Preventing Contrast Nephropathy, Role of CO² Angiography

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DISCLOSURES

Consultant/Medical/Scientific Boards
- Abbott
- Boston Scientific
- Cardiva
- Cook Medical
- CR Bard
- Lake Regional Medical
- Medtronic
- Spectranetics

PVD Training
- Abbott
- Bard
- Boston Scientific
- Spectranetics
- TriReme Medical

Stockholders
- CardioProlific
- Cardiva
- Spectranetics
- Vasamed

Speaker’s Bureau
- Abbott
- Bard
- Boehringer-Ingelheim
- Bristol-Myers-Squibb/Sanofi
- Cardiva
- Cook Medical
- Cordis
- DSI/Lilly
- Spectranetics
DEFINITION OF CIN

• Rise in serum Cr > .5 mg/dl
• Rise of serum Cr > 25% baseline
CIN (Iodinated contrast media)

- 3rd most common cause of hospital acquired acute renal failure (behind shock and nephrotoxic drugs).
- Dramatically increases mortality, morbidity, length of stay, and cost.
- Average increased cost $10,345 in hospital and $11,812 1st year
- Only absolute prevention is no iodinated contrast

Nash et al; Am Jour Kidney Dis.
Dangas, G et al; AmJCardio. 95 2005:13-19
Lindsey, J et al; AmJCardio. 94 2004:786-789
Figure Legend: Postulated Pathophysiology of Contrast-Induced AKI. In the presence of a reduced nephron mass, the remaining nephrons are vulnerable to injury. Iodinated contrast, after causing a brief (minutes) period of vasodilation, causes sustained (hours to days) intrarenal vasoconstriction and ischemic injury. The ischemic injury sets off a cascade of events largely driven by oxidative injury causing death of renal tubular cells. If a sufficient mass of nephron units are affected, then a recognizable rise in serum creatinine will occur.
INDEPENDENT CIN RISK FACTORS

**Risk Factors**

- Hypotension: 5
- IABP: 5
- CHF: 5
- Age >75 years: 4
- Anemia: 3
- Diabetes: 3
- Contrast media volume: 1 for each 100 cc
- Serum creatinine >1.5 mg/dl
  - OR
  - eGFR <60 ml/min/1.73 m²
    - eGFR (ml/min/1.73 m²) = \(186 \times (\text{Scr})^{-1.114} \times (\text{Age})^{-0.203}\)
    - \(x (0.742 \text{ if female}) \times (1.210 \text{ if African American})\)

**Integer Score**

- 5
- 5
- 5
- 4
- 3
- 3
- 1 for each 100 cc
- OR
- 4
- 2 for 40-60
- 4 for 20-40
- 6 for <20

**Calculate**

**Risk Score**

- ≤ 5
- 6 to 10
- 11 to 16
- ≥ 16

**Risk of CIN**

- 7.5%
- 14.0%
- 26.1%
- 57.3%

**Risk of Dialysis**

- 0.04%
- 0.12%
- 1.09%
- 12.6%

Figure Legend: Scheme to define contrast-induced nephropathy (CIN) risk score. Anemia = baseline hematocrit value <39% for men and <36% for women; CHF = congestive heart failure class III/IV by New York Heart Association classification and/or history of pulmonary edema; eGFR = estimated glomerular filtration rate; hypotension = systolic blood pressure <80 mm Hg for at least 1 h requiring inotropic support with medications or intra-aortic balloon pump (IABP) within 24 h periprocedurally.

From: A simple risk score for prediction of contrast-induced nephropathy after percutaneous coronary intervention: Development and initial validation
Figure Legend: Risk score development dataset. Increasing risk of contrast-induced nephropathy with increasing risk score is evident with inclusion of either baseline serum creatinine value or estimated glomerular filtration rate in the multivariate model. Solid bars = serum creatinine-based model; open bars = estimated glomerular filtration rate-based model.
Figure Lengend: The contrast-induced nephropathy risk score derived from the development dataset predicted this complication in the validation set, as well. Blue bars = development dataset; Red bars = validation dataset.

From: A simple risk score for prediction of contrast-induced nephropathy after percutaneous coronary intervention: Development and initial validation
In-hospital dialysis, %

Risk groups: Low
Risk score: = 5

Moderate
6 to 10

High
11 to 15

Very High
≥16

Figure Legend: In-hospital hemodialysis can be predicted by a high or very high risk score value similarly in the development and validation datasets. Blue bars = development dataset; Red bars = validation dataset.

From: A simple risk score for prediction of contrast-induced nephropathy after percutaneous coronary intervention: Development and initial validation
Figure Legend: The prognostic significance of the proposed risk score for contrast-induced nephropathy extended to prediction of one-year mortality, as indicated by the results obtained from both the development and validation datasets. Blue bars = development dataset; Red bars = validation dataset.
Figure Legend: Risk of Contrast-Induced AKI According to Baseline Renal Function (eGFR or CrCl ml/min)

Contrast-induced acute kidney injury (AKI) was defined as serum creatinine increase of 25% and/or 0.5 mg/dl and is shown separately for patients with (solid circles) and without (open circles) diabetes. CrCl = creatinine clearance; eGFR = estimated glomerular filtration rate. Data adapted from McCullough et al. (12).
Guidelines for Contrast-Induced Nephropathy (CIN)

Prevention in Adults

- CIN is a common cause of acute renal failure in hospitalized patients. Iodinated radiographic contrast media has been associated with an increase in morbidity, mortality, and costs of medical care during hospitalization as well as prolongation of hospital stay. This nephropathy can result in the need for dialysis treatment and the development of CIN. Multiple prevention strategies have been investigated with varying results. Based on this data, the following algorithm has been developed to assist with selecting the most evidenced based strategies to prevent CIN. **However, the most important strategy to prevent CIN is to avoid to minimize the use of contrast dye.**
ALGORITHM TO AVOID CIN IN CAD

Calculate eGFR or CrCl
Assess contrast-induced AKI risk

**eGFR < ml/min**
- Start/continue statin
- Discontinue NSAIDs
- Other nephrotoxic drugs, metformin

- Hospital admission
- Other strategies as for eGFR 30-59
- Nephrology consultation
- Consider hemofiltration pre- and post-procedure

- Serum Cr before discharge and/or 24-96 hr after
- Expectant care

**eGFR 30-59 ml/min**
- Start/continue statin
- Discontinue NSAIDs, other nephrotoxic drugs, metformin

- IV isotonic (NaCl/NaHCO₃)
  - *1.0-1.5 ml/kg/hr 3-12 hrs pre and 6-24 post*
  - *Ensure urine flow rate > 150 ml/hr*
- Iso-osmolal contrast
  - *DM, ACS, other added risks*
- Low osmolal contrast
  - *No other added risks*
- Limit contrast volume
  - *< 30 mil diagnostic*
  - *< 100 ml diagnostic + intervention*
- Consider adjunctive medication
  - *Antioxidants*
    - *NAC 1200 mg po bid pre- and post-procedure*
  Or
  - *Ascorbic acid 3 g po pre- 2 g po bid post-procedure*

**eGFR ≥ 60 ml/min**
- Discontinue metformin

**Good clinical practice**

1 plans should be made in case AKI occurs and dialysis is required
2 Potentially beneficial agents (NAC, ascorbic acid, aminophylline, PGE) none approved for this indication

Figure Legend: Advanced Algorithm for Management of Patients Receiving Iodinated Contrast Media. ACS = acute coronary syndromes; bid = twice daily; Cr = creatinine; DM = diabetes mellitus; IV = intravenous; NAC = N-acetylcysteine; NSAIDs = nonsteroidal anti-inflammatory drugs; PGE₁ = prostaglandin E₁; po = by mouth; other abbreviations as in Figure 2.

From: Contrast-Induced Acute Kidney Injury
• CO$_2$ displaces blood increasing the penetration of X-ray energy (opposite of iodinated contrast)
• CO$_2$ is cleared from the body within 2 respiratory cycles (COPD not a problem)
• Cath lab must have a CO$_2$ setting
• Patient must not move (images taken in subtracted format)
• 300x less viscous than contrast
Diabetes is epidemic

More interventions are being performed

More complex interventions (limb salvage)

Older patient

Even patients on dialysis have contrast risk. If a patient is actively making urine iodinated contrast may result in the patient becoming anuric.
CIN SUMMARY

- CIN increases acute and long-term mortality
- CIN increases acute and long-term morbidity
- CIN increases acute and long-term cost
- CIN is strongly associated with independent risk factors that should be assessed
- CIN MUST BE AVOIDED
The only way to absolutely avoid CIN is to not administer iodinated contrast.

In PAD there are viable options
- External duplex guidance
- CO$_2$ angiography - THIS HAS TOTALLY CHANGED MY PRACTICE
  - 1) No renal function too impaired
  - 2) No limit on imaging – better results
  - 3) No pre-admission or prolonged stay
  - 4) Can image with smaller catheters (less viscous)
CO₂ CASE 1
CO$_2$ CASE 2
CO$_2$ CASE 5
Closing Remarks