How to Avoid the Risk and Cost of Contrast Induced Nephropathy

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## Disclosures

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DEFINITION OF CIN

• Rise in serum Cr > .5 mg/dl
• Rise of serum Cr > 25% baseline
Reduced Nephron Mass Vulnerable To Injury Associated
Factors: Diabetes, Poor Renal Perfusion, Others

Contrast Enters Renal Vasculature
Endothelium-independent Transient Vasodilation (minutes)

Adenosine Release from Mascular Densa
(Tubuloglomerular Feedback)

Endothelin Release

Prostaglandin Dysregulation
Decreased Nitric Oxide Synthesis Release

Sustained Intrarenal Vasoconstriction (hours)

Prolonged contrast transit time in kidneys
increased contrast exposure to renal tubular cells

Medullary Hypoxia

Contrast Direct Cellular Injury And Death – Ischemic Injury and Death
Oxidative Stress, Inflammation, Other Organ Injury Processes

Acute Kidney Injury

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.

WHY CONSIDER C02 ANGIO

Avoiding contrast induced nephropathy
• Rise in serum Cr > .5 mg/dl
• Rise of serum Cr > 25% baseline

Avoiding severe allergic response

Lower viscosity
• Can image via smaller bore longer catheters
• Can image with close tolerances (6F compatible device in 6F sheath as example.)
• Occasionally allows visualization of critically stenotic grafts that appear totally occluded by iodinated contrast images.

Cost
• Two cents/cc vs. $1.00
• Indirect costs (longer stays, meds, dialysis, etc.)
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
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.

Figure Legend:
From: A simple risk score for prediction of contrast-induced nephropathy after percutaneous coronary intervention: Development and initial validation


Figure Legend: 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.

Risk groups:

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<th>Risk score:</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
<th>Very High</th>
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<td></td>
<td>7.5</td>
<td>14</td>
<td>26.1</td>
<td>57.3</td>
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<td>8.4</td>
<td>12.8</td>
<td>29.9</td>
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Contrast induced nephropathy, %
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.


Risk groups:
Risk score: = 5  6 to 10  11 to 15  ≥16
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.
CIN RISK IS INCREASING IN PAD CASES

- Diabetes is epidemic
- More interventions are being performed
- More complex interventions (limb salvage)
- Older patients
Minor allergies and Anaphylaxis

- Pre-medications required
- Patient apprehension
- Mortality risk
WHY CO2

Extensively studied in angiography

Produced endogenously at 200-250 cc’s/min

- 120 liters stored in soft tissues
- Transported to lungs for excretion in three ways
  - 7% - dissolution directly into the blood
  - 10% - Bound to hemoglobin
  - 83% - Carried as a bicarbonate molecule

NO RISK OF ALLERGIC RESPONSE OR CIN
1895 Conrad Roentgen discovered X-ray
1914 Rotenberg placed air in abdomen to visualize viscera.
1921 Rosenstein and Carelli administered gasses retroperitoneally to identify masses. (air emboli)
1950-60’s Scatliff, Paul, and others utilized CO2 as a venous agent to identify pericardial effusion.
1969 Hipponia utilized CO2 to image IVC.
1971 Hawkins noted visualization of celiac axis on cut film after an inadvertent injection of air.
GAS X-RAY IMAGES

X-ray travels more easily through gas therefore the image is the negative of that created by iodinated agents.

There is less contrast therefore motion severely impairs image quality.
CHARACTERISTICS OF CO2

- Non-toxic (no allergic response or nephrotoxicity)
- Non-flammable
- Bouyant
- Compressible
- Low viscosity
- Highly soluble (>40x more soluble than O2 which is far more soluble than nitrogen)
CO2 DOES NOT MIX WITH BLOOD

It floats anterior
Must displace blood to get ideal images (may be problematic in very large vessels.)
May trap in AAA which can cause ischemia when given in large doses under pressure resulting in ischemia
• Consider aspiration
• Consider rotating patient
Single dose of 1.6 cc / kg showed no hemodynamic effects.
Is totally cleared from the body within 30 – 60 seconds
Requires DSA imaging. It is crucial the patient not move. Use end-hole catheters (less bubbles). Place the catheter as close to the artery to be imaged as possible. Slow low-pressure injection.

Rotate patient or camera if excessive bowel gas. May consider glucagon.

Recognize that gravity affects imaging. May need to elevate lower leg, renal artery imaging may require rotation of patient if non-selective.
Seeger demonstrated close correlation in peripheral arterial imaging.

- 92% when CO2 was utilized as sole agent
- 100% when supplemented by small doses of iodinated contrast.
POSITIVES OF CO2

No renal toxicity
No dose limitations
Can image via longer and smaller bore catheters because of less viscosity
Less cost
NEGATIVES OF CO2

More radiation
Must have CO2 settings
Most systems don’t allow road mapping
Motion artifact dramatically limits imaging
Overlying gas may limit imaging.
May be sub-optimal in very large vessels.
Image quality slightly less crisp than iodinated contrast.
Can’t use to image cerebral or coronary vessels.
Tanks
• Carbonic acid
• Particulate matter including rust
• Water

Closed system could limit contamination with other gasses.
CO2 COMMANDER
No pre-admission for renal insufficiency
No pre-medication for allergy
Has dramatically decreased number of patients on whom I wouldn’t consider intervention in the past.
Closing Remarks / Thank You