patients (26%) had an elevated of at least 0.5 mg/dl of SCr
- I.V.F. alone=3/28 patients 11%
- I.V.F.+ mannitol=7/25 patients 28%
- I.V.F.+ furosemide=10/25 patients 40%

Prevention

- Pre hydration in any patient with creatinine >1.5 mg/dl
- Normal saline or 3 ampules of sodium bicarbonate (50 meq/amp) 150 meq in 850 ml or 1 liter of 5% dextrose*
- 1 ml/kg/hr 6-12 hours before and after procedure

*YMMV at your institution
Prevention

• Low ionic contrast
• Minimal amount of contrast
• 24-48 hours between procedures if possible
• N-Acetylcystine can be used but is not a substitute for hydration (if you believe that it works then it works-w/hydration)
MRI w/ gadolinium

- ? link to Nephrogenic systemic fibrosis
- Do not use if GFR<30 ml/min.
- Caution in GFR 31-44 ml/min.
- Hydration of no value
- If the patient has a functioning access can do dialysis after procedure
NSAIDS

• Don’t use
• In CKD the kidney becomes dependent on vasodilating prostaglandins (PGE2, PGI₂) to counteract the vasoconstricting catecholamines in the afferent arteriole
• NSAIDs inhibit PG synthesis, abolishing this effect leading to vasoconstriction and ischemia
• Don’t use
NSAIDs and COX-2 inhibitors
Acetaminophen

- Not as safe as advertised
- Daily use increases risk of CKD
- Can lead to reduced glutathione and generation of 5-Oxoproline/pyroglutemetic acid
- Lactic acidosis

Fenves Clin J Am Soc Nephrol 2006;1(13) 441-7
Diabetes Medications

• Avoid metformin if S Cr > 1.5 mg/dl in men or 1.4 mg/dl in females, role in lactic acidosis may be overstated.
• Glyburide: avoid if GFR < 50 ml/min
• Glipizide: no renal dose adjustment needed until late CKD
• SGLT-2: avoid GFR < 45-60 ml/min.
• Insulin: renal metabolism, decrease dose
Hypoglycemia in CKD

- Decreased renal metabolism, prolonged half life of insulin
- Diminished glycogen stores
- Decreased gluconeogenesis
- Impaired counter regulatory mechanisms
- Decreased oral appetite from uremia or gastroparesis
- Infection, sepsis
- Alcohol use

Antihypertensive Medication

- Thiazides: hold if GFR<30 ml/min
- Hydrophilic Beta blockers dosage adjustment: atenolol, bisoprolol, naldol, acebutolol, sotolol
- No dosage needed: metoprolol (both forms), propranolol and labetalol
- Loop diuretics: *increase* dose
- CCBs: no dosage but non-DHP’s may increase risk of heart block w/ mild hyperkalemia
ACE/ARBs

• Multiple studies have demonstrated efficacy in slowing down the progression of CKD.
• Can and should be utilized over all stages of CKD
• BUT need to hold in AKI, sepsis, hypotension, dehydration
Analgesics

- Avoid meperidine, tramadol, due to increased toxicity
- Morphine, codeine, hydromorphone, hydrocodone, oxycodone can be used, but at a lower dose
- GFR > 50 ml/min. 100% of dose
- GFR 10-50 ml/min 75% of dose
- GFR < 10 ml/min 50% of dose

Midazolam

• In AKI/CKD/ESRD active metabolites accumulate, prolonging sedative effects for days.

Mayo clinic – 33/594 with GFR < 90 ml/min developed side effects

7/9 ESRD patients had side effects

Table 5: Symptoms of Gabapentin Intoxication, Corresponding Serum Gabapentin Concentration, and Hospital Admission

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Group II</th>
<th></th>
<th>Group III</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Symptomatic Patients</td>
<td>33</td>
<td></td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Symptoms</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced consciousness</td>
<td>(13, 21.9 ± 1.29, 4)</td>
<td></td>
<td>(6, 59.6)</td>
<td></td>
</tr>
<tr>
<td>Unsteady gait or ataxia</td>
<td>(9, 31.7 ± 4, 0)</td>
<td></td>
<td>(1, 25.0)</td>
<td></td>
</tr>
<tr>
<td>Dizziness and weakness</td>
<td>(8, 29.5 ± 3.84, 1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Myoclonus</td>
<td>(8, 29.9 ± 5.71, 0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Confusion</td>
<td>(5, 23.0 ± 0.49, 2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tremulousness and asterixies</td>
<td>(5, 42.6 ± 3.84, 1)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Gabapentin

<table>
<thead>
<tr>
<th>CrCl (mL/min)</th>
<th>Total daily dose (mg)</th>
<th>Dosage regimen</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 60</td>
<td>1,200</td>
<td>400 mg TID</td>
</tr>
<tr>
<td>31 – 60</td>
<td>600</td>
<td>300 mg BID</td>
</tr>
<tr>
<td>15 – 30</td>
<td>300</td>
<td>300 mg QD</td>
</tr>
<tr>
<td>&lt; 15</td>
<td>150</td>
<td>300 mg QOD</td>
</tr>
<tr>
<td>Hemodialysis</td>
<td>—</td>
<td>200 – 300 mg post-HD</td>
</tr>
</tbody>
</table>

**Loading dose:** 300 – 400 mg  
**Maintenance dose:** 200 – 300 mg after each 4-h HD session
Lipid-lowering drugs

• Statins
  – No renal dose adjustment needed for atorvastatin
  – Dose adjustments needed when eGFR <30 ml/min for fluvastatin, pravastatin, lovastatin, simvastatin and rosvastatin

• Fibrates
  – Associated with AKI esp. in CKD patients
  – May transiently raise SCr by increased creatinine production rather than decreased GFR

Other medications

- Avoid aluminum or magnesium based antacids, Maalox, Mylanta, Amphojel
- Avoid citrate containing compounds: increased GI aluminum absorption
- Avoid phosphorus containing laxatives
- Baclofen, lamotrigine, keppra, carbamazepine, oxycarbazepine, allopurinol all renally cleared
ESRD patients

• Frequently on multiple medications
• Phosphate binders given with meals can prevent absorption of some medication, try to give other oral medication at the same time.
• Poly-pharmacy is a real issues and an accurate medication list is essential to proper care.
Key Points

• Formulas are great for stable renal function, but not in AKI
• Match the lab values to the patient
• Your clinical pharmacist and nephrologist will help you stay out of trouble
• Check and follow levels when possible
• Stay away from NSAIDs and sulfa if possible