The views presented reflect those of the author/presenter and do not necessarily reflect those of ASDIN nor serve as an endorsement of safety, efficacy or applicability of said procedure.

Use of CO₂ and Other Contrast Agents in Endovascular Procedures

Kyung Cho, MD, FSIR
Interventional Radiology
University of Michigan

The ASDIN 9th Annual Scientific Meeting
February 15-17, 2013
Washington, DC

Disclosure
None

Outline
- CO₂ Angiography
- Gadolinium Angiography
- Saving Iodinated contrast

Which is which?
MRA  CO₂  CTA

Which contrast agent?
Iodine, gadolinium or CO₂

CO₂
Which contrast agent?
Iodine, gadolinium or CO₂

CO₂ IS THE ONLY PROVEN “SAFE” CONTRAST FOR ALLERGY AND/OR RENAL FAILURE

CO₂ for Diagnosis and Intervention in the arterial circulation “EXCEPT”
Thoracic aorta, Coronary and cerebral circulations

CO₂ for Diagnosis and Intervention in the venous circulation

20 SWINE CO₂ IV
.2cc - 6.4 cc/kg

EXTENSIVE MONITORING
PA PRESSURE
Blood gases
- 60cc: no change
- 60 cc: ↑ PA pressure
- 600cc: 1 death

BP response to intracaval CO₂
PA pressure response to CO₂

CO₂ Cylinder

Delivery of CO₂
- Hand-held Syringe
- Plastic bag
- CO₂mmander w/AngiAssist
- CO₂ injector

Properties of CO₂
- High solubility
- Low viscosity
- Buoyancy
- Compressibility

CO₂ is 20 times more soluble than oxygen

CO₂ is 400 times less viscous than iodinated contrast
CO₂ is extremely buoyant and displaces rather than mixes with blood.

CO₂ in the aorta floats, filling the celiac and SMA.

30 CC CO₂ X-TABLE LAT

20 cc CO₂ L Side UP

According to Boyle’s Law, CO₂ will be compressed in the catheter during the injection.

CO₂ Reflux

Buoyant and compressed CO₂ injected between wire and catheter refluxes into the aorta.
Applications of CO₂ Angiography

Arterial Applications

- A & O
- Renal artery
- Mesenteric artery
- Renal transplant
- Detection of bleeding
- Tumors
- Aneurysm, AVM, AVF
- Interventions
**CO2 A & O**

**Occlusion of SFA**

**eds 1v**

Renal Artery Rupture

**Coil Embolization**

**Renal Cell Carcinoma**

**CO2-guided Renal Stenting**
Post Renal Biopsy Hematuria

Common Iliac Artery Aneurysm

Venous Applications of CO₂ Angiography

Indications

- Opacify central veins
- PTA and stent placement
- IVC filter placement
- TIPS
- Transjugular liver biopsy
- Splenoportography
- Portal vein access

Upper Limb Venograms

CO₂ Central Venograms
CO₂ Jugal Venogram

CO₂ Jugular Venogram

CO₂ for PICC

CO₂ fistulogram

Occlusion of left subclavian vein

Axilosubclavian Vein Thrombosis
Potential Complications of CO₂ Angiography

- Air contamination
- Vapor lock:
  - Pulmonary artery (hypotension)
  - Mesenteric artery (Intestinal ischemia)
  - Simultaneous nitrous oxide anesthesia
- Neurotoxicity (CO₂ injection in carotid artery)
- Paradoxical embolism
- Hepatic capsule laceration (CO₂ wedge injection)

CO₂ guided Vascular Mapping for Hemodialysis Access Surgery in a Patient with Failing Renal Allograft

Case History

- 51 y/o F w/ PCKD and ESRD
- Failing renal txp
- Failed dialysis fistula, bil UE
- L basilic vein-radial artery fistula
- Request for:
  - L arm venogram
  - L arm arteriogram
**L arm CO₂ venogram**

**Brachial Artery Puncture for CO₂ DSA**

Adverse reaction: lightheaded, bradycardic and hypotensive

**L forearm DSA**

**How to make CO₂ angiography work better?**

- DSA
- Endhole catheter
- Reflux angiography
- Selective injections
- New mask (move mask)
- Stacking
- Elevate area of interest
- Vasodilators

**Monitoring CO₂ Angiography**

- Oxygenation = Pulse oximetry
- Perfusion = BP, HR, ECG
- Ventilation = Capnography

**Capnography monitor**
Conclusions

- CO₂ is the only proven safe contrast agent in allergy and renal failure.
- CO₂ should not be used as an arterial contrast agent above the diaphragm.
- Use a closed system for CO₂ delivery to prevent air contamination.
- Do not use with nitrous oxide anesthesia.
- The advantages of CO₂ include use of unlimited total volume and low viscosity for vascular diagnosis and endovascular intervention.

Gadolinium Angiography

Physical Properties of CO₂, Gadolinium and Iodine

<table>
<thead>
<tr>
<th></th>
<th>Atomic number</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂</td>
<td>C = 6, O = 8</td>
</tr>
<tr>
<td>Gd</td>
<td>64</td>
</tr>
<tr>
<td>Iodine</td>
<td>53</td>
</tr>
</tbody>
</table>

Fewer Gd atoms /cc of contrast: 1/3 attenuation values.

Radiopacity Comparison

Saline  Omni 240  Gadolinium  Omni 300

Gadolinium-assisted Renal Stenting
Hematuria after percutaneous renal biopsy. Gd renal arteriogram demonstrates active extravasation in lower pole of left kidney that was embolized with microcoils.

**Iodinated Contrast Saving Strategies**

- $CO_2$ for arteriography and venography, and endovascular intervention
- Dilute iodinated contrast agent when needed.

**Thank you**