IVUS and CO$_2$ angiogram for aortic disease: strategy to minimize the use of contrast

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Contrast-Induced Acute Kidney Injury

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- Contrast-induced acute kidney injury (AKI) is an important complication after the use of iodinated contrast media.

- Significant Economic impact: with more procedures and longer hospital stay.

- the most important risk is Compromised renal function.
Contrast-induced AKI is defined as:

- an increase in serum creatinine within the first 24 h after contrast exposure
- and peaking up to 5 days afterwards

The most commonly used definition in clinical trials is:

- a rise in SCr of 0.5 mg/dl or a 25% increase from the baseline value, assessed at 48 h after the procedure.
American College of Cardiology
Risco de IRA

• eGFR < 60 ml/min/1.73 m²
• DM
• Intraarterial injection
• Contrast with high osmolality
• Emergency and hypotension
• Volume of contrast >100 ml
Epidemiology

• In a large retrospective study of over 16,000 hospitalized patients, a total of 183 cases of contrast-induced AKI

• **Mortality raised from 7 to 34%** in matched control

• After adjusting for comorbid disease, patients with AKI had a **5.5-fold increased risk of death**

After Interventional procedures: Contrast-induced AKI is associated worst adverse outcomes

• 16% rate of death or MI at 1 year after PCI;

• rising to 26.3% if CK-MB levels were also elevated
American College of Cardiology/American Heart Association recommend the use of IOCM as a class I, Level A of Evidence:

- Low or Isosmolal contrast
• **Volume of contrast** is a important **risk factor**

• As a **general rule**, the volume should **not exceed** twice the baseline level of **eGFR** in milliliters
Strategies for Reducing Risk

• Avoiding nephrotoxic drugs:
  • nonsteroidal anti-inflammatory drugs,
  • calcineurin inhibitors,
  • high-dose loop diuretics,
  • aminoglycosides, and other

• Volume expansion = 1-1.5 ml/kg/h of intravenous fluid
  • for 3 to 12 h before and 6 to 12 h after contrast exposure

• Dialysis and hemofiltration should be considered only in the very highest-risk patient after nephrology consultation
Pharmacologic strategies

• **Vitamin C** over: 3 g orally the night before and 2 g orally twice a day after the procedure

• **N-acetylcysteine (NAC):** 1,200 mg orally twice a day on the day before and after the procedure.

• **Statins:** for cardiovascular patients - a standard of care
Strategies to minimize the use of iodinated contrast during endovascular Aortic Procedures:

• CO$_2$ angiogram
• IVUS – intravascular Ultrasound
**CO₂ Angiogram**

- **Experimental use since 1970**, as technology continued to improve, CO₂ evolved into a viable vascular imaging agent since the 80ths

- CO₂ is a **nontoxic, nonflammable, buoyant**, compressible gas that has **low viscosity**

- **Endogenous**: we produce 200 – 250 cc de CO₂ per minute

- Around 120 liters stored in human soft tissues
**CO₂ Angiogram**

- **Eliminated by the lungs:**
  - dissolution directly in the blood (7%),
  - bound to hemoglobin (10%),
  - or *predominantly carried as a bicarbonate ion* (85%)

- **No** concern for **allergy or renal toxicity**

- **Highly soluble**: 30 times greater than O₂

- Administered intravascularly, it tends to **dissolve** within a vessel in **30 seconds to 60 seconds**
CO$_2$ Angiogram

- **Negative** visualization

- Recommended **30 to 60 seconds** between injections

- Patients with **COPD**, should be increased to **2 minutes**

- Due to **Rapid expansion** may cause **pain** (general anesthesia)

- **Low viscosity**: may be used with microcatether
  - 1/400 of iodinade contrast
  - Less chance of occlusion
CO$_2$ – Principal Indications

- Iodinated contrast allergy
- High-risk patients for contrast-induced neuropathy
- High-volume contrast procedures
- Renal transplant evaluation
- Detection of hemorrhage
- Peripheral artery occlusive disease
- Endovascular aneurysm repair
- Interventional oncology
- Venous diagnosis and intervention (central veins, hepatic/portal, IVC) TIPS
- Splenoportography
CO₂ – CONTRAINDICATIONS

- Arterial above the Diaphragm*
- **Respiratory insufficiency**
- Use of nitrous oxide general anesthesia
- Right-to-left shunts
- Pulmonary artery hypertension and a patent foramen ovale
- Pulmonar AVM
- Don’t tolerate Supine position or Trendelenburg.
- Severe aortic obstruction
CO\textsubscript{2} Angiogram

- The **quality and accuracy** of the image will depend on the **amount of blood displaced** by the CO\textsubscript{2}:

**Figure 4.** Carbon dioxide (white) will generate a representative image depending on the amount of blood that is displaced.
Angiografia com CO$_2$

- CO$_2$ is lighter than blood and floats anterior to it
- An advantage to visualize anterior vessels such as the celiac, the SMA and IMA
- Buoyancy may compromise analysis of Aneurysm
Equipments used by our team

CO₂-Angioset

Injetor de CO₂
Intervenção Angiográfica Periférica
Applications

Angiogram and treatment of dialysis access
Applications

Detection of hemorrhage
Peripheral Arterial Occlusive Disease
Aortic, iliac, femoral and distal
Peripheral Arterial Occlusive Disease

Tips:
- 0.2 ml of papaverin
- Legs elevation in 30°
Vena Cava Filter

Carbon Dioxide Digital Subtraction Angiography (CO₂ DSA): A Comprehensive User Guide for All Operators

James G. Caridi, MD, FSIR¹; Kyung J. Cho, MD²; Christian Fauria, MD, MSW, MPH¹; Navid Eghbalieh, MD¹
From the ¹Tulane University Medical Center, New Orleans, Louisiana and the ²University of Michigan Health System, Ann Arbor, Michigan.
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Aortic Aneurysm

20 - 50 ml per injection – association with IVUS
CO$_2$ Angiogram for EVAR

- The **incidence of renal insufficiency** in patients undergoing EVAR approximates 7% to 25%.

- With **acute renal failure** occurring in 2% to 16%.

- If **ARF** associated **mortality rise** to 30% to 50%.
$\text{CO}_2$ Angiogram for EVAR

- $\text{CO}_2$ can be used as the **exclusive contrast agent** or in addition to **smaller volumes of iodinated contrast**

- Due of its **low viscosity** is more sensitive for detecting **endoleaks**
Clinical Research

Midterm Outcomes of Endovascular Aortic Aneurysm Repair with Carbon Dioxide–Guided Angiography

Yuriko Takeuchi,¹ Noriyasu Morikage,¹ Yutaro Matsuno,² Tamami Nakamura,¹ Makoto Samura,¹ Koshiro Ueda,¹ Takasuke Harada,¹ Yoshitaka Ikeda,² Kotaro Suehiro,¹ Hiroshi Ito,² Kensuke Sakata,² and Kimikazu Hamano,¹ Ube and Shimonoseki, Yamaguchi, Japan

- Retrospectively reviewed
- Subjects in the CO2-EVAR group had severe renal dysfunction (n = 27)
- and IC allergy (n = 4).
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- **Similar results:**
  - The fluoroscopy time,
  - operative time,
  - number of stent grafts placed,
  - and technical success rates

- There was no acute kidney injury

- **Conclusion:** CO₂-EVAR is **technically feasible** and exhibits prominent **renal protection**
Prospectively, 31 consecutive patients were submitted to standard EVAR

- CO2-DSA allowed to identify the juxta-renal landing zone of the endograft in 19/31 cases (61%) and the distal one in 31/31 (100%)

- Completion CO2-DSA detected type II endoleaks in 10 cases compared with 2 of conventional contrast media.
- CO₂ EVAR procedure is effectively in the majority of cases;

- In some cases, a single injection of a minimum amount of contrast medium can be used to overcome the renal arteries
The Assessment of Carbon Dioxide Automated Angiography in Type II Endoleaks Detection: Comparison with Contrast-Enhanced Ultrasound

Chiara Mascoli, Gianluca Faggioli, Enrico Gallitto, Vincenzo Vento, Giuseppe Indelicato, Rodolfo Pini, Andrea Vacirca, Andrea Stella, and Mauro Gargiulo

Vascular Surgery, DIMES, University of Bologna, Policlinico S. Orsola-Malpighi, Bologna, Italy

- Twenty-one patients were enrolled in the study to identify endoleak Type II
- Iodinated contrast media angiography (ICM-A)
- CO₂ Angiogram (CO2-A)
- Contrast-enhanced ultrasound (CEUS)
- Iodinated contrast
- CO₂ Angiogram
- Contrast-enhanced ultrasound (CEUS)
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Table 4: Type II endoleak detected by CO₂-A, ICM-A, and CEUS.

<table>
<thead>
<tr>
<th>ID</th>
<th>CO₂-A</th>
<th>ICM-A</th>
<th>CEUS</th>
</tr>
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<tbody>
<tr>
<td># 5</td>
<td>✓</td>
<td>–</td>
<td>✓</td>
</tr>
<tr>
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<td>–</td>
</tr>
<tr>
<td># 21</td>
<td>✓</td>
<td>–</td>
<td>✓</td>
</tr>
</tbody>
</table>

ID: patient series number; ✓: type II endoleak presence; –: type II endoleak absence.

CO₂-A is safe and effective method for ELII detection in EVAR, with a significantly higher agreement with CEUS if compared with ICM-A.
IVUS provides real-time data during aortic interventions, which results in appropriate diagnosis, graft selection, and deployment.

Information that can reduce the contrast load.

IVUS- Ultrassom intravascular

- Also can assess the adequacy of **graft apposition** after deployment.

- For **type I and III endoleaks**, the IVUS is a valuable tool to assess conformation of the device within the proximal neck and graft apposition.

- **Aortic dissections**: utility in defining the often confusing series of **entry and reentry sites**.

IVUS: Phillips/Volcano and Boston ScientiC

<table>
<thead>
<tr>
<th></th>
<th>French</th>
<th>Fio Guia (in)</th>
<th>Frequência</th>
<th>Diâmetro</th>
<th>Especificações</th>
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<tbody>
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<td>0,014, Rx</td>
<td>20 MHz</td>
<td>16 mm</td>
<td>Gray Scale, CromaFlow, Histologia Virtual</td>
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<tr>
<td>Visions PV 0.018</td>
<td>3,4</td>
<td>0,018, Rx</td>
<td>20 MHz</td>
<td>24 mm</td>
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<tr>
<td>Visions PV 0.035</td>
<td>8,2</td>
<td>0,038, OTW</td>
<td>10 MHz</td>
<td>60 mm</td>
<td>Gray Scale</td>
</tr>
</tbody>
</table>
Measurements

- Renal Vein
- Rt Renal
- Below Left Renal
- Left Renal
- Right Common Iliac
Good results in the 20 patients for EVAR, despite the presence of renal dysfunction or severe contrast allergy.

- Non-iodinated contrast-based imaging modalities (IVUS, CO₂ and MRA/Gad)

Table III. Imaging modalities used in preoperative assessment, endograft implantation, and follow-up

<table>
<thead>
<tr>
<th>Modality</th>
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<tbody>
<tr>
<td>Preoperative assessment</td>
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<td>Gadolinium-enhanced MRA</td>
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<td>Non-contrast CT</td>
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<td>CO₂ aortography</td>
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<td>Intraoperative assessment</td>
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<td>IVUS</td>
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<td>Postoperative surveillance</td>
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<td>Duplex ultrasound</td>
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</tbody>
</table>
Aortic Disease

- Penetrating ulcer
- Intramural Hematoma
- Aortic Trauma
- Aortic Dissection
Intramural Hematoma
Type B Disseccion

- IVUS can confirm true lumen access and precisely define the proximal entry site
- Branches involved
- Oversizing appropriately
- Confirm technical success
- Less Contrast and fluoroscopy time
Type III Endoleak
Endoleak tipo III
Conclusion

• **CO₂ Angiogram and IVUS** are **effective tools** to minimize the effect of media contrast in aortic procedures.

• More studies are needed to define if **indications** should be **expanded**.

• **CO₂** can be used only in **abdominal aorta**.

• **IVUS** is essential for **complex aortic disease**.
Thank you

SEE YOU NEXT YEAR

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