Zero contrast procedures, myth or reality?
Pre-interventional workup with no-contrast MR angiography followed by CO2 angiography

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Zero Contrast Procedures

- Use of non-enhanced MRA and CO$_2$ angiography for work-up
  - (EVAR)
  - Peripheral applications
Iodinated contrast

- Nephrotoxicity
- Allergic reactions
Iodinated contrast

### CI-AKI in patients undergoing angiography with CO2 vs ICM

<table>
<thead>
<tr>
<th>Study name</th>
<th>Statistics for each study</th>
<th>CO2</th>
<th>ICM</th>
<th>(n)</th>
<th>Odds ratio and 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Odds ratio</td>
<td>Lower limit</td>
<td>Upper limit</td>
<td>Z-Value</td>
<td>p-Value</td>
</tr>
<tr>
<td>Stegemann et al 2015</td>
<td>0.246</td>
<td>0.056</td>
<td>1.083</td>
<td>-1.854</td>
<td>0.064</td>
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<tr>
<td>Knipp et al 2010</td>
<td>0.481</td>
<td>0.016</td>
<td>14.702</td>
<td>-0.419</td>
<td>0.675</td>
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<tr>
<td>Chao et al 2007</td>
<td>16.355</td>
<td>0.637</td>
<td>420.156</td>
<td>1.687</td>
<td>0.092</td>
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<tr>
<td>Liss et al 2005</td>
<td>0.457</td>
<td>0.083</td>
<td>2.508</td>
<td>-0.902</td>
<td>0.367</td>
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<tr>
<td>Dowling 2003</td>
<td>0.184</td>
<td>0.009</td>
<td>3.942</td>
<td>-1.082</td>
<td>0.279</td>
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<tr>
<td>Steren et al 2001</td>
<td>1.429</td>
<td>0.159</td>
<td>12.813</td>
<td>0.319</td>
<td>0.750</td>
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<tr>
<td>Spinosa et al 1999</td>
<td>0.288</td>
<td>0.052</td>
<td>1.598</td>
<td>-1.424</td>
<td>0.154</td>
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<tr>
<td>Frankhouse et al 1995</td>
<td>0.388</td>
<td>0.017</td>
<td>9.034</td>
<td>-0.589</td>
<td>0.556</td>
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<tr>
<td></td>
<td>0.465</td>
<td>0.218</td>
<td>0.992</td>
<td>-1.981</td>
<td>0.048</td>
</tr>
</tbody>
</table>
Gd-based contrast

- Occurrence of nephrogenic systemic fibrosis
- Nephrotoxicity
  - Various case reports of acute renal failure at high dose
  - Safe in dosage <0.4 mmol/kg

Gemery et al, AJR 1998; 171:1277-1278
Kaufman et al, Radiology 1999; 212:280-284
Le Blanche et al, AJR 2002; 179:1023-1028
Roserioreanu et al, JVIR 2005;16:297-298
Nyman et al, Radiology 2002; 223:311-318
MRA without contrast

- In-flow techniques (TOF)
  - Limited FOV
  - Susceptible to artifacts
Figure 1: Diagram of QISS pulse sequence. A two-dimensional single-shot balanced steady-state free precession (bSSFP) pulse sequence is used to image arterial spins within the section during diastole, when flow is slow or absent. $k_y$ = phase-encoding line, $QI$ = quiescent interval, $\alpha/2$ = one half the radiofrequency excitation flip angle.
MRA-QISS

Edelman RR et al, Magnetom Flash 2014
CTA-MRA QISS-DSA PAD

Varga-Szemes A et al, Magnetom Flash 2015
CTA-MRA QISS-DSA PAD

Varga-Szemes A et al, Magnetom Flash 2015
QISS vs. CE-MRA PAD
QISS vs. CE-MRA PAD

QISS

CE-MRA
QISS vs. CE-MRA PAD

QISS

CE-MRA
QISS-MRA vs. CTA vs. DSA

- QISS-MRA provides high diagnostic accuracy compared with DSA
- QISS-MRA less prone to image artifacts than CTA
- QISS-MRA better visualizes heavily calcified segments with impaired flow
- QISS-MRA obviates the need for contrast administration in PAD patients

Varga-Szemes A et al, JACC Cardiovasc Imaging 2017;10:1116-1124
CO$_2$ angiography

- Lack of toxicity or allergic reactions
- Rapid intravascular clearance
- Buoyancy (potentially disadvantageous)
- Ultra-low viscosity/density
- Reflux (ostial depiction)
- Nonmiscibility (fluid displacement)
- Colorless and odorless (potentially dangerous with ‘old technology’)
- Compressibility (pressure build-up)

Sharafuddin MJ et al JVS 2017;66:618-637
Old technology
Hand-held injector
Automated CO\textsubscript{2} injector

Angiodroid
CO$_2$ angiography-PAD
$\text{CO}_2$ angiography-PAD
$\text{CO}_2$ angiography-PAD
$\text{CO}_2$ angiography-PAD
Conclusions

• Current technology allows for zero-contrast procedures for peripheral arterial endovascular procedures
• Zero-contrast procedures are not a ‘myth’ anymore
• MORE CO$_2$!
MORE CO$_2$!
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