Objectives:

1. Review the NKF definition of chronic renal disease
2. Review risk factors for CIN and NSF
3. Provide a framework for using eGFR to manage patients at risk for CIN & NSF when giving contrast for CT & MR
4. Review recommendations by various societies for administering IV contrast media based on renal function

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National Kidney Foundation - Kidney Disease Outcomes Quality Initiative (KDOQI)

- Chronic Kidney Disease (CKD)
  - Patients with kidney failure have annual mortality rate of 15%
  - Average life expectancy for 60 year-old
    - w/o CKD - 21 years
    - w/ CKD - 4.6 years

- What changed? In 2002, the NKF made a big effort to increase awareness of CKD publishing clinical guidelines based on GFR
### GFR and mortality rates

**Death:**
- from any cause
- from CV event

<table>
<thead>
<tr>
<th>e-GFR:</th>
<th>(ml/min/1.73 m²)</th>
<th>Age-Standardized Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;60</td>
<td>0.76</td>
<td>0.76</td>
</tr>
<tr>
<td>45-59</td>
<td>1.08</td>
<td>2.11</td>
</tr>
<tr>
<td>30-44</td>
<td>3.65</td>
<td>4.76</td>
</tr>
<tr>
<td>15-29</td>
<td>11.29</td>
<td>11.36</td>
</tr>
<tr>
<td>&lt;15</td>
<td></td>
<td>21.8</td>
</tr>
</tbody>
</table>

CKD - definition & prevalence

- CKD defined as GFR < 60 ml/min/1.73m² for more than 3 months … or …
- Kidney damage documented by biopsy, proteinuria

- Prevalence of CKD
  - Stage 1 GFR ≥ 90 64%
  - Stage 2 GFR 60-89 31%
  - Stage 3 GFR 30-59 4.3%
  - Stage 4 GFR 15-29 0.2%
  - Stage 5 GFR < 15 0.2%

4.5% is the population we are concerned with
Minimizing CIN & NSF requires identifying patients at increased risk

- Most radiologists use serum Creatinine to assess CKD
- Cutoffs used are variable
  - 1.5 mg/dl – 35%
  - 1.7 mg/dl – 27%
  - 2.0 mg/dl – 31%
    - Elicker et al 2006

- Serum creatinine
  - depends on body mass, wt, age, and sex
  - does not rise until GFR is reduced by 50%

- You are not alone?!
  - There is a general lack of awareness of significance of GFR
  - eGFR 15-59 ml/min/1.73m² - 24.3% aware of kidney disease
Contrast-induced Acute Kidney Injury

• Definition: typically 25% or 0.5 mg/dl increase in serum creatinine
  – AFTER excluding other causes … this part often forgotten

• Usually self-limited (2 -3 weeks)

• Majority of studies looking at incidence of CI-AKI are of …
  – Intra-arterial injections (angiography, cardiac catheterization)
  – Contrast agent studies assessing high v. low, low v. iso-osmolar

• Few studies looking directly at CI-AKI with intravenous contrast for CT scans, even fewer with NCCT controls
Risk factors for CI-AKI / NSF - who do we screen?

- **CIN risk factors**
  - Dehydration
  - CHF
  - Diabetes
  - Kidney disease
  - Large contrast volume
  - Age > 70 yrs

- **CKD risk factors**
  - Age > 60 yrs
  - HTN
  - DM
  - CVD
  - Family history

- **AKI / CKD risk factors**
  - Nephrotoxic drugs
  - Renal surgery / infection

- **NSF risk factors**
  - Kidney disease
  - Contrast volume
  - Pro-inflammatory factors
Estimating GFR - MDRD v. Cockcroft-Gault
(because we cannot measure GFR in all of our patients)

• C-G - Canadian VA inpatients
  – Estimates measured creatinine clearance
  – Mostly male (VA) patients

✓ MDRD based on outpatients with CKD
  • Estimates GFR from $^{125}$I-iothalamate clearance

• C-G ‘less inaccurate’ in normal renal function
• C-G ‘less accurate’ in older and obese patients
• MDRD same to more accurate than C-G in CKD

✓ We are not looking for accuracy of normal renal function, just need sensitivity for identifying renal insufficiency – therefore choose MDRD
Scope of the problem for CT – Number of patients with normal serum creatinine but renal insufficiency presenting for outpatient CT

- 15.2% of outpatients with sCr < 1.5 mg/dl had Creatinine clearance (Cockcroft-Gault) < 50 ml/min
  - Duncan et al, Nephrol Dial Transplant 2001

- 9.9% of patients with sCr < 1.5 mg/dl had eGFR < 60 ml/min/1.73m²
  - Herts et al, Radiology 2008
European Society of Uroradiology (ESUR)

• CIN Risk: eGFR < 60, dehydration, CHF, Age > 70, meds
  – Recent eGFR < 7 days
  – Recommendations for eGFR < 60 or with increased risk of nephrotoxicity
    – Stop nephrotoxic drugs x 24 hrs before

• Recommendation: IV hydration 1 ml/kg 6 hours before and after

Canadian Association of Radiologists

• CIN risk: DM, renal disease or solitary kidney, dehydration, age > 70 yrs, CVD, chemotherapy, CVD

• GFR 30 - 60 mL/min/1.73m² - low-to-moderate CIN risk =

• GFR 15 - 30 mL/min/1.73m² - high CIN risk*

• Fluid administration - 300-500 ml 0.9% saline or NaHCO3 solution IV before contrast, or oral hydration (salt & H2O)
Publications influencing Cleveland Clinic policy:

  – 421 patients with eGFR < 60 ml/min/1.73m²
  – 6.5% developed sCr increase ≥ 25%, but
  ✓ < 1% of patients with eGFR > 45 ml/min/1.73m² developed sCR increase > 0.5 mg/dl
  – None required dialysis
  – Hospitalization and death (30-days) were unrelated to CI-AKI

• Solomon (commentary)
  ✓ Outpatient risk extremely low, especially with eGFR > 45 ml/min/1.73m²
Cleveland Clinic guidelines (as of Jan 2009)

• Who gets screened for CKD?
  – Known chronic kidney disease
  – Diabetes Mellitus
  – Patient age greater than or equal to 60 yrs
  – Dehydration
  – Congested Heart Failure (CHF)
  – Multiple Myeloma
  – History of kidney surgery / Kidney neoplasm
  – Recent nephrotoxic chemotherapy or other nephrotoxic drugs

• Estimated GFR within 2 months or more recent per history
  – eGFR is now automatically generated by HIS for outpatients
## Cleveland Clinic guidelines - Iodinated contrast

<table>
<thead>
<tr>
<th>eGFR ≥ 60 mg / ml / 1.73 m²</th>
<th>Considered at no increased risk of CIN</th>
</tr>
</thead>
</table>
| eGFR 45-59 mg / ml / 1.73 m² | w/ risk factors (diabetes, dehydration, drugs)  
Oral hydration suggested, consider IV hydration individual basis  
w/o risk factors  
Oral hydration suggested (but not proven to be helpful) |
| eGFR 30-44 mg / ml / 1.73 m² | w/ risk factors (diabetes, dehydration, drugs)  
IV hydration necessary  
w/o risk factors  
Oral hydration minimum, consider IV |
| eGFR 15-29 mg / ml / 1.73 m² | Consider alternative studies  
IV hydration necessary |
| eGFR < 15 mg / ml / 1.73 m² | Only if on dialysis or emergent indication |
Cleveland Clinic guidelines - Gadolinium contrast

<table>
<thead>
<tr>
<th>eGFR &gt;30 mg / ml / 1.73 m²</th>
<th>No specific recommendation</th>
</tr>
</thead>
</table>
| eGFR 15-30 mg / ml / 1.73 m² | Obtain informed consent  
                               Single dose only, minimum needed for exam  
                               Nephrology consult  
                               ProHance |
| eGFR < 15 mg / ml / 1.73 m² | Not advised |

*based on FDA guidelines*
IV hydration

• Inpatients - 1 mg/kg/hr for 12 hours both before and after contrast (coordinated with primary service)

• Outpatients
  – 300-500 ml over 2-3 hours depending on patient
    – 0.9% normal saline solution or
    – Bicarbonate solution (3 amps in 500 ml D5W)
  – Push p.o. fluids after (helpful)
Renoprotective agents

• Meta-analysis of 41 studies by Kelly AM, Ann Intern Med 2008
• N-Acetylcysteine scavenges oxygen free radicals & vasodilatory
  – NAC - relative risk of CI-AKI 0.62
  – 600 mg bid day before and day of the procedure is the dosing generally studied
• Theophylline - relative risk 0.49 - but not statistically significant
• Saline - relative risk 0.62
• Bicarbonate - relative risk 0.12
• Ascorbic acid - relative risk 0.46
• Others without effect…
  – Furosemide, mannitol, fenoldopam
“Minimizing the risk” of CI-AKI & NSF

• General recommendations
  – Formulate a policy for eGFR < 60 ml/min/1.73m²
    – worry at eGFR < 45 ml/min/1.73m²
  – Minimize dehydration - d/c Lasix other diuretics for 24 hours before study (if clinically feasible)
    – rarely done in practice
  – IV hydration for those at greatest risk
  – N-acetylcystine (Mucomyst) inexpensive and may be beneficial
  – Minimize use of Gd in patients eGFR < 30. Try non-enhanced MR or alternative studies
  – Determine for yourself the relative risk & benefits of CECT v. MR w/ Gd
  – Don’t do high dose or multiple Iodine or Gd studies
References

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• Go AS et al, N Engl J Med 2004
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