Carbon Dioxide (CO_2) Digital Subtraction Angiography

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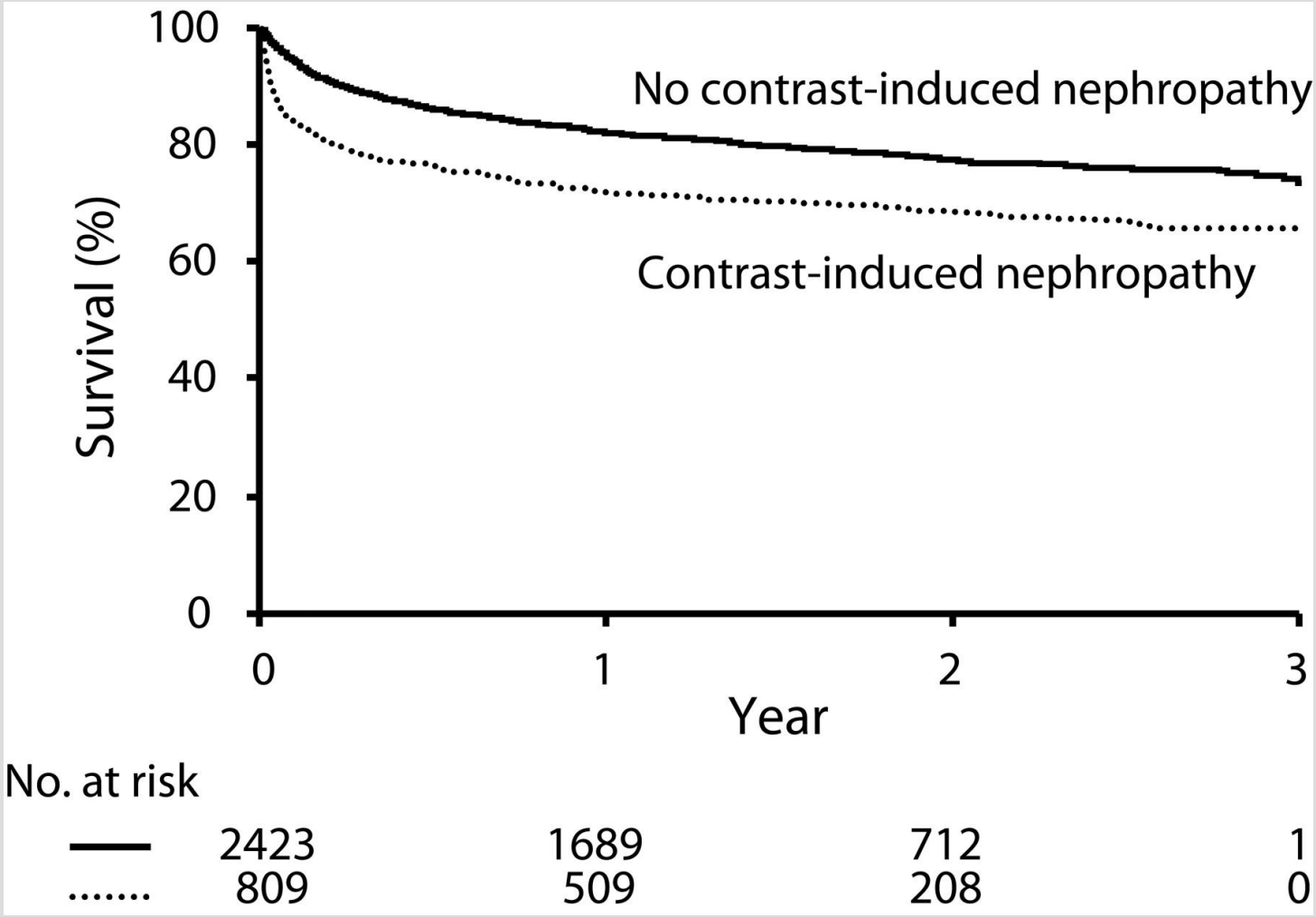
Disclosures

Fred A Weaver MD
Nothing to Disclose

Objectives

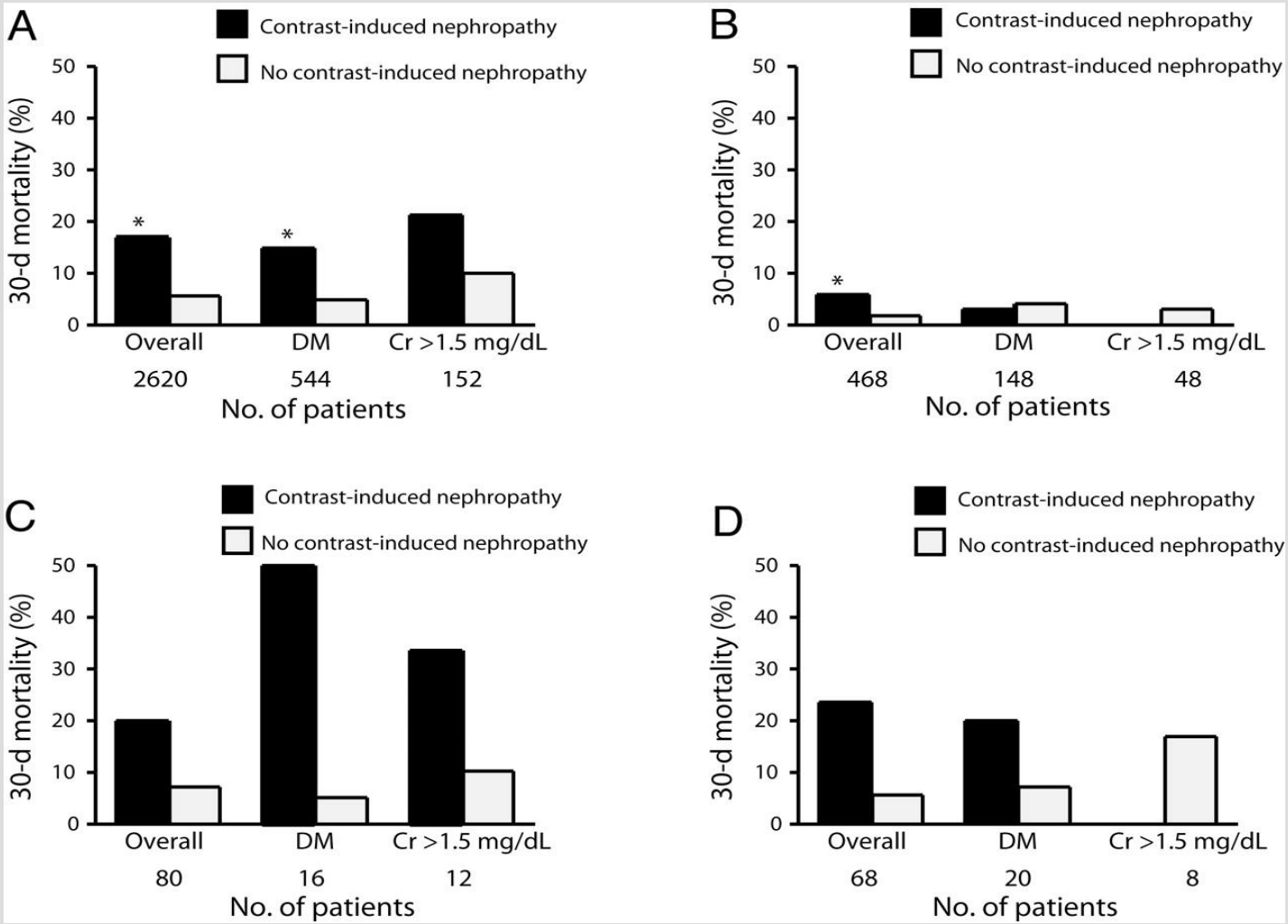
- Contrast Nephrotoxicity
- CO_2 Angiography Technique
- CO_2 Angiography Applications

Mortality stratified by contrast-induced nephropathy



From A M et al. Mayo Clin Proc. 2008;83:1095-1100

Thirty-day mortality rates with different types of radiographic procedures and routes of contrast administration, stratified by presence of diabetes mellitus (DM) and elevated creatinine



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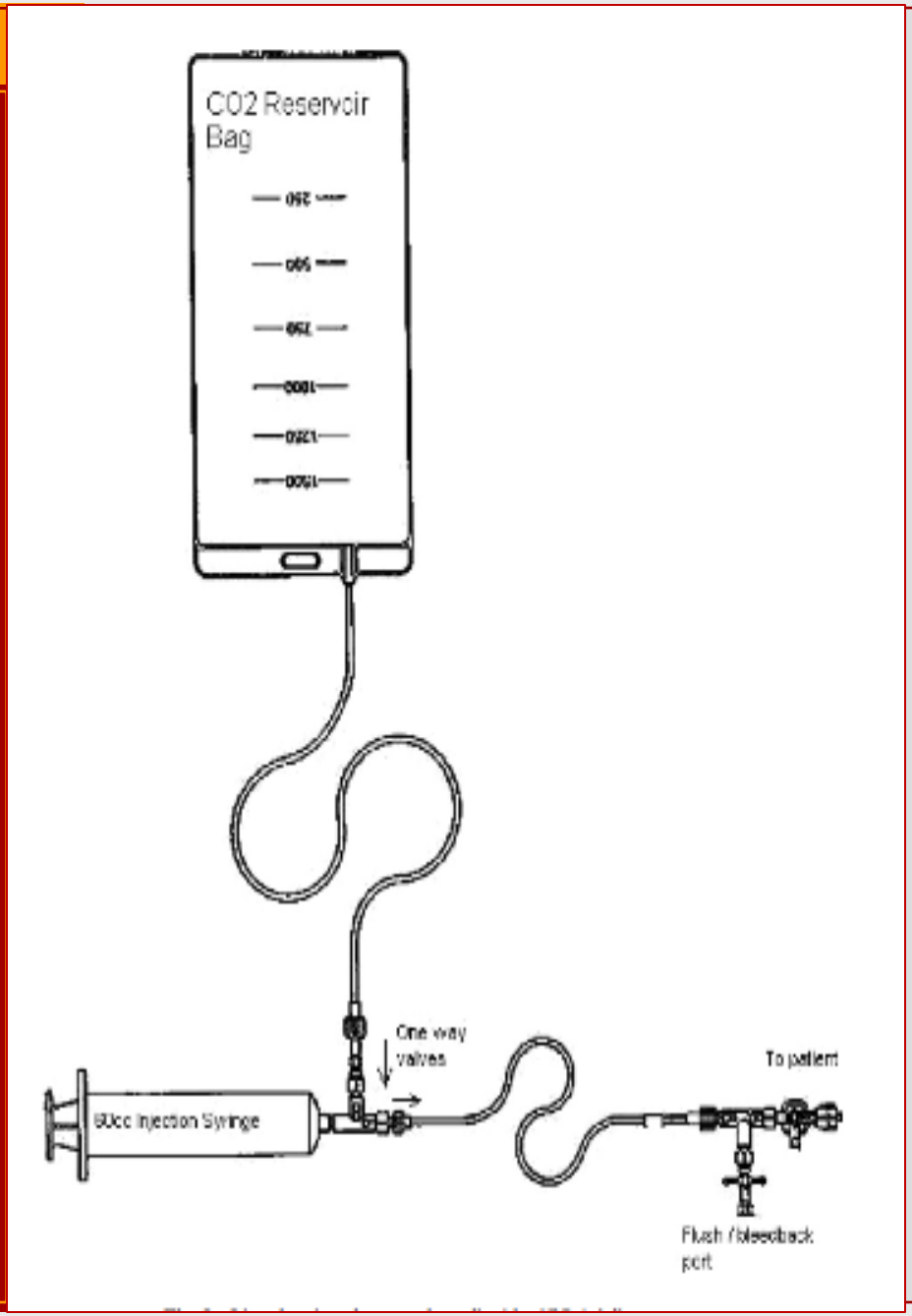
A. CT with IV B. Coronary C. Venography D. Non cardiac Angio

Carbon Dioxide as Intravascular Contrast Agent

- Used in 1950's
- Diagnosis of pericardial effusion
- 100-200 bolus of CO_2 intravenous
- Trapping of CO_2 in Right Atrium

CO_2 Advantages

- Inexpensive
- Widely Available
- Highly Soluble in blood
- Eliminated via lungs
- No nephrotoxicity
- No allergic reactions
- Low Viscosity (smaller catheters)



- Fill bag 3x directly
- Fill 60cc syringe 3x
- Self contained, closed one –way valve system
- Room air contamination minimized

Technology Requirements

- Digital, Flat Panel
- Increased frame rate, 3 to 6 frames per second, stacking technology is required
- Fixed dedicated angiographic equipment, portable C-arm inadequate

Technique

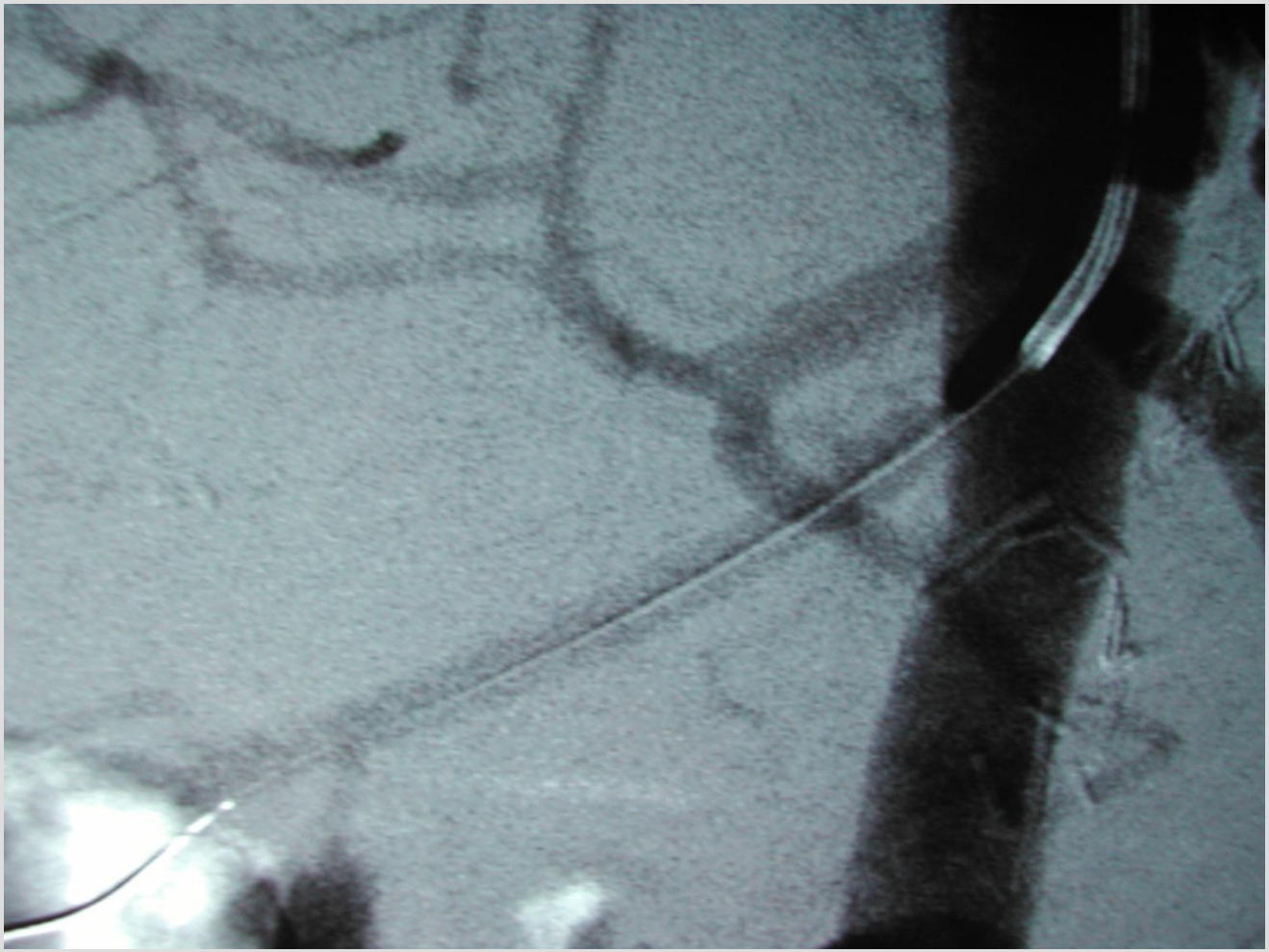
- Hand inject $\leq$ 50 cc
- Closed, self contained system
- Change position of patient for clearing
- Allow reabsorption time
- Decrease volume around viscerals

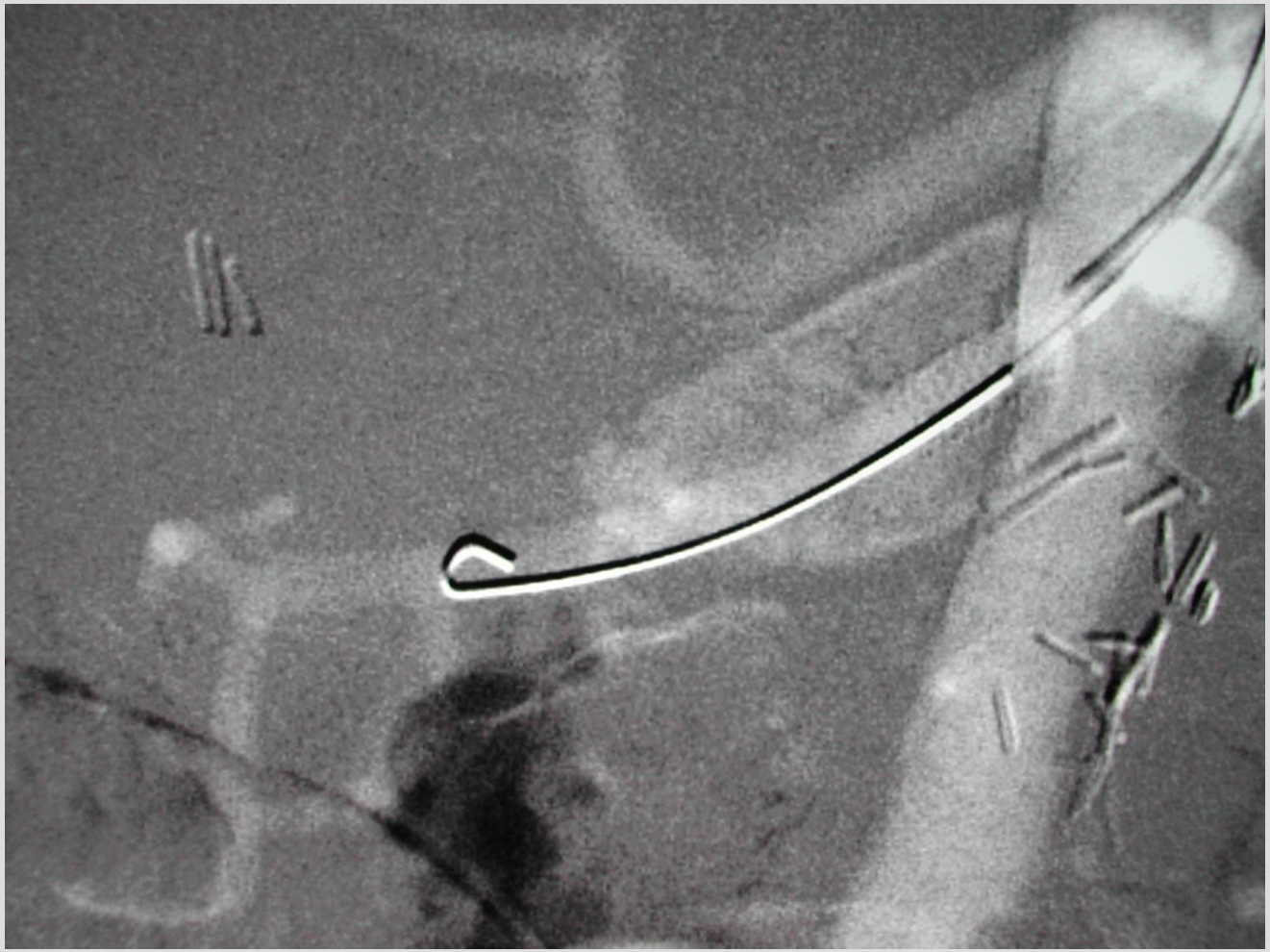
Vapor Lock

- CO_2 bouyant gas
  - Filling of non-dependent vessels
- Bouyancy > Energy of Blood flow = trapped gas “vapor lock”
- Increased with room air contamination
- Use of a self contained system reduces room air contamination

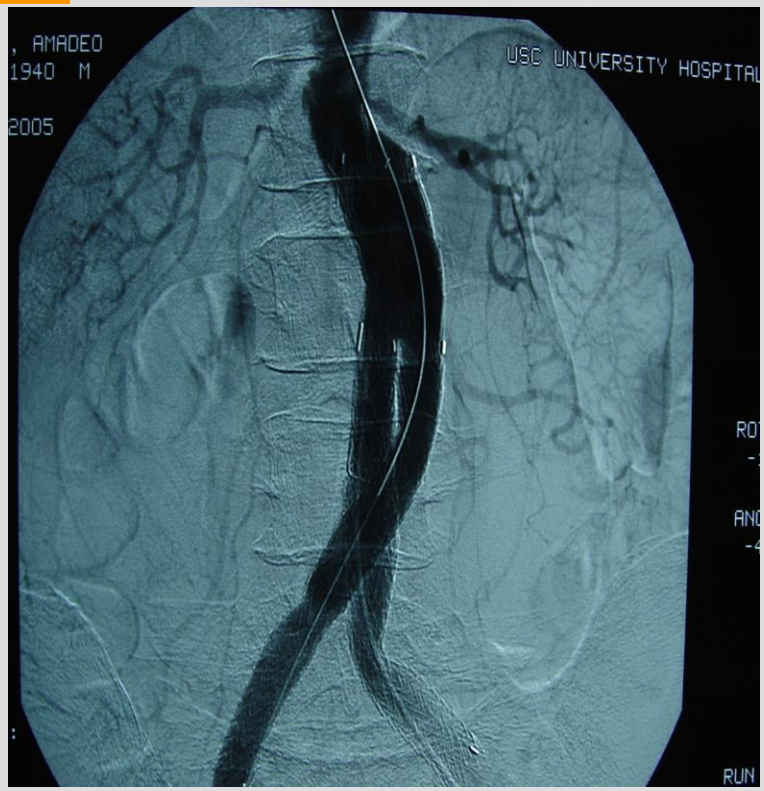
Applications of Carbon Dioxide Angiography

- EVAR
- Renal
- Peripheral
- TIPS
- Vena Cava and Hepatic venography





Iodine vs CO_2



Iodine

CO_2

Endoleak

Iodine

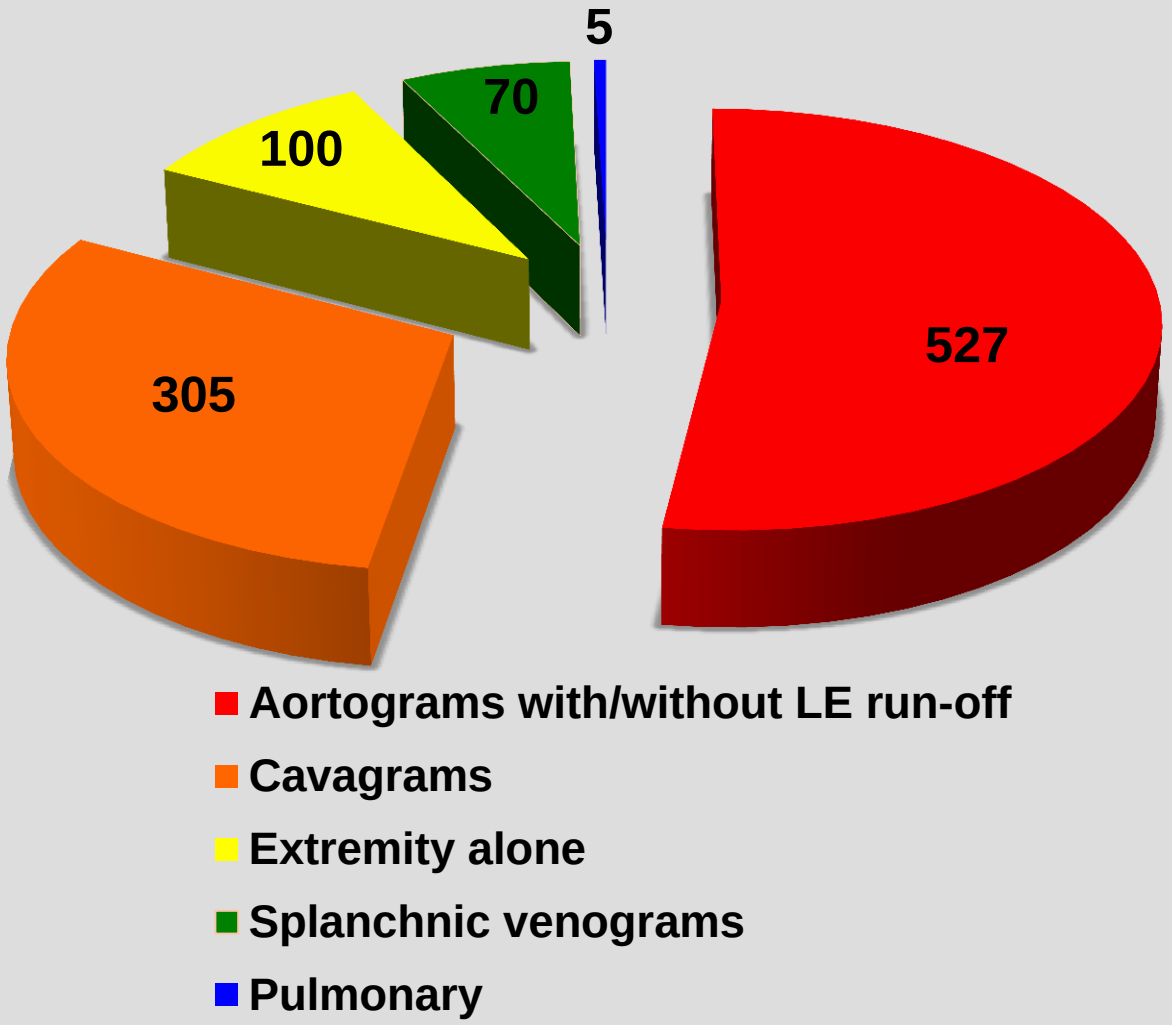
CO_2

Results

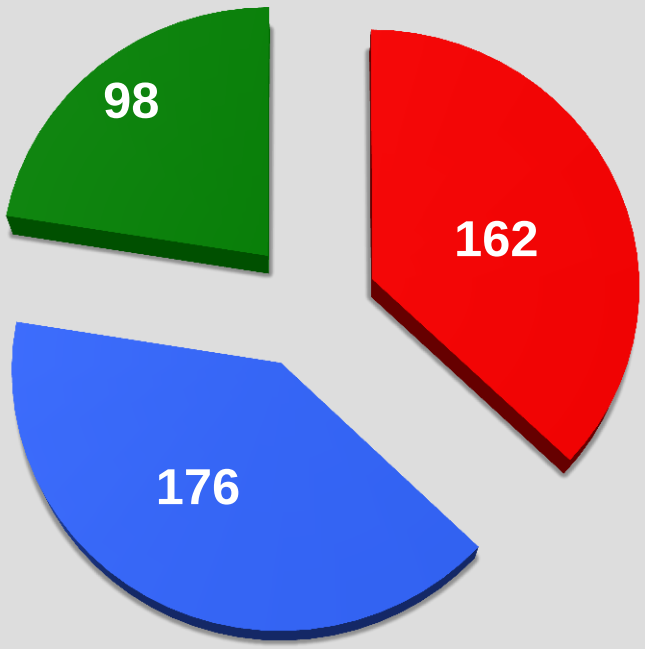
Moos, Arch Surg. 2011;146(12):1428-1432

- 1988 - 2009
- 951 patients
- 1,007 cases using CO_2
  - 519 Iodine
- Average age: 64 years old
- Male: 60.4%

Angiograms (1007)

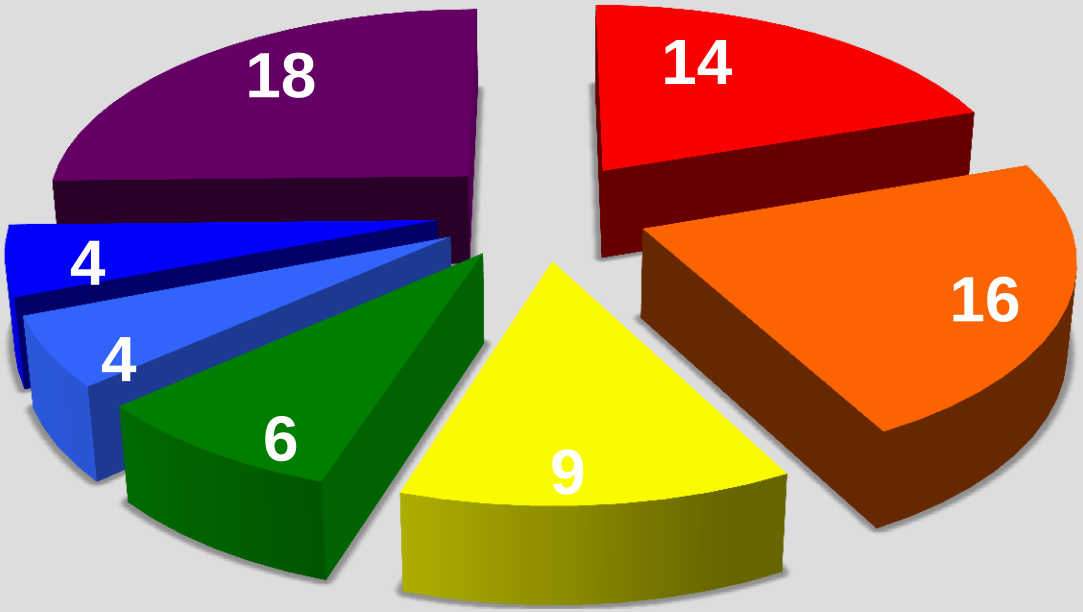


Interventions (499)



Contrast used, by procedure				
Procedure (n)	*CO_2 alone (%)*	*Median (mL)*	*CO_2 + Iodine (%)*	*Median (mL)*
Aortography (527)	246 (46.7)	240	281 (53.3)	15
Renal/visceral PTA/Stent (53)	12 (22.6)	225	41 (77.4)	10
Extremity PTA/stent (41)	31 (75.6)	180	10 (24.4)	4
EVAR (62)	21 (33.9)	180	41 (66.1)	30
TIPS (98)	27 (27.6)	100	71 (72.4)	125
TJLB (54)	48 (88.9)	60	6 (11.1)	10
IVC (176)	170 (96.6)	60	6 (3.4)	3
Hepatic venography (30)	25 (83.3)	60	5 (16.7)	30

Complications



Complications

- **Total: 6%**
- **Puncture site hematoma = 16 (1.6%)**

<u>CO_2 specific complications</u>

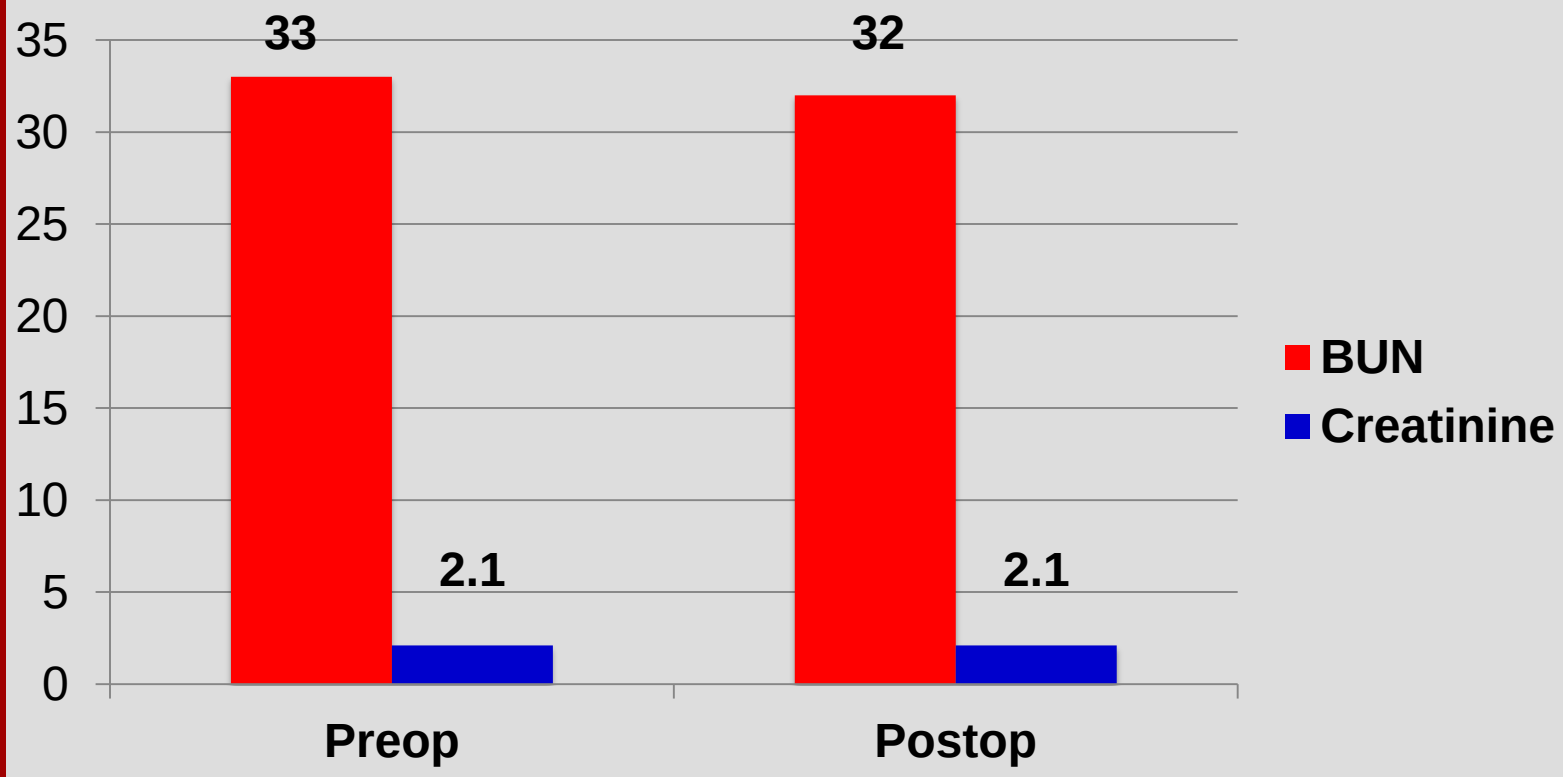
- **Abdominal Pain = 14 (1.4%)**
  - **Transient = 10**
  - **Pancreatitis = 4 (3 resolved)**

None since self contained, closed system adopted

Complications

- **Deaths = 4 (0.4%)**
  - **Metastatic adenocarcinoma**
  - **Refractory cardiomyopathy**
  - **TIPS/Left hepatic perforation**
  - **Suppurative pancreatitis**

Pre-op and Post-op Renal Function



Comparison of preoperative and postoperative creatinine values

Pre-procedure creatinine (mg/dL)	n (%)	preop cr, mean ± SD (mg/dL)	postop cr, mean ± SD (mg/dL)	P value	Rise in Cr (>0.5), n	*Δ, mean ± SD*
<1.2	196 (28)	0.9 ± 0.2	0.9 ± 0.3	NS	5	0.05 ± 0.3
1.3 - 1.9	259 (37)	1.6 ± 0.2	1.6 ± 0.5	NS	12	0.04 ± 0.45
>2	245 (35)	3.1 ± 1.3	3.2 ± 1.6	NS	27	0.19 ± 0.91
Total	700	2.1 ± 1.2	2.1 ± 1.4	NS	44	

Conclusions

- CIN is significant and potentially lethal entity
- CO_2 applications for diagnostic and interventional procedures are safe
- CO_2 as a contrast agent effectively preserves renal function
- CO_2 should be considered for patients with renal dysfunction
- With the exception of hydration only documented preventative strategy to prevent renal dysfunction
- Room air contamination responsible for majority of CO_2 mediated complications, self contained closed system important