CO_2 Digital Subtraction Angiography for Diagnosis and Intervention: Indications & Contraindications

Jim Caridi MD FSIR
jimcaridi@gmail.com

Professor of Vascular and Intervetional Radiology
Charimand Dept. of Radiology
Tulane University School of Medicine
New Orleans, L A USA

NCVH
New Cardiovascular Horizons

19th Annual Conference

2018

May 30 - June 01

THE PERIPHERAL EVENT OF THE YEAR

WHAT CAN WE DO WITH CO_2?

IMAGINATION!

Disclosures

Consultant: AngioAdvancements LLC

Intravascular CO_2 is not FDA approved


NEED MONEY
FOR
BEER, POT & HOOKER
(HEY, AT LEAST I'M NOT
BULLS IN YOU)

CO_2 UNIQUE PROPERTIES

- Invisible
- Buoyant
- Low viscosity
- Compressible

CO_2 ADVANTAGES

- Non-allergic
- Non-nephrotoxic (unlimited volumes)
- Rapidly absorbed (20-30X O_2)
- Low viscosity (1/400 iodinated contrast)
  - Easier to use with microcatheters
  - Can inject in-between catheter and wire
  - Better visualization of collaterals
  - Detection of bleeding, AVF
  - Portal vein visualization
- Central reflux
  - Ability to identify vessel/pathology central to catheter tip
- Cost (100cc = .03)

CO_2 DISADVANTAGES

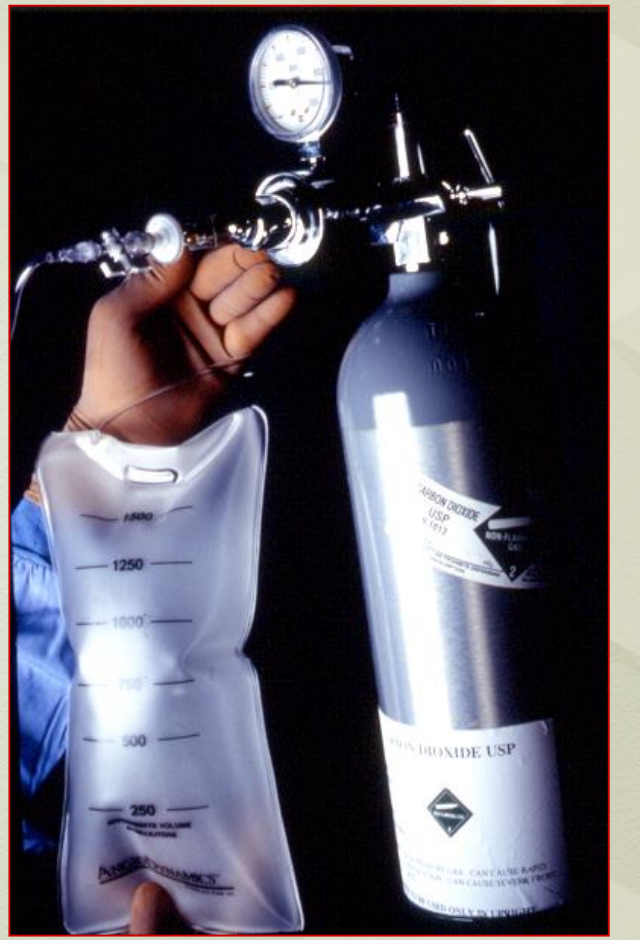
- Requires unique delivery system
- Invisible – concern for undetected contamination
- Cerebral vessels should be avoided
- Bowel gas can interfere with abdominal images
- Potentially more labor intensive

CO_2 CONCERNS

- Contamination
- Excessive volumes
- Intracerebral exposure
- Compressive delivery
- COPD
- Pulmonary HTN

PREVENT CONTAMINATION

1. Use a disposable source of medical grade CO_2
2. Use a closed delivery system
3. Eliminate stopcocks
4. Glue connections
5. Flush system

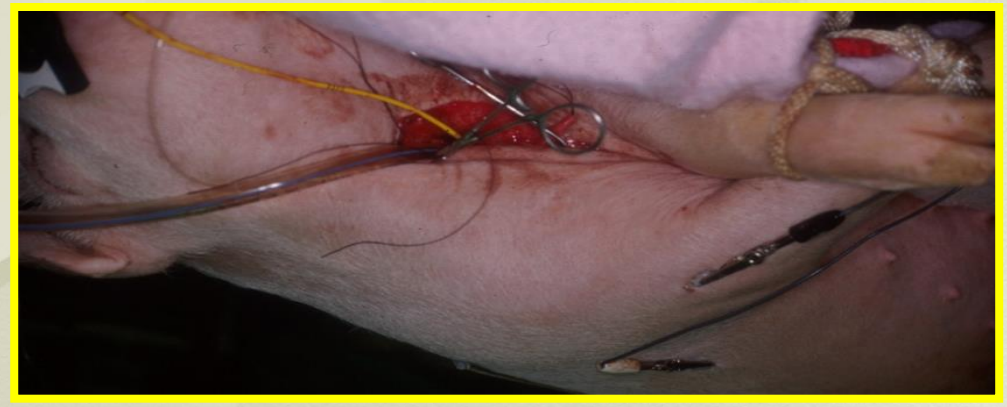



Avoid
excessive
volumes

EXCESSIVE VOLUME

- One large bolus
- Multiple small boluses without time for CO_2 to absorb

THE HEMODYNAMIC AND VENTILATORY RESPONSES TO INTRACAVAL ADMINISTRATION OF ASCENDING DOSES OF GASEOUS CARBON DIOXIDE: EXPERIMENTAL STUDY IN 20 SWINE – Kyung Cho



CO_2: .2 – 6.4 cc/kg

Position in supine, LLK, RLD

Monitoring:

HR	RR	BP
PA	SaO2	pCo2
pO2	PH	HCO2

$ETCO_2$ at 1.3.5. & 10 min post CO_2

Histology of the lungs

CONCLUSIONS:

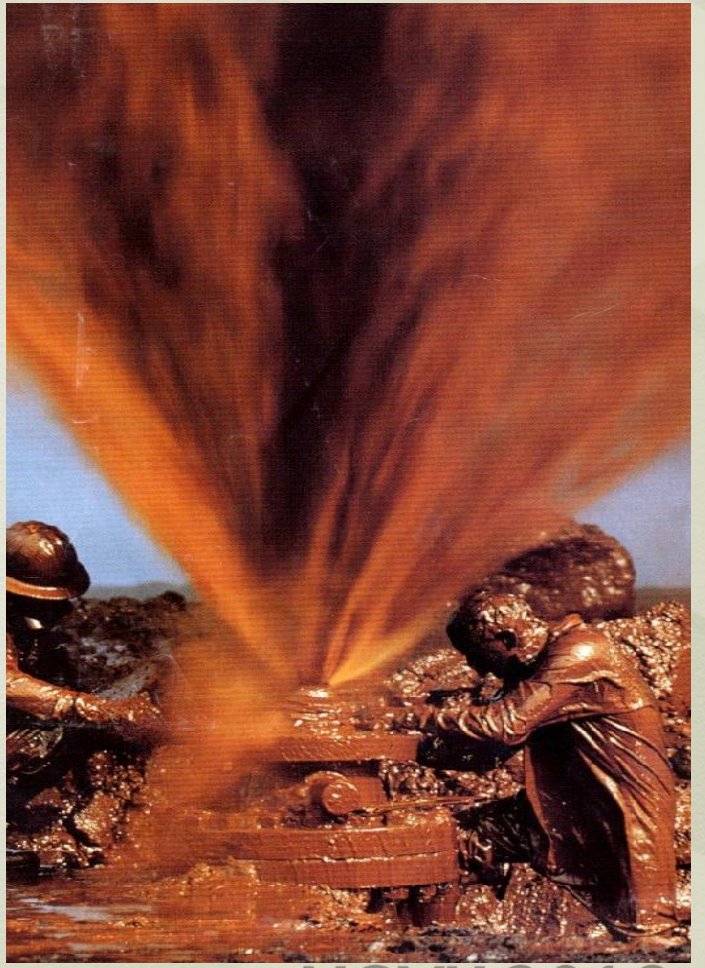
- Higher volumes showed changes in various parameters
- CO_2 in doses of .2 -1.6 cc/kg (112 cc in 70 kg) showed no cardiopulmonary effects
- Intravenous diagnostic CO_2 DSA may increase PA pressure so use cautiously in known pulmonary hypertension

CO_2 IS COMPRESSIBLE

- Inaccurate volumes
- Explosive delivery

PREVENT EXPLOSIVE DELIVERY

- Use a non-compressed closed system
- Purge to atmosphere
- Purge catheter before definitive injection



COPD

- CO_2 endogenous production 250 cc/min
- No problem unless in respiratory failure
- Precaution: decrease volume and increase interval between delivery

PULMONARY HTN

- Avoid high volume venous procedures
- Potential PFO

CONTRAINDICATIONS

- Supra-diaphragmatic arterial injections (intracranial CO_2)

- Known right to left shunts

CO_2 CONTRAST

CO_2 can be used as a contrast agent in any tubular structure.

All venous structures

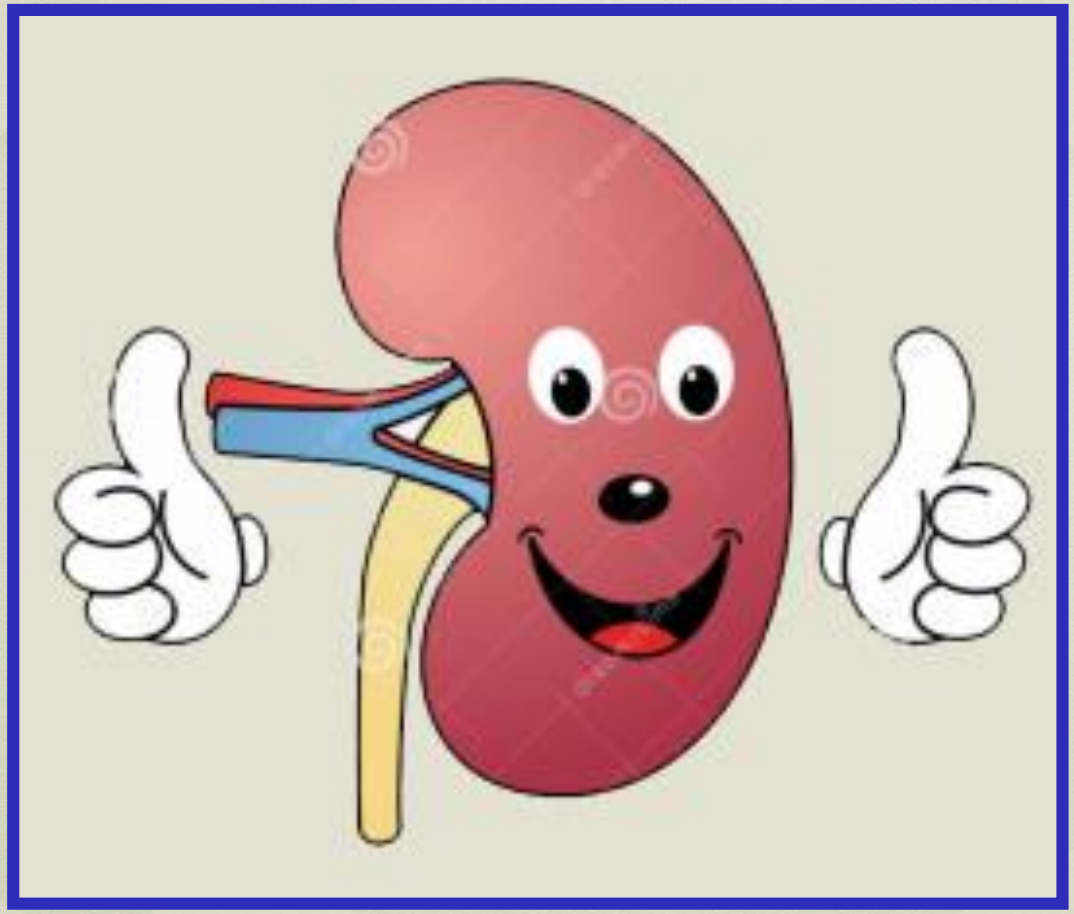
All arteries except above the diaphragm

INDICATIONS

- Iodinated contrast allergy
- Renal insufficiency
- High volume contrast procedures
- Detection of AVF/arterial bleeding
- Intervention: arterial and venous

NON-NEPHROTOXIC

CO_2 IS THE ONLY NON-NEPRHOTOXIC CONTRAST AGENT!



HOSPITAL ACQUIRED CIN

Risk of death	(34%) 6 x ↑
Hospitalization	2 x ↑
1 and 2 year mortality	2 x ↑

Increase comorbid complications

McCullough P. Contrast Induced Acute Kidney Injury. J. Am.Coll. Cardiol 2008; 51:1419-1428

HOSPITAL ACQUIRED CIN

7500 Patients

In hospital mortality (22% vs 1.4%)

1 and 5 year mortality 4 x

Rihal et al.

CIN

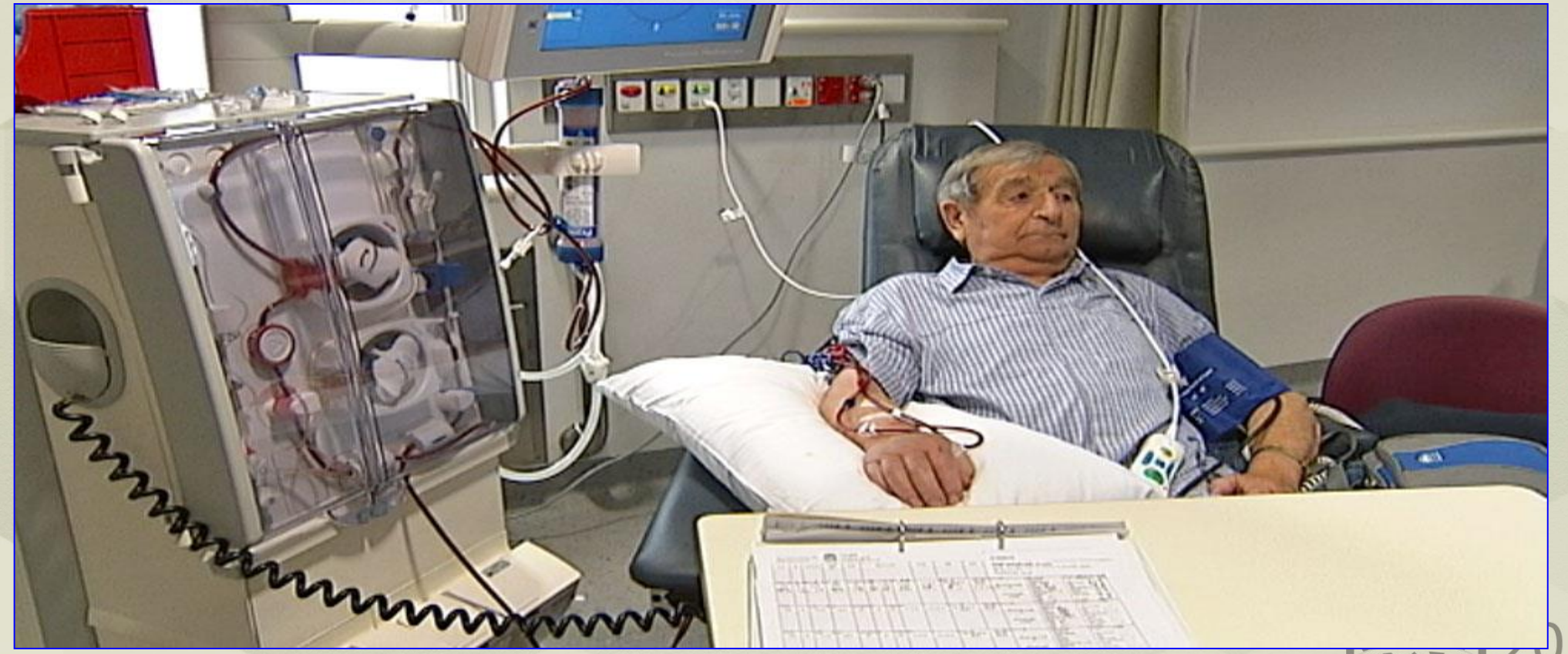
- Patient population is aging
- Diabetes is increasing
- Vascular interventional procedures are increasing
- CLI & CTO 40% have renal insufficiency
- Creatinine clearance subnormal in > 80% of PAOD
- Serum Cr is inaccurate in 30% 40-49 yo and 90% > 70 yo
- 30% of Cr Clearance abnormal for > 70 yo
- CIN correlates with 30 day and 1 year mortality and is the strongest one year predictor of death

BOTTOM LINE!!!

REDUCE OR PREVENT CIN

LIMIT THE VOLUME OF CONTRAST

WHAT GOOD IS IT IF YOU HELP THEM WALK AND NOW THEY HAVE TO WALK TO DIALYSIS!!!!!



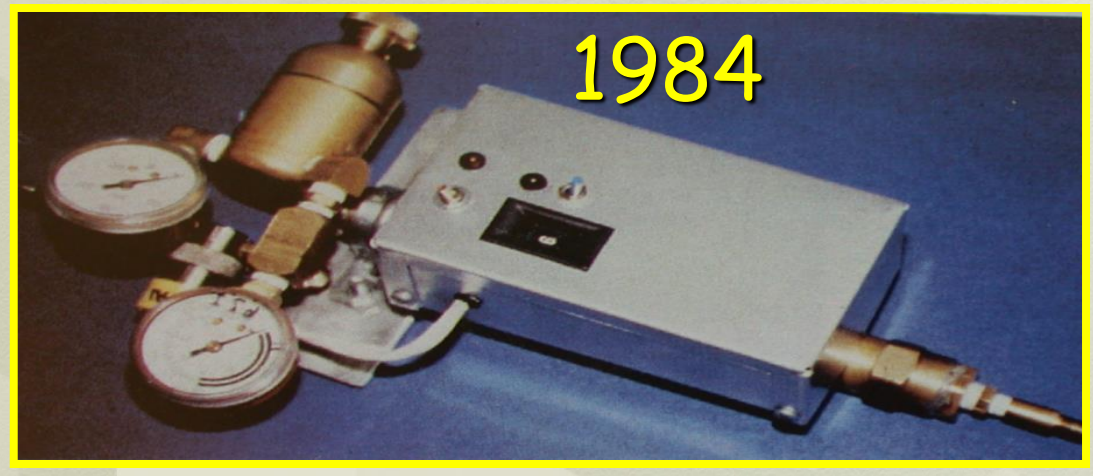
CO_2

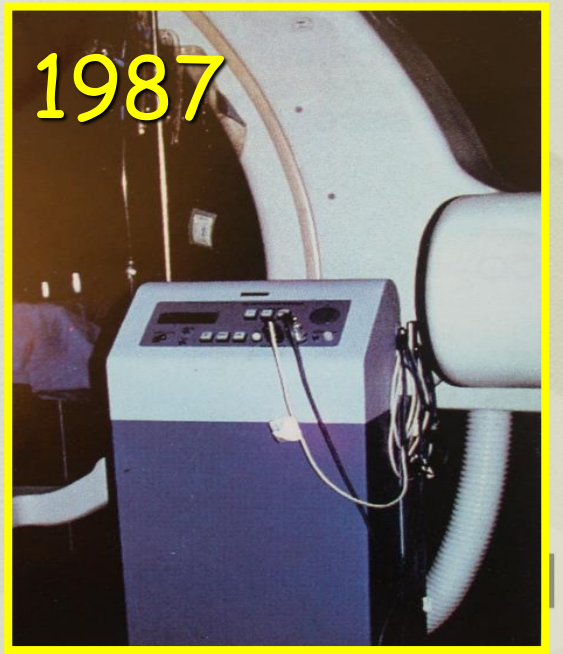
- Eliminates CIN
- Permits procedures previously precluded in patients with renal insufficiency!!!

DELIVERY

EVOLUTION OF CO_2 INJECTOR

- 1971 - Hand Syringe
- 1972 - Standard Angio Injector
- 1973 - CO_2 Cylinder (animals only)





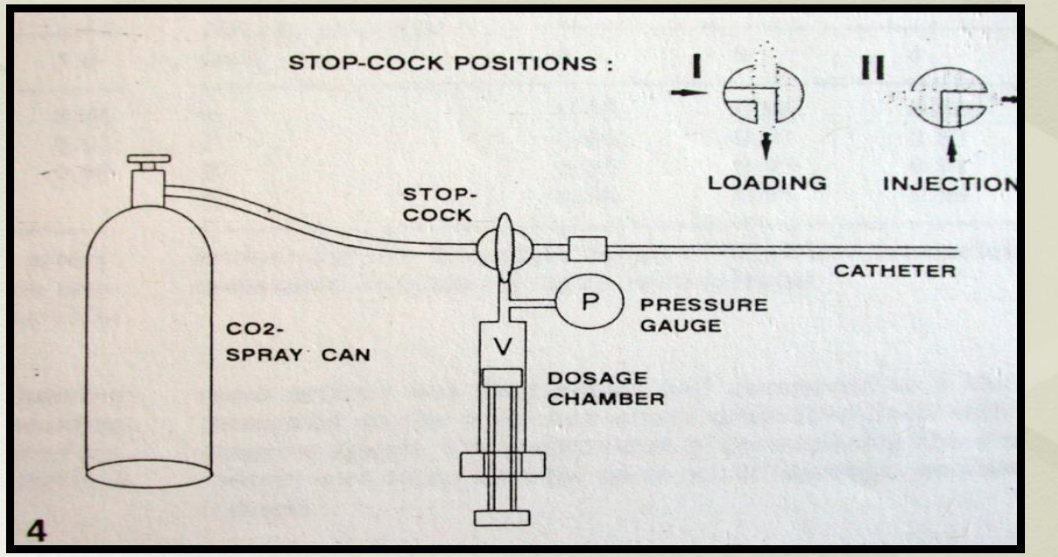
EVOLUTION OF CO_2 INJECTOR

CO_2 Power-Assisted Hand-Held Syringe: Better Visualization During Diagnostic and Interventional Angiography

A. Krieger, MD, Ariel E. Furst, BS, BA, Frank J. Hildner, MD, Jay Midwall, MD, and Joshua Kieval, MD

Recent technology has produced high-flow and large-lumen catheters as well as other angiographic accessories to enhance the visualization of the coronary arteries during diagnostic and percutaneous transluminal coronary angioplasty (PTCA) procedures. In spite of these technological advances, there are still many cases in which the quality of the coronary angiography could be significantly improved. This paper reports on a clinical evaluation of a hand-held power syringe. The syringe offers the ability to power inject contrast safely and effectively during routine angiograms as well as through guiding catheters with the balloon catheter present during PTCA. At the same time, control of the injection is equal to that associated with manual syringes.

Key words: power injectors, coronary arteries, balloon catheter



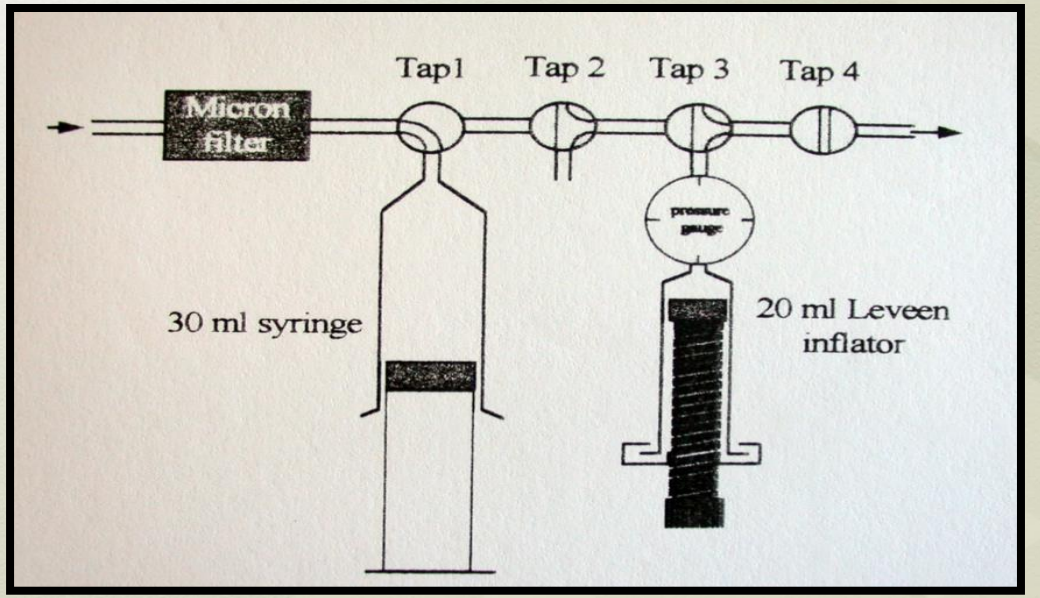
Technical Note

A Simple Gas Injector for Carbon Dioxide Angiography

T. M. SNOW, H. A. RICE

Department of Radiology, Gold Coast Hospital, Queensland 4215, Australia

Received: 16 October 1998 Revised: 28 January 1999 Accepted: 2 February 1999



CO_2 JECT

- Commercial model
- Monitors
- Contrast injection
- Automatic flush
- Closed system
- Mass flow indicator
- Outside US

angiodroid

The CO_2 Angiography

What is Angiodroid?

Is the only Device on the Market

- **100% DIGITAL**
- **100% AUTOMATIC**
- **100% SAFE**
- **100% USER FRIENDLY**

Plastic Bag Delivery System

Hawkins, Caridi, and Kerns. AJR 165: 1995:1487-1489

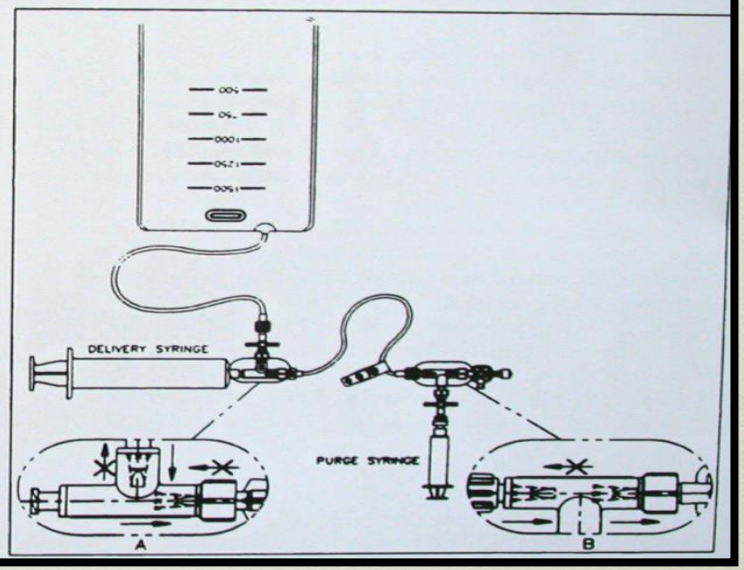
Plastic Bag Delivery System for Hand Injection of Carbon Dioxide

Irvin F. Hawkins, Jr.[1], James G. Caridi, Scott R. Kerns

Digital subtraction angiography with carbon dioxide as a contrast agent provides images useful in making a diagnosis and occasionally gives information not obtainable with use of iodinated contrast material. However, delivery of the gas is difficult because carbon dioxide is compressible and invisible [1, 2]. Over the past 10 years, we have developed a reliable, 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.

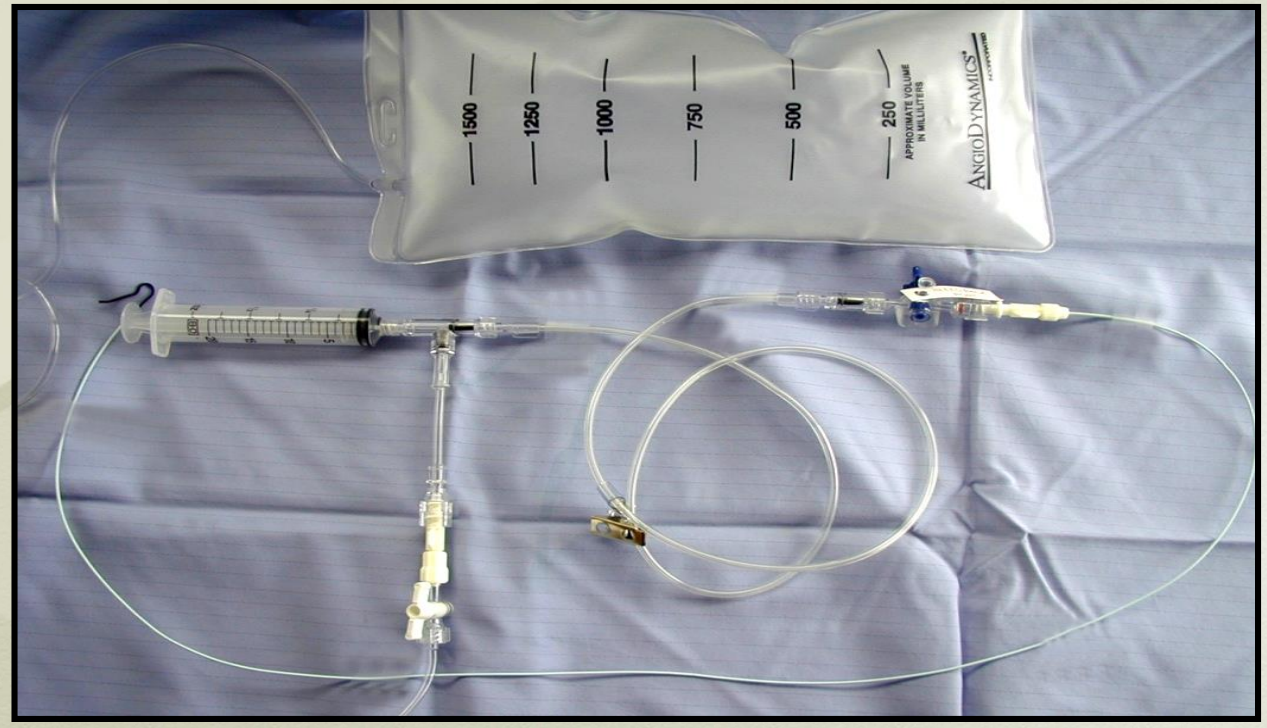
Materials and Methods

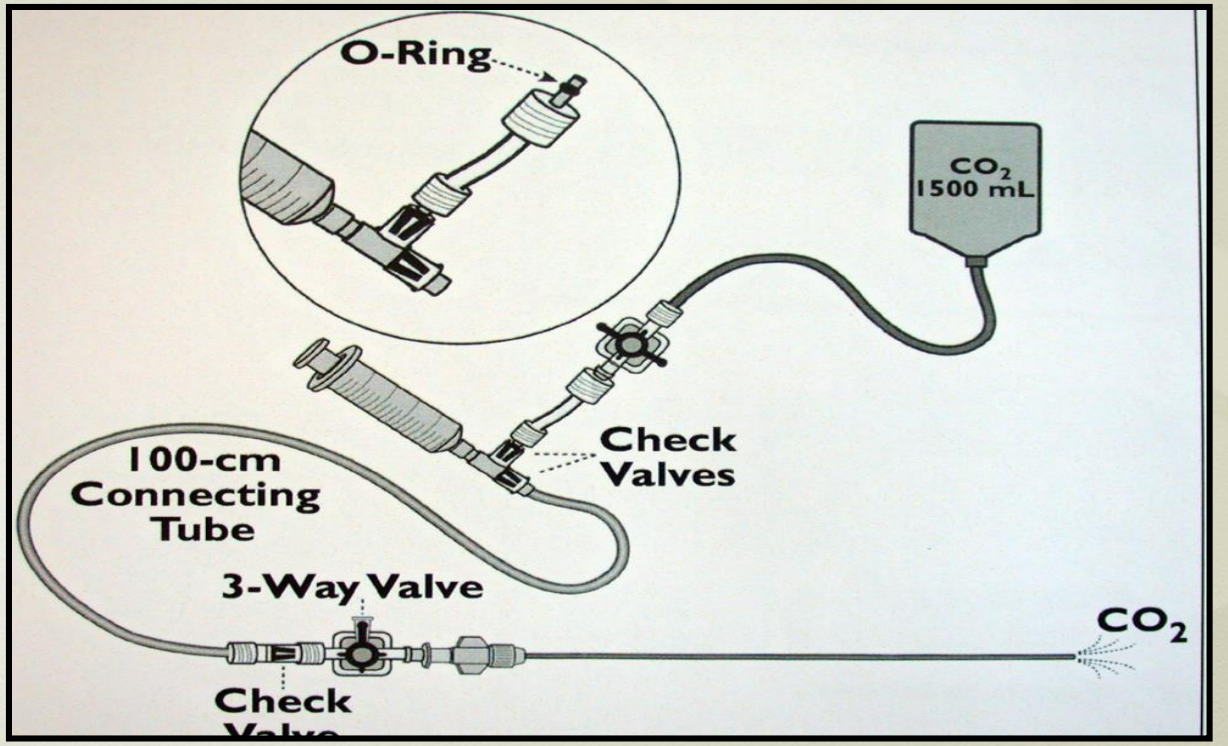
The system has two major components (Fig. 1): a plastic bag (AngioFill Bag Collection System; AngioDynamics, Queensbury, NY) that is used as a reservoir for the carbon dioxide and a closed fluid (or gas) delivery system (AngioFlush II, AngioDynamics) consisting of multiple check valves, stopcocks, and a connecting tube. The reservoir is a 1500-ml plastic bag with a 100-cm connecting tube. In order to remove residual air from the connecting tubing and the bag, a special female-to-female adaptor is connected to the one-way stopcock. After air is removed from the bag, the stopcock is



AngioFill Bag Collection System and Angioflush 11. AngioDynamics

FLACCID CO2 RECEPTACLE





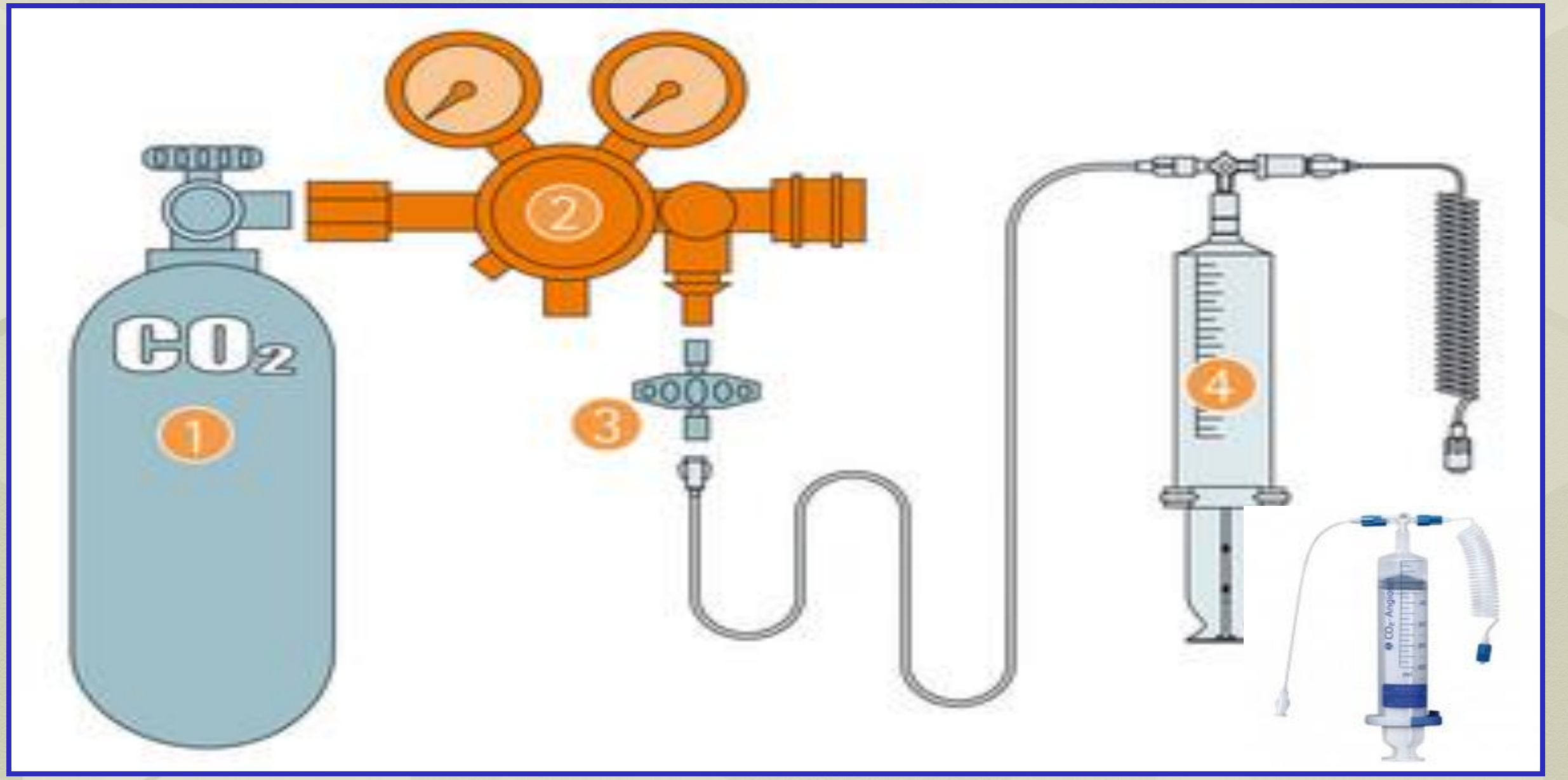
MERIT MEDICAL CUSTOM WASTE BAG AND CONTRAST DELIVERY SET

2018

WASTE BAG AND CONTRAST DELIVERY SET

CO_2 ANGIOGRAPHY TECHNIQUE

OPTIMED CO_2 ANGIOSET



CO2MMANDER AND ANGIASYST


REF
LOT
USE AT ROOM TEMPERATURE


CO2MMANDER®
Elite
SN/ 5274


CO2MMANDER®
Elite
SN/ 5000


BD
CO2MMANDER®
Elite

ANGIASSIST:

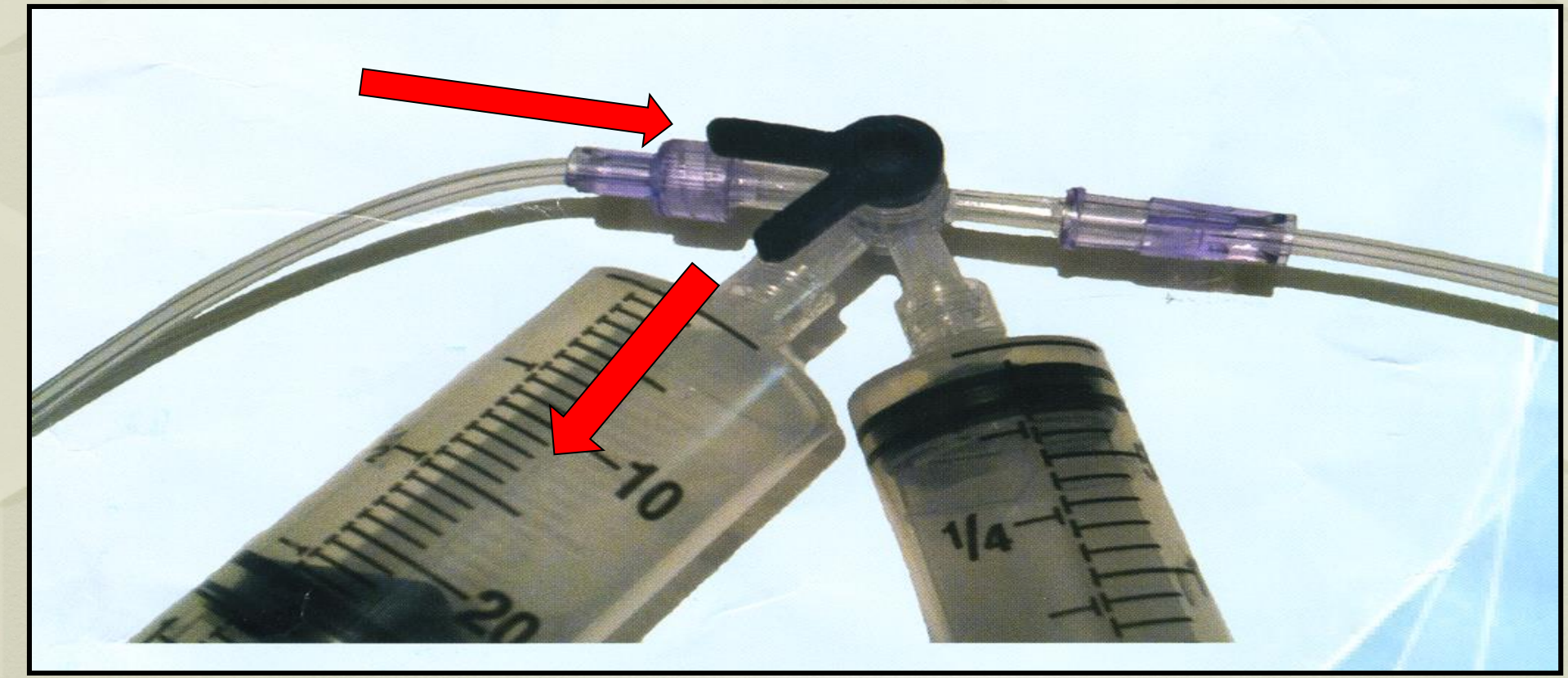
CO2MMANDER,

One way valve

One way valve

3 way stopcock

Proprietary K valve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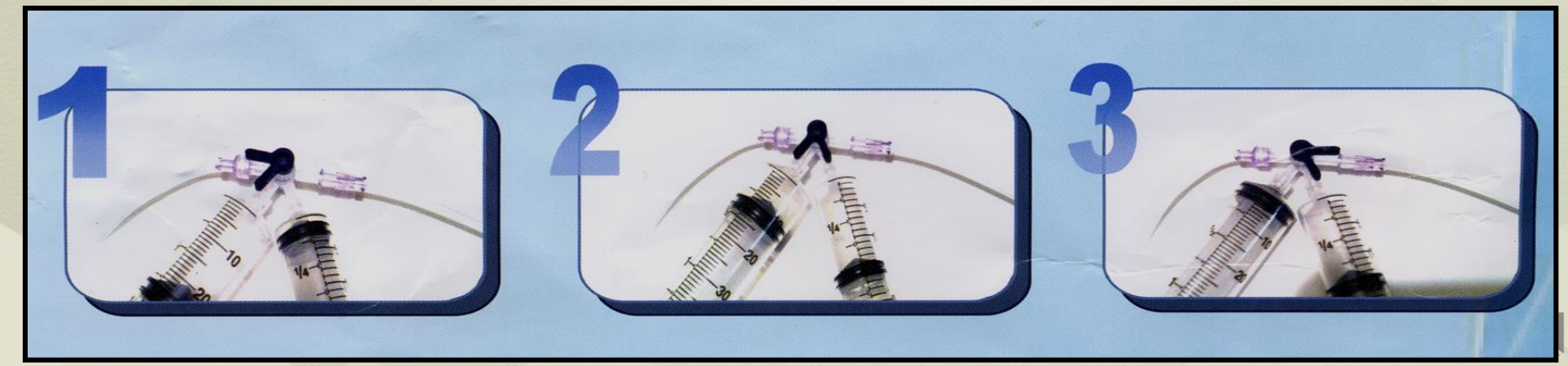
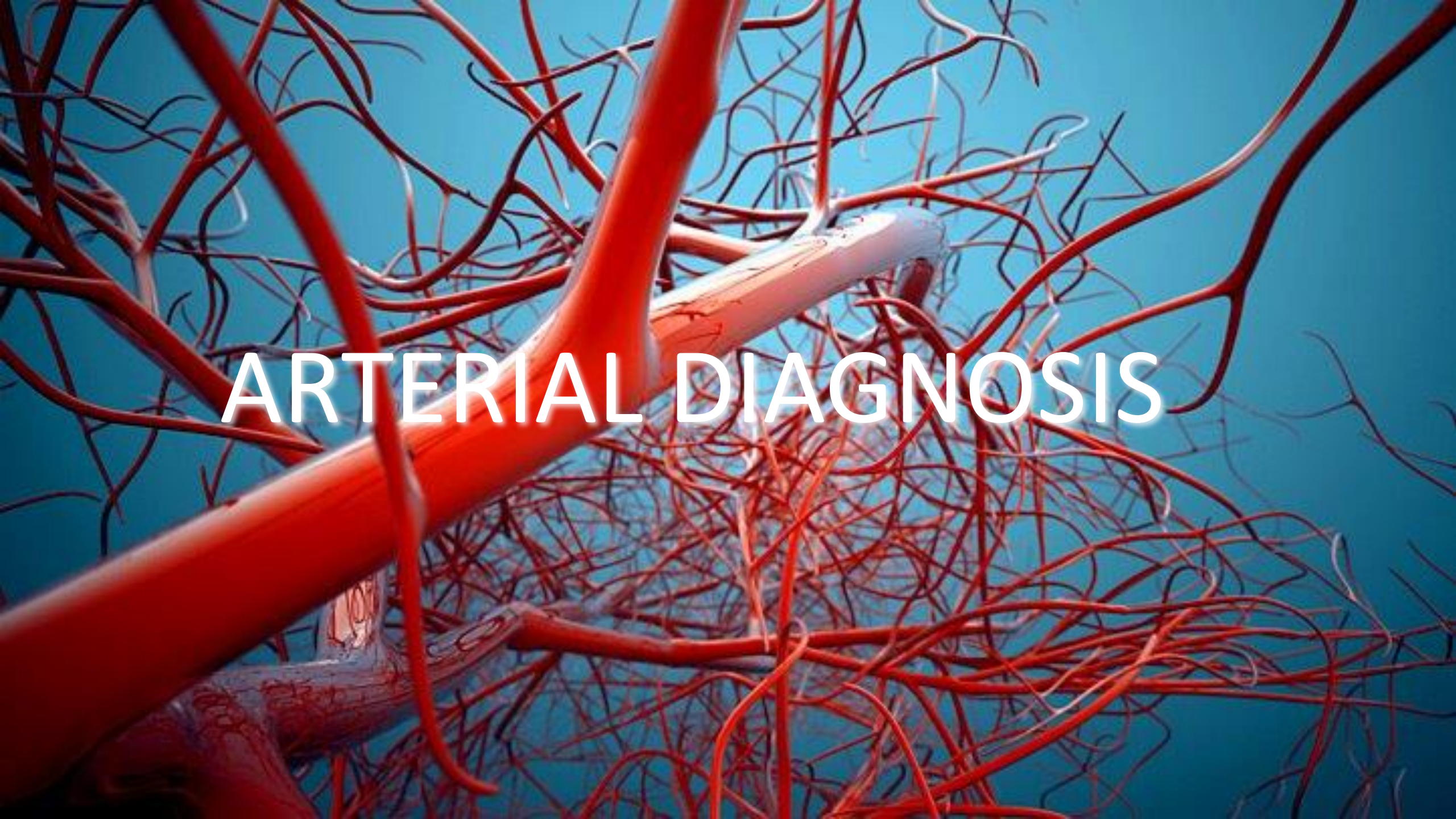
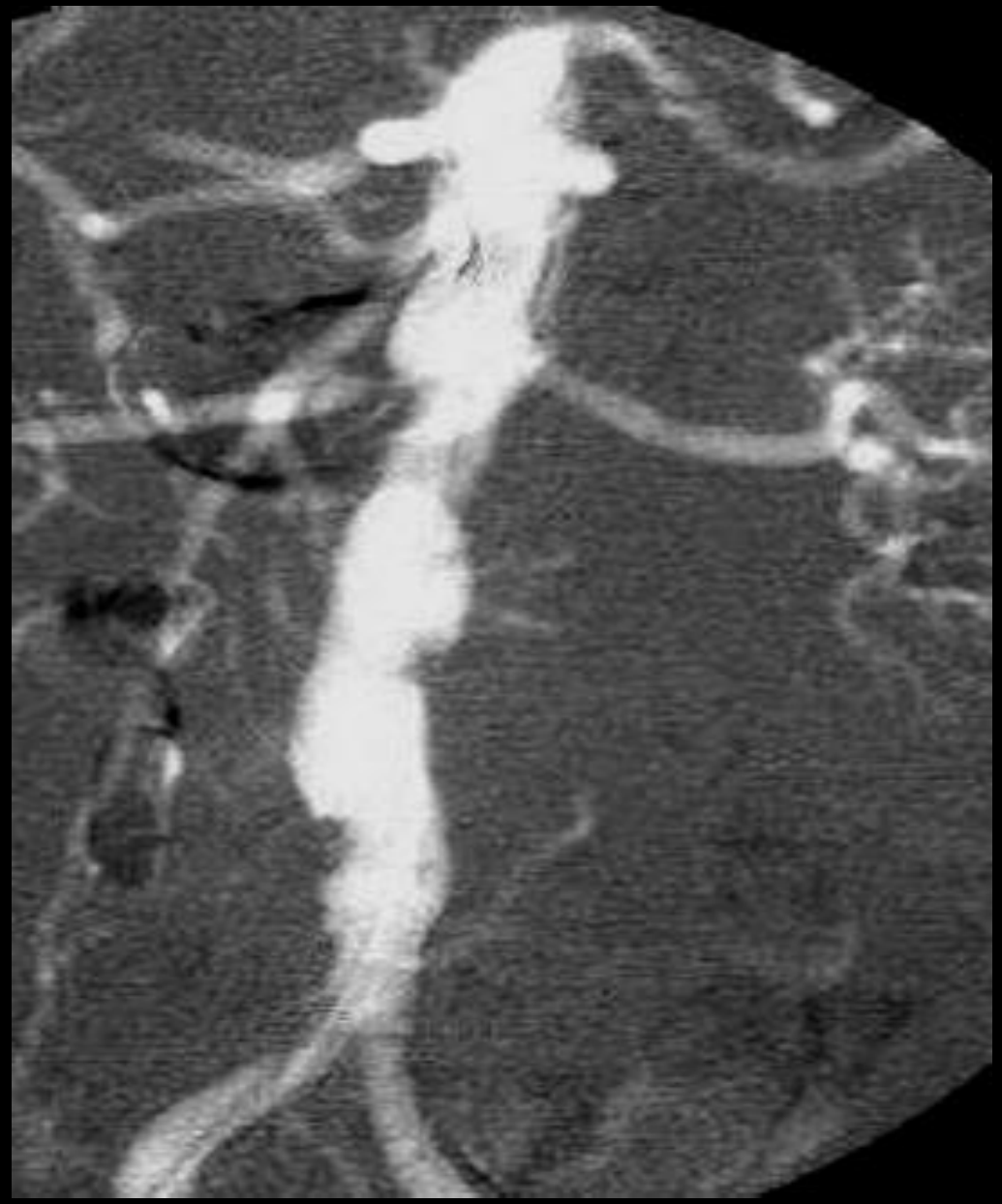
20
1/4


1
2
3

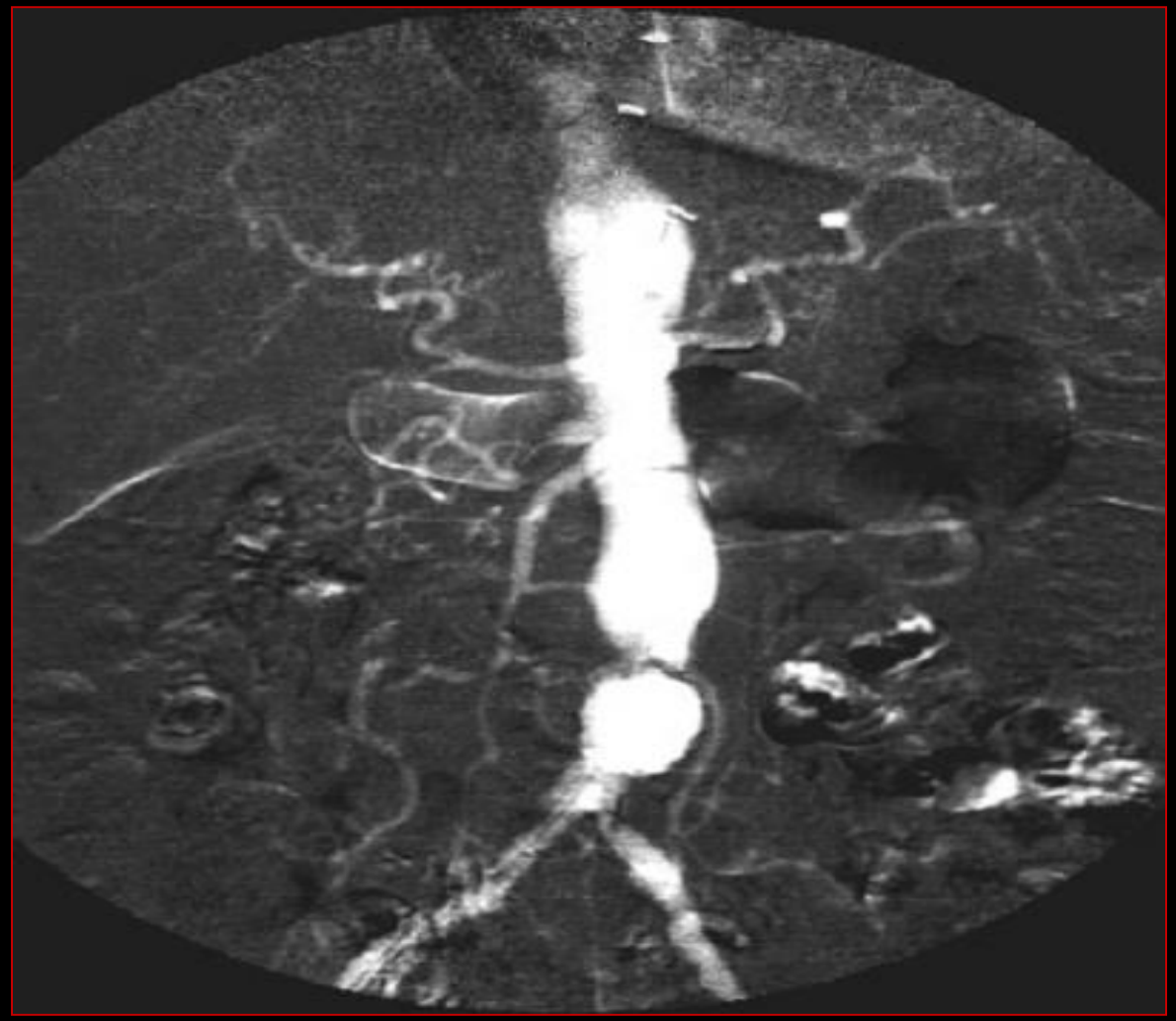
CLINICAL APPLICATIONS

- Arterial diagnosis
- Arterial intervention
- Detection of bleeding and or fistulas
- Interventional oncology
- Venous diagnosis and intervention
- Dialysis
- Portal venography and intervention
- TIPS

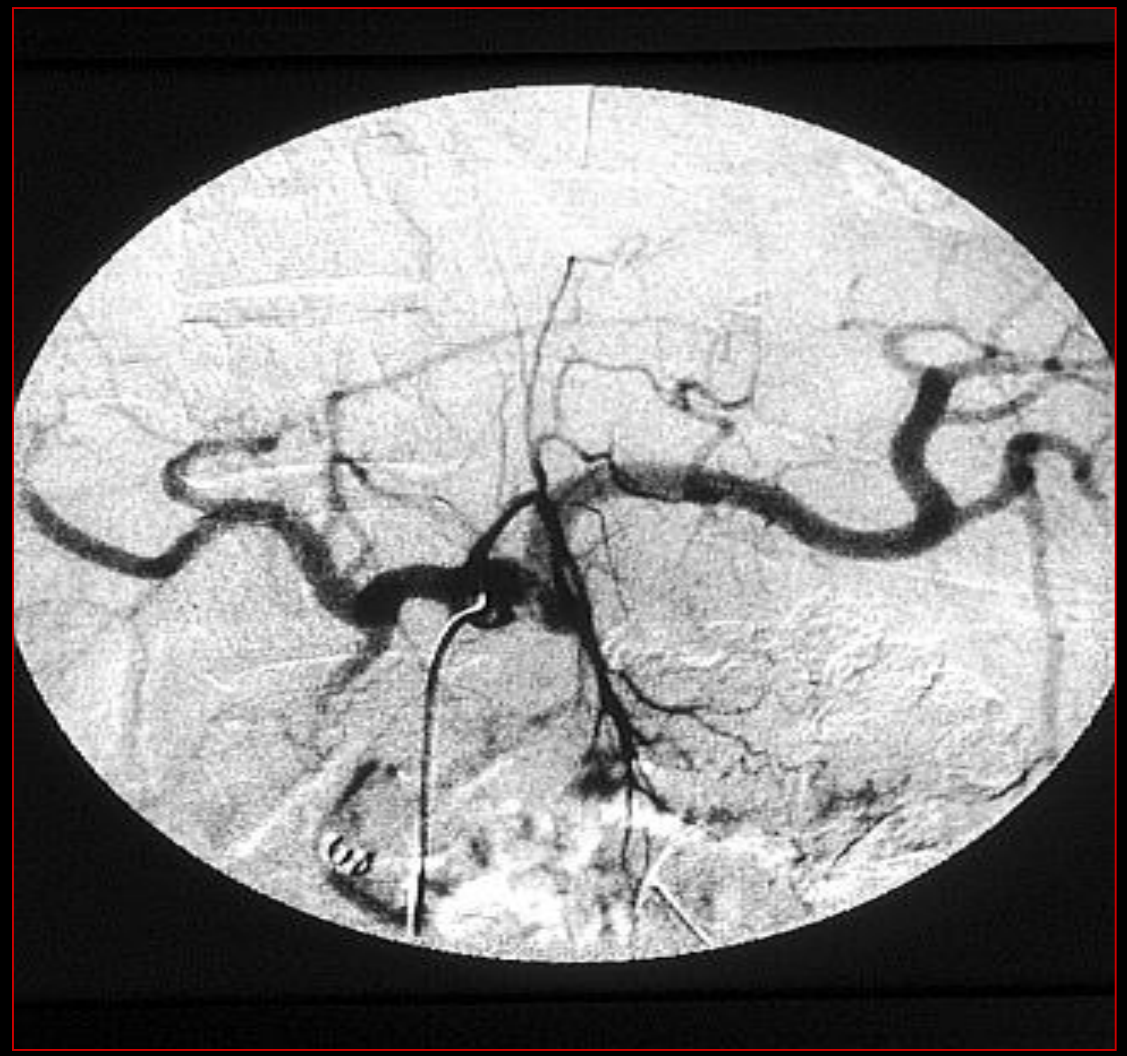

ARTERIAL DIAGNOSIS



CO_2 IS BOUYANT

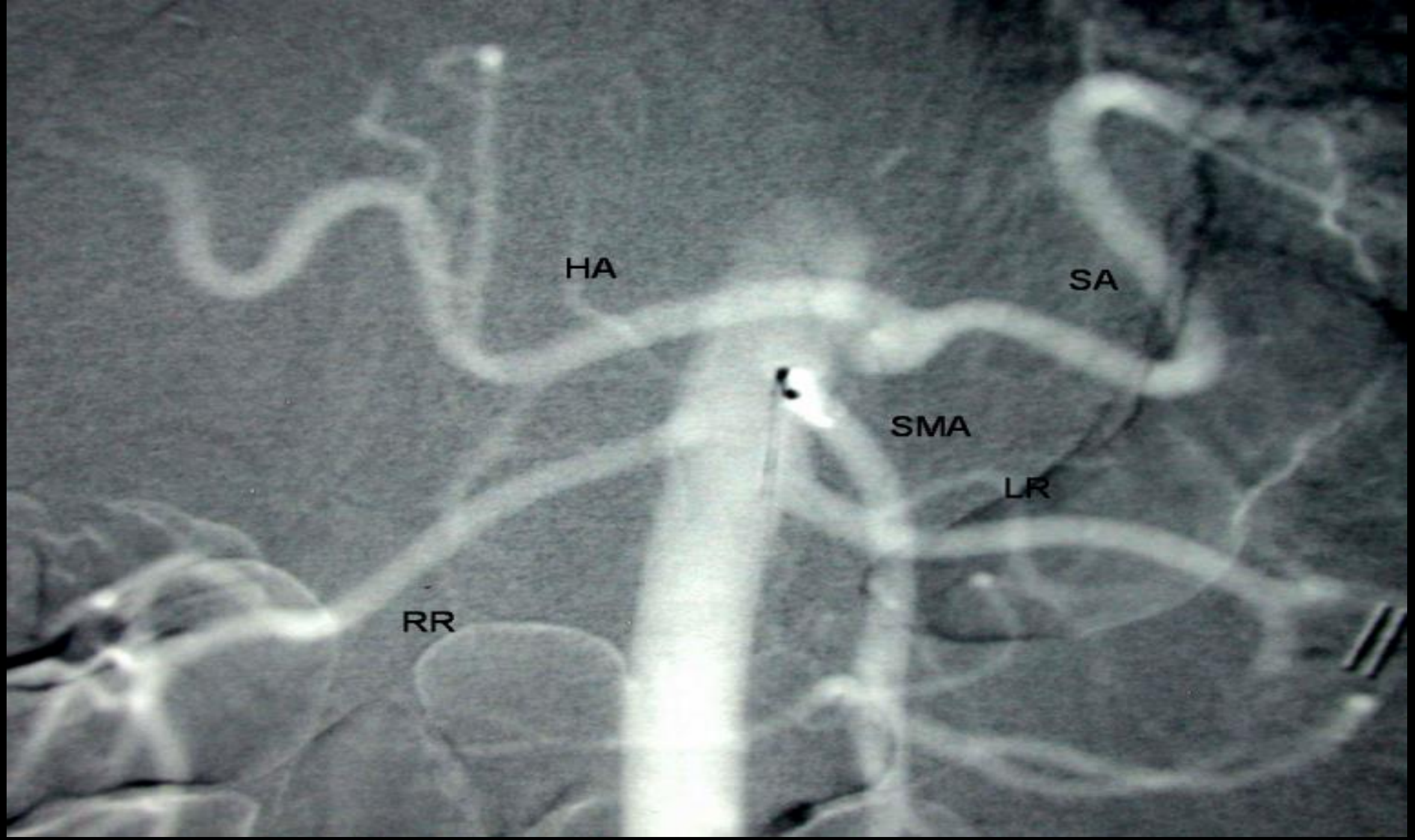


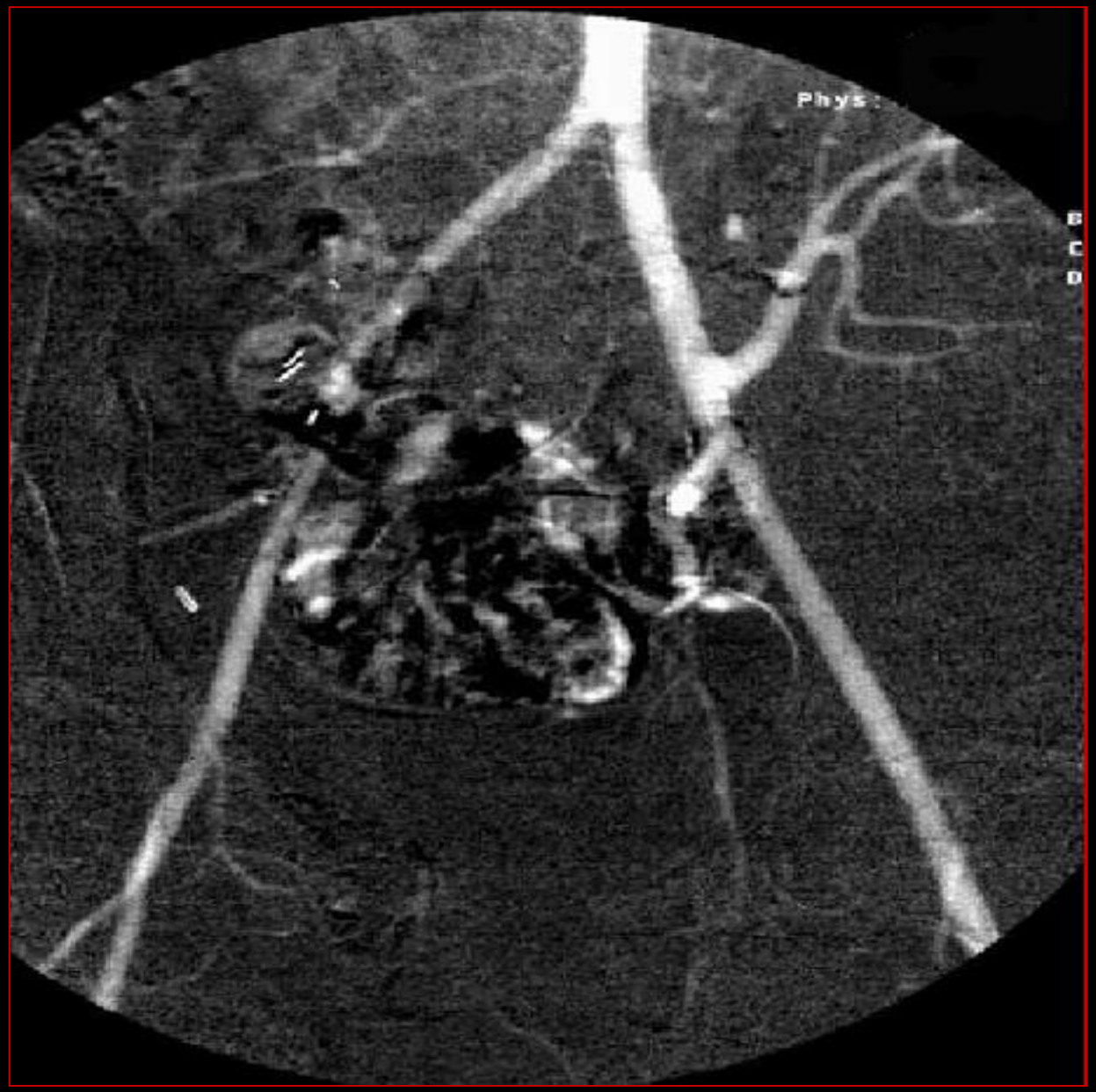
VASCULAR STRUCTURES LESS THAN 10 MM HAVE 1/1 CORRELATION WITH LIQUID CONTRAST



Contrast

CO_2

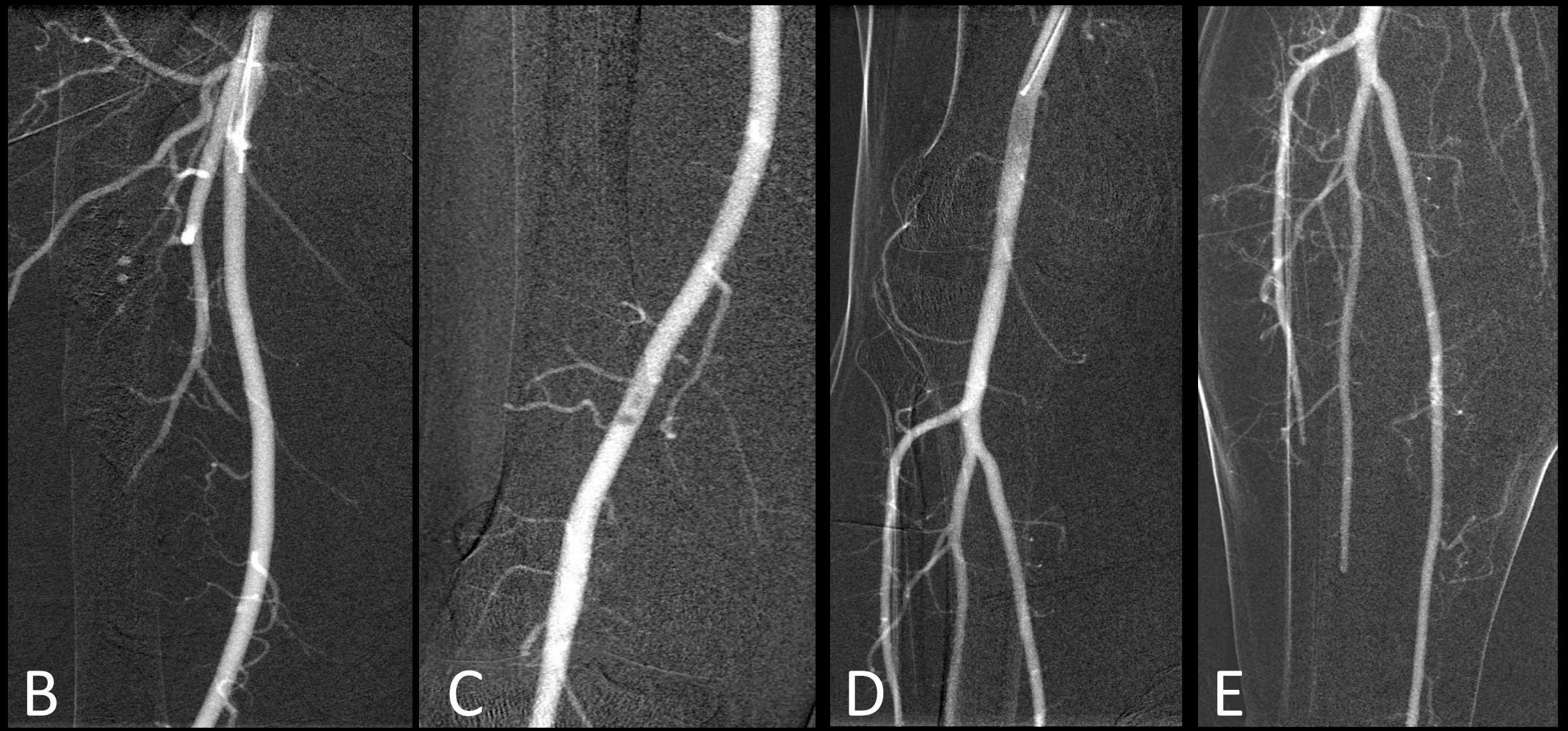

HA
SA
SMA
LR
RR


Phys:

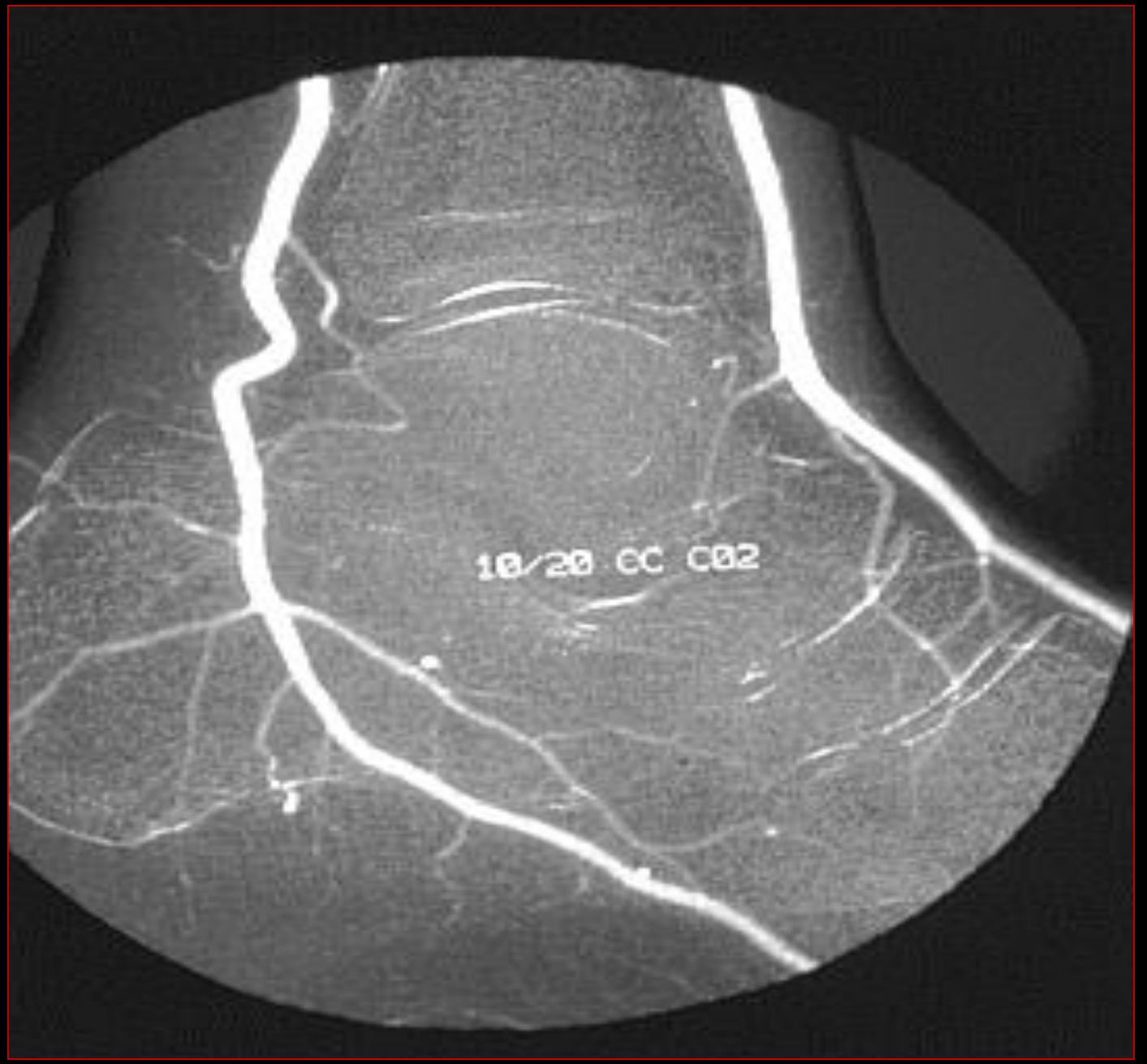

Phys:

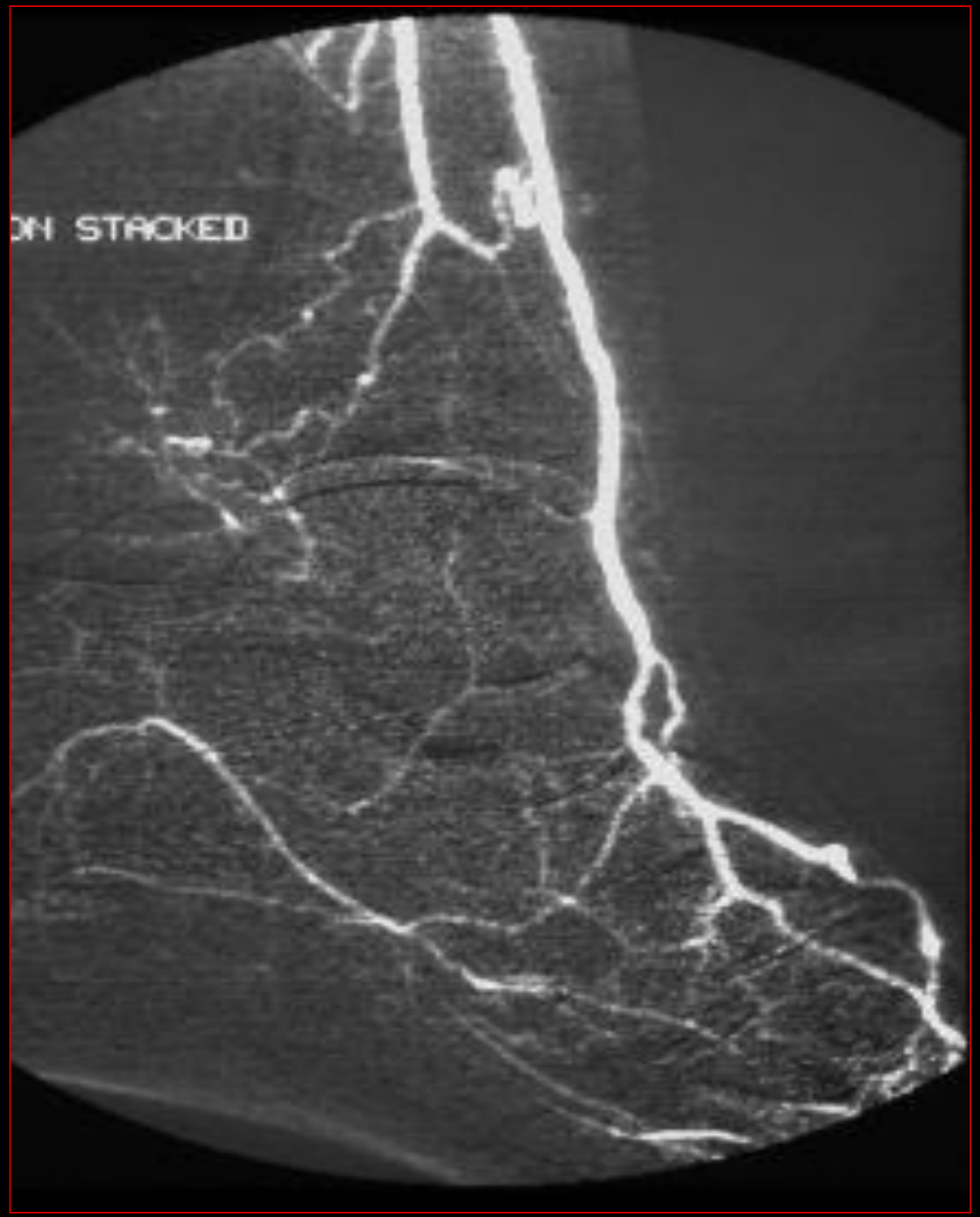
RUNOFF

3 FRENCH CATHETER

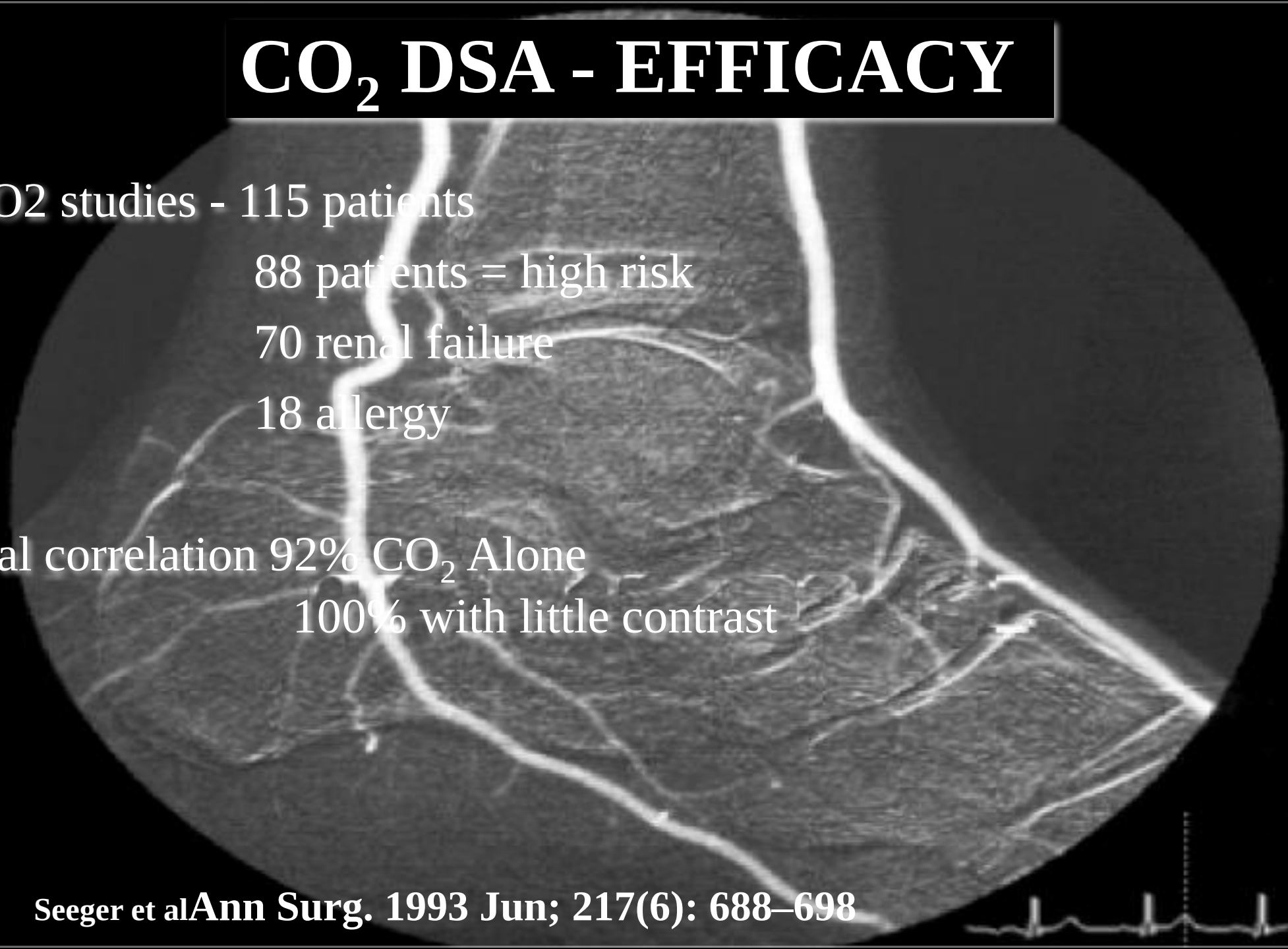

B
C
D
E




10/20 EC C02


ON STACKED

CO_2 DSA - EFFICACY



- 128 CO2 studies - 115 patients
  - 88 patients = high risk
  - 70 renal failure
  - 18 allergy
- Surgical correlation 92% CO_2 Alone
  - 100% with little contrast

Seeger et al **Ann Surg. 1993 Jun; 217(6): 688–698**

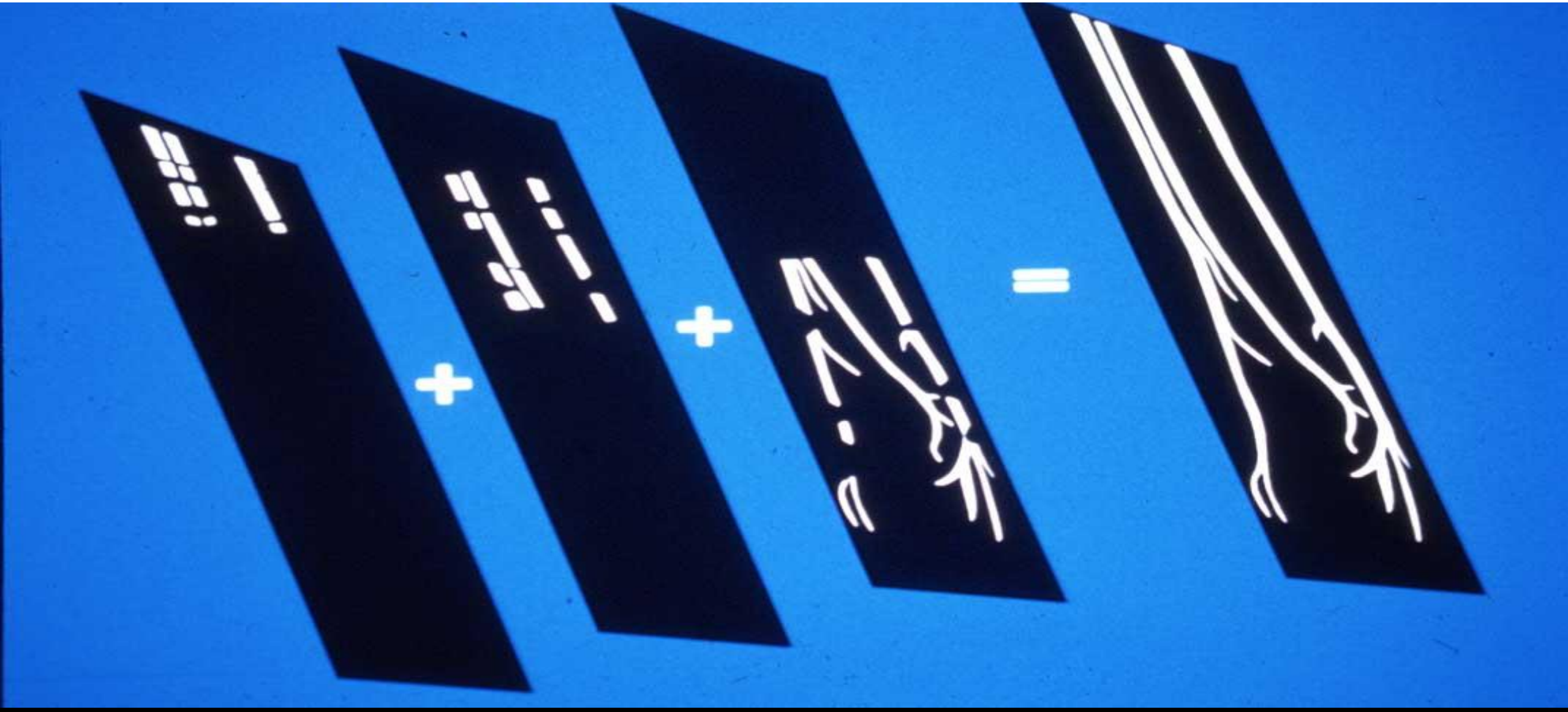
TIPS FOR IMPROVING (RUNOFF) IMAGING

- Reduce motion
- Faster exposure (6 frames/sec)
- Elevate the extremity or area of interest
- Stacking software
- Endhole catheter
- Increase CO_2 volume
- (super) Selective injections
- Vasodilator (NTG 100 mcg)


ELEVATE THE AREA OF INTEREST


257-8426

STACKING SOFTWARE



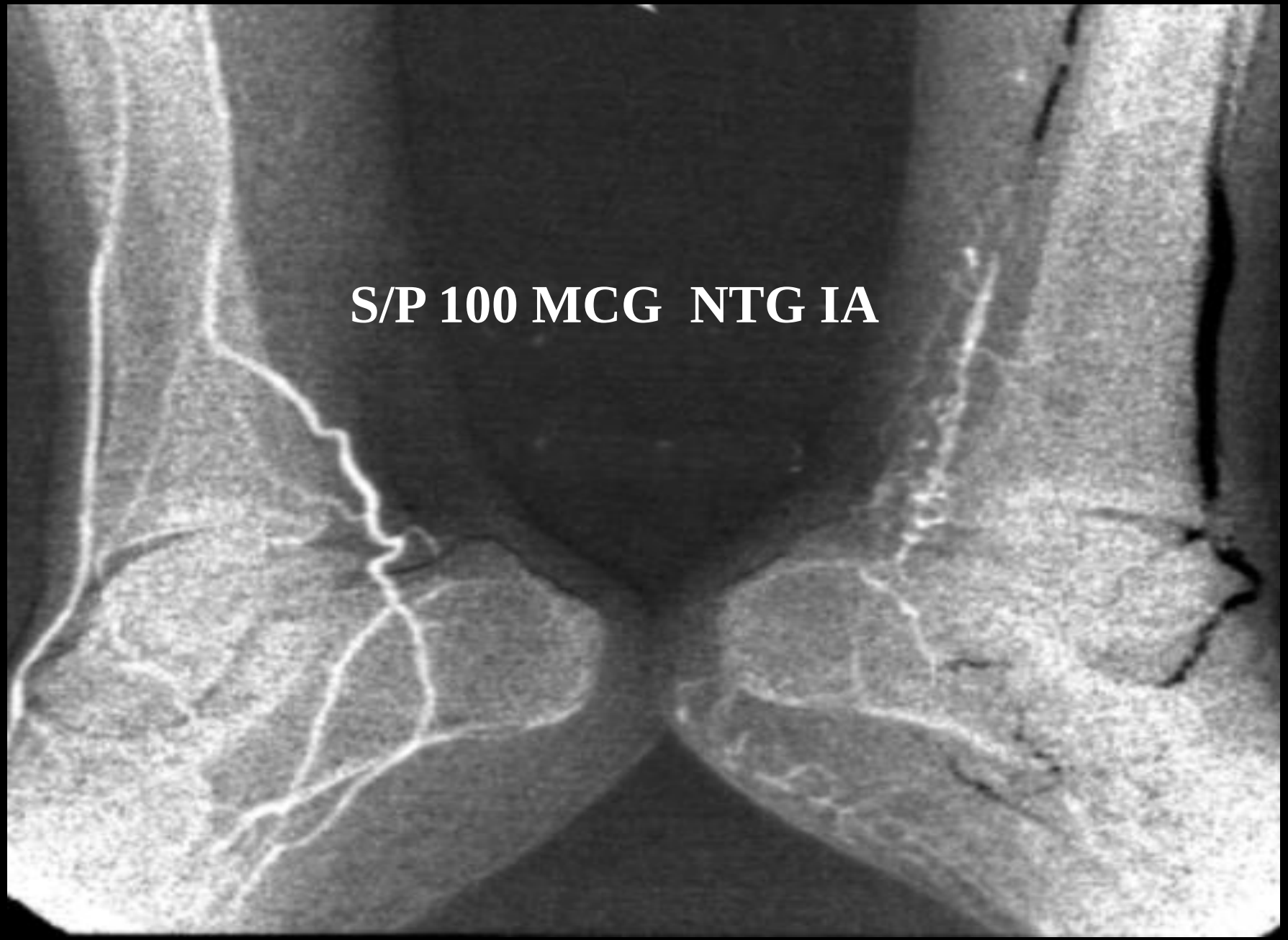

C02 10CC


C02 10CC


C02 10/2


10/20 STACKED


No nitro

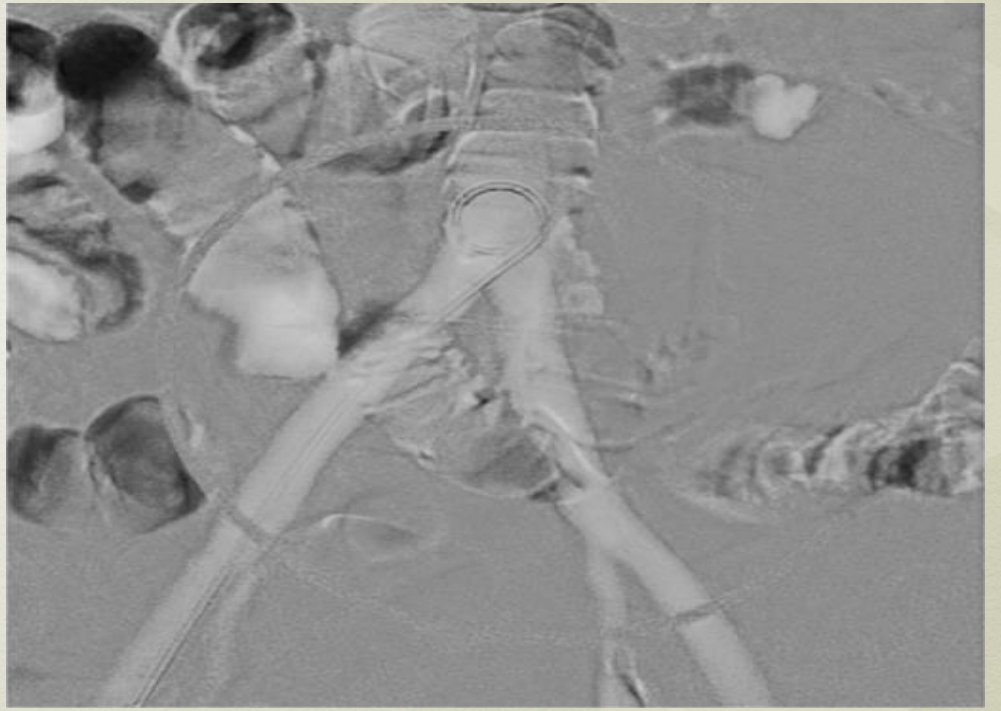

S/P 100 MCG NTG IA

BOWEL GAS?

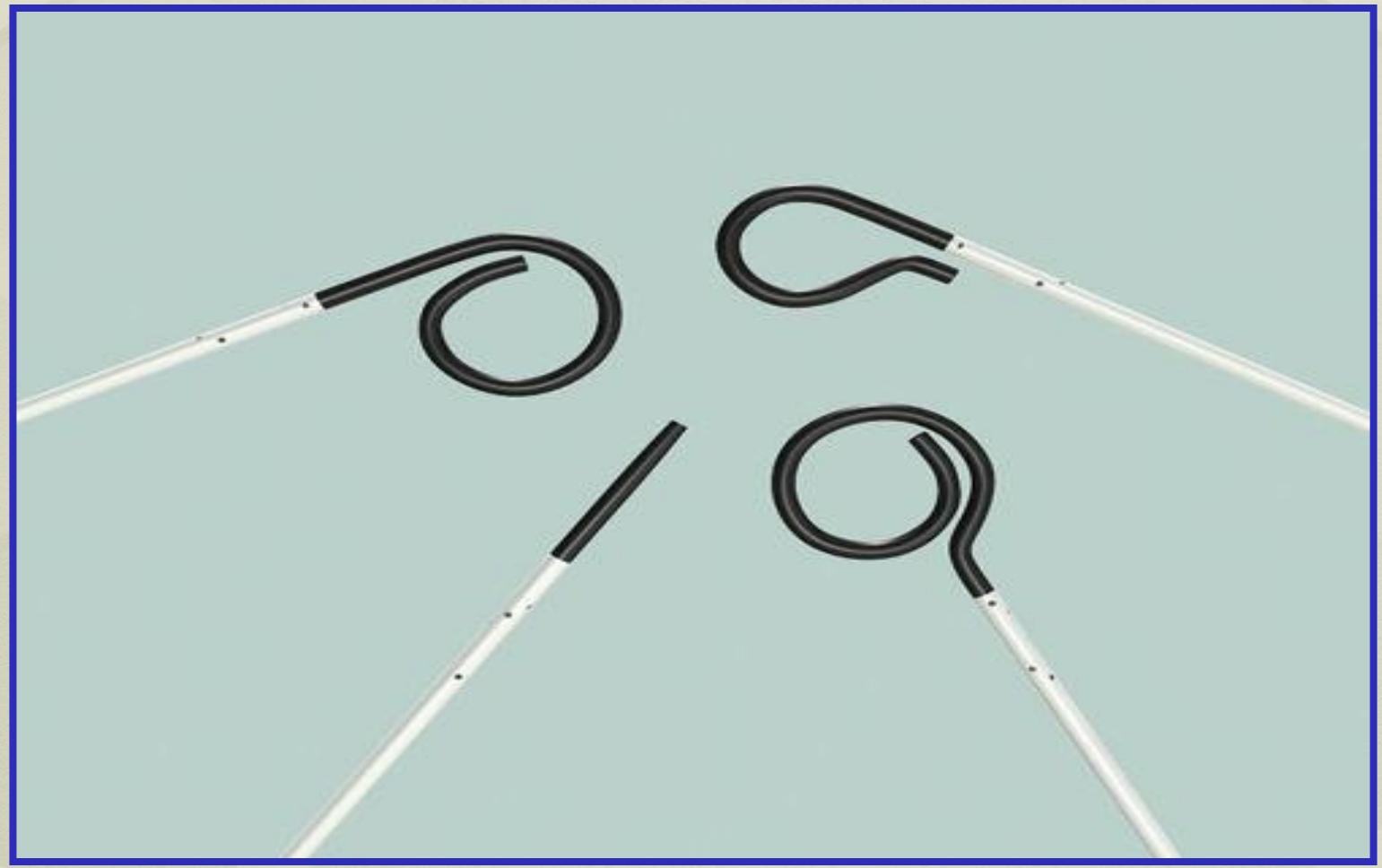
GLUCAGON 1 mg IV

“THE PADDLE”

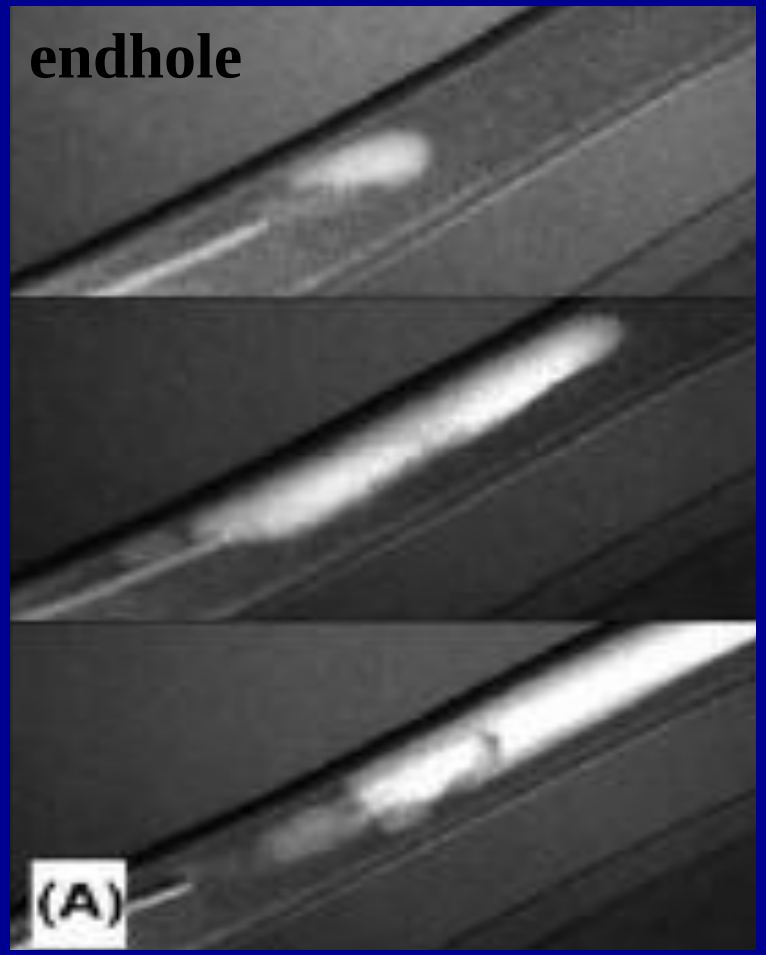
DISPLACE GAS WITH COMPRESSION

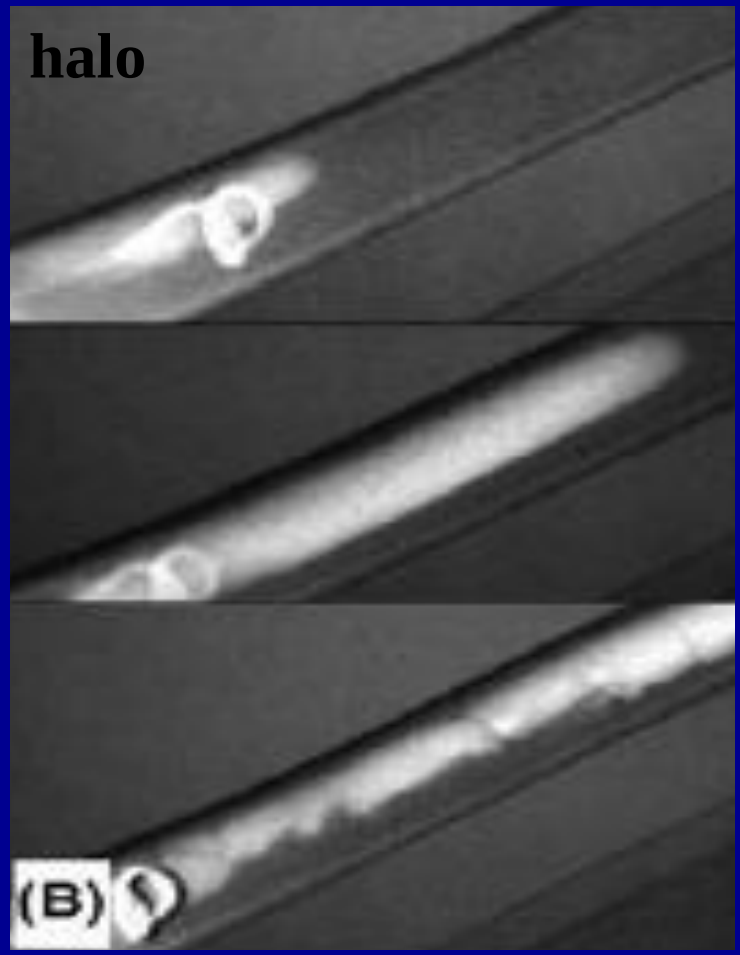


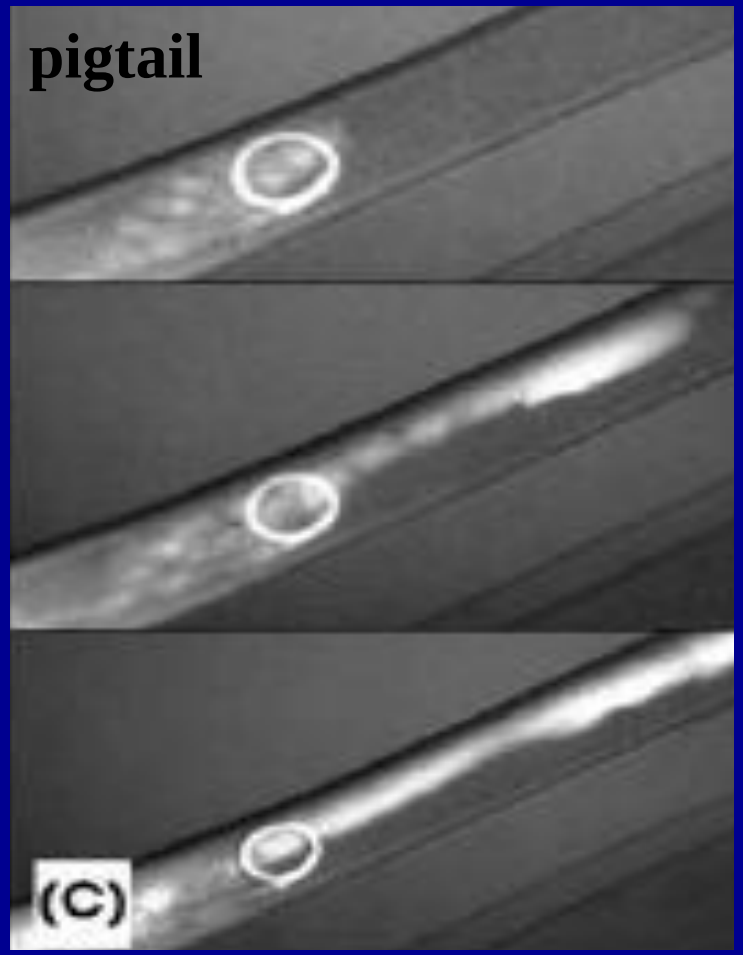
DELIVERY CATHETER



CO_2 DISPERSION PATTERNS FORM THE DIFFERENT CATHETERS



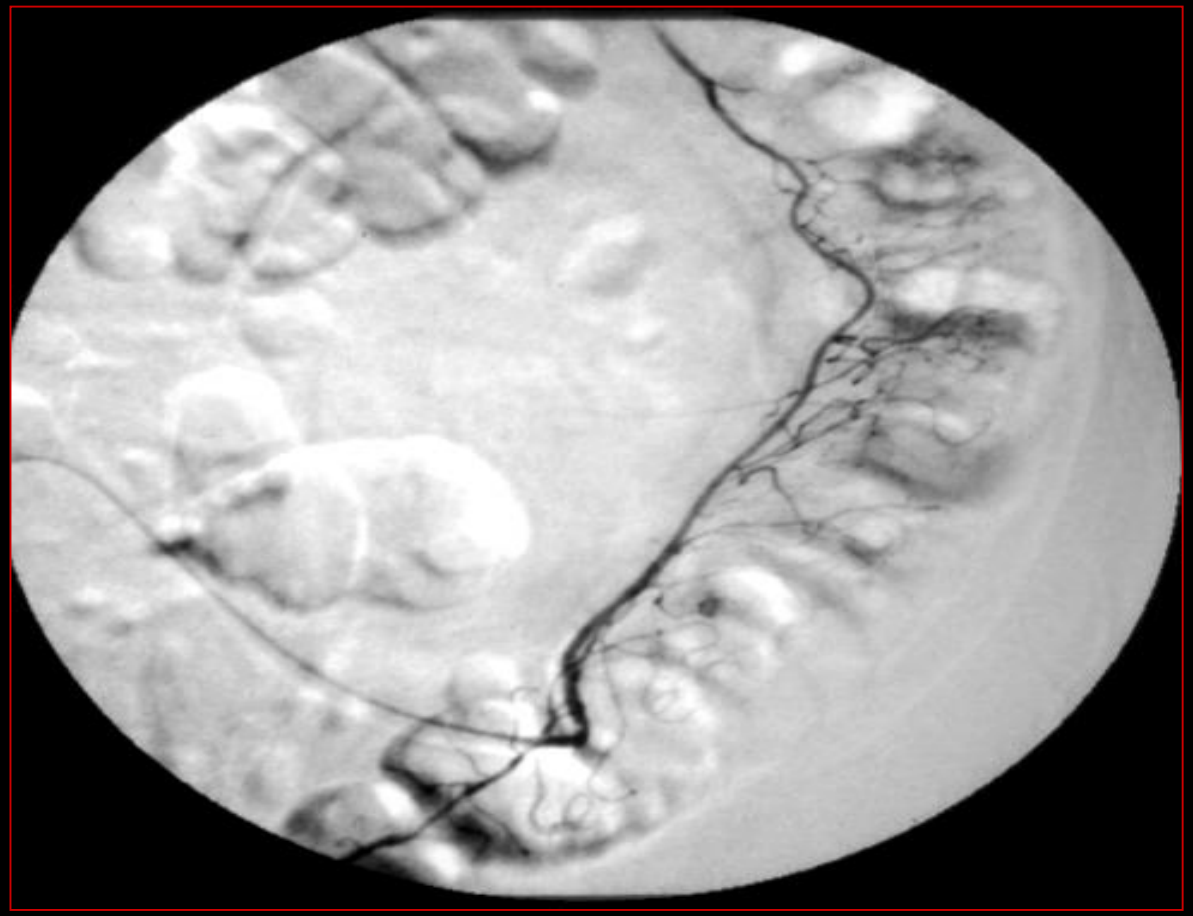




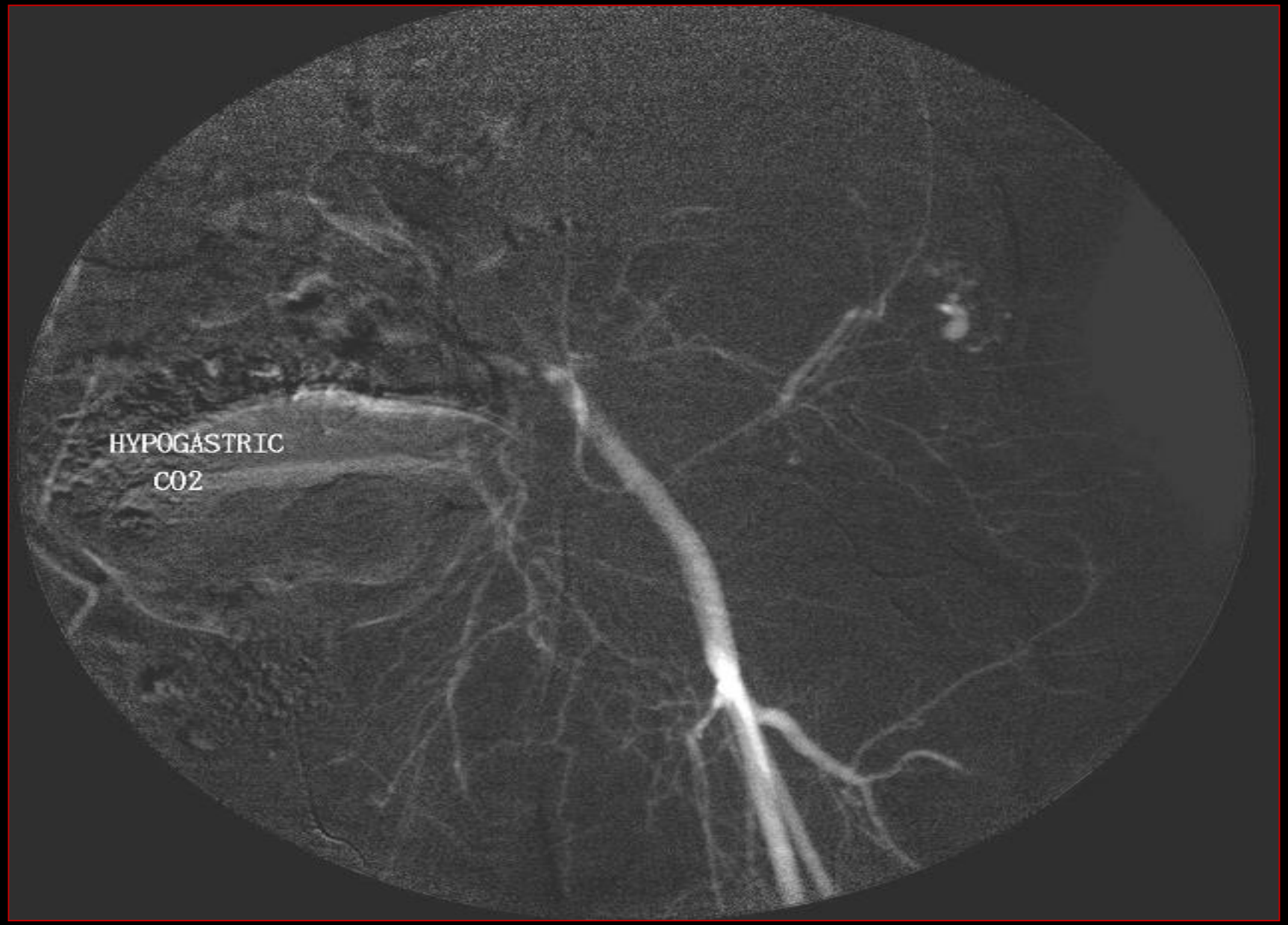
DETECTION OF BLEEDING

1. CO_2 - low viscosity
2. CO_2 exits the vessel and expands
3. Little or no capillary phase to obscure CO_2
4. CO_2 is not diluted by blood

Hashimoto et al, Sem Interven Rad 1997; 14:163-173
Hawkins et al, Sem Interven Rad 1997; 14:175-180




HYPOGASTRIC


HYPOGASTRIC
CO2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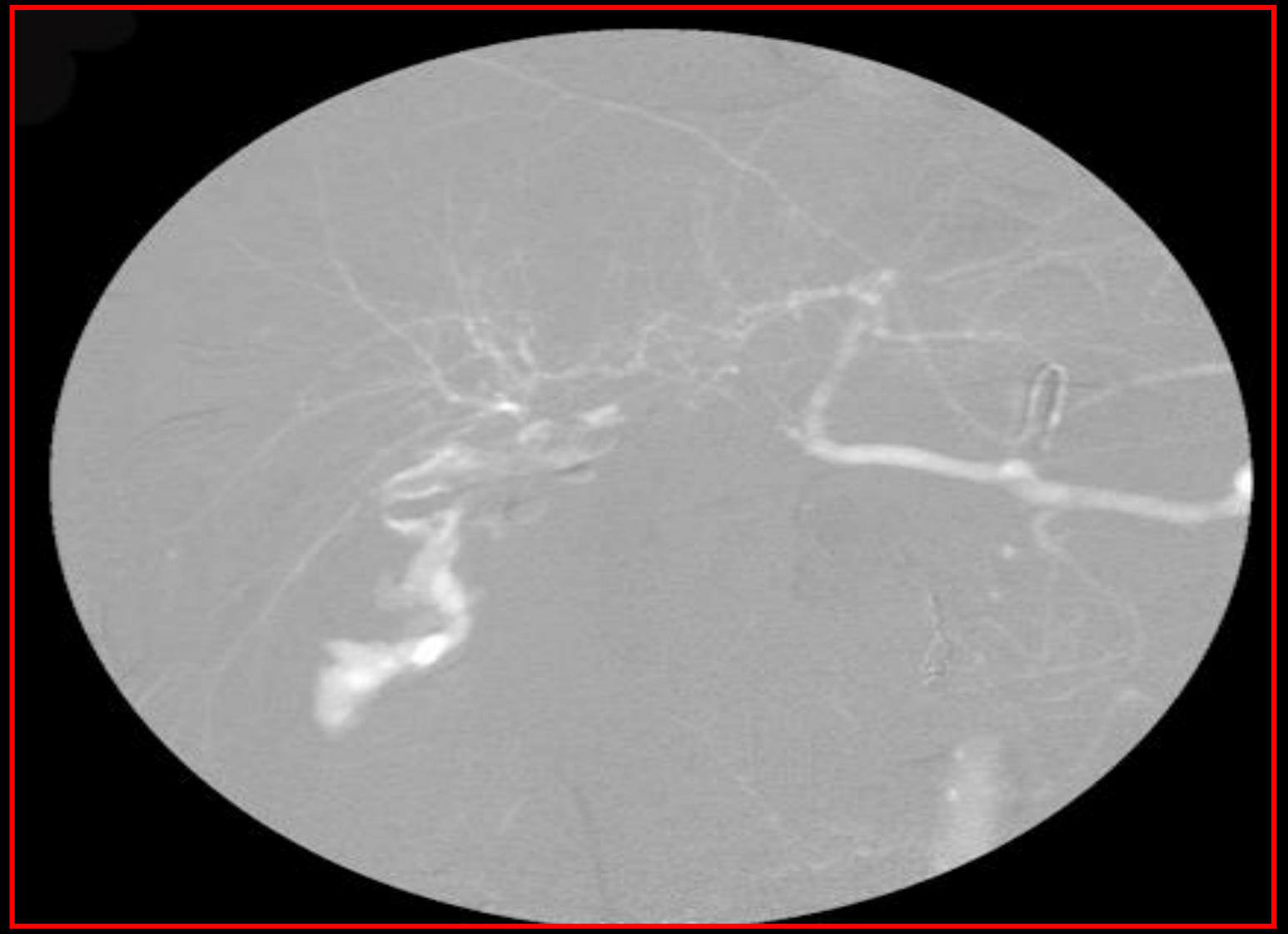
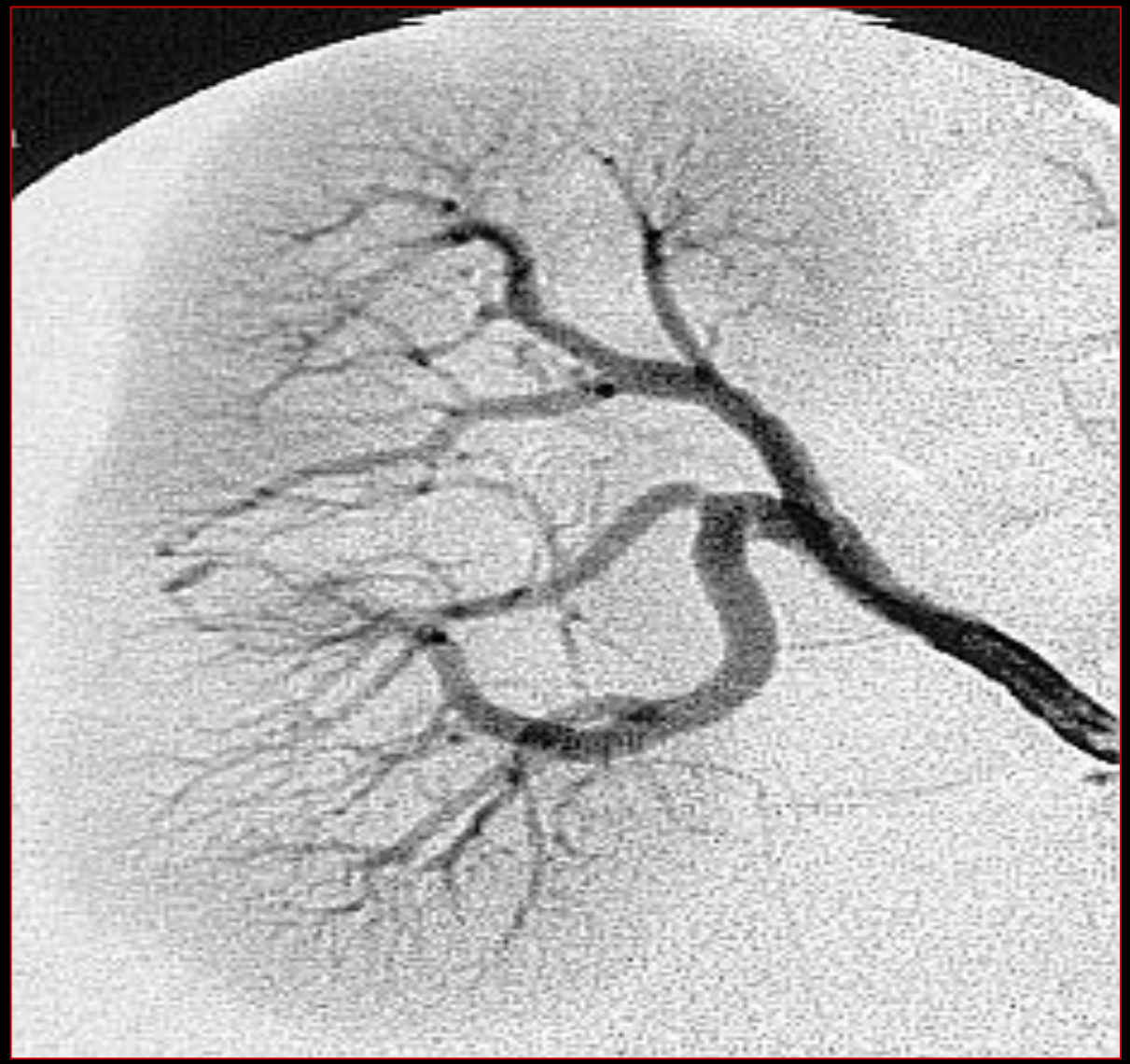
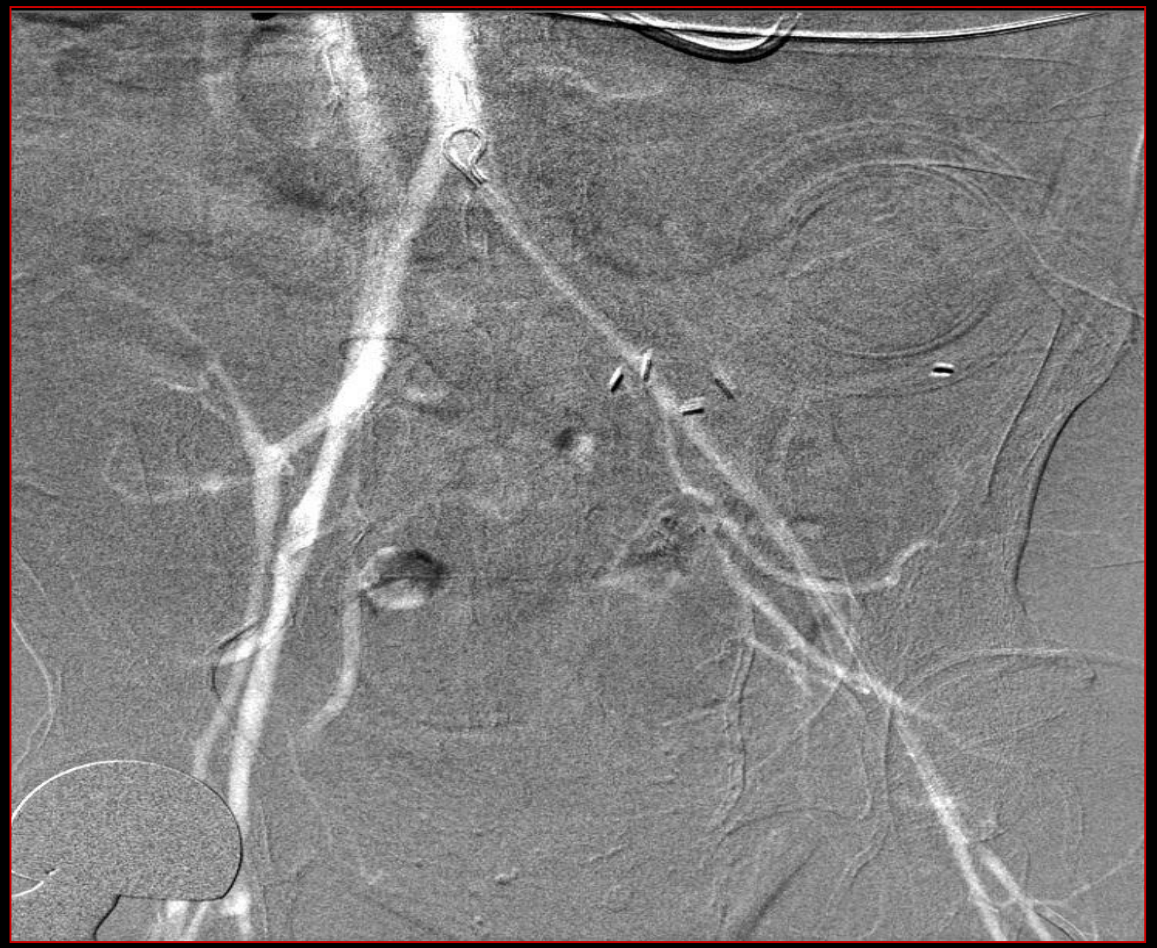
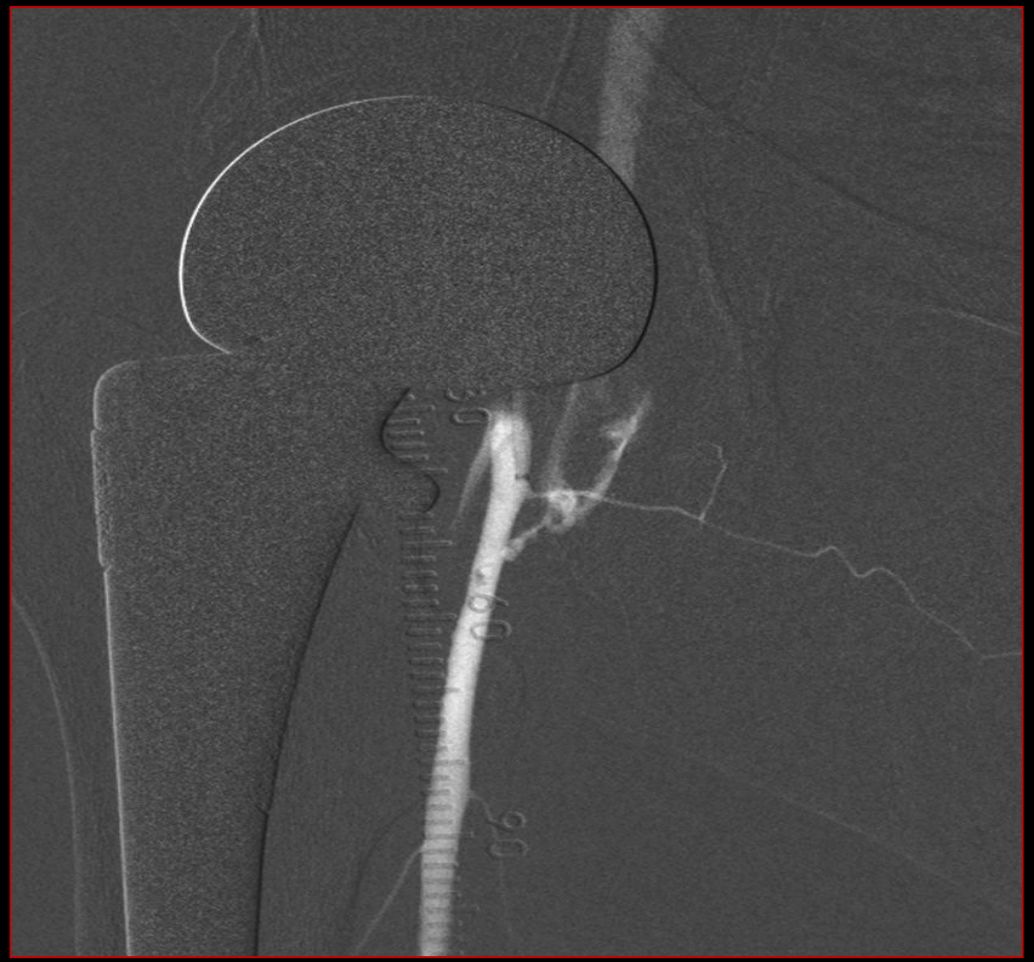





Phys:


02-Apr
Phys: ADDON1



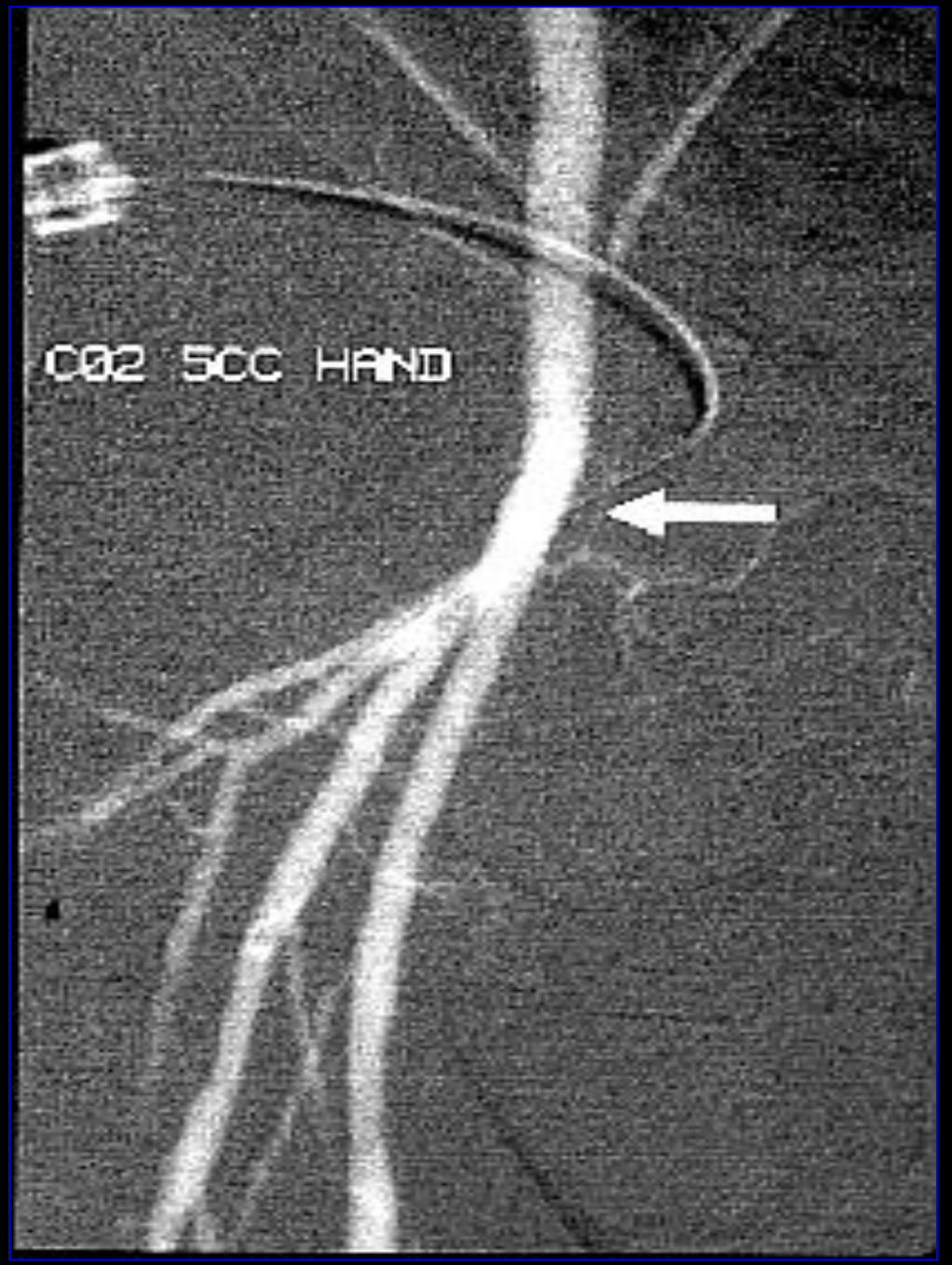


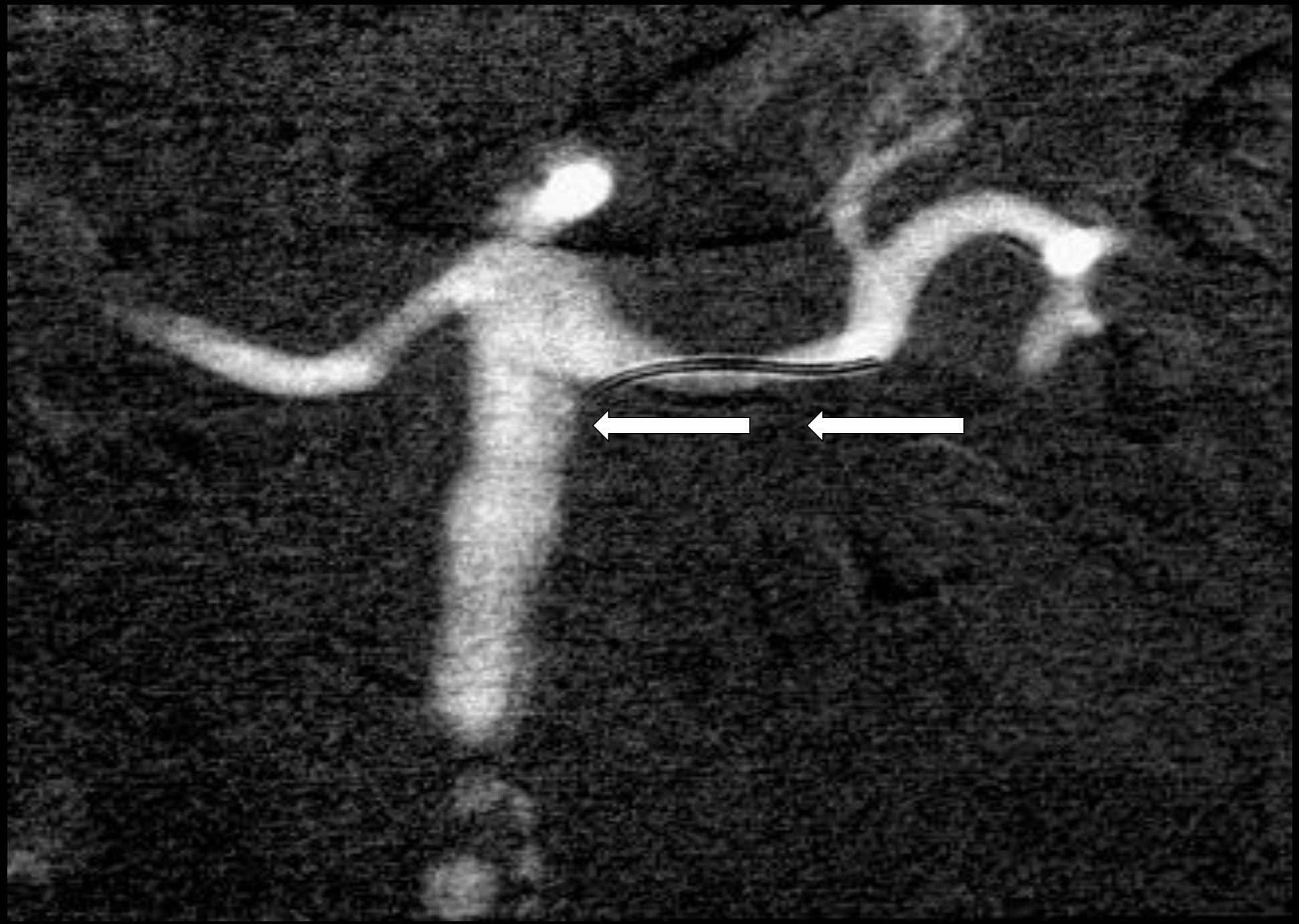

30
60
90

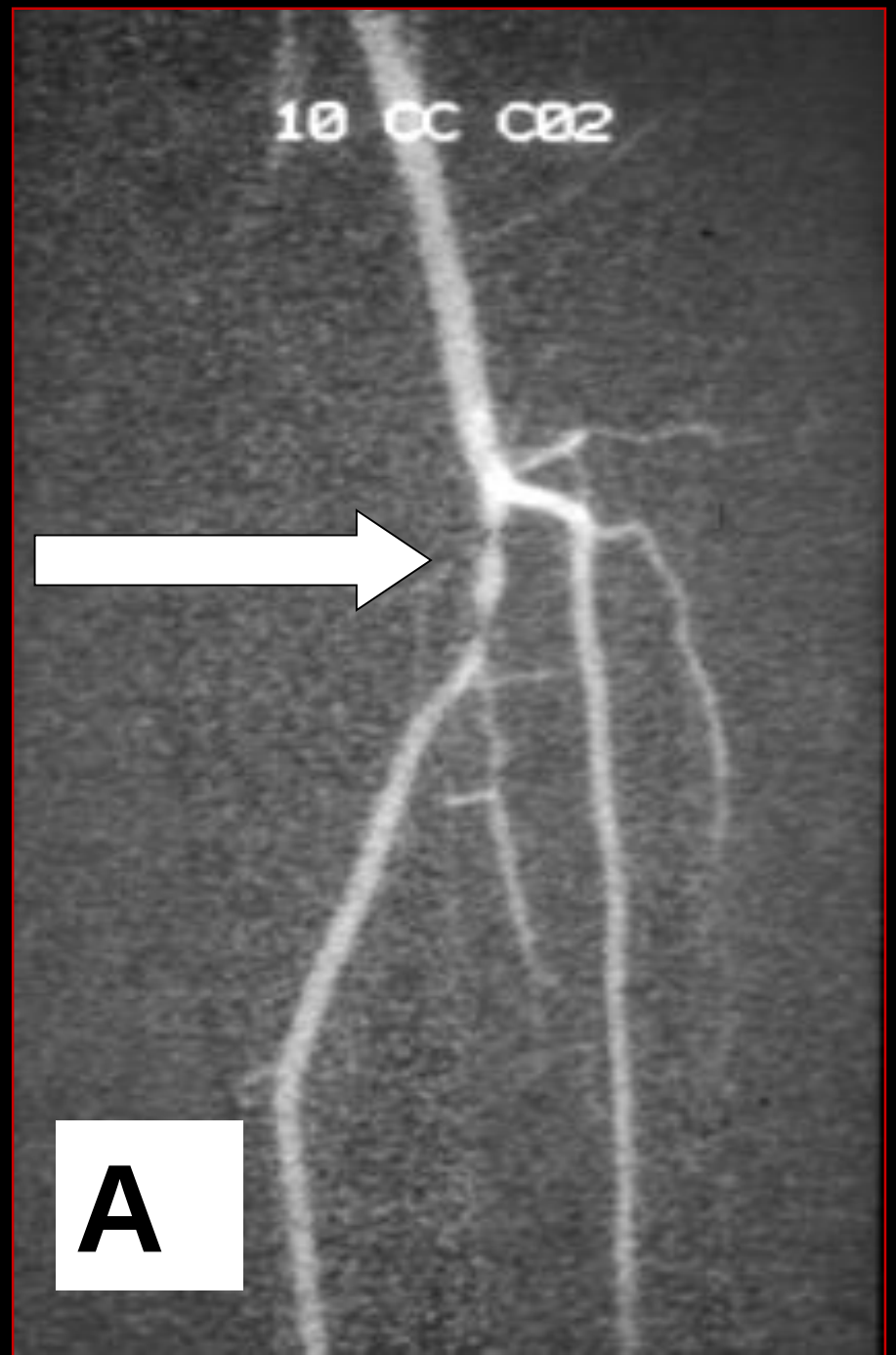
ARTERIAL INTERVENTION

- Reflux - can opacify the entire vessel including ostium for more precise stent placement
- Can inject between guide cath and catheter or wire and catheter to check placement without compromising position for PTA and stenting
- Microcatheter injections for easy opacification
- Can perform repeated injections without the fear of renal failure


3F 4 CC NO


CO2 5CC HAND

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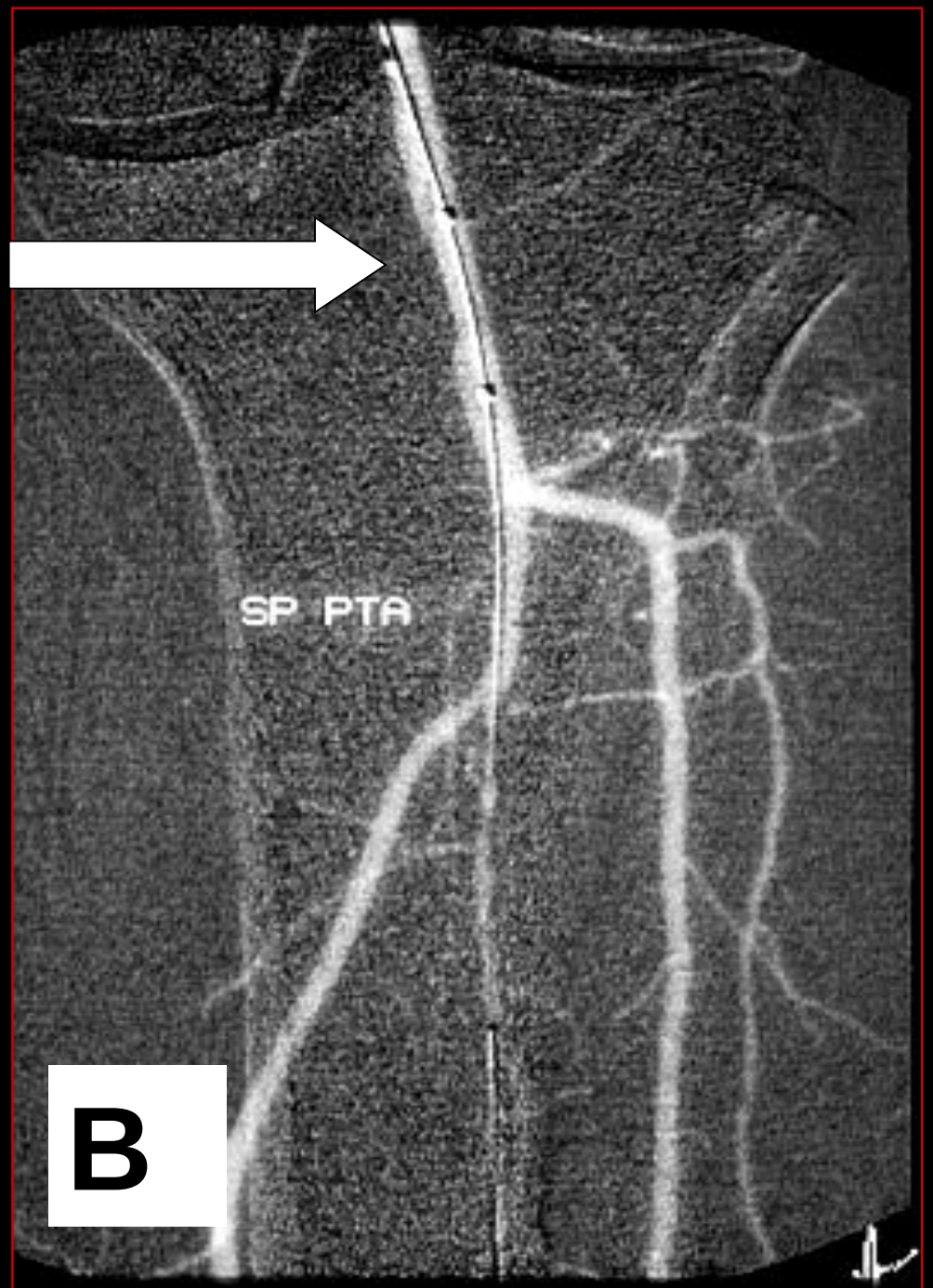
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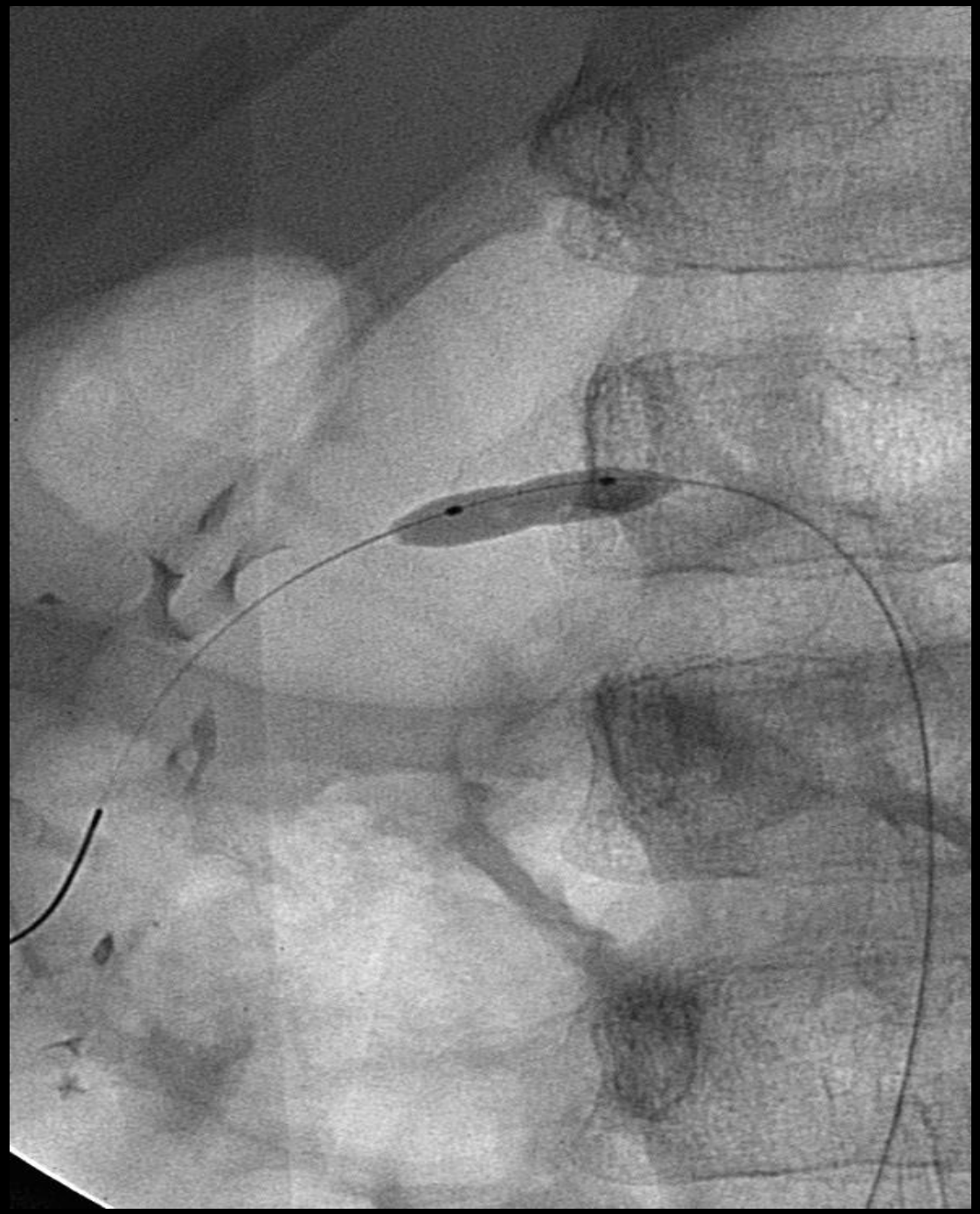
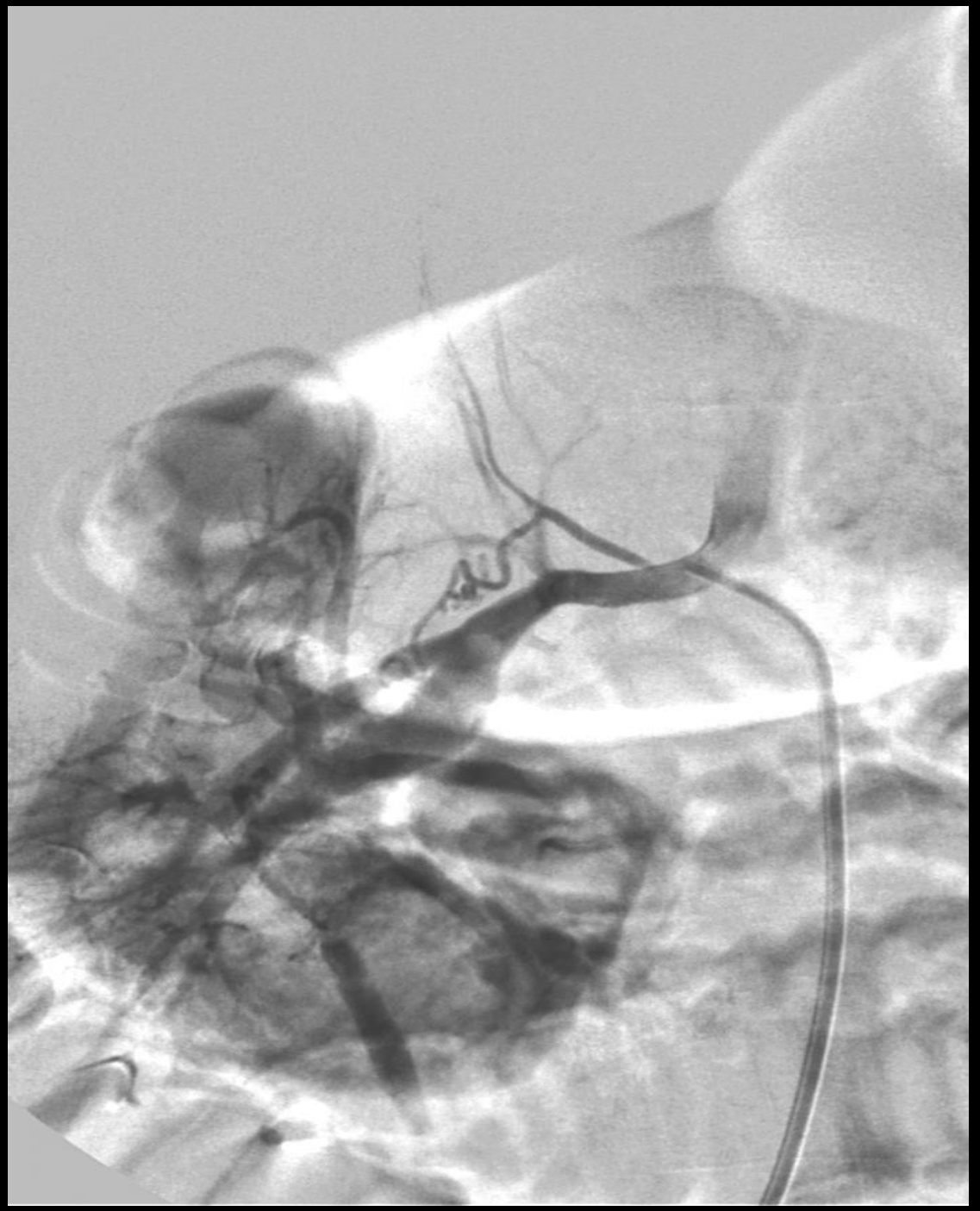




AN INTERNATIONAL JOURNAL OF RADIOLOGY,
RADIATION ONCOLOGY AND ALL RELATED SCIENCES

BJR

Short communication

The use of carbon dioxide angiography for renal sympathetic denervation: a technical report

CLINICAL KIDNEY JOURNAL

ckj | OXFORD | ERA-EDTA Leading European Nephrology

Clinical Kidney Journal, 2017, 1–5

doi: 10.1093/ckj/sfx066
Original Article

ORIGINAL ARTICLE

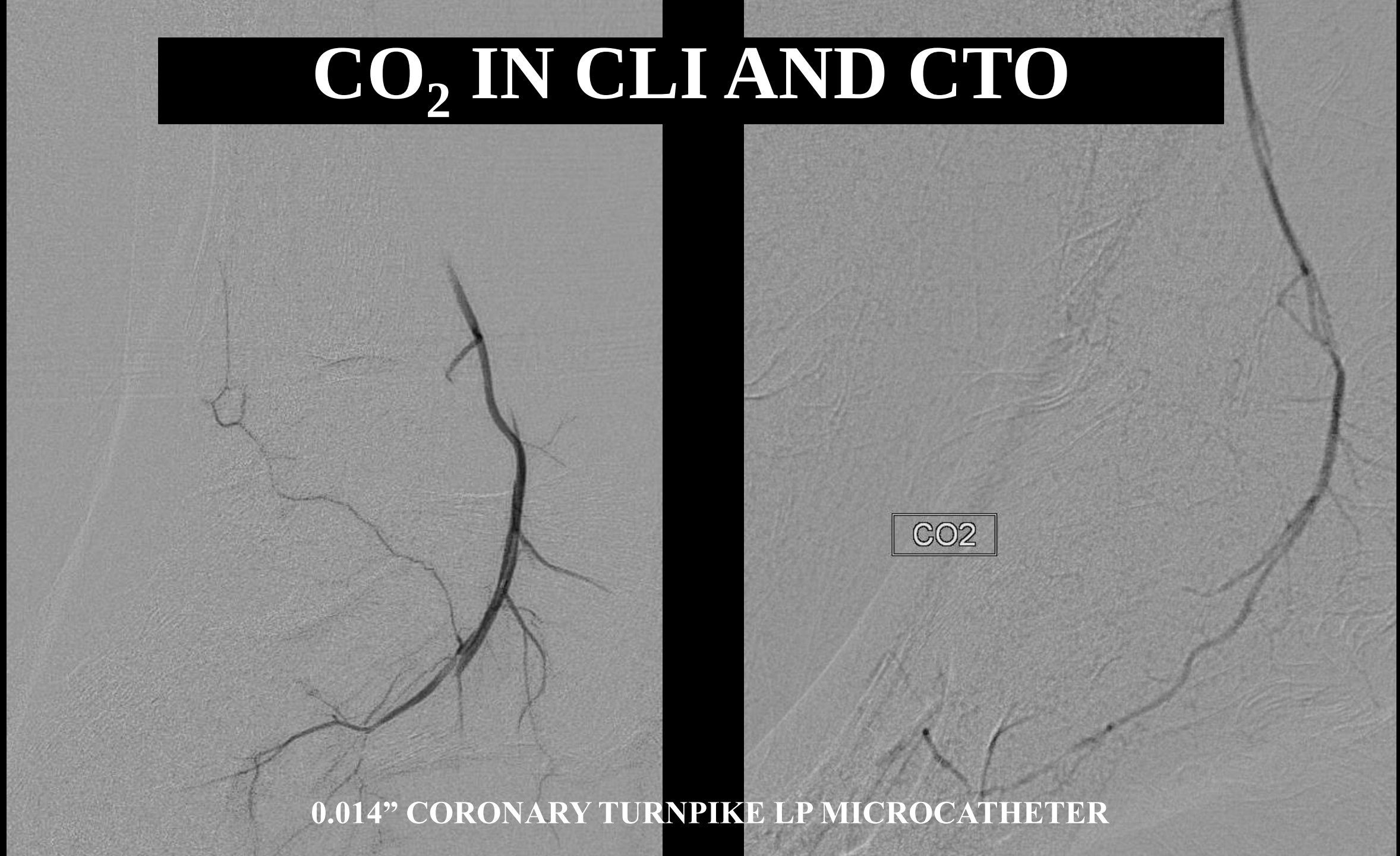
Renal denervation using carbon dioxide renal angiography in patients with uncontrolled hypertension and moderate to severe chronic kidney disease

Mohammed Awais Hameed[1,2], Jonathan S. Freedman[2], Richard Watkin[2], Arul Ganeshan[2] and Indranil Dasgupta[2,3]

[1]Institute of Applied Health Research, University of Birmingham, Birmingham, UK, [2]Heart of England NHS Foundation Trust, Birmingham, UK and [3]Aston Medical School, Aston University, Birmingham, UK

2018

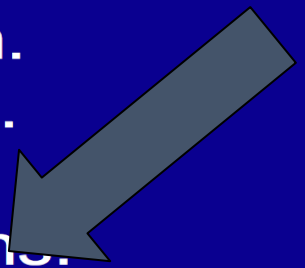
CO_2 IN CLI AND CTO



0.014” CORONARY TURNPIKE LP MICROCATHETER

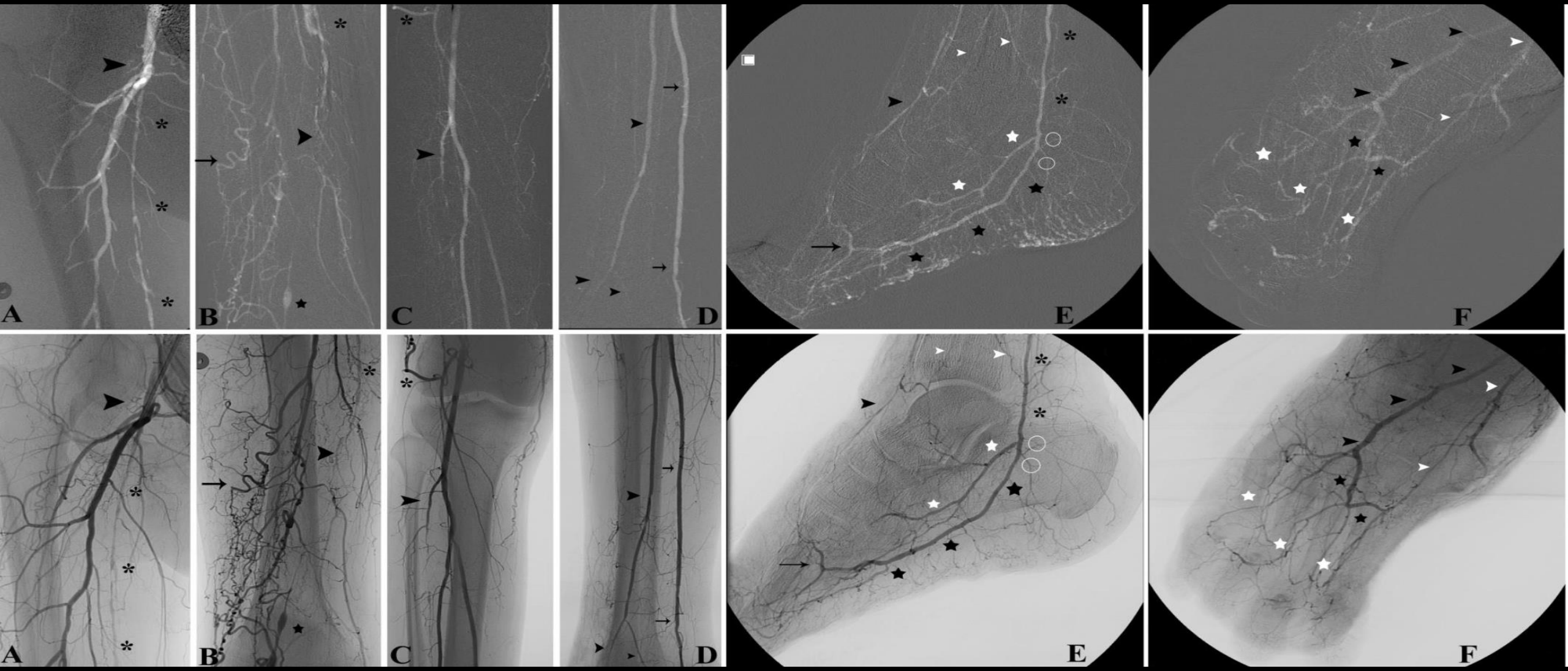
CO_2 IN CLI AND CTO

- Single center, Prospective.
- 36 patients with DM, CLI (Rutherford V, VI) & CKD ≥ 3.
- PVA and PVI guided by ACDA. No image degradation.
- TcPO2 improved from 11.8 to 58.4 mmHg (P<0.0001).
- Clinical improvement in 100% of patients.
- No changes were seen in CrCl & no CO_2 complications.
- ACDA is safe and efficient to guide PVI in pts with DM, CLI and CKD ≥ 3.



***Journal Endovascular Therapy* 2016; 23(1):40-48.**

Thanks to L.M. Palena, Policlinico Albano Terme, Italy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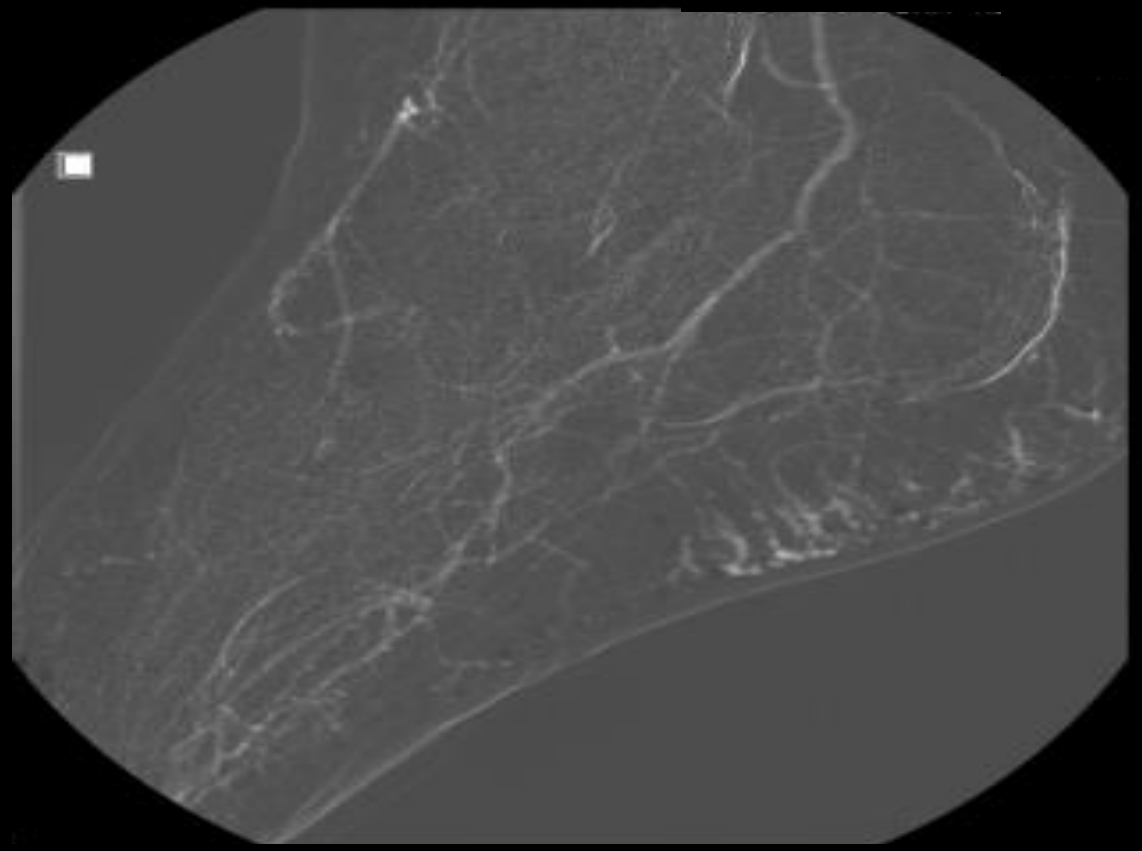
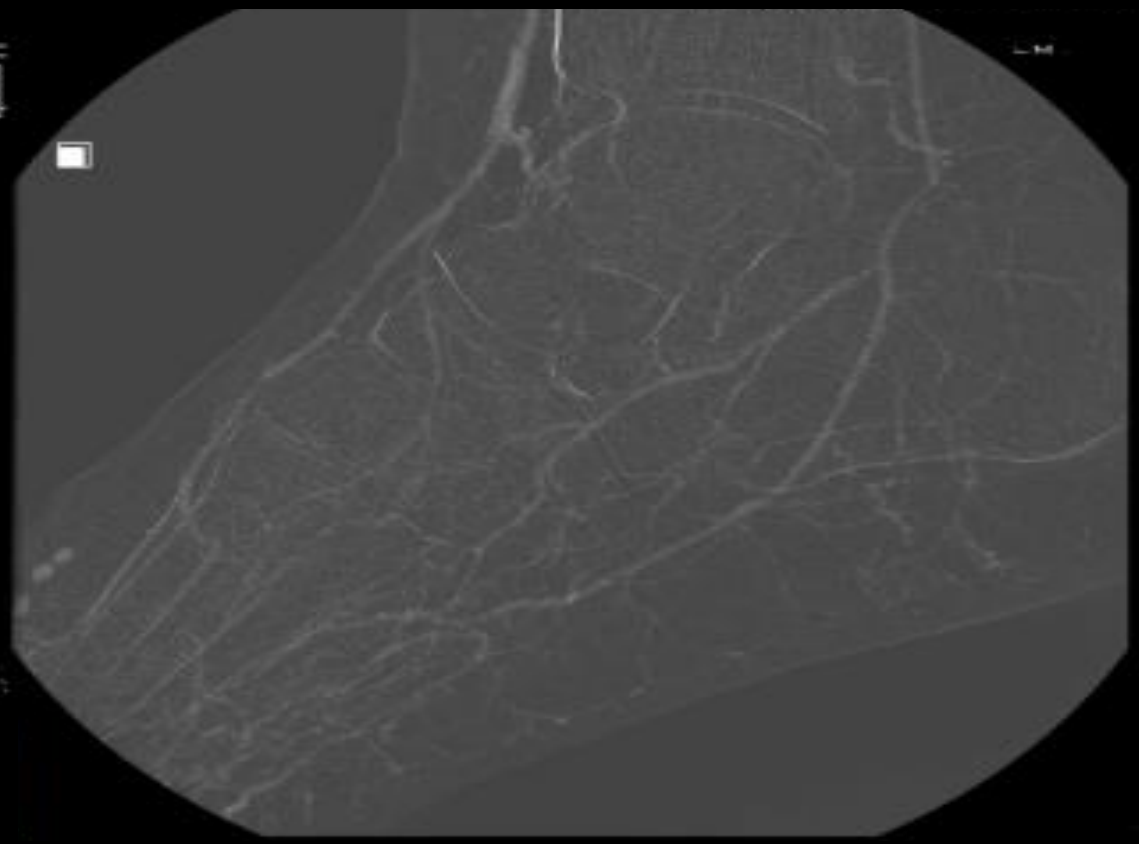

CO2


CO2

CO_2 IN CLI AND CTO

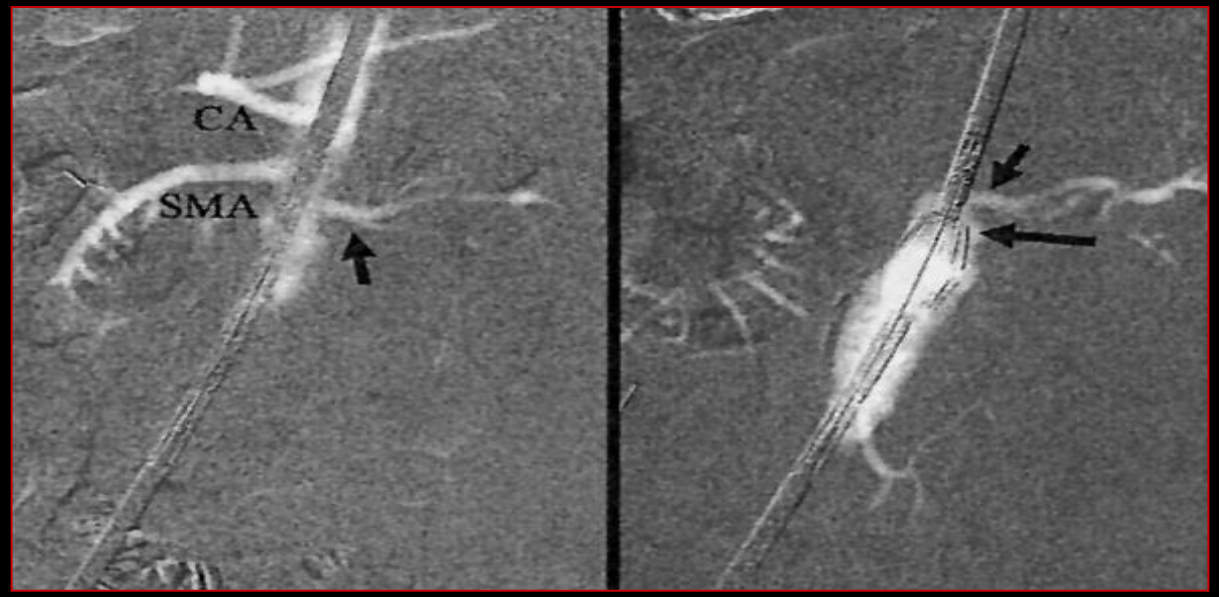
- Size of vessels is ideal
- Little soft tissue interference
- CO_2 can be used to roadmap and game plan and if necessary filled in with dilute contrast
- Small catheters (< 2 Fr) can be used with ease because of low viscosity
- Reflux allows opacification of central and peripheral structures with one injection
- Can be used with small amounts of dilute contrast if necessary

EVAR FACTS

- Predisposition for renal dysfunction > open
- Renal impairment independent predictor of mortality
- Occurs in pts with & without renal insufficiency
- ARF = 7 – 25% with & 2.5% without
- Associated mortality is 30 – 50%

Greenberg RK et al. J Vasc Surg 2004 Chao A et al. J Vasc Surg 2007

Sailer A et al. Eur Radiol. 2016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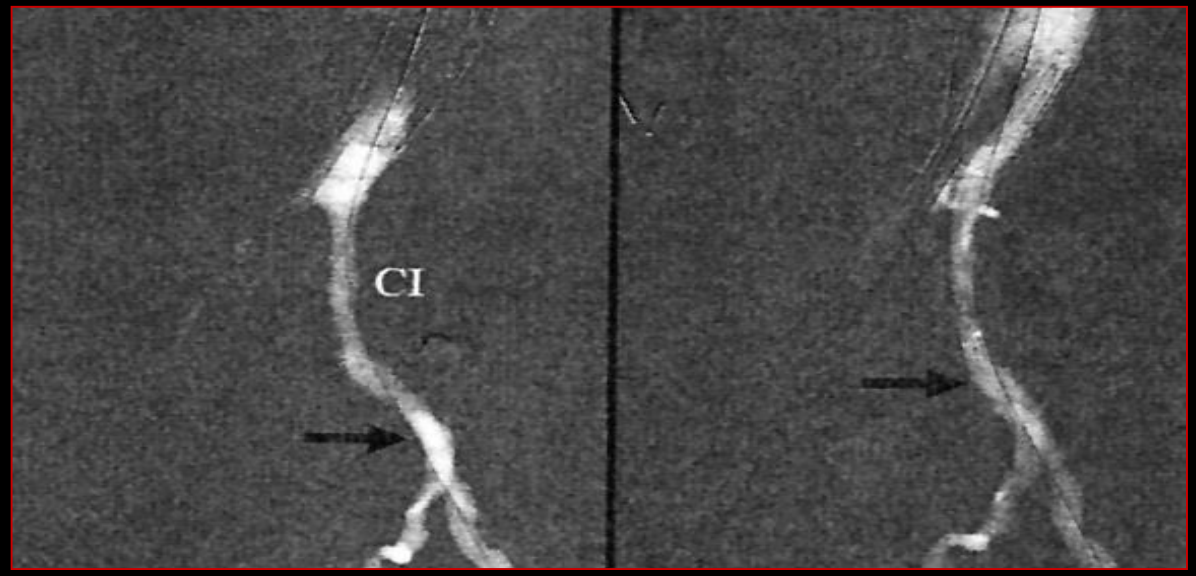
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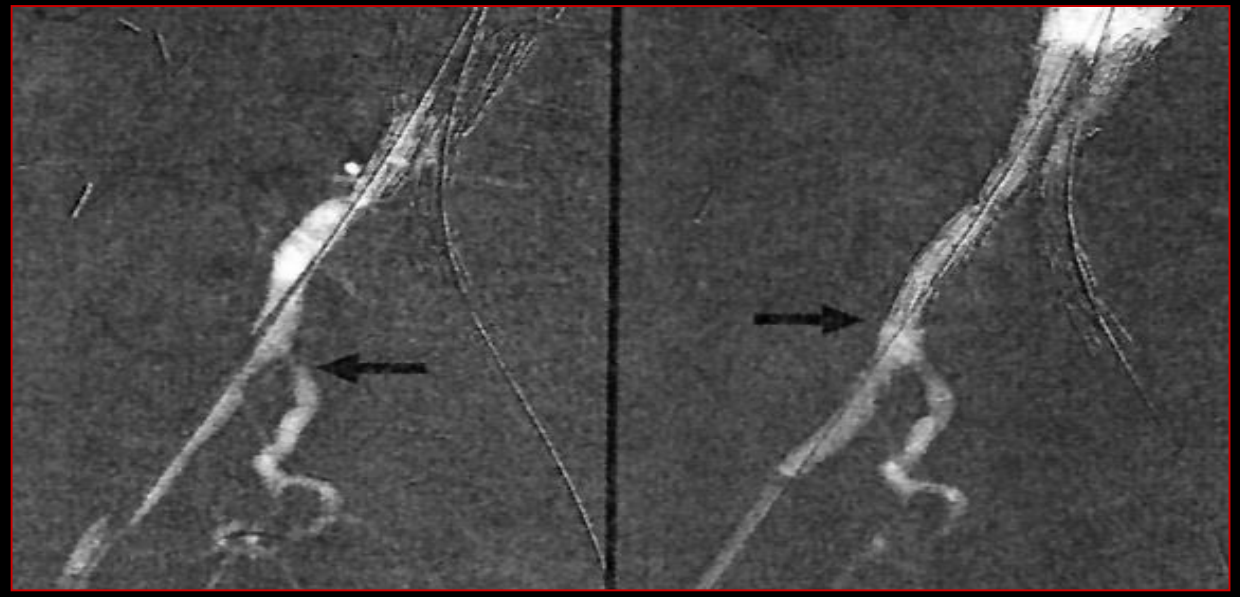
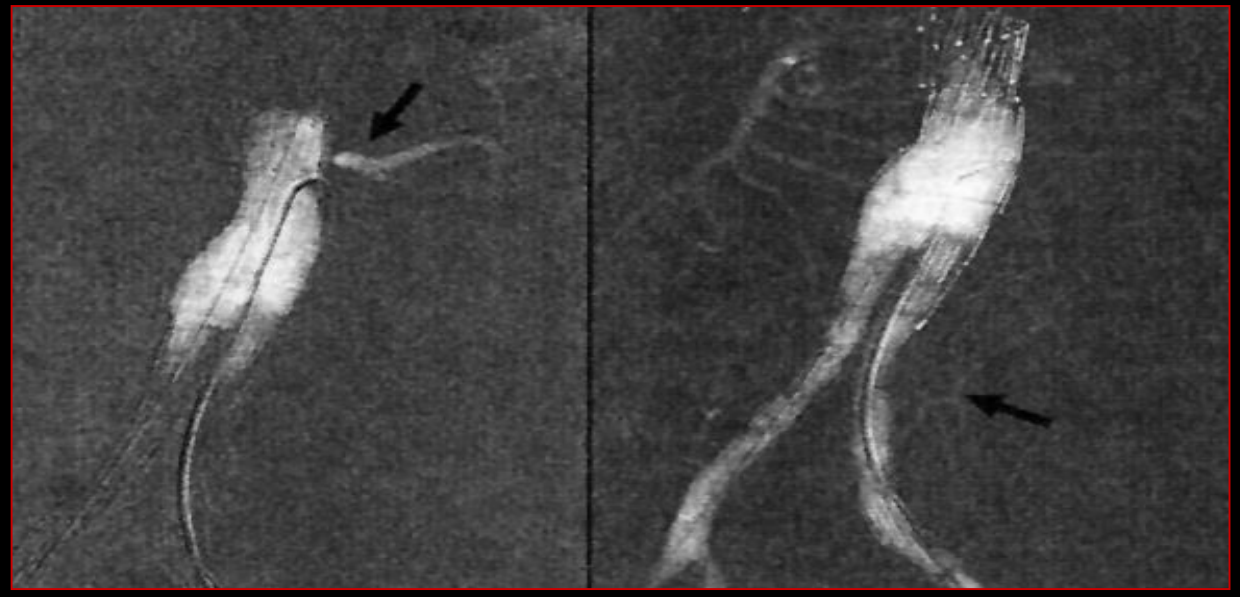




N	Author	Year	Journal	Title
1	Chao A et al	2007	J Vasc Surg	***Carbon dioxide*** *digital subtraction angiography-assisted endovascular aortic aneurysm repair in the azotemic patient .*
2	Criado E et al	2008	J Vasc Surg	*Catheter-less angiography for endovascular aortic aneurysm repair: a new application of* ***carbon dioxide*** *as a contrast agent.*
3	Criado E et al	2012	J Vasc Surg	*Endovascular aortic aneurysm repair with* ***carbon dioxide****-guided angiography in patients with renal insufficiency.*
4	Huang SG et al	2013	Ann Vasc Surg	*A prospective study of* ***carbon dioxide*** *digital subtraction versus standard contrast arteriography in the detection of endoleaks in endovascular abdominal aortic aneurysm repairs.*
5	Sueyoshi E et al	2015	J Vasc Surg	***Carbon dioxide*** *digital subtraction angiography as an option for detection of endoleaks in endovascular abdominal aortic aneurysm repair procedure.*
6	De Almeida Mendes C et al	2017	Ann Vasc Surg	***Carbon Dioxide*** *as Contrast Medium to Guide Endovascular Aortic Aneurysm Repair.*
7	De Angelis C et al	2017	Int J Cardiovasc Imaging.	***Carbon dioxide (CO2)*** *angiography as an option for endovascular abdominal aortic aneurysm repair (EVAR) in patients with chronic kidney disease (CKD).*

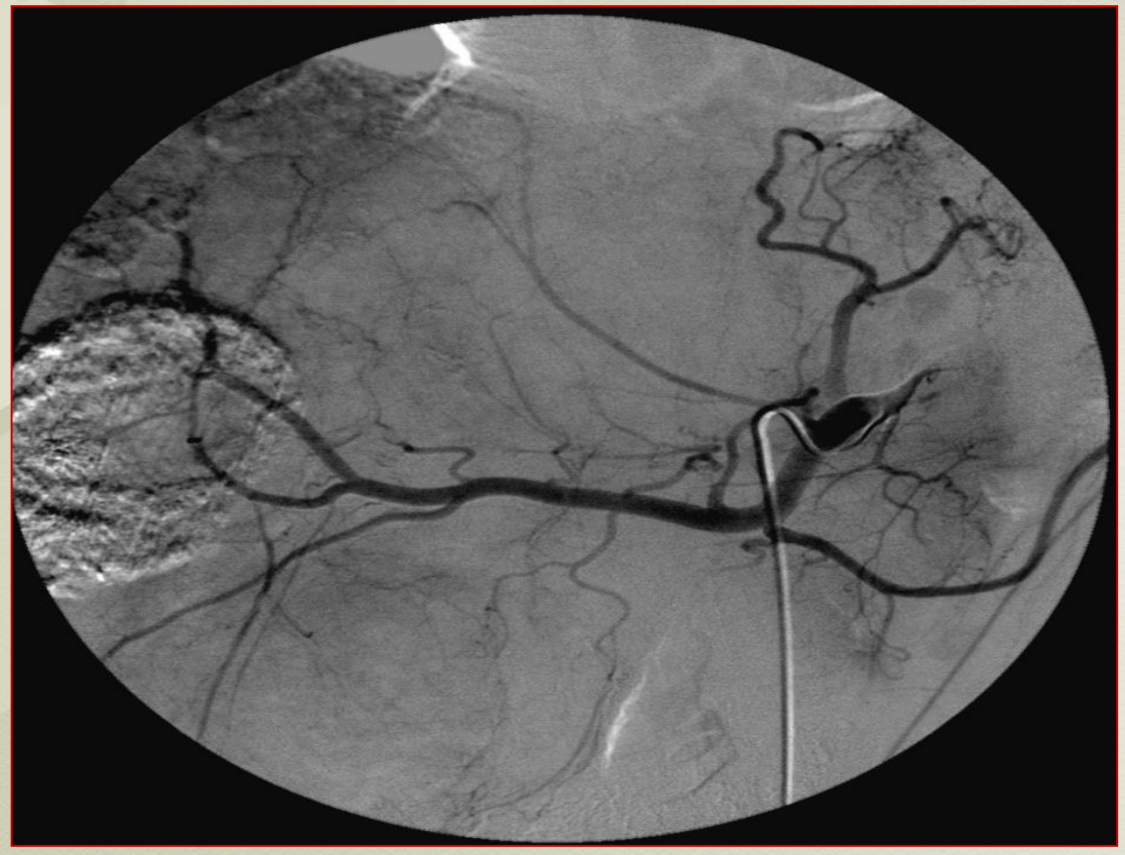

DX

PRE-OP EVAR

- No fruit and vegetables 4 days prior to EVAR
- Simeticarbon intake the day before and the same morning of the EVAR
- Use of angiobelt or paddle to move possible bowel gas and reduce peristalsis
- Glucagon 1 mg IV

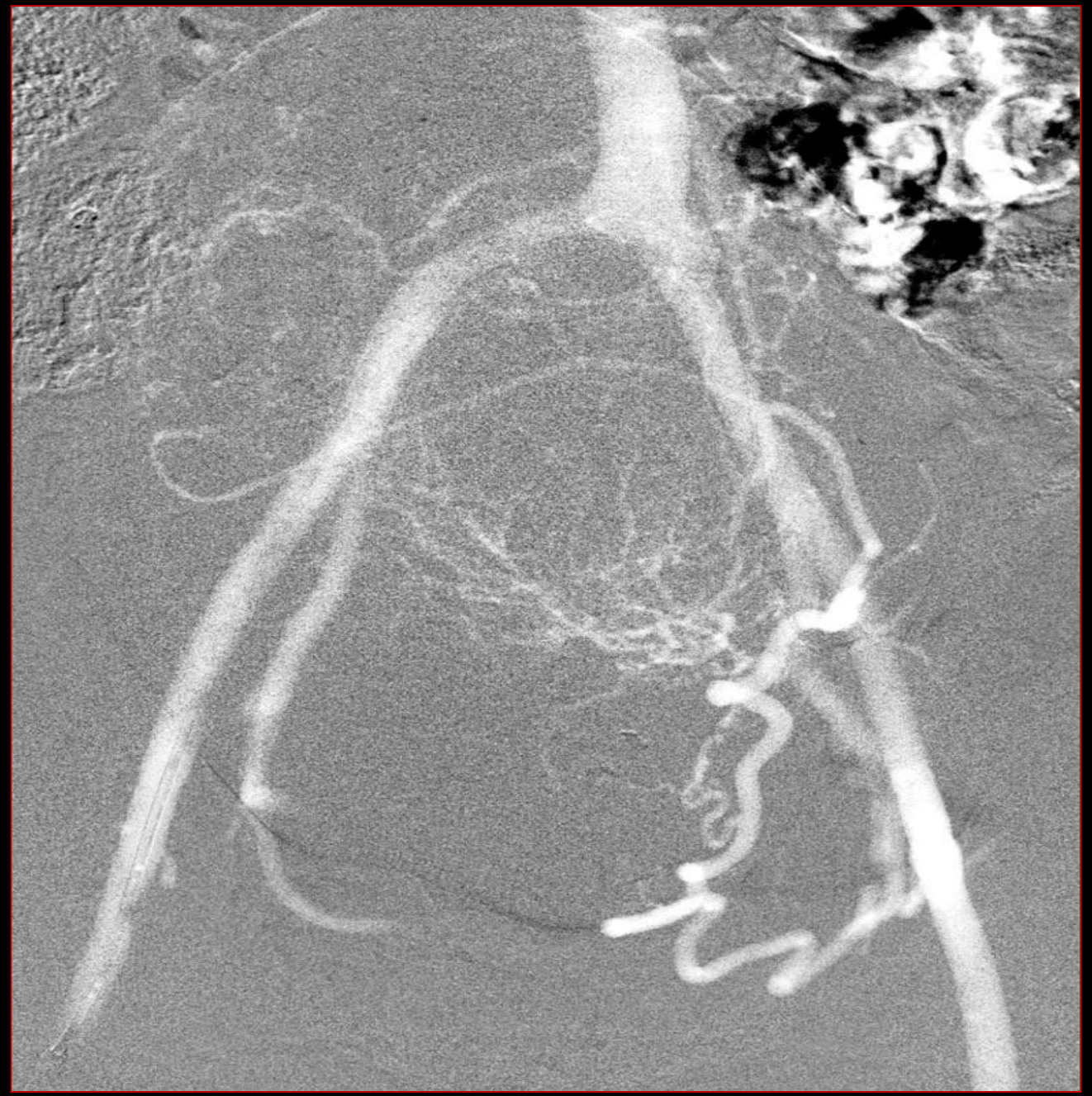
INTERVENTIONAL ONCOLOGY

- Comorbid conditions predisposing to CIN
  - Renal insufficiency, Diabetes, Hepatic insufficiency
- Peri –procedural medications can predispose to renal failure
  - NSAIDS
- Post embolization syndrome can deplete intravascular volume
- Many embolization procedures require high volume contrast
- Tumor lysis symdrome can induce renal failure
- Rare - non-target embolization of kidneys



Contrast

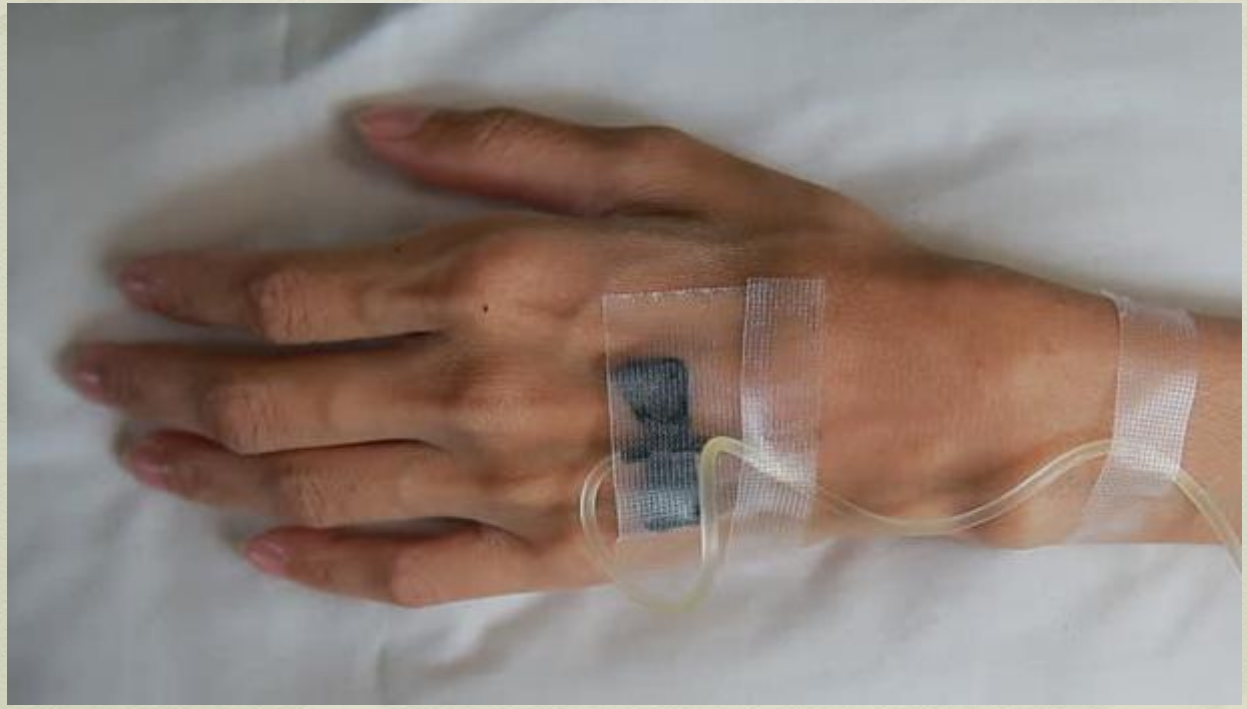
CO_2



VENOUS DX & TREATMENT

- Slow gentle injection of 15-30 cc
- CO_2 is not diluted by blood and can opacify central veins more readily from a peripheral approach
- Venous PTA and stent placement
- IVC filter placement
- Ultra fine needle splenoportography
- Portal vein access

CO_2 BILATERAL UPPER EXTREMITY VENOGRAM FROM HAND ACCESS

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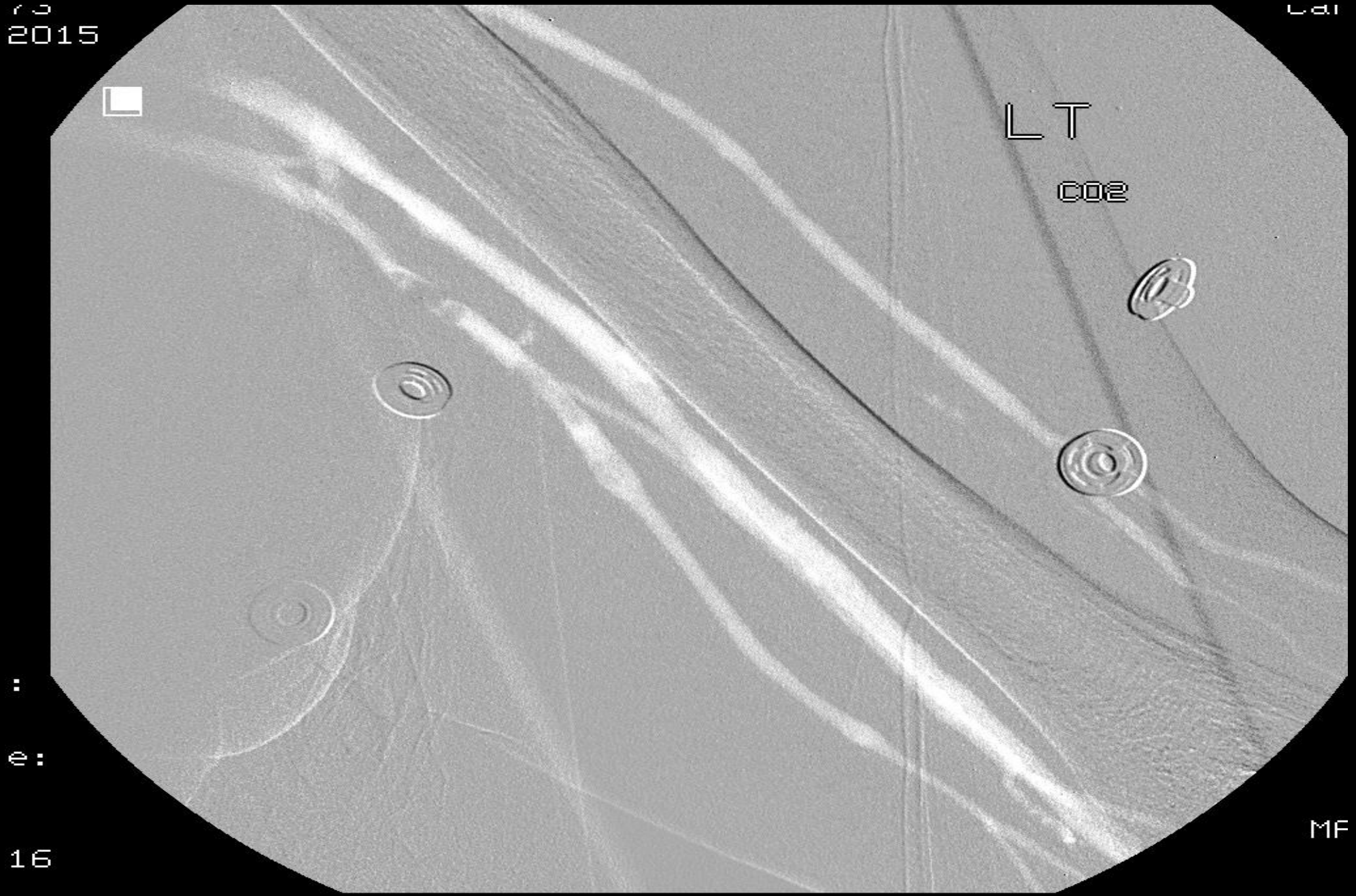
2015
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LT
C02

Radiology

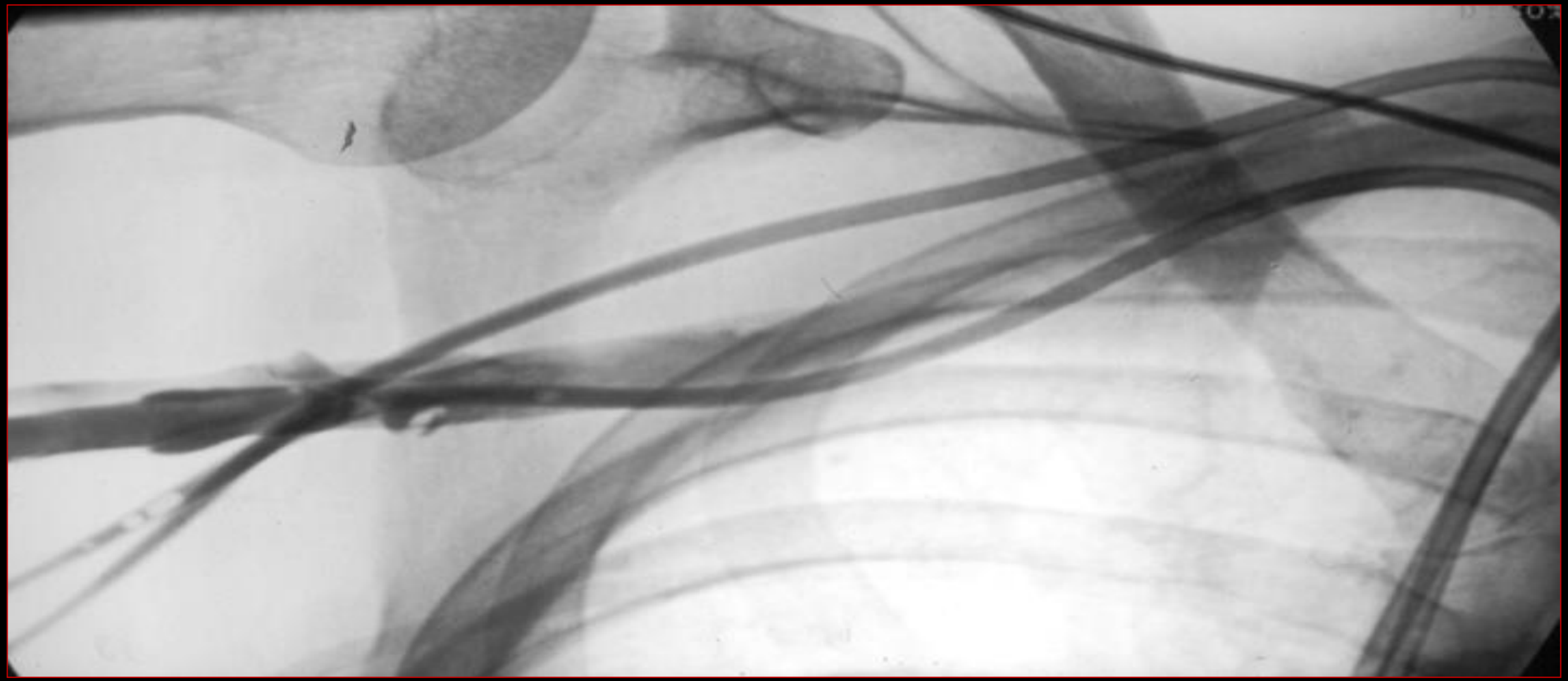
Upper-Extremity Venography: CO_2 versus Iodinated Contrast Material[1]

Sam Heye, MD
Geert Maleux, MD
Guy J. Marchal, MD, PhD

Purpose: To determine prospectively the diagnostic performance of CO_2 venography, by using conventional venography with iodinated contrast material as the reference standard, for the preoperative evaluation of upper-limb and central veins before creation of fistulas for hemodialysis access.

Results: For CO_2 venography, global interobserver agreement was good, with a κ value of 0.90 (range, 0.71–1.00; 95% confidence interval: 0.84, 0.95). A κ value of 0.96 (range, 0.86–1.00; 95% confidence interval: 0.93, 0.99) was calculated for global interobserver agreement for conventional venography. The sensitivity, specificity, and accuracy of CO_2 venography for all vein segments were 97%, 85%, and 95%, respectively.

Conclusion: CO_2 venography had a sensitivity of 97% and a specificity of 85% in the assessment of upper-limb and central vein patency and stenosis, with conventional venography used as the reference standard.

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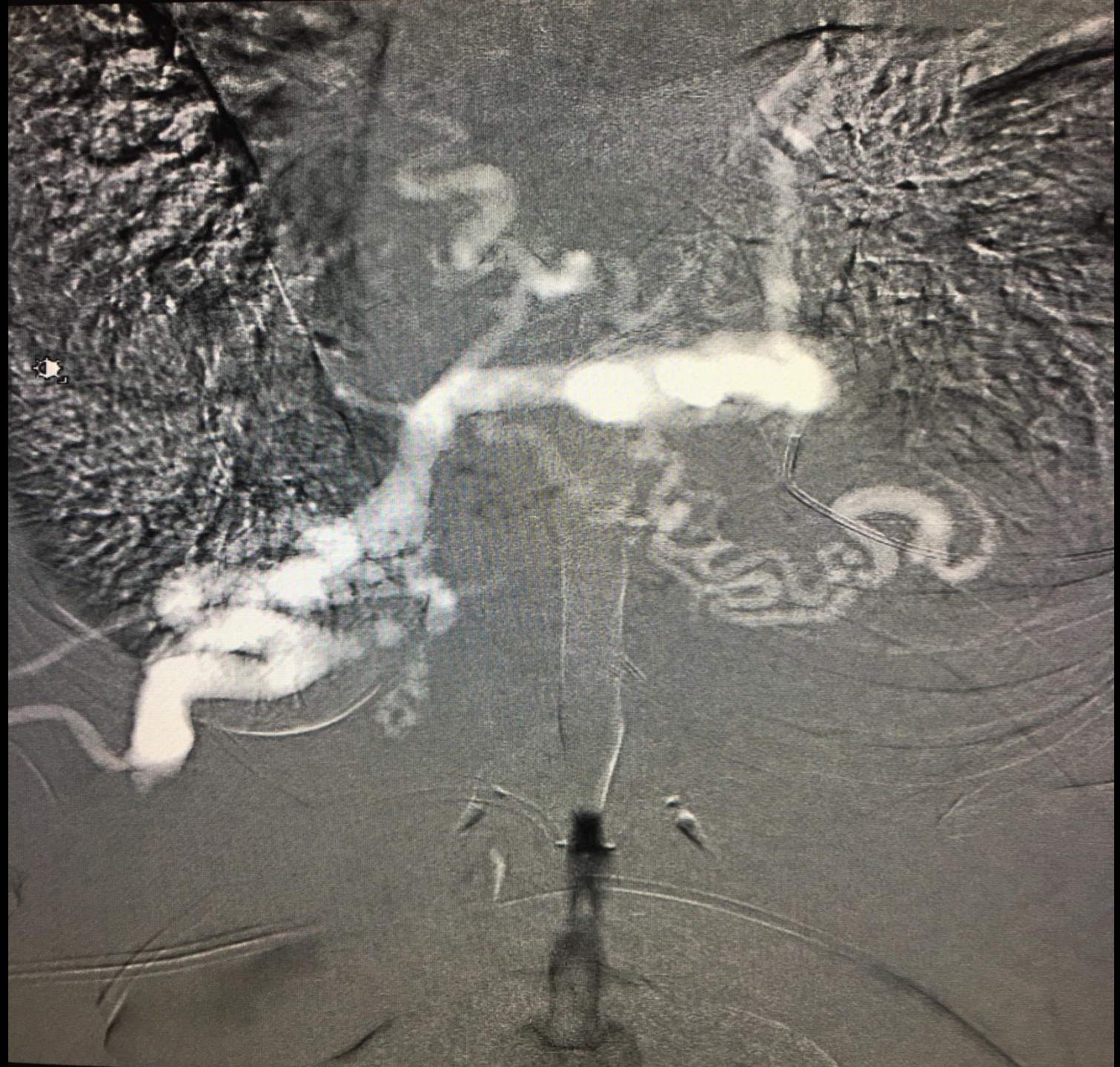


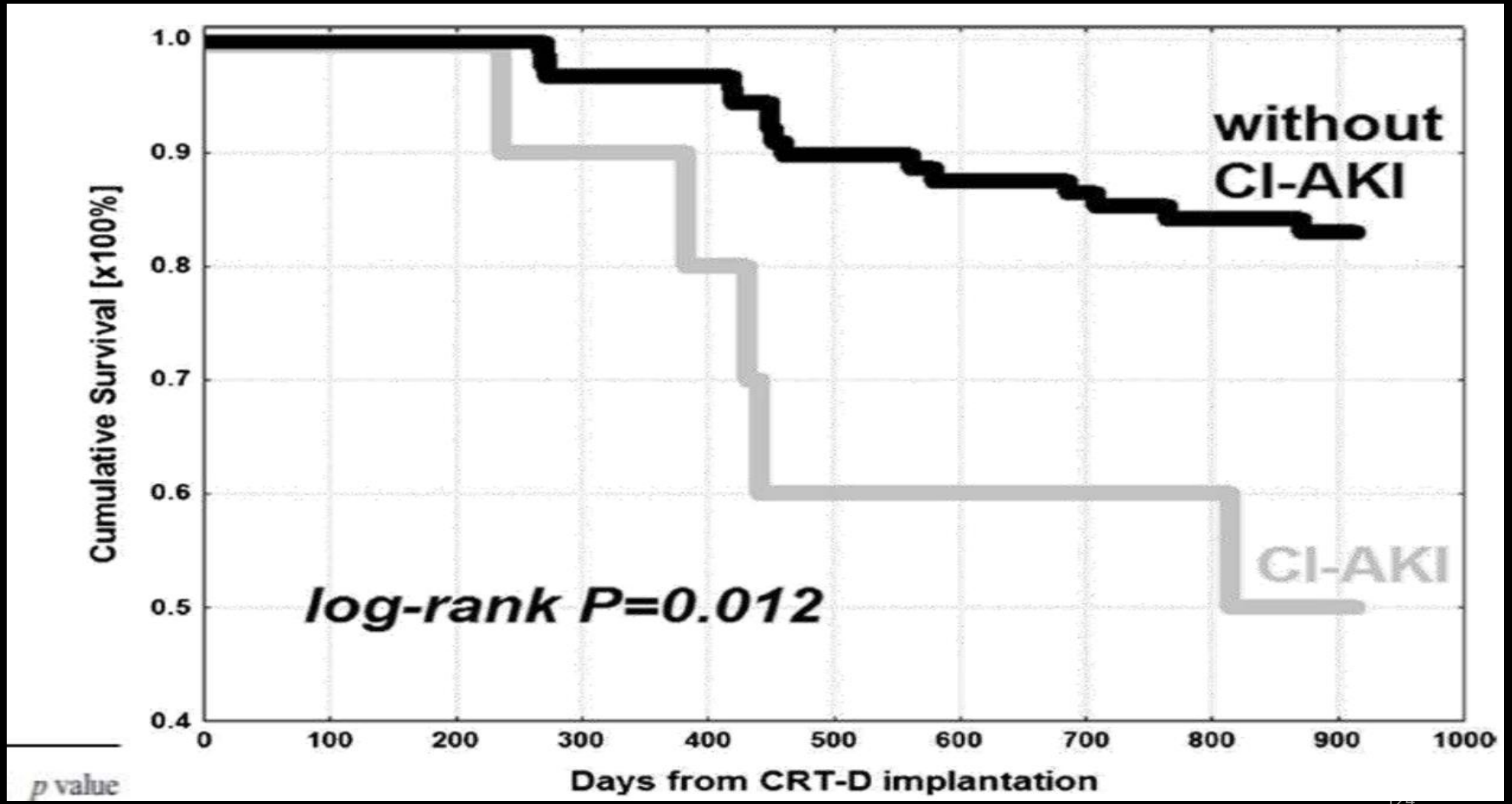
CARDIAC RESYNCHRONIZATION TREATMENT

Contrast-induced acute kidney injury in patients undergoing cardiac resynchronization therapy—incidence and prognostic importance. Sub-analysis of data from randomized TRUST CRT trial

Jacek Kowalczyk · Radoslaw Lenarczyk · Oskar Kowalski · Tomasz Podolecki · Pawel Francuz · Patrycja Pruszkowska-Skrzep · Mariola Szulik · Michal Mazurek · Ewa Jedrzejczyk-Patej · Beata Sredniawa · Zbigniew Kalarus · for the Triple-Site Versus Standard Cardiac Resynchronization Trial (TRUST CRT) Investigators

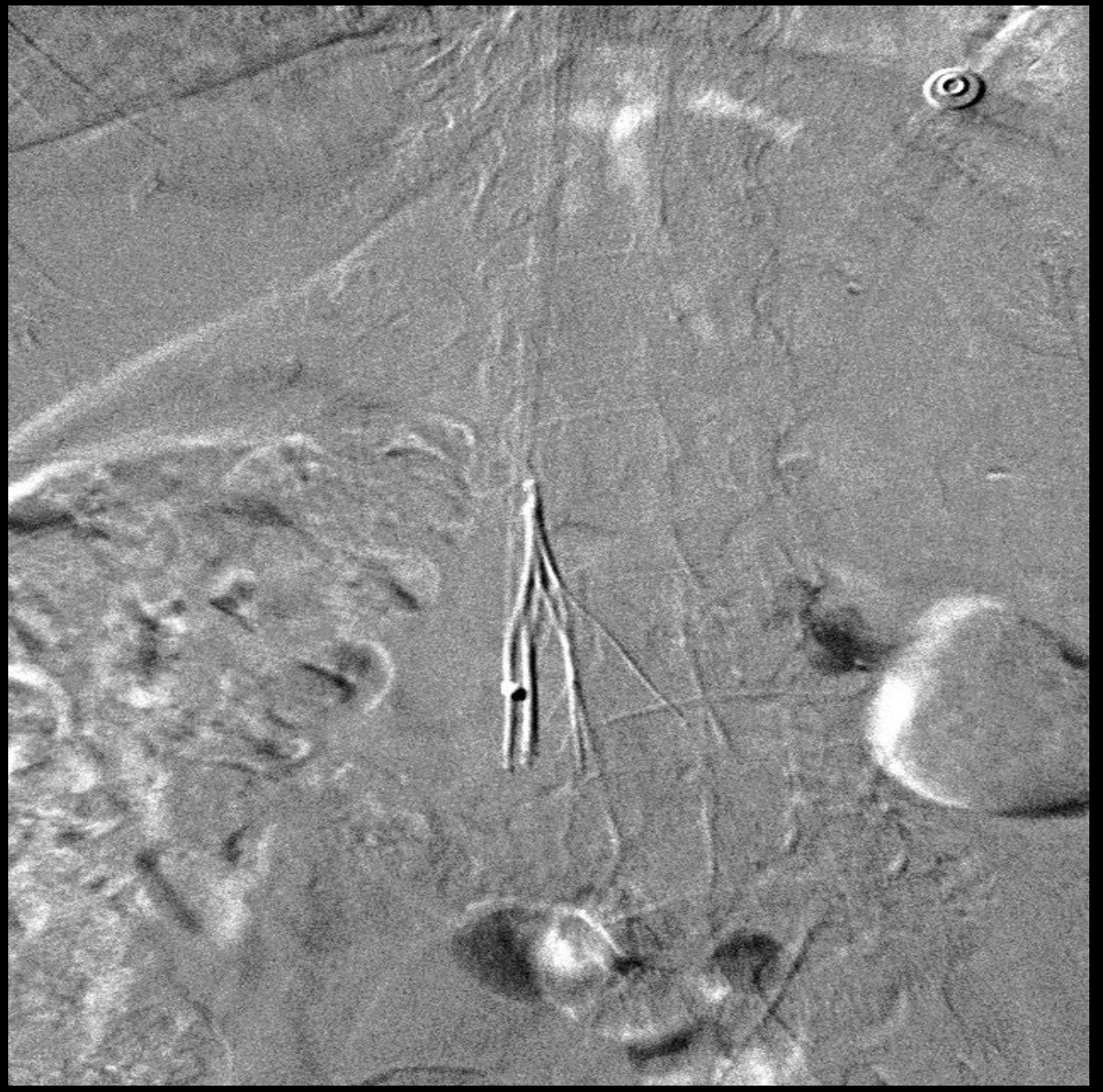
Received: 5 December 2013 / Accepted: 12 February 2014 / Published online: 14 March 2014

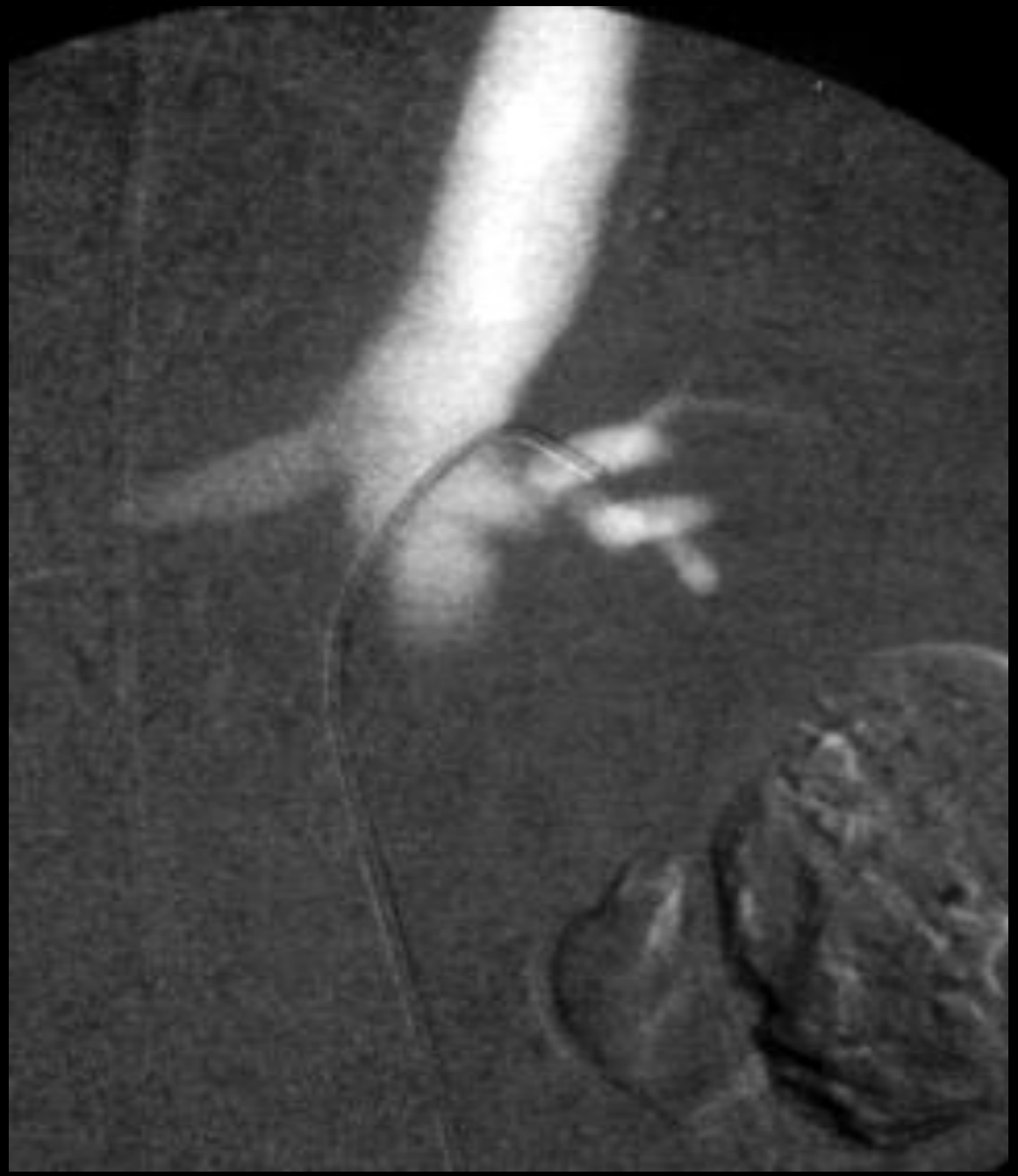
- 98 patients/30 months f/u
- CIN 10.2%
- GFR< 60, CIN double those > 60
- Mortality CIN 50%, no CIN 17%
- CIN = number one risk factor for death


1.0
0.9
0.8
0.7
0.6
0.5
0.4
Cumulative Survival [x100%]
0
100
200
300
400
500
600
700
800
900
1000
Days from CRT-D implantation
without CI-AKI
CI-AKI
log-rank P=0.012

p value

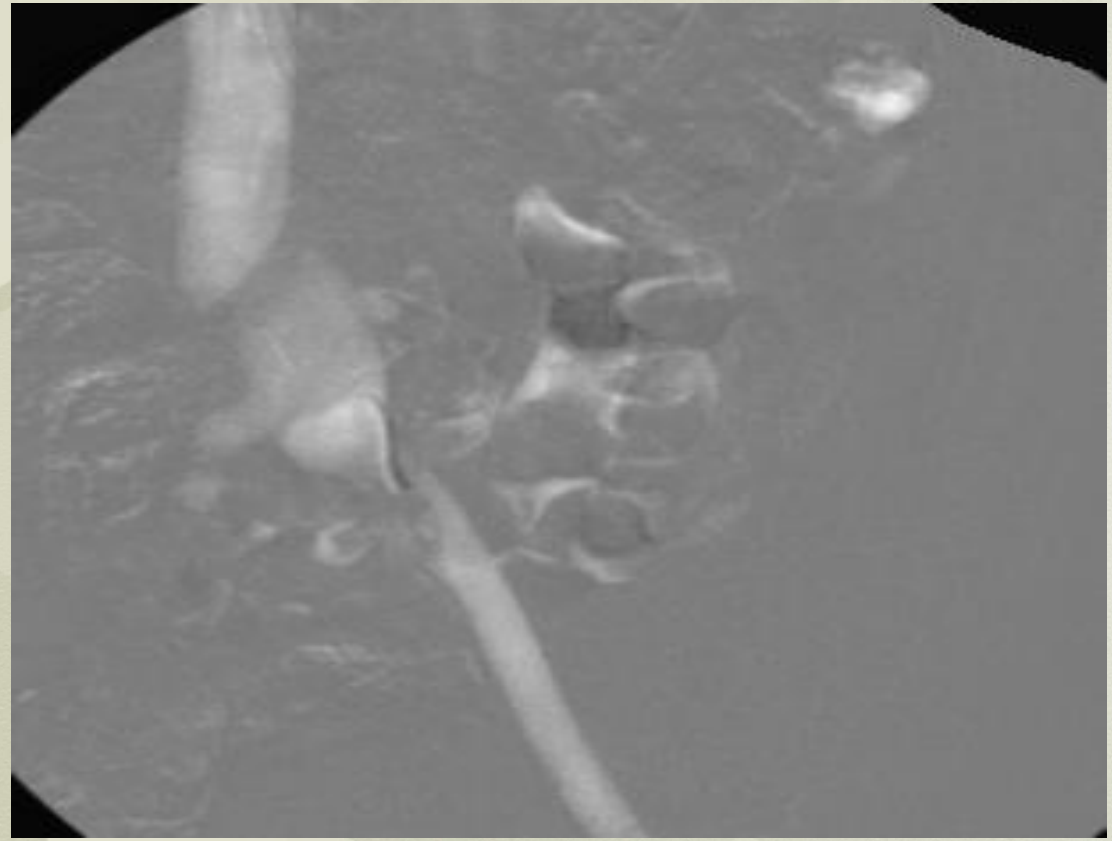
CO_2 IVC FILTER PLACEMENT

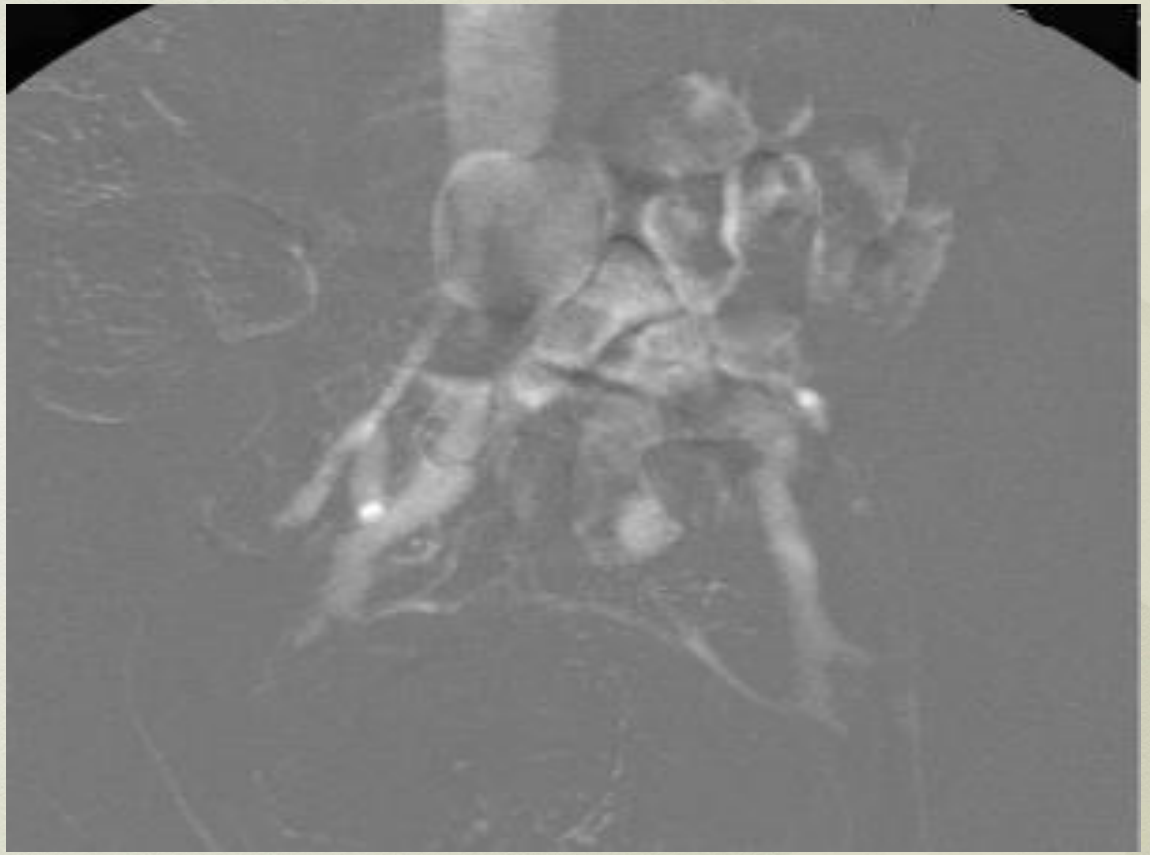





CO2 15CC HAND

MAY THURNER





DIALYSIS ACCESS

RENAL FAILURE PATIENT ON DIALYSIS

- Advantage of maintaining some renal function
- Patients are much easier to manage
- Tolerate a missed dialysis much better
- Fluid and potassium management is much easier in this group of patients
- A one point drop in GFR = increase in mortality of 12%

DIALYSIS IS TOO LATE TO NEGATE THE NEGATIVE EFFECTS OF CONTRAST ON THE KIDNEYS!!

CAVEATS IN DIALYSIS ACCESS

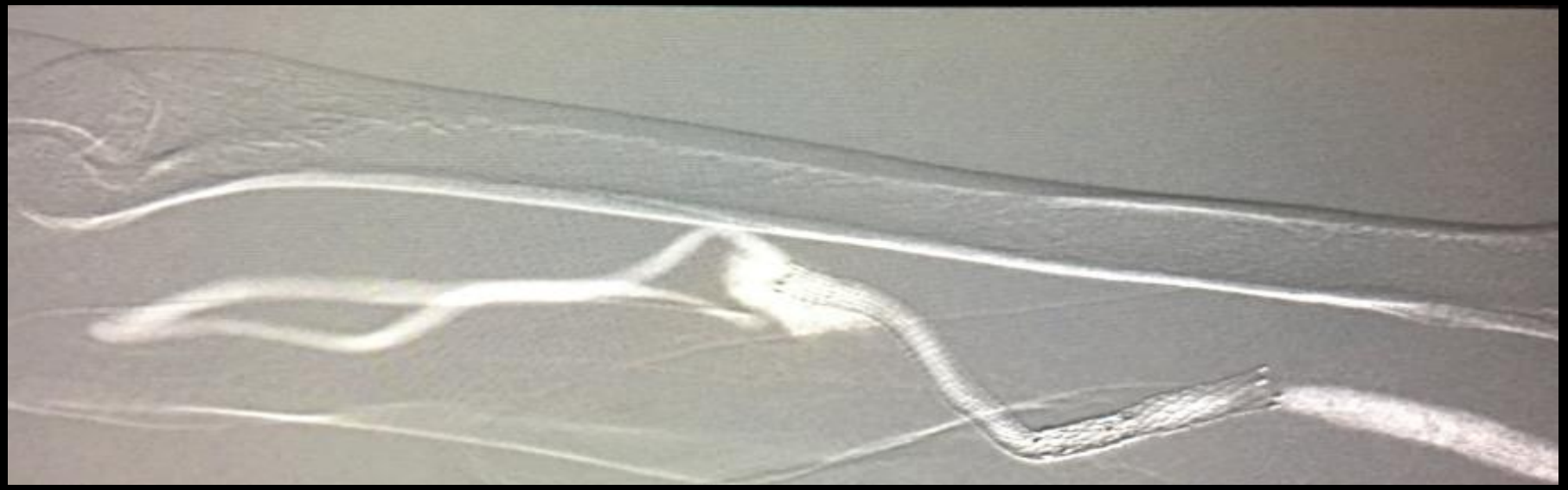
- The mission is to visualize the access without refluxing CO_2 into the cerebral vessels!!!!

- Has reportedly led to seizures and short term semi consciousness

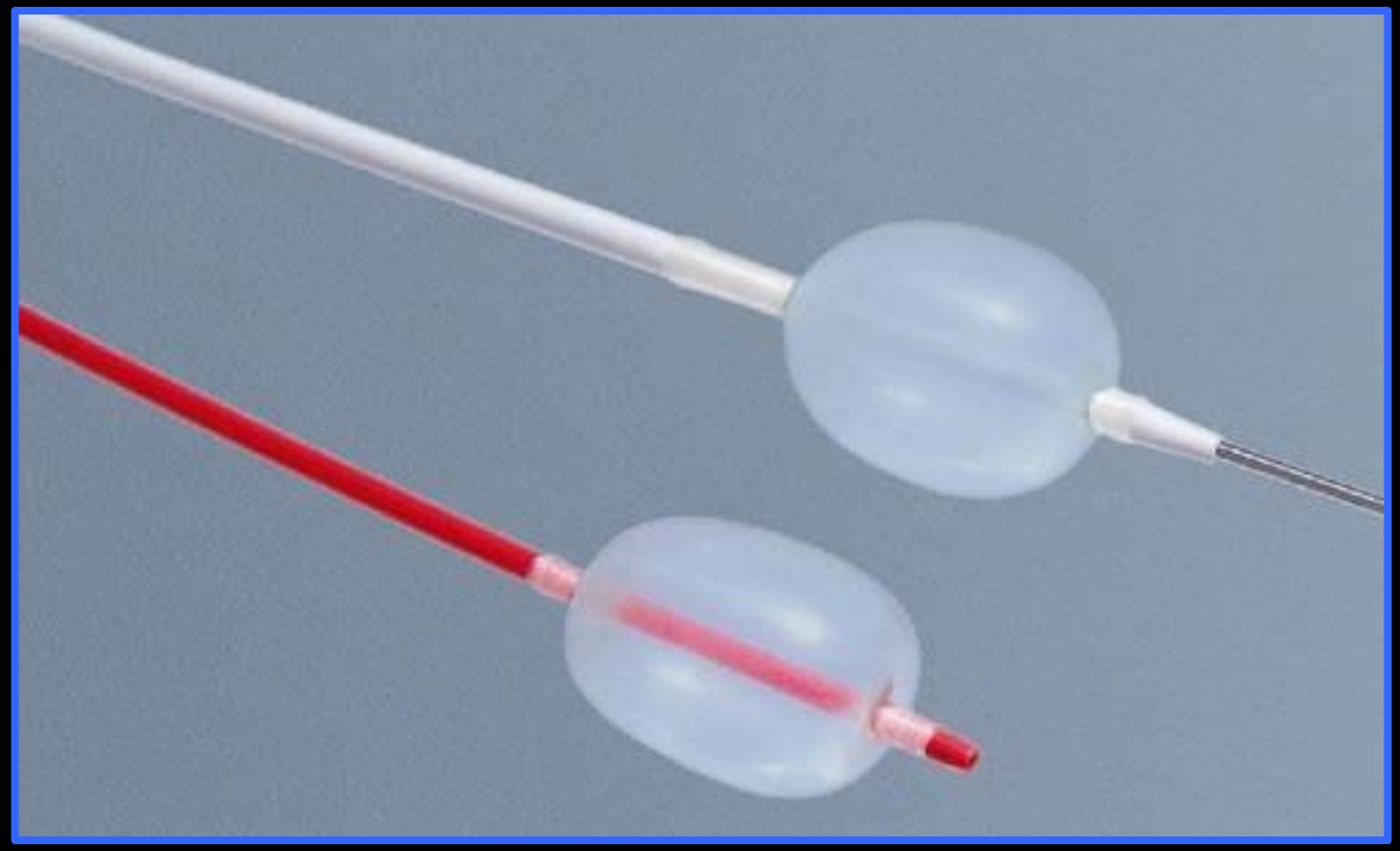
DIALYSIS ACCESS GUIDELINES

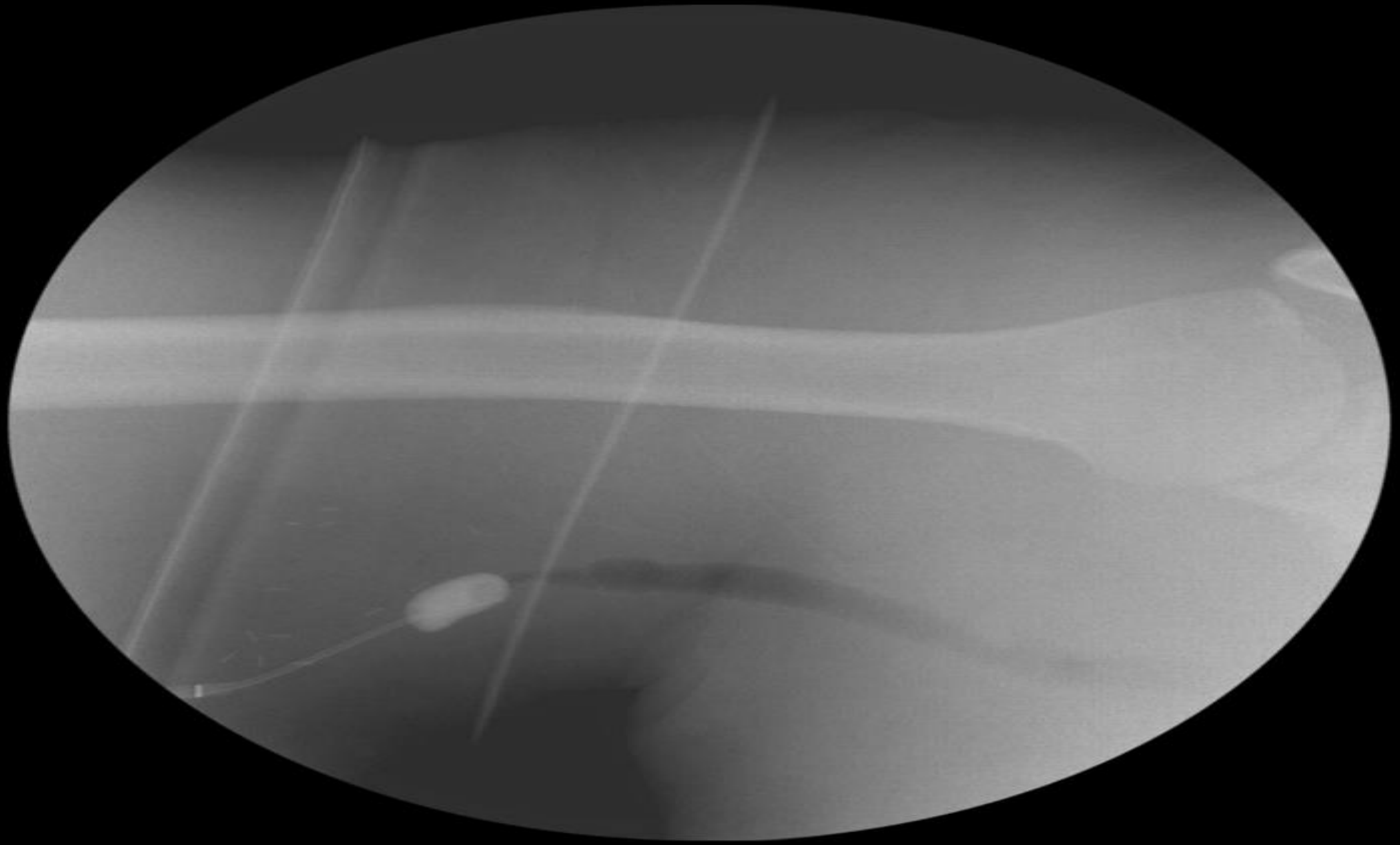
- View central venous outflow first
- Don’t explosively deliver in venous limb especially if thrombus present, avoids reflux in to artery
- Can inflate occlusion balloon to see venous outflow and prevent arterial reflux
- Don’t purposely reflux into arterial limb to see anastomosis
- Place microcatheter in arterial limb to deliver small, gentle injection
- Place patient in Trendelenburg to limit central arterial reflux
- Or use small amount of dilute contrast ¼ to see arterial anastomosis

CO_2 FISTULAGRAM



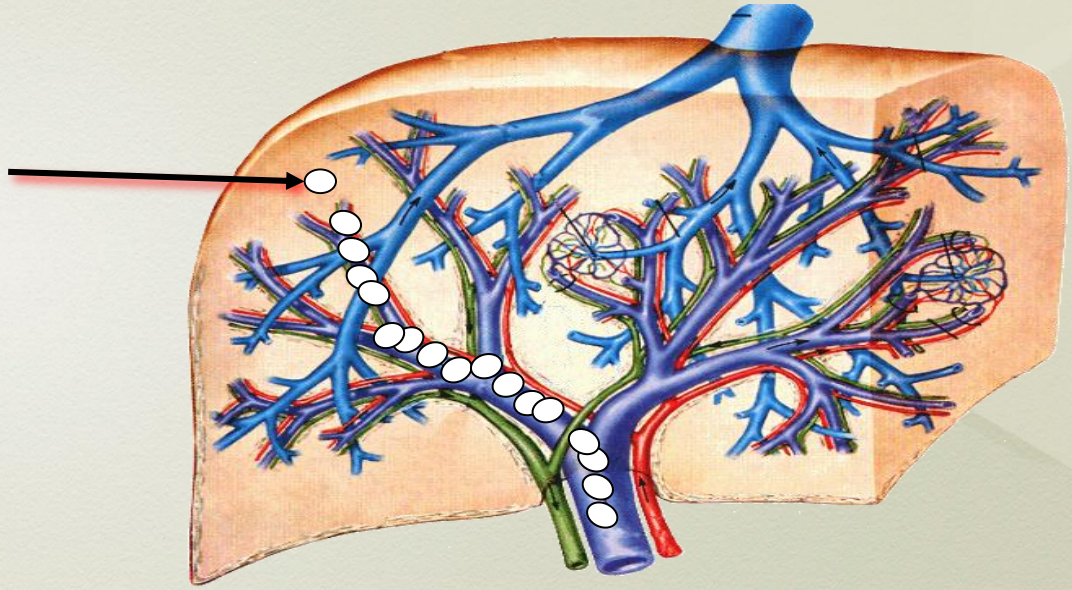
FOGARTY BALLOON

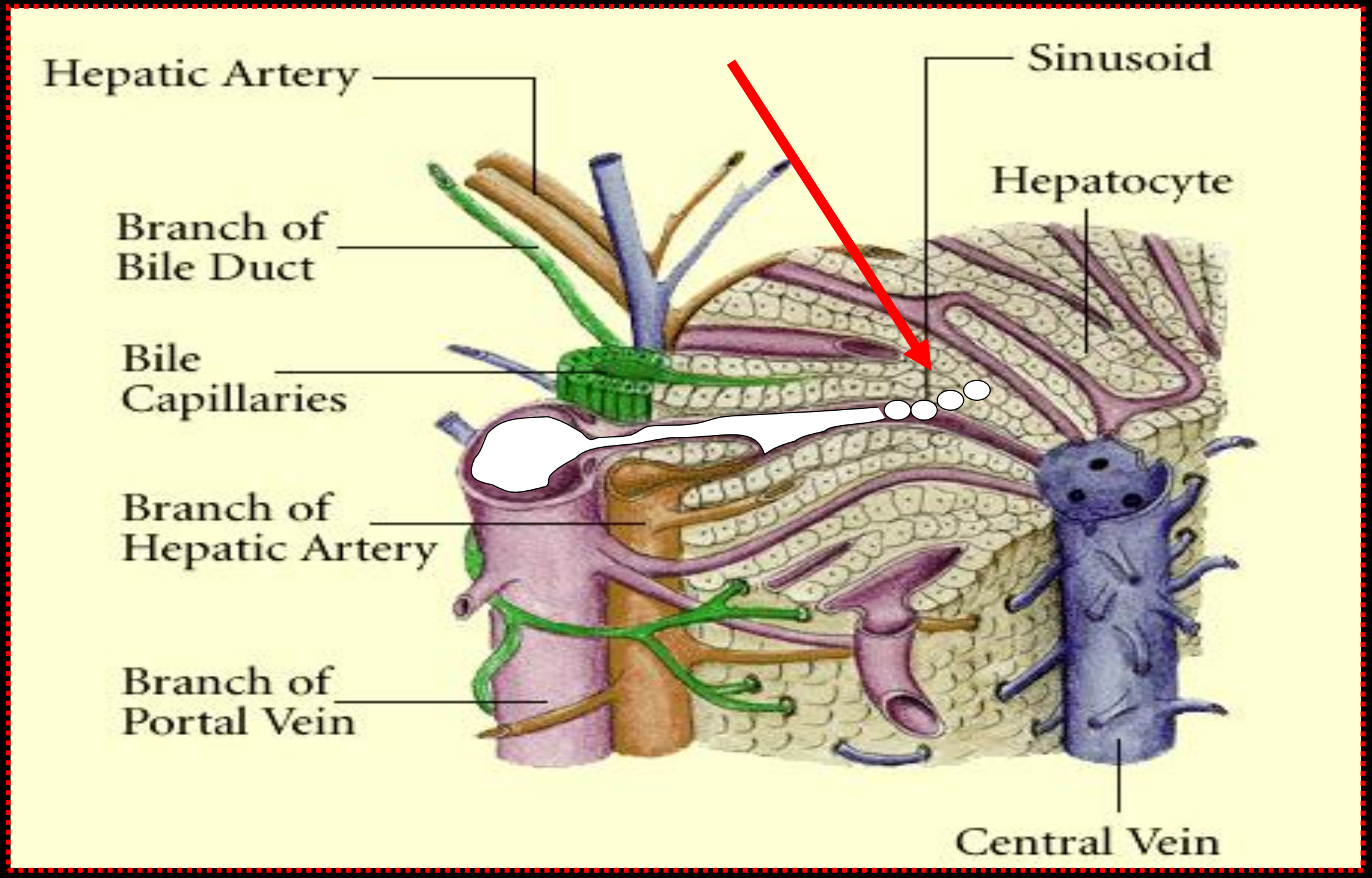




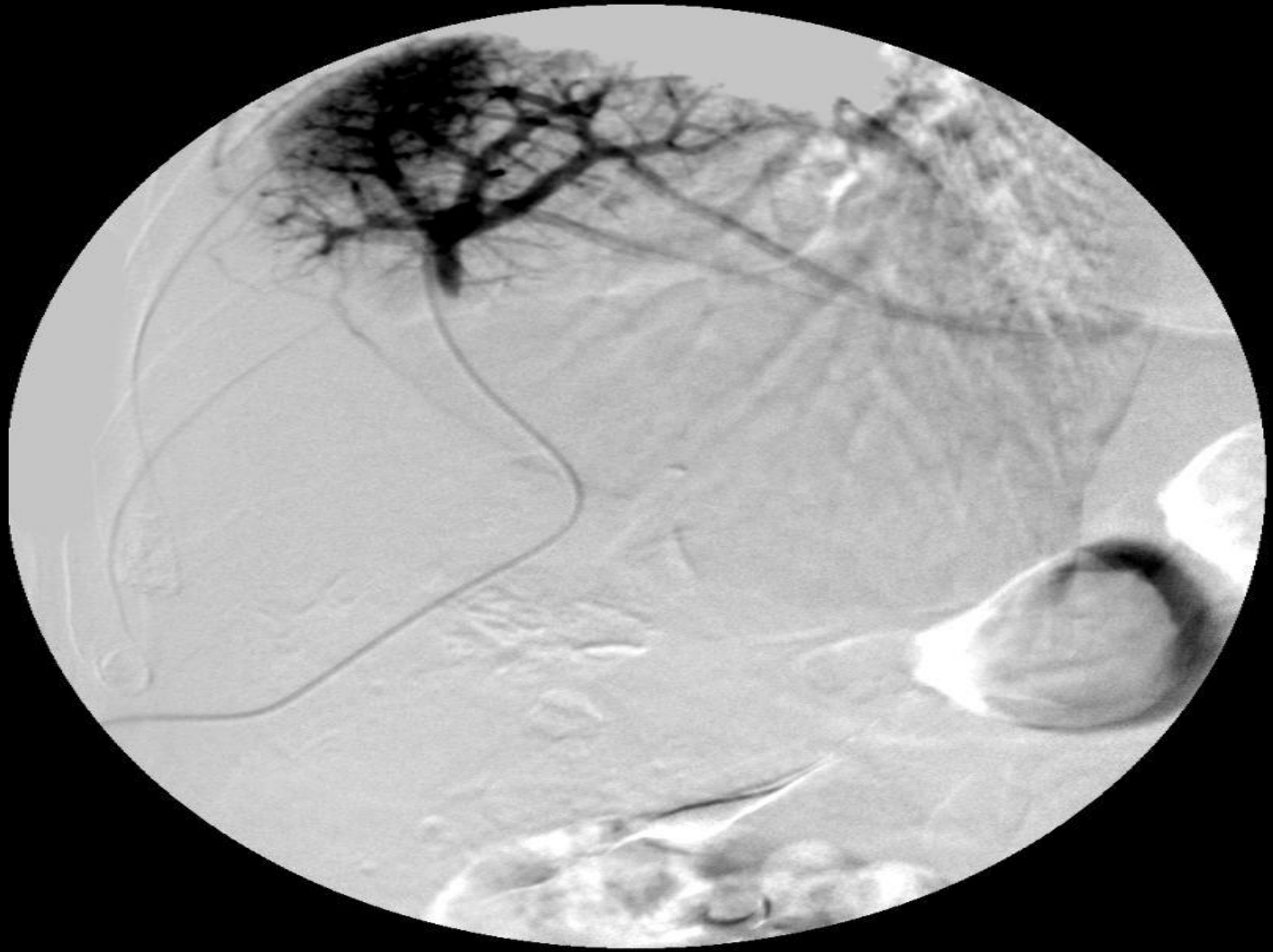
CO_2 GUIDED SPLENOPORTAL VEIN INTERVENTION

- Portal vein embolization
- Portal vein thrombosis
- Portal vein stricture
- TIPS




Hepatic Artery
Sinusoid
Hepatocyte
Branch of
Bile Duct
Bile
Capillaries
Branch of
Hepatic Artery
Branch of
Portal Vein
Central Vein

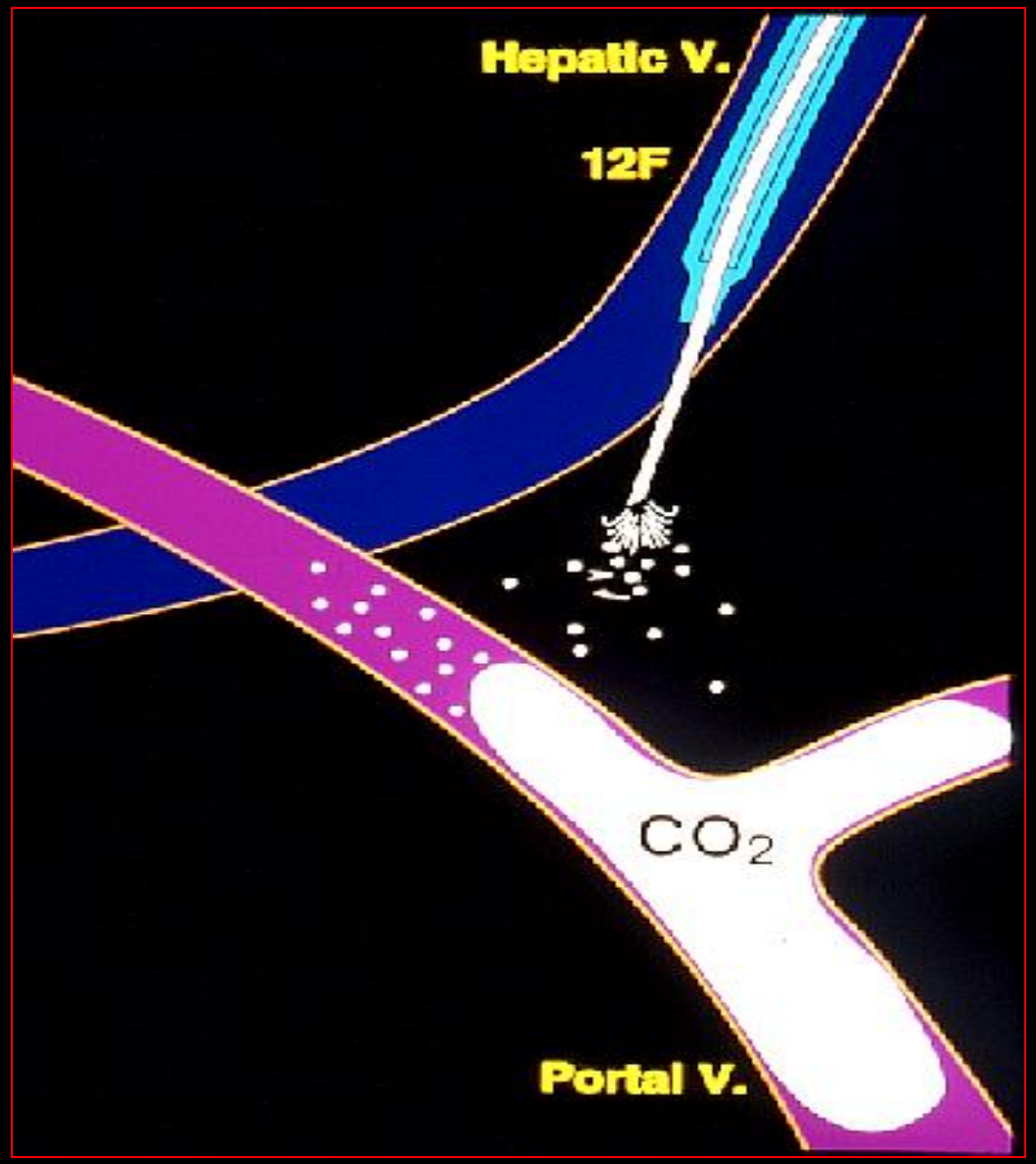
CO_2 PORTOGRAM

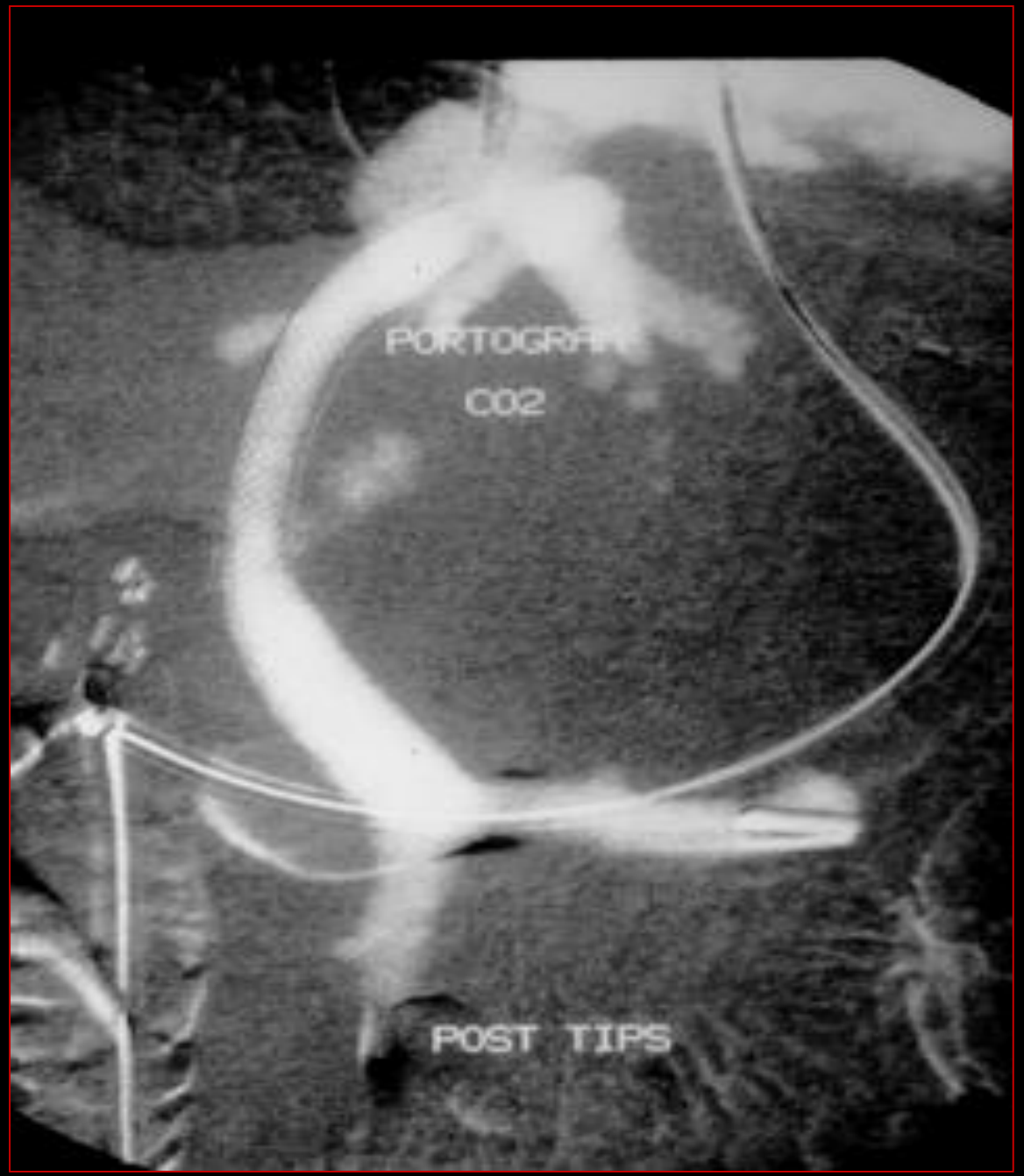


CO_2 GUIDED TIPS

- Hepatic vein evaluation
- Intraparenchymal portal venogram
- Entry site verification
- Portal venogram
- Post procedure portogram

DIRECT INTRAPARENCHYMAL CO_2

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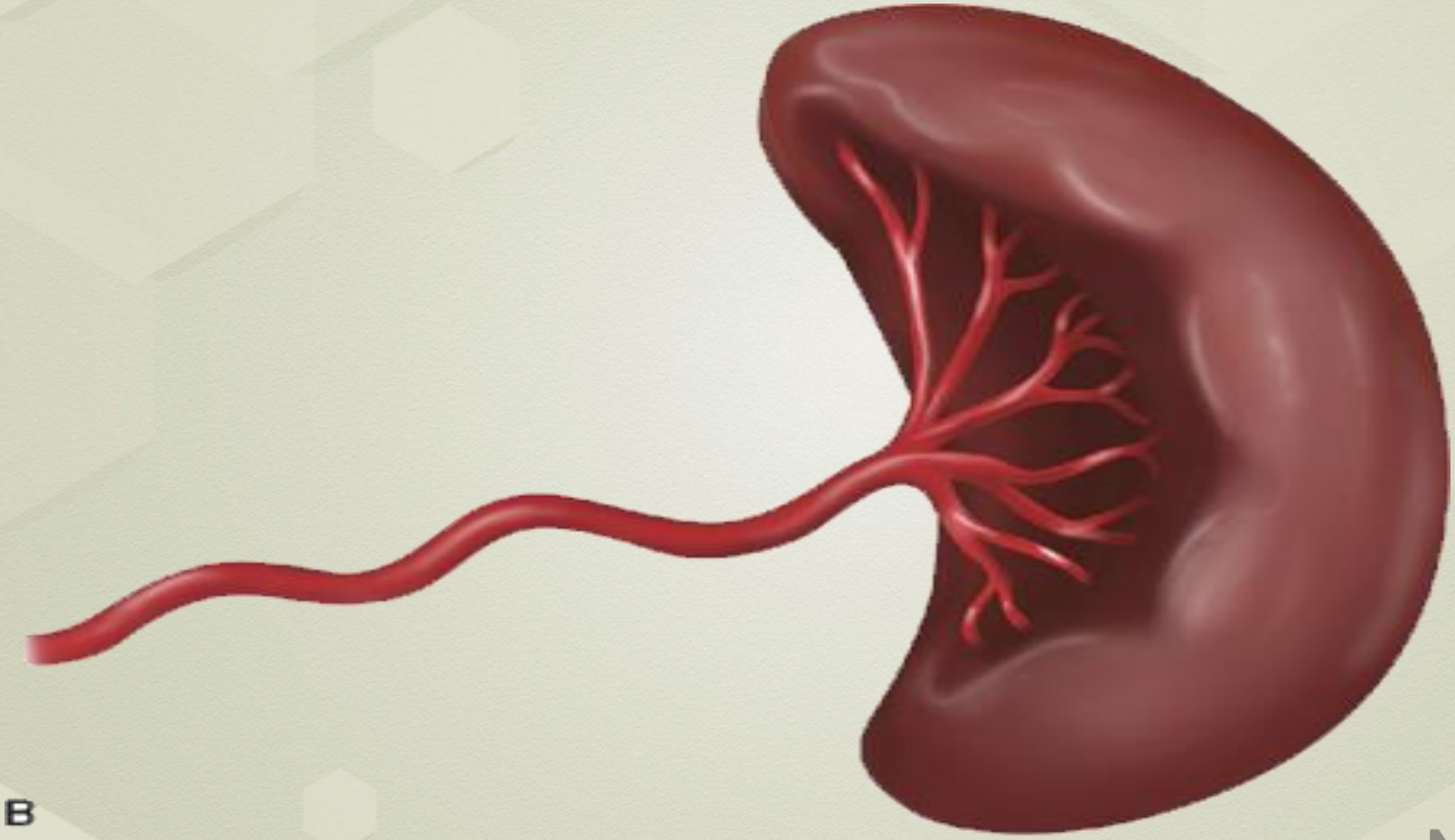
POST TIPS

SPLENIC INTERVENTION



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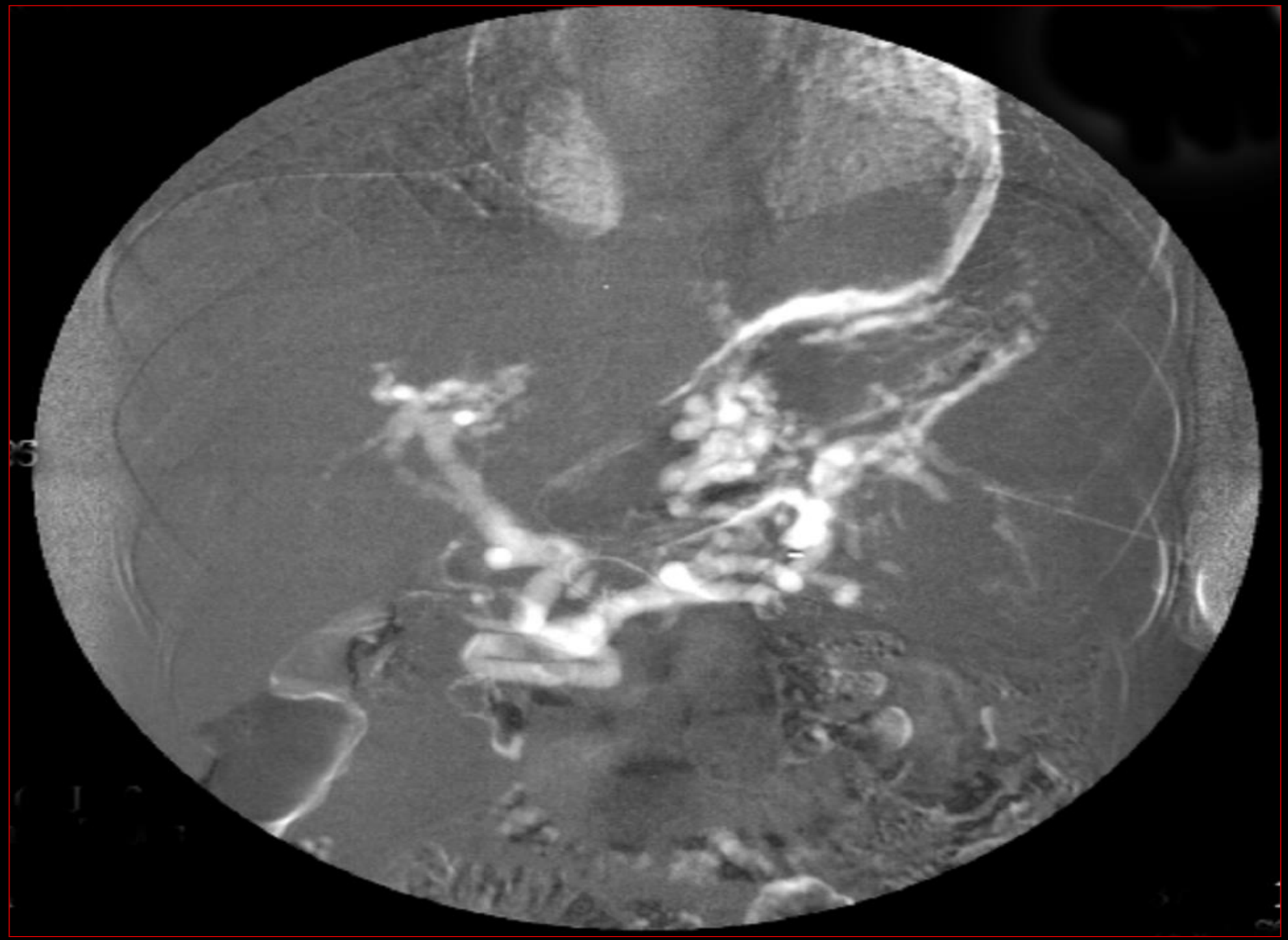

PRE-OP LIVER TX

PATENT

OCCLUDED

NEW HORIZONS

First experimental study of carbon dioxide digital subtraction lymphangiography

Article *in* European Journal of Plastic Surgery · May 1997

DOI: 10.1007/BF01002046

Noboru Tanigawa[1]
Atsushi Komemushi
Shuji Kariya
Hiroyuki Kojima
Satoshi Sawada

Intraosseous Venography with Carbon Dioxide Contrast Agent in Percutaneous Vertebroplasty

OBJECTIVE. Our objectives were to ascertain whether CO_2 can be used as a contrast agent in venography during percutaneous vertebroplasty and to evaluate whether it might be capable of replacing nonionic iodinated contrast agents.

CONCLUSION. Intraosseous venography with CO_2 contrast agent was slightly inferior to iodine venography in terms of its ability to visualize the vertebral bodies and perivertebral veins, but it remains a useful technique because no interference with optimal visualization of bone cement occurs during the cement injection when CO_2 remains within the fracture cleft.

Percutaneous vertebroplasty has an excellent pain-relieving effect on compression fracture due to various causes [1–7] and has therefore attracted much attention as a new therapeutic technique for this condition. It is a relatively simple technique that involves advancing a

that CO_2 can also be used in patients with iodine hypersensitivity.

Our objectives were to ascertain whether CO_2 can be used as a contrast agent in venography during percutaneous vertebroplasty and to evaluate whether it might replace nonionic iodine contrast agents.

ELSEVIER Volume 28, Issue 1, January 2003, Pages 68-69

Case Reports

Splanchnic neurolysis using carbon dioxide as the contrast agent

Kazuhiko Hirata M.D., Kazuo Higa M.D., Shinjiro Shono M.D., Kazunori Hirota M.D., Tetsuya Shinokuma M.D.

Show more

https://doi.org/10.1053/rapm.2003.50018

Abstract

Background and Objective: Iodinated contrast agents are

Carbon Dioxide-Contrasted Computed Tomography Angiography: High Pitch Protocols and Adapted Injection Parameters Improve Imaging Quality

Kohlendioxid-kontrastierte computertomografische Angiografie: Protokolle mit hohem Pitch und angepassten Injektionsparametern verbessern die Bildqualität

EPOS™
Electronic Presentation Online System

ESR
European Society of Radiology

320-row multidetector CT angiography for hepatocellular carcinoma using CO2 gas instead of iodinated contrast agents: Experiment and preliminary clinical study

DOI 10.1007/s00270-013-0834-5

CIRSE

CLINICAL INVESTIGATION ARTERIAL INTERVENTIONS

High-Pitch Carbon Dioxide Contrasted CT Angiography: Pilot Study

Tobias Penzkofer · Karin Slebocki · Jochen Grommes · Philipp Bruners · Peter Isfort · Thomas Schmitz-Rode · Stephan Langer · Christiane K. Kuhl · Andreas H. Mahnken

Carbon Dioxide Contrast Enhancement for C-Arm CT Utility for Treatment Planning during Hepatic Embolization Procedures

Adrian A. Wong, MD, Resmi A. Charalel, MD, John D. Louie, MD, and Daniel Y. Sze, MD, PhD

JOURNAL OF ENDOVASCULAR THERAPY
A SAGE Publication
An official publication of the International Society of Endovascular Specialists

Technical Note

Carbon Dioxide Flushing Technique to Prevent Cerebral Arterial Air Embolism and Stroke During TEVAR

Tilo Kölbel, MD, PhD[1], Fiona Rohlffs, MD[1], Sabine Wipper, MD, PhD[1], Sebastian W. Carpenter, MD[1], Eike Sebastian Debus, MD, PhD[1], and Nikolaos Tsilimparis, MD, PhD[1]

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CARBON DIOXIDE DIGITAL SUBTRACTION ANGIOGRAPHY

- CO_2 angiography is safe when used appropriately
- The new delivery system is user friendly
- CO_2 has unique properties as a contrast agent
- These properties make it a useful tool in both diagnosis and intervention alone or in combo with liquid contrast

THANK YOU FOR YOUR ATTENTION

CO_2 Digital Subtraction Angiography for Diagnosis and Intervention: Indications & Contraindications

Jim Caridi MD FSIR
jimcaridi@gmail.com

Professor of Vascular and Intervetional Radiology
Charimand Dept. of Radiology
Tulane University School of Medicine
New Orleans, L A USA

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