

CO₂ Angiography

Properties, History, Body's response,
Dosage, and Indications

Kyung J. Cho, MD, FSIR
University of Michigan



Disclosure

None

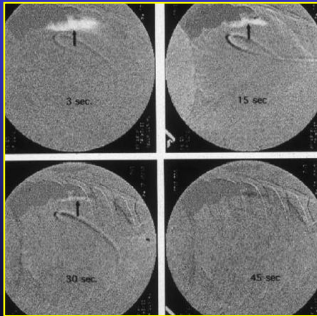


CO₂ Properties

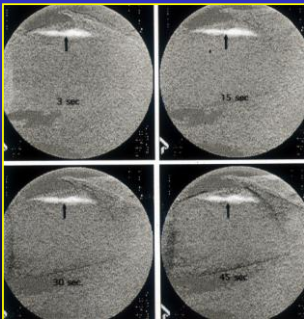
- Invisible gas
- High solubility
- Low viscosity
- Buoyancy
- Compressibility
- Non-allergenic
- Non-nephrotoxic



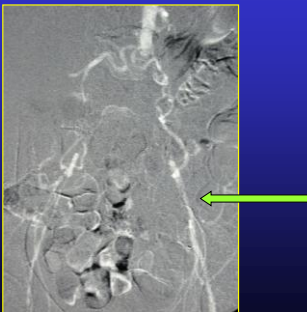
Absorption of CO₂ bubble in RA after injection of 5 cc of CO₂



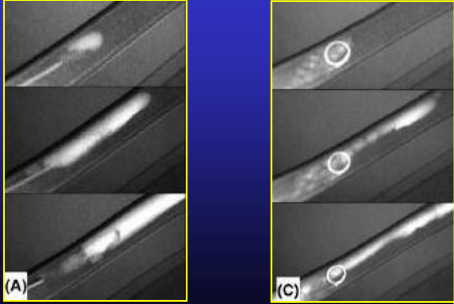
Non-absorption of air bubble in RA after injection of 5 cc of air



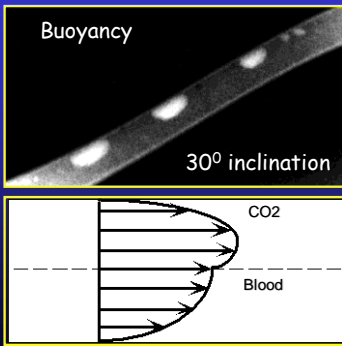
Injection of 30 cc of CO₂ into L external iliac artery via a 3F dilator



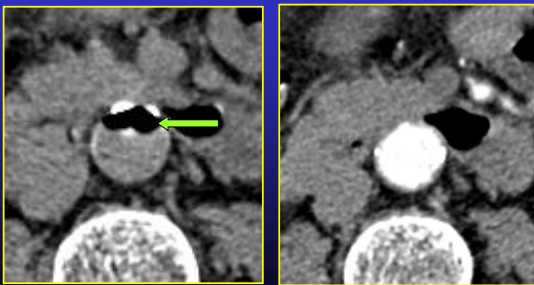
CO₂ injection Endhole catheter vs. Pigtail catheter



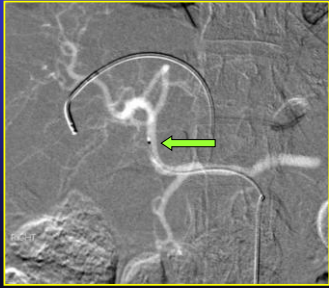
CO₂ Flow Dynamics



Axial CT scan after intra-aortic injections of CO₂ or contrast medium

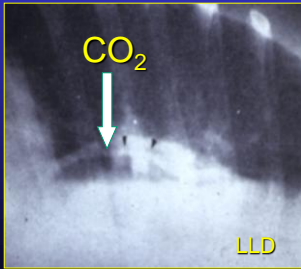


Injection of 20 cc of CO₂ into proper hepatic artery via a 3Fr microcatheter

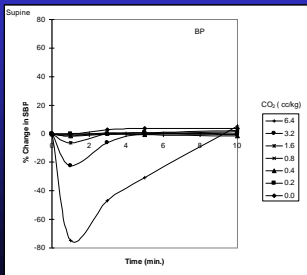


1950-1970

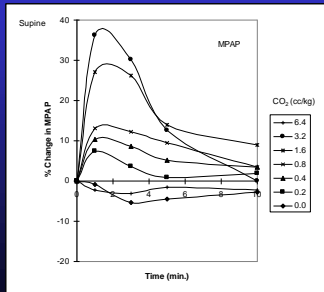
CO₂ as an intravenous contrast



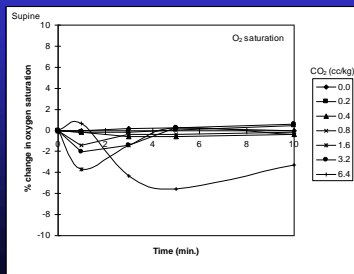
Percent changes in blood pressure following intracaval injections of ascending doses of CO₂ in swine



Percent changes in pulmonary arterial pressure following intracaval injections of ascending doses of CO₂ in swine



Percent changes in SaO₂ following intracaval injections of increasing doses of CO₂ in swine



Conclusions

- CO₂ in doses of 0.2-1.6 cc/kg causes no cardiopulmonary effects.
- Because diagnostic CO₂ DSA increases PA pressure, CO₂ should be used cautiously in patients with pulmonary hypertension.
- Blood pressure monitoring and capnography provide the earliest sign of "vapor lock" in the pulmonary artery from an inadvertent injection of large volume of CO₂ or air.

Injection factors for CO₂ angiography

- Aortography 20 - 40 cc/sec
- Celiac arteriography 15 - 20 cc/sec
- Superior mesenteric 15 - 20 cc/sec
- Renal arteriography 15 - 20 cc/sec
- Iliac arteriography 15 - 20 cc/sec
- Femoral arteriography 15 - 20 cc/sec
- Inferior vena cavography 20 - 40 cc/sec



Indications

- Contrast allergy
- High risk patients for CIN
- Arteriography below diaphragm
- Venography (central veins, hepatic/portal vein, IVC)
- Parenchymal injection (liver & spleen)
- Intervention:
 - Arterial intervention
 - EVAR
 - Venous intervention
 - Hepatic-portal intervention



Conclusions

- CO₂ is the only safe contrast agent in contrast allergy and renal failure.
- Understanding properties of CO₂ and development of a facile catheterization technique with the use of CO₂ reflux and stacking are essential in obtaining a successful CO₂ angiogram.
- CO₂ is preferable in many diagnostic arteriography and endovascular interventions that often require large amounts of contrast.



Carbon Dioxide Vascular Imaging and Interventions

Daniel Simon, MD
Vascular Access Center of West Orange
West Orange, New Jersey

Carbon Dioxide Imaging

Angiography
Venography

CO₂ Imaging - Advantages

Non nephrotoxic
No effect on GFR
Ideal for patients with renal Insufficiency
Competitive alternative for MRA/CTA

Less Well Known Advantages

- Low viscosity agent
- Non allergic
- Relative unlimited dose limit

Disadvantages

- Conspicuity
- Patient discomfort
- Unpredictable patient reactions
- Unpredictable imaging quality

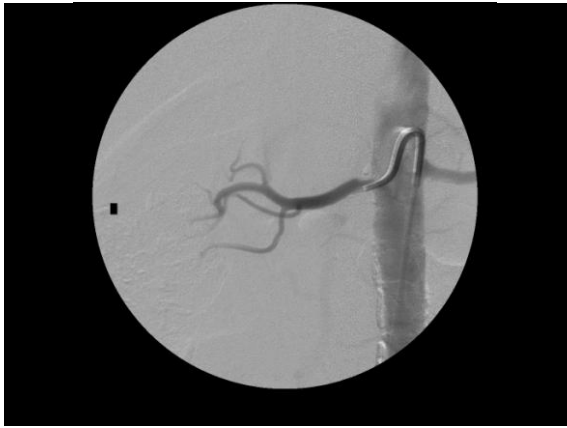
Carbon Dioxide Imaging

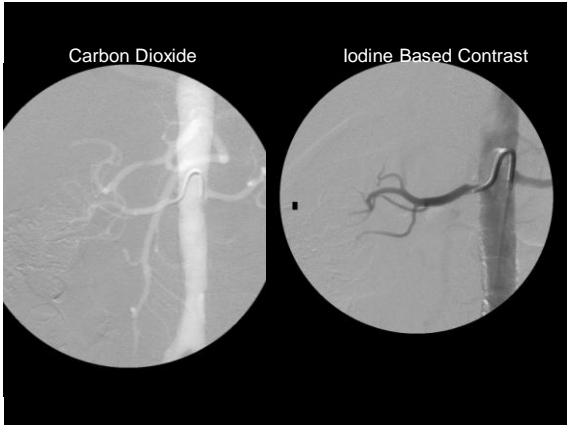
WHITE CONTRAST = CARBON DIOXIDE













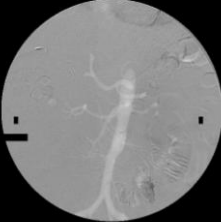






Carbon Dioxide Imaging

Subtracted Image



Aorta filled with CO2 - unsubtracted image

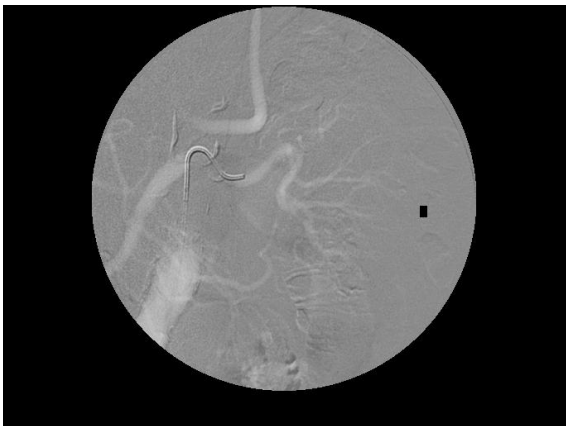


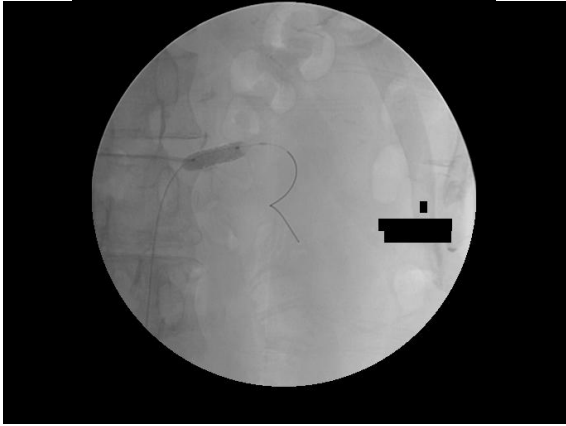
Carbon Dioxide Imaging with Interventions







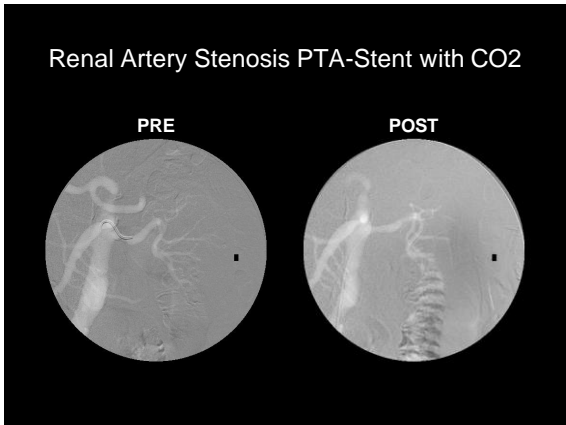








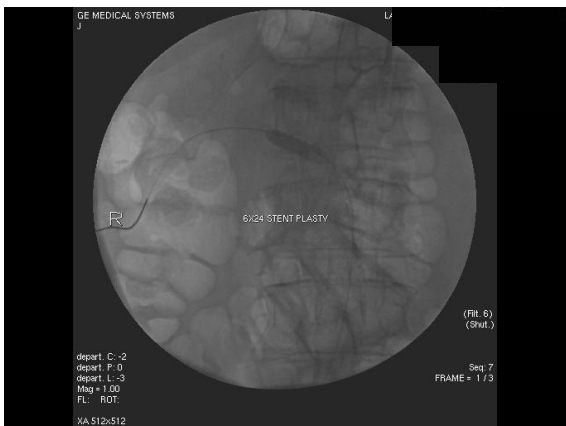




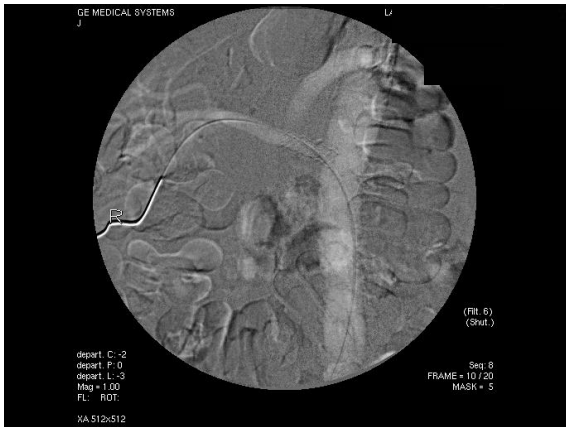




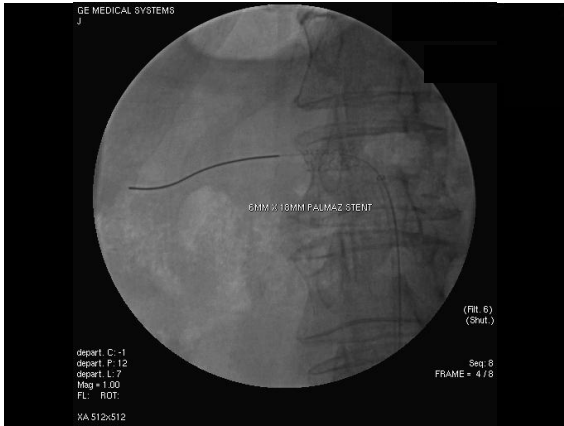


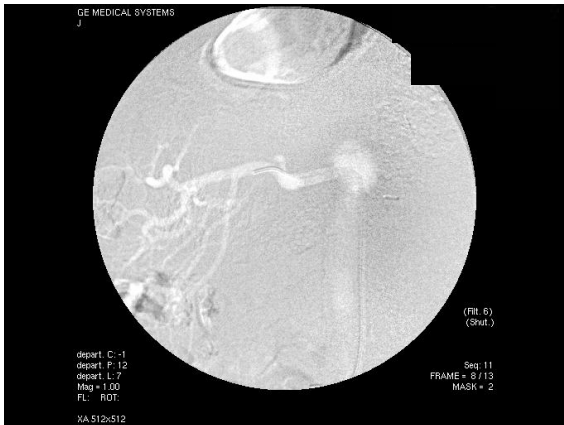


















Renal Transplant Assessment







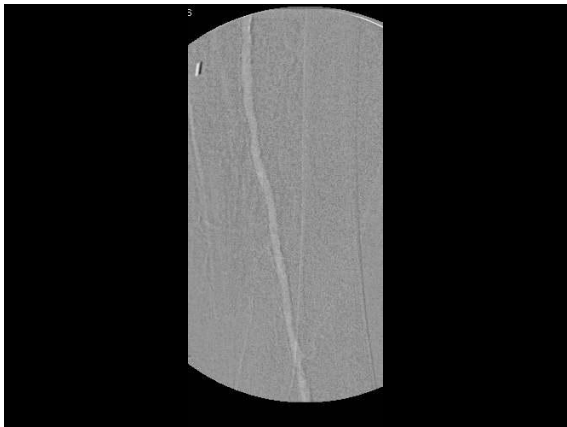


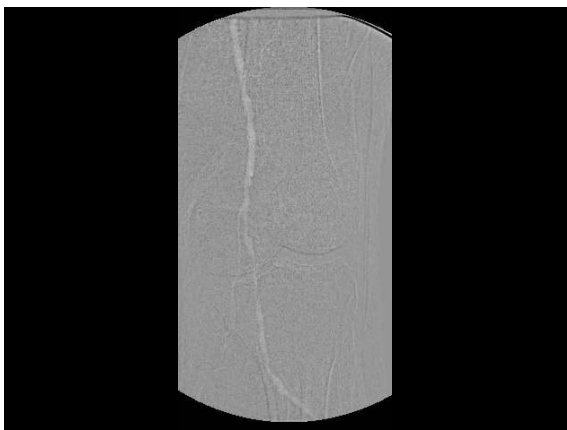
Carbon Dioxide Imaging

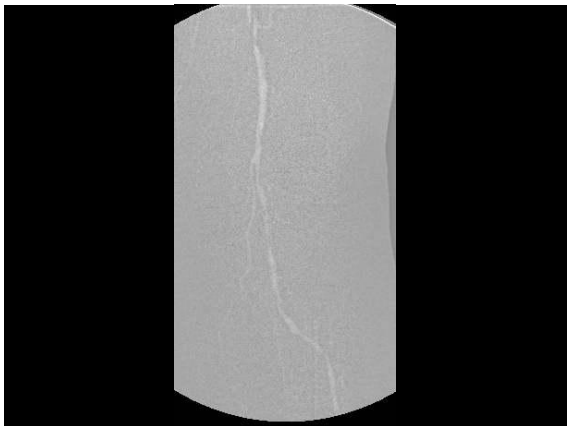
Lower Extremity

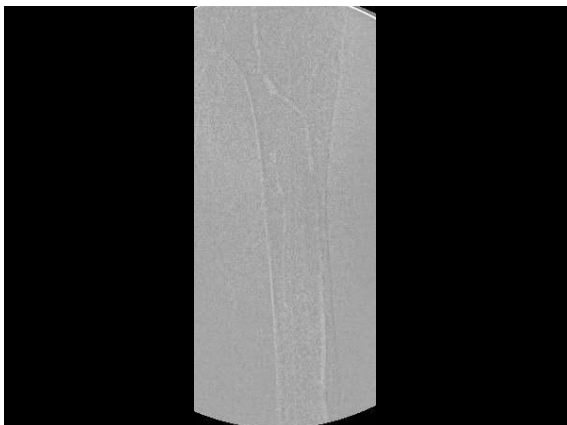


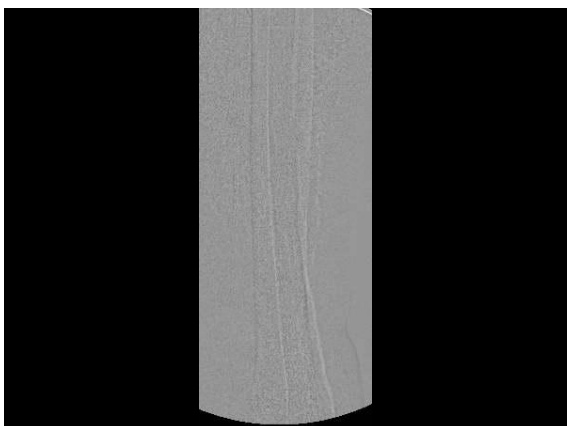


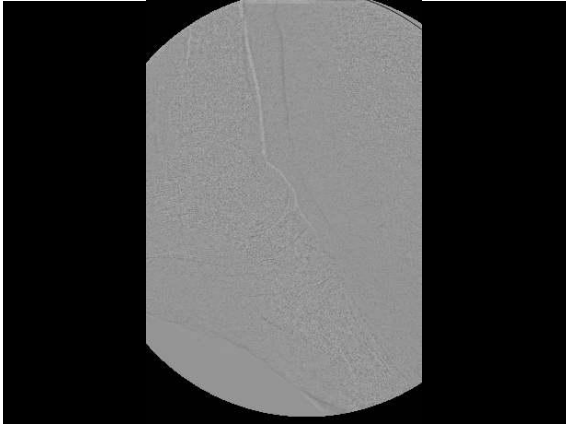




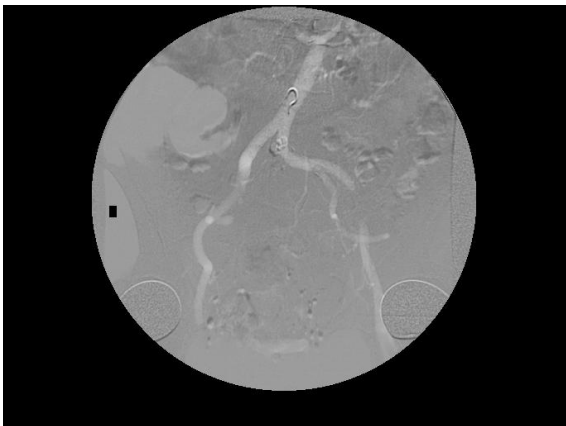












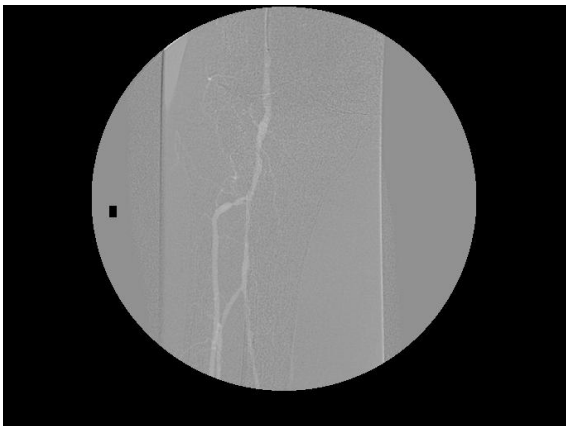


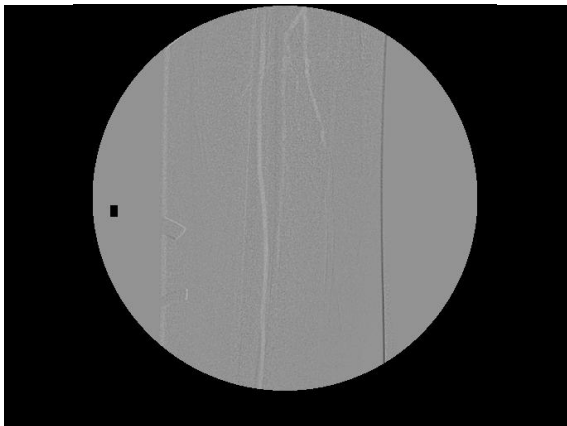




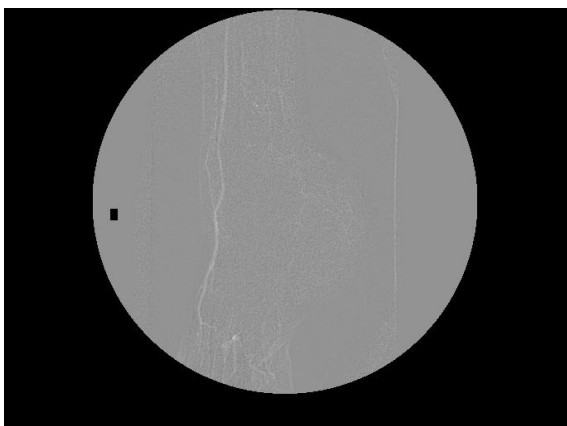








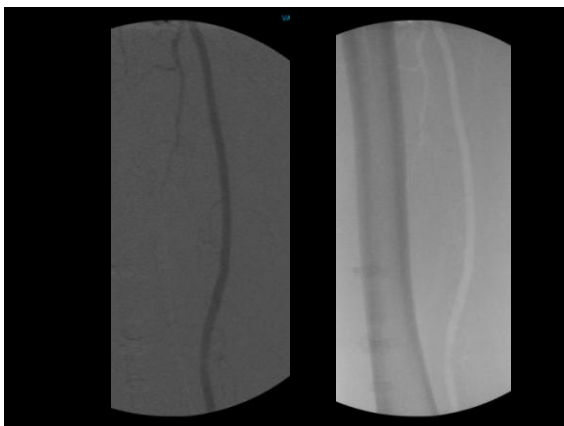


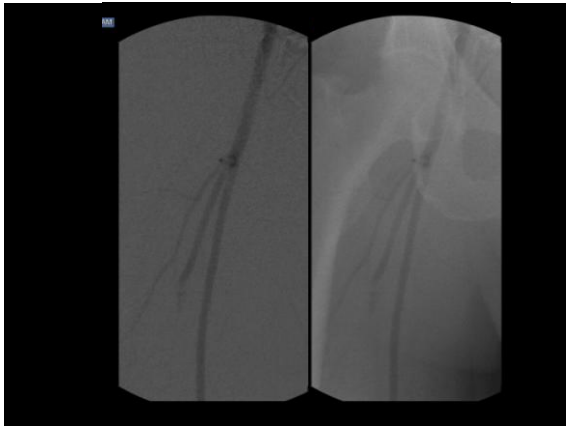


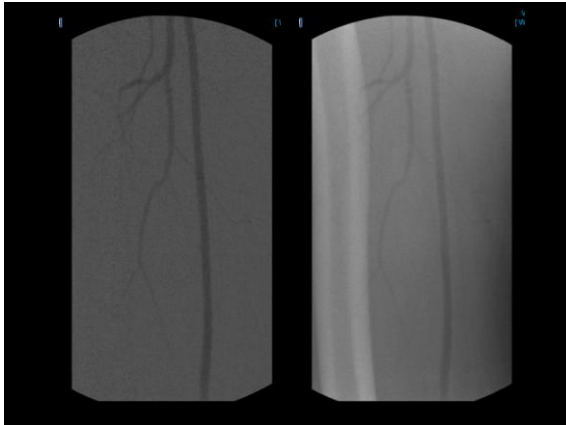


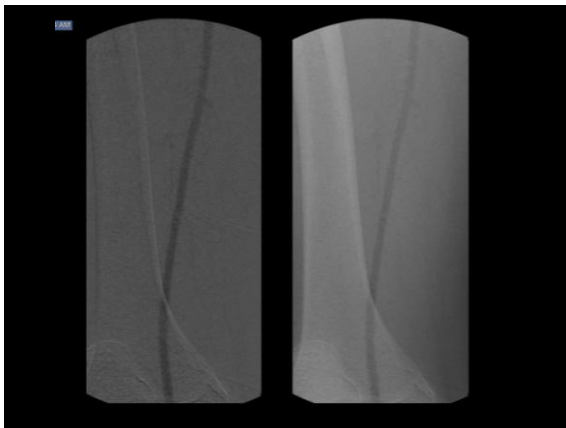
Carbon Dioxide Lower Extremity Angiography

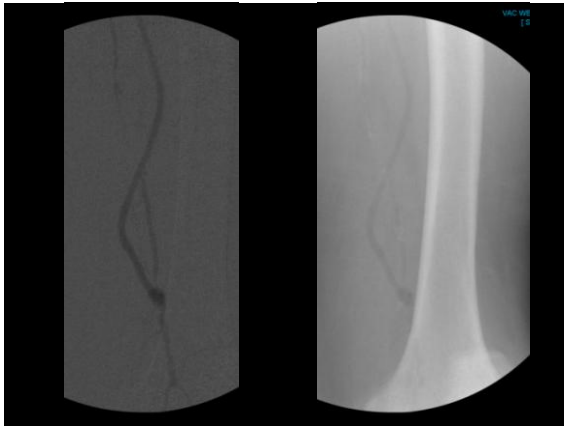
Carbon Dioxide performs well in occlusive disease







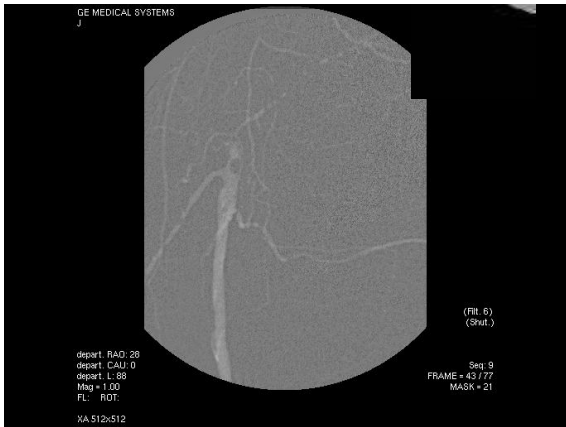




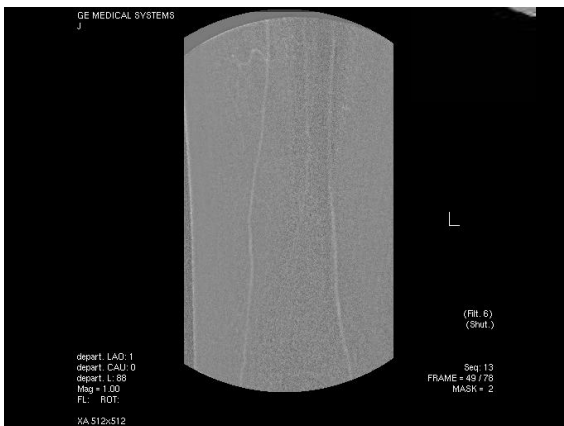
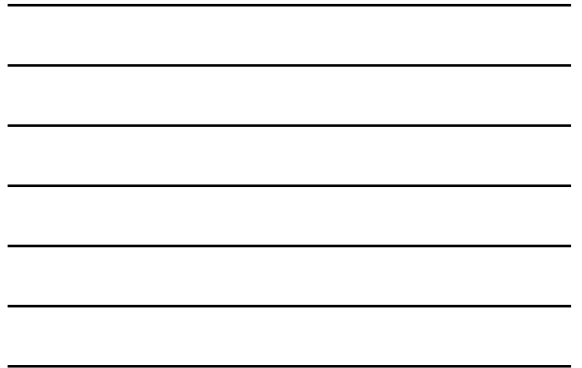






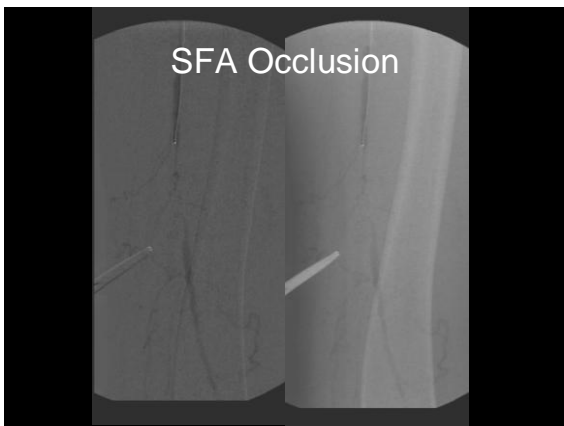






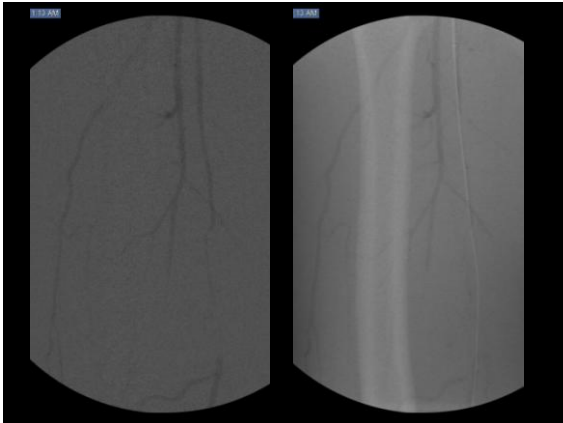


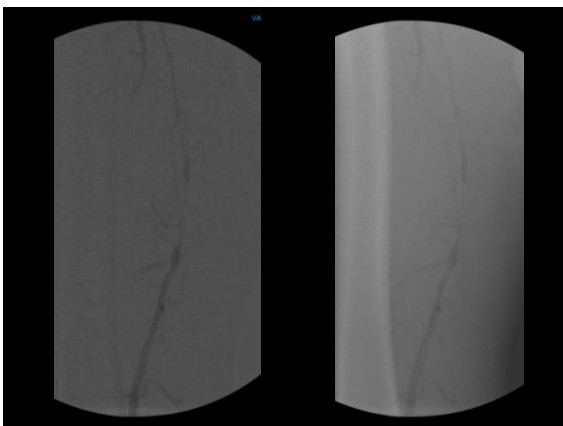
Peripheral Interventions

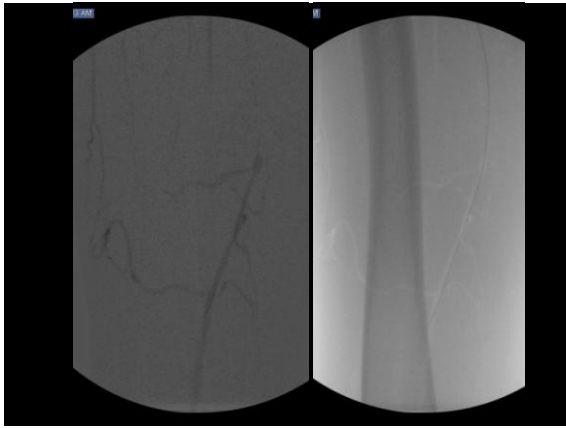


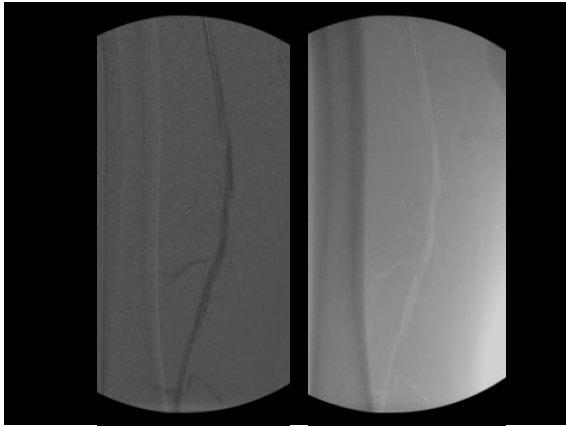
Post Angioplasty and
Atherectomy

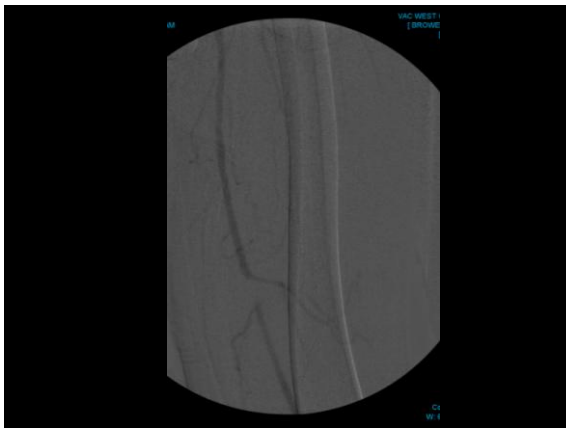


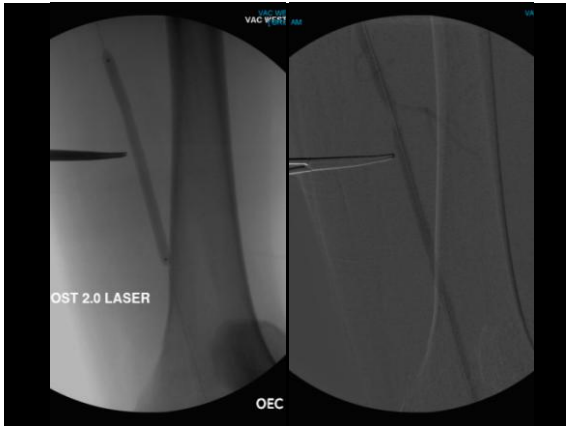


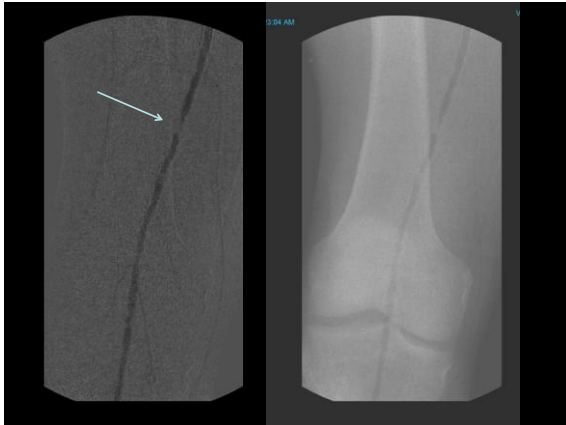


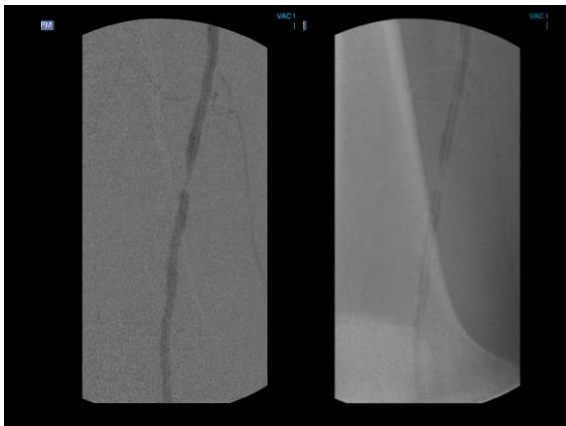




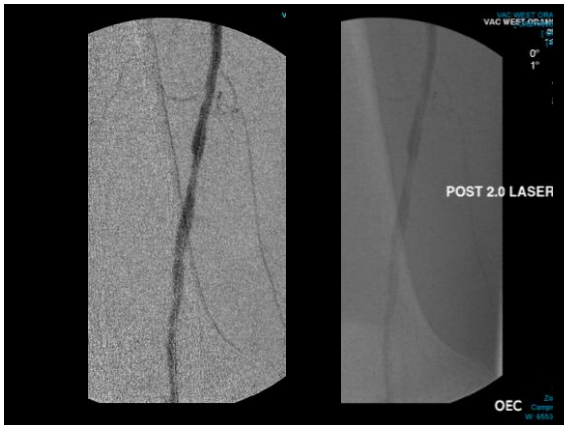




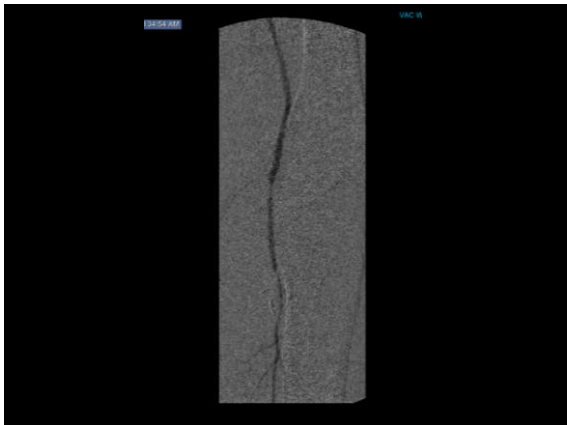


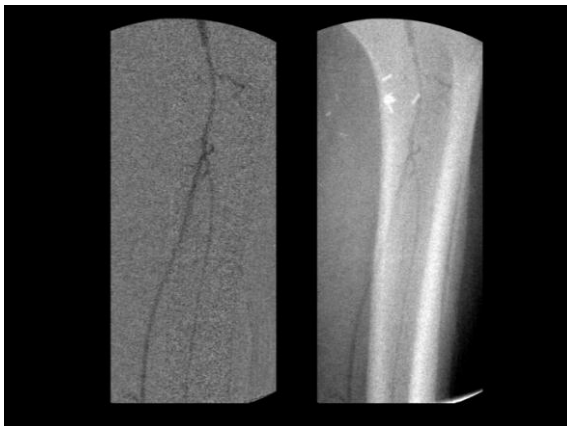




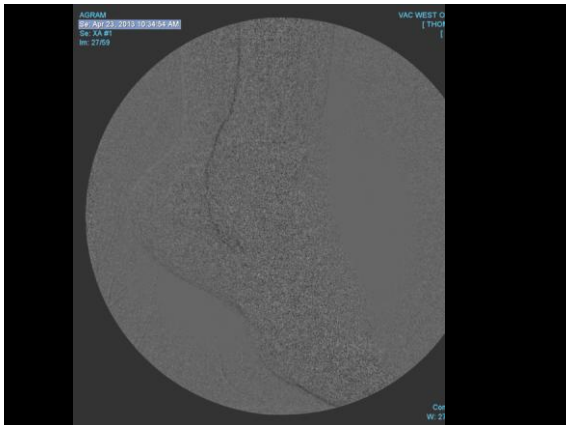










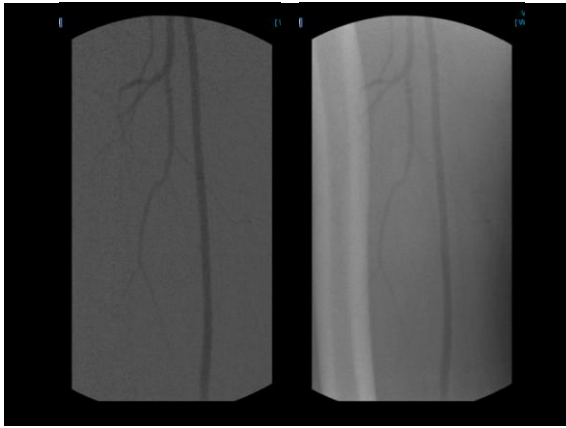


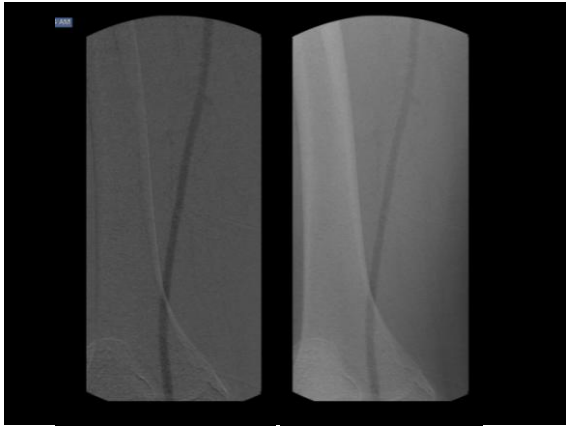


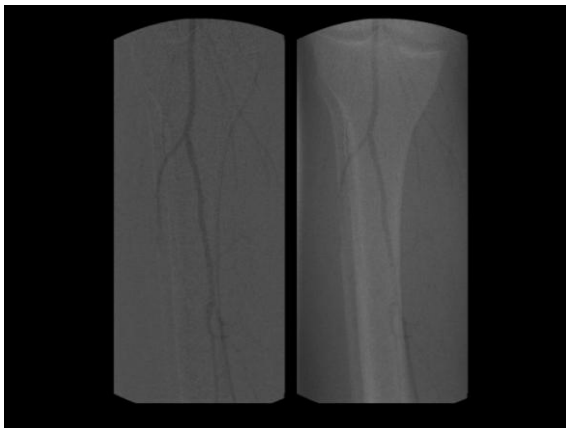


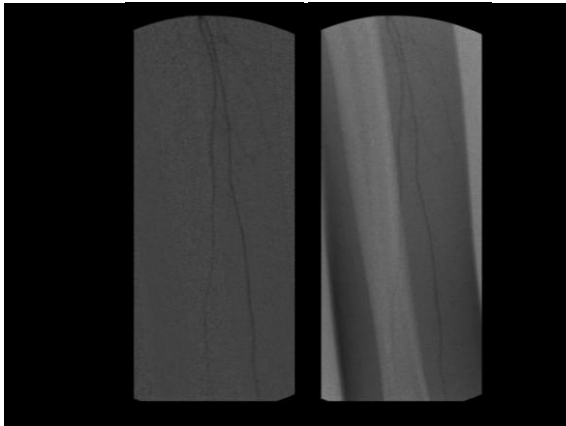


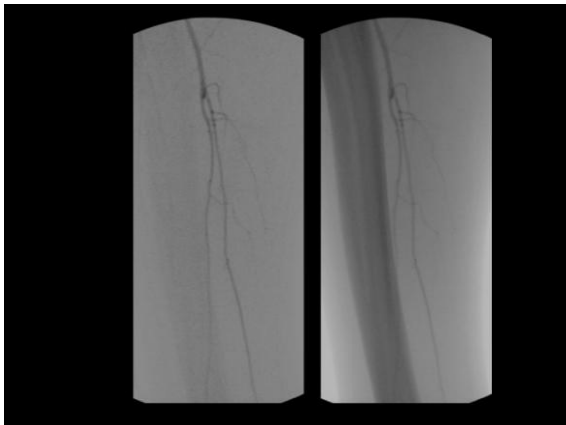


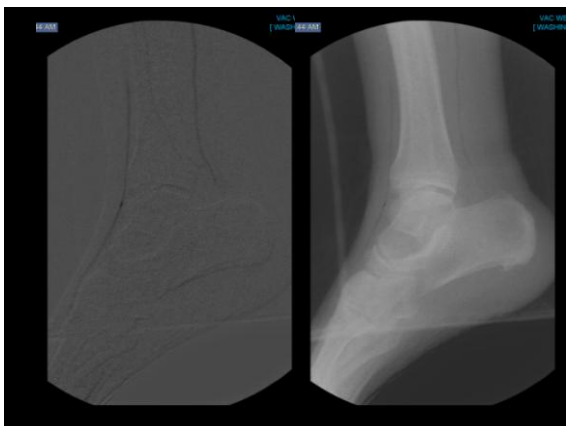


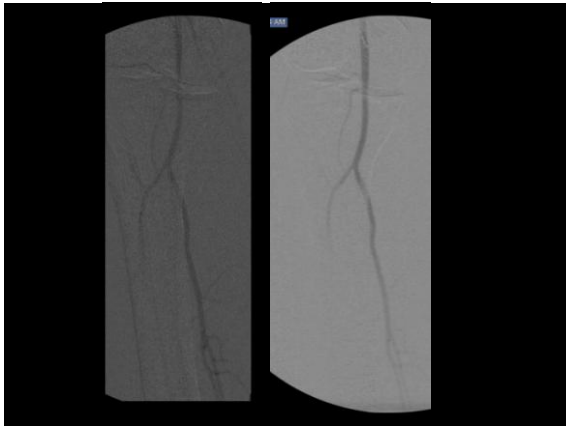


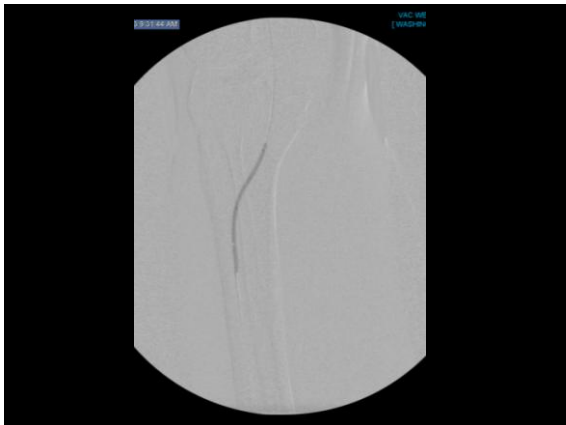


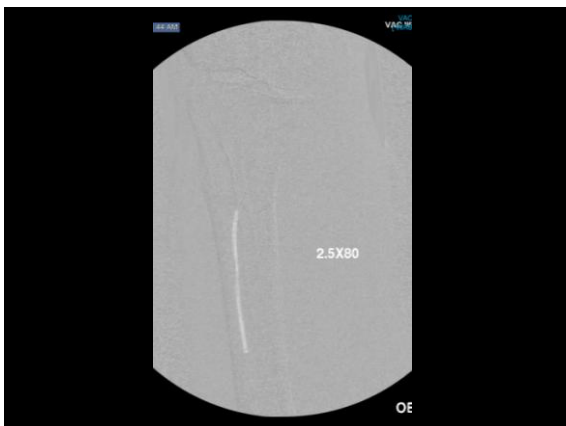


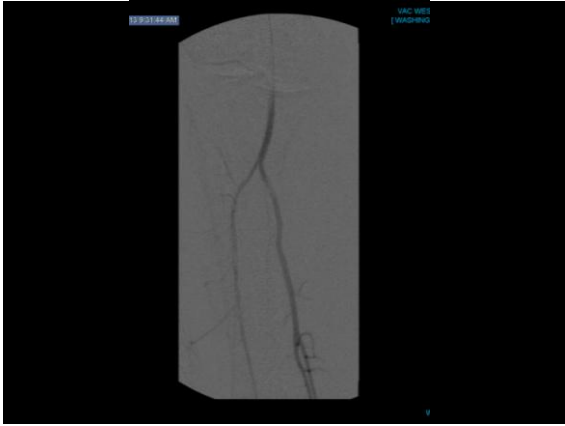


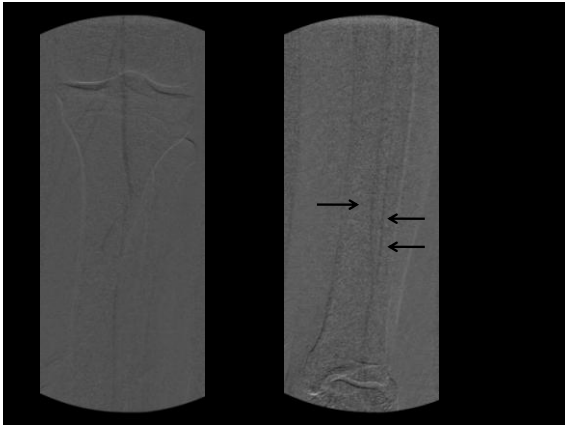


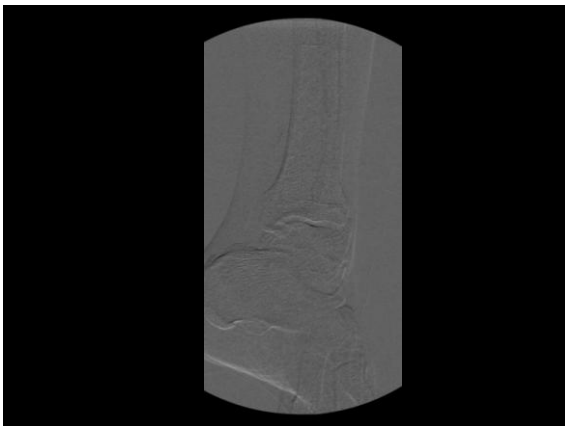


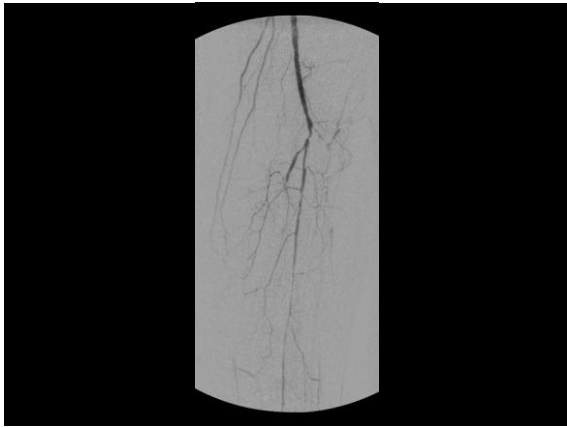




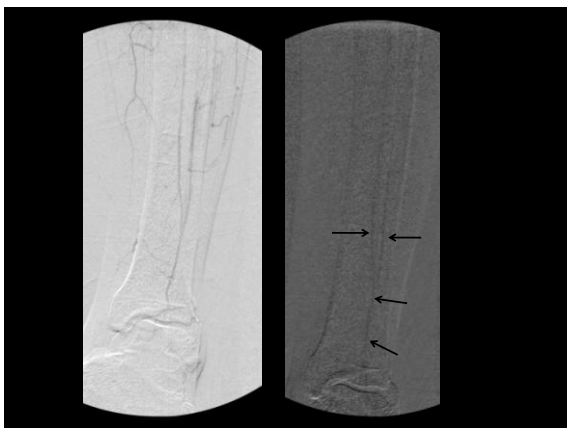


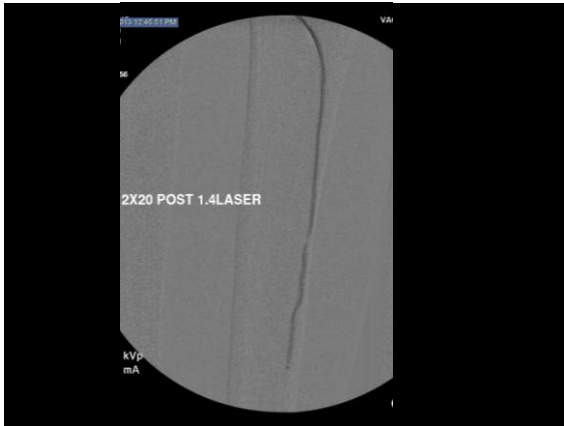


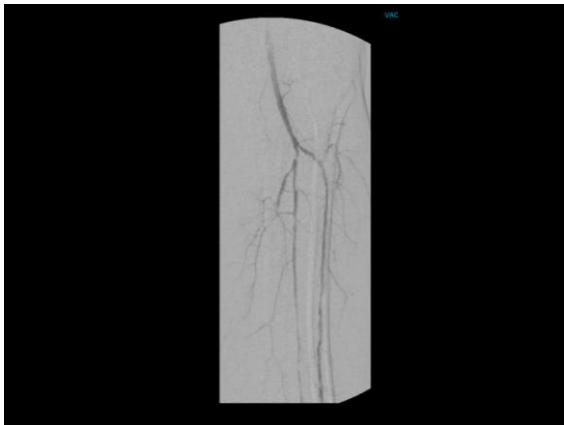




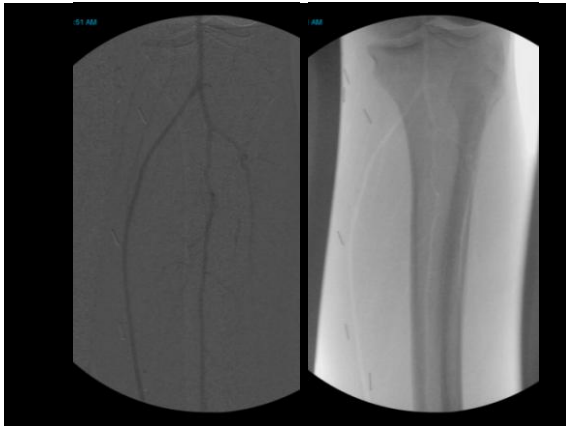


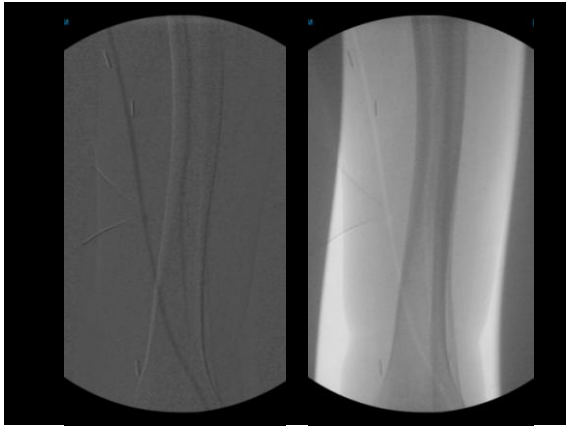


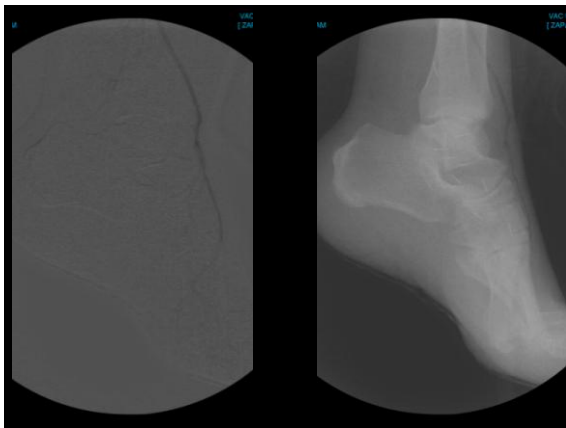












Technique Matters

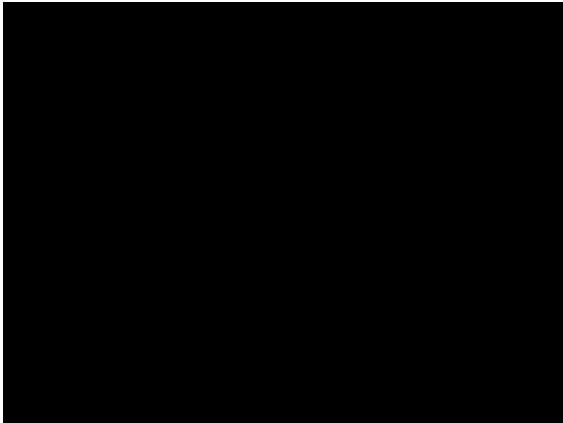
- Patient positioning
- Breath holding
- Motion
- Bowel gas
- Injection rate





Manage Your Expectations

- Approach as a LOW contrast study rather than a NO contrast study
- Pain resolves.
- When you see nothing its usually because there is nothing there.



CO2: Applications

Hector Ferral, MD
NorthShore University HealthSystem
Interventional Radiology



Disclosure

- Consultant for Terumo

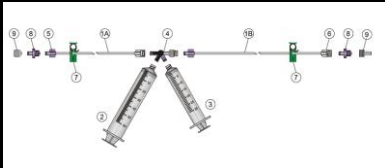
CO2: Applications

- TIPS procedures
- Aneurysm repair
 - Borderline Kidney Function
- Dialysis access interventions
 - Allergy to Contrast

CO2:Basics

- Do not load your syringe directly from a source (CO2 tank)
- Always use a closed delivery system
 - CO2mmander system
- Keep record of injection volumes
- Analyze your runs carefully
 - Understand CO2 distribution after injection
 - Avoid "vapor-lock"

CO2MMANDER



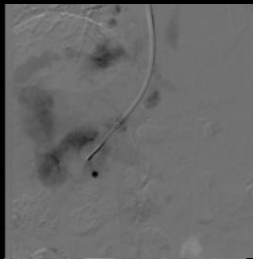
TIPS procedures

- We use CO2 for all our TIPS procedures
- CO2 portogram is critical for the portal vein localization stage of the procedure

CO2 Portogram in TIPS



CO2 Portogram in TIPS



TIPS procedures

- AP and oblique views
 - Excellent to localize the portal vein
- Wedge injection
 - Wedged catheter or balloon catheter
 - Gentle injection of 15-20 cc
 - Careful in patients with ascites
- Intraparenchymal injection



ANEURYSM REPAIR

Case Presentation

- 78 year old man with severe atherosclerotic disease, chronic renal failure with a stable serum creatinine at 2.5 mg/dL and a large iliac artery aneurysm
- Needs aneurysm repair but it is desirable to avoid iodinated contrast

CO₂ arteriogram and embolization

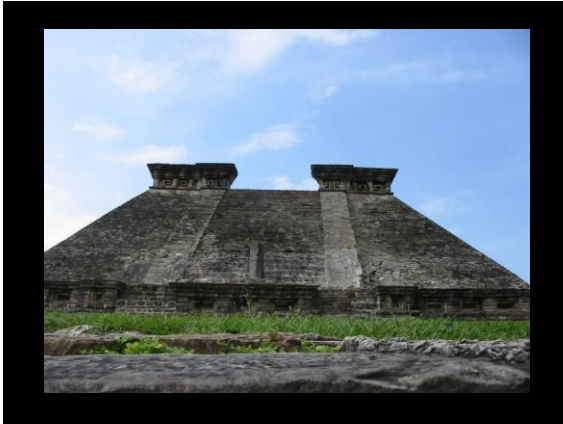


Aneurysm repair



Aneurysm repair

- Iliac aneurysm coiling with CO₂
- AAA stent-graft using CO₂ & IVUS
- Total contrast used: 30 cc
- Renal function unchanged



DIALYSIS ACCESS INTERVENTION

- Case Presentation
- 68 year old woman with ESRD
 - On hemodialysis via an AV fistula
 - Allergic to iodinated contrast
 - Refractory to pre-medication
 - Ongoing problems with her AV fistula
 - Bleeding post-dialysis
 - Requires 3 month-surveys

CO₂ Fistulogram

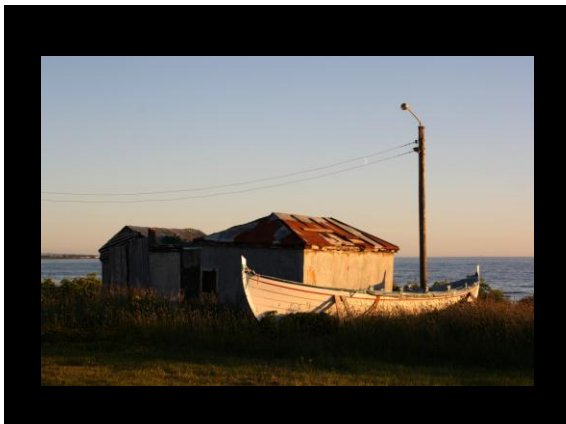


CO₂ Fistulogram



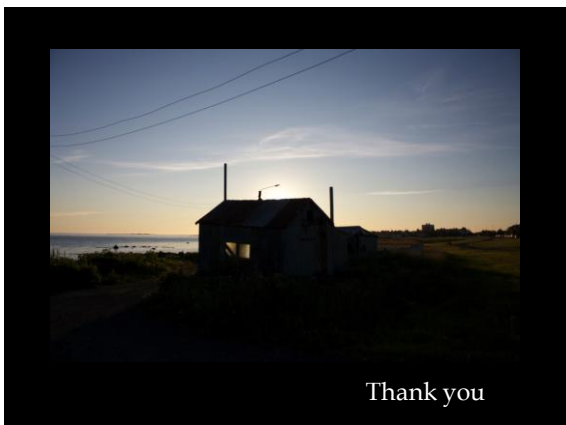
Dialysis access intervention

- This patient's procedures are completed whenever necessary without the use of contrast medium
- **No further allergic reactions**



Final comments

- CO2: Applications in the angio-suite
 - Safe
 - Reliable
 - Reproducible
 - Cheap (save on contrast and drugs)
- Excellent problem-solving tool



Thank you

**CARBON DIOXIDE
DIGITAL SUBTRACTION
ANGIOGRAPHY
&
INTERVENTION**

Jim Caridi
University of Florida
jimcaridi@gmail.com

DISCLOSURES

Consultant and investor:
AngioAdvancements LLC

2

**DELIVERY OF
INTRAVASCULAR CO₂ IS
CURRENTLY
CONSIDERED OFF LABEL
BY THE FDA**

3

CO₂ ADVANTAGES

- Non-allergic
- Non-nephrotoxic (unlimited volumes)
- Rapidly absorbed (20 - 30X O₂)
- Low viscosity (1/400 iodinated contrast)
 - Easier to use with microcatheters
 - Can inject in-between catheter and wire
 - Detection of bleeding, AVF
 - Portal vein visualization
- Central reflux
 - Ability to identify vessel (ostium) central to catheter tip
- Cost (1cc = .005)

4

CO₂ DISADVANTAGES

1. Requires unique delivery system
2. Invisible – concern for undetected contamination
3. Cerebral vessels should be avoided
4. Bowel gas can interfere with abdominal images
5. Potentially more labor intensive

5

PROCEDURES

- Renal insufficiency / allergy
- High volume contrast procedures
- Arterial and Venous Dx
- Detection of Acute hemorrhage / fistula
- IVC filters
- EVAR
- TIPS
- Portal vein intervention
- Interventional oncology

6

CO₂ CAVEATS

- Contamination
- Excessive volumes
- Compressive delivery
- Pulmonary HTN

7

CONTAMINATION

1. CO₂ cylinder
Rust, methane, H₂O, particulate matter,
carbonic acid
2. Room air
diffusivity
malpositioned stopcock
inadequate flushing

8

PREVENT CONTAMINATION

1. Use a disposable source of medical grade CO₂
2. Use a closed delivery system
3. Eliminate 3-way stopcocks
4. Secure connections
5. Flush system



9

Plastic Bag Delivery System
 Hawkins, Caridi, and Kerns. AJR 165: 1995:1487-1489

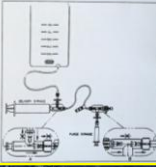
Plastic Bag Delivery System for Hand Injection of Carbon Dioxide

David F. Hawkins, Jr.¹, James G. Caridi, Scott R. Kerns

Digital subtraction angiography with carbon dioxide as a contrast agent provides images useful in diagnosing stenoses and occlusions gives information not obtainable with use of iodinated contrast material. However, delivery of the gas is difficult because carbon dioxide is compressible and readily dissolves in blood. In 1976, we have developed a simple, user-friendly, computer-controlled injector, which is not yet approved by the Food and Drug Administration. We describe a hand-delivery system designed on the basis of principles learned from the development of the computer-controlled injector system.

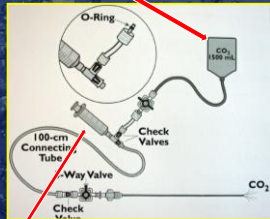
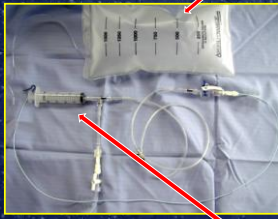
Materials and Methods

The system has two major components (Fig. 1): a plastic bag (AngioFill Bag Collection System; AngioDynamics, Quantico, VA) that is used as a reservoir for the carbon dioxide and a manual hand-delivery system (Angioflush II; AngioDynamics) consisting of multiple check valves, a syringe, and a connecting tube. The reservoir is a 1000-cc plastic bag with a 100-cm connecting tube to allow controlled removal of gas from the collecting bag and into the syringe. After air is removed from the bag, the reservoir is



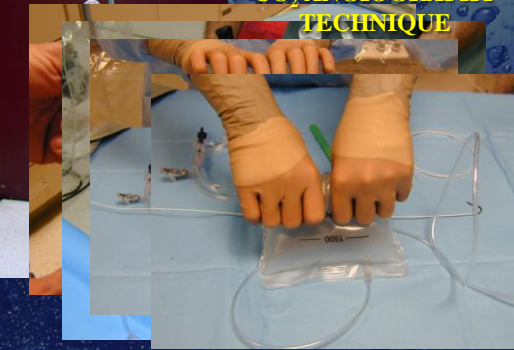
AngioFill Bag Collection System and Angioflush II.
AngioDynamics

FLACCID CO2 RECEPTACLE



DELIVERY SYRINGE

CO₂ ANGIOGRAPHY
TECHNIQUE



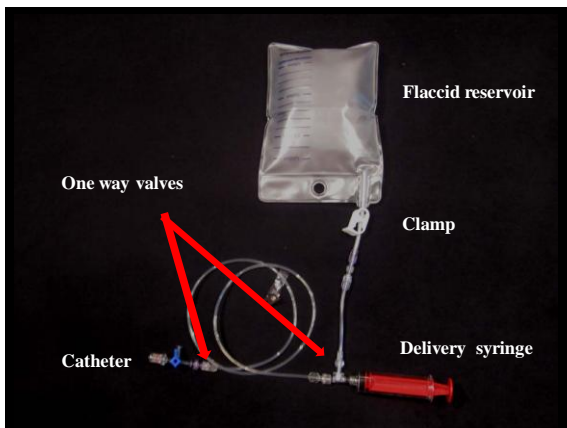
MERIT MEDICAL CUSTOM WASTE BAG AND CONTRAST DELIVERY SET



13

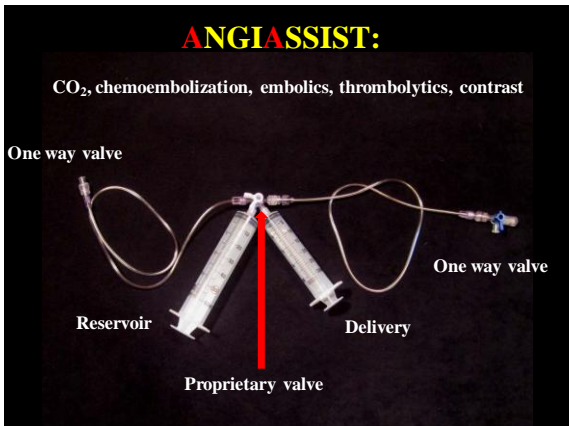
MERITMEDICAL CUSTOM WASTE BAG AND CONTRAST DELIVERY SET

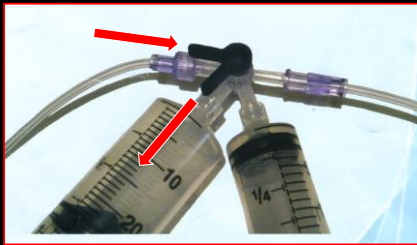










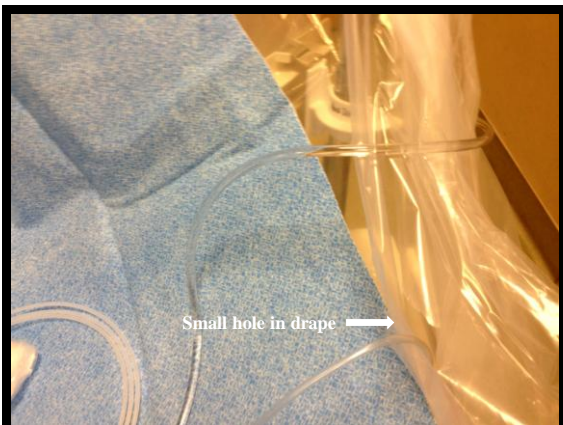


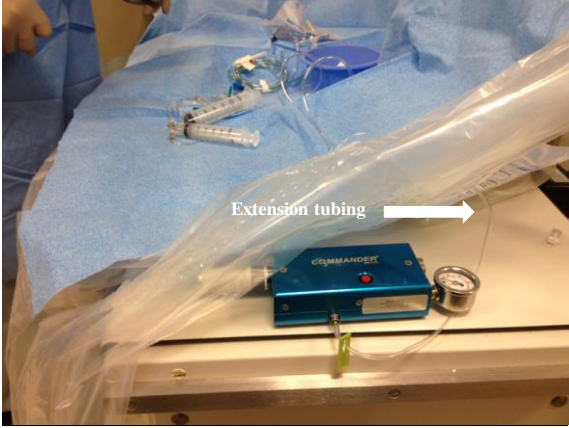
19

ADVANTAGES

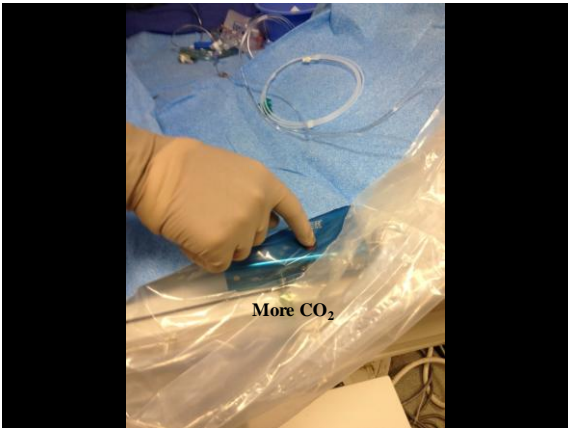
- Pre-assembled
- Compact
- User friendly cannot be connected inappropriately
- CO₂ cannot go directly to patient
- One purge
- No explosive delivery

20









DELIVERY SYSTEM

- **Non-compressed** - for accurate volume and prevent explosive delivery
- **Closed system** – to prevent contamination
- **One way valves** - prevent reflux and necessity to remove delivery syringe
- **Glued components** - helps prevent air contamination
- **Hand injection** - purge catheter first to prevent explosive delivery

25

CARBON DIOXIDE DIGITAL SUBTRACTION ANGIOGRAPHY

- CO₂ angiography is safe when used appropriately
- The delivery system is simple
- CO₂ has unique properties as a contrast agent
- It is a useful tool in both diagnosis and intervention alone or as an adjunct with I contrast

26



THANK YOU
